An Architecture of a Network Controller for QoS Management in Home Networks with Lots of IoT Devices and Services

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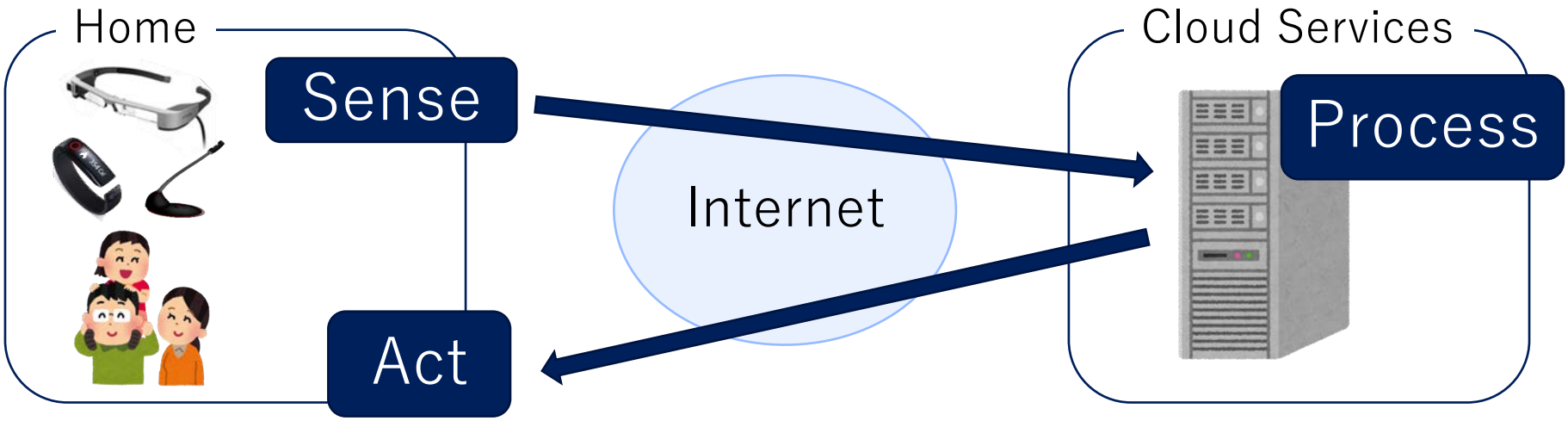
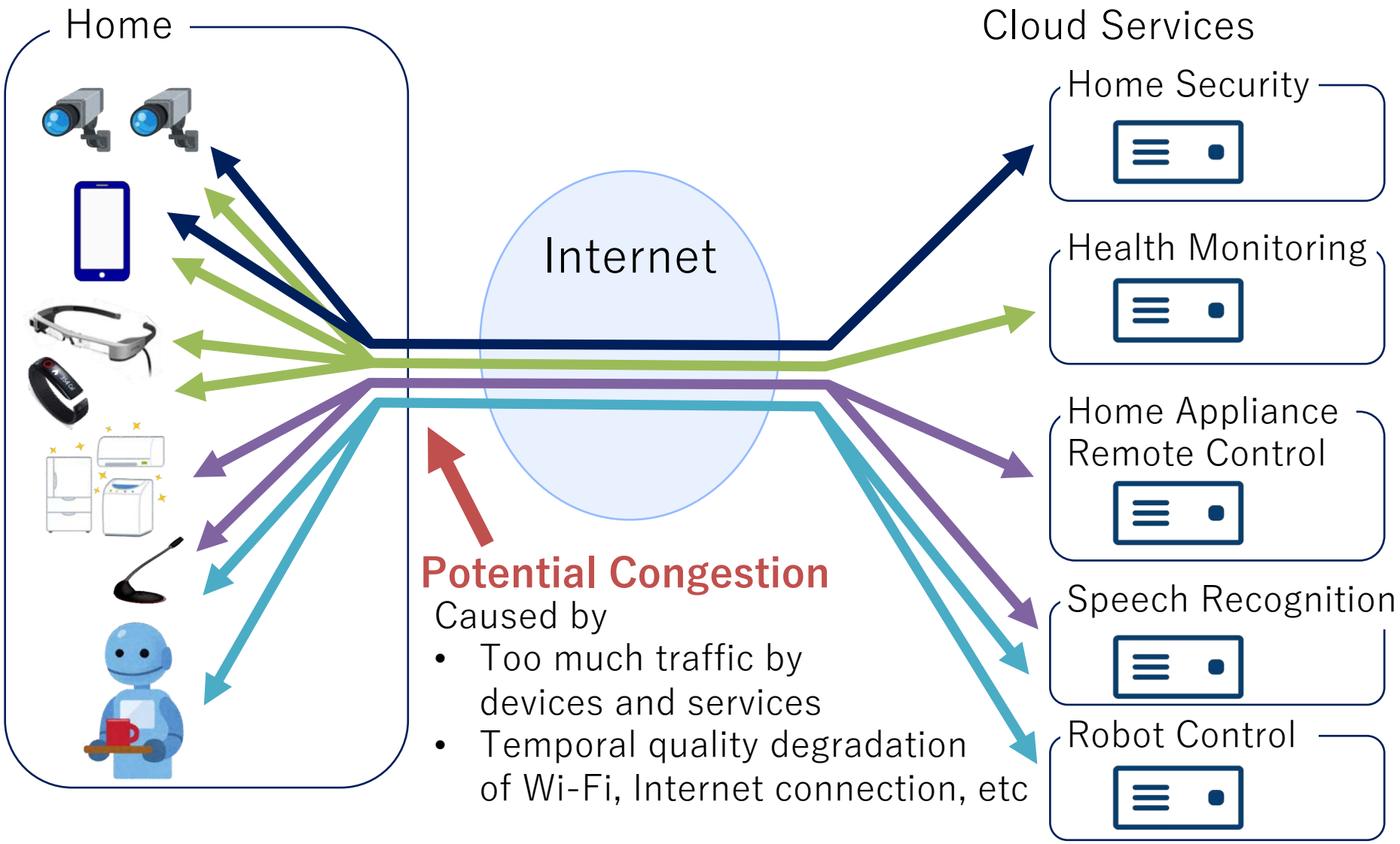
IoT Services in Home

- So many use cases are proposed
  - Energy monitoring and management
  - Home Security
  - Remote control of home appliances based on users' lifestyle
  - Health management

- Our focus: Cloud-based IoT services



Too Much Traffic by Many Services



Handling Congestion

- Once congestion happens,
  - Data may not be delivered to destinations timely
  - Quality of Life (QoL) of the users is degraded

    Users cannot enjoy services that they need to use

- QoS has been applied to prioritize certain types of traffic
  - Latency, bandwidth, etc
    - Implemented by IntServ, DiffServ, SDN, etc
  - QoS in IoT can be thought as broader than network term, such as data accuracy, timeliness, etc [Li 2014]
- Applying QoS to IoT traffic in home could improve QoL

Problem to apply QoS to IoT Traffic in Home

- Which and how traffic should be prioritized?

- It depends on
  - Devices – What kind of data each device sends/receives?
  - Services – Which data is more important to provide service?
  - Users – How do users think importance of each service?

- No one has enough knowledge to decide
  - Usually no skilled administrator manages the home network
  - Details on devices and services are hidden from users

We cannot apply QoS to IoT traffic in home, because we cannot know which traffic should be prioritized

Contribution

- Propose an architecture of the controller for applying QoS to IoT traffic in a home network without skilled administrator
  - Key is to design interfaces for IoT devices, service providers, and users **separately**
  - Controller decides which traffic is important
- Simple prototype implementation based on architecture
- An example use case scenario

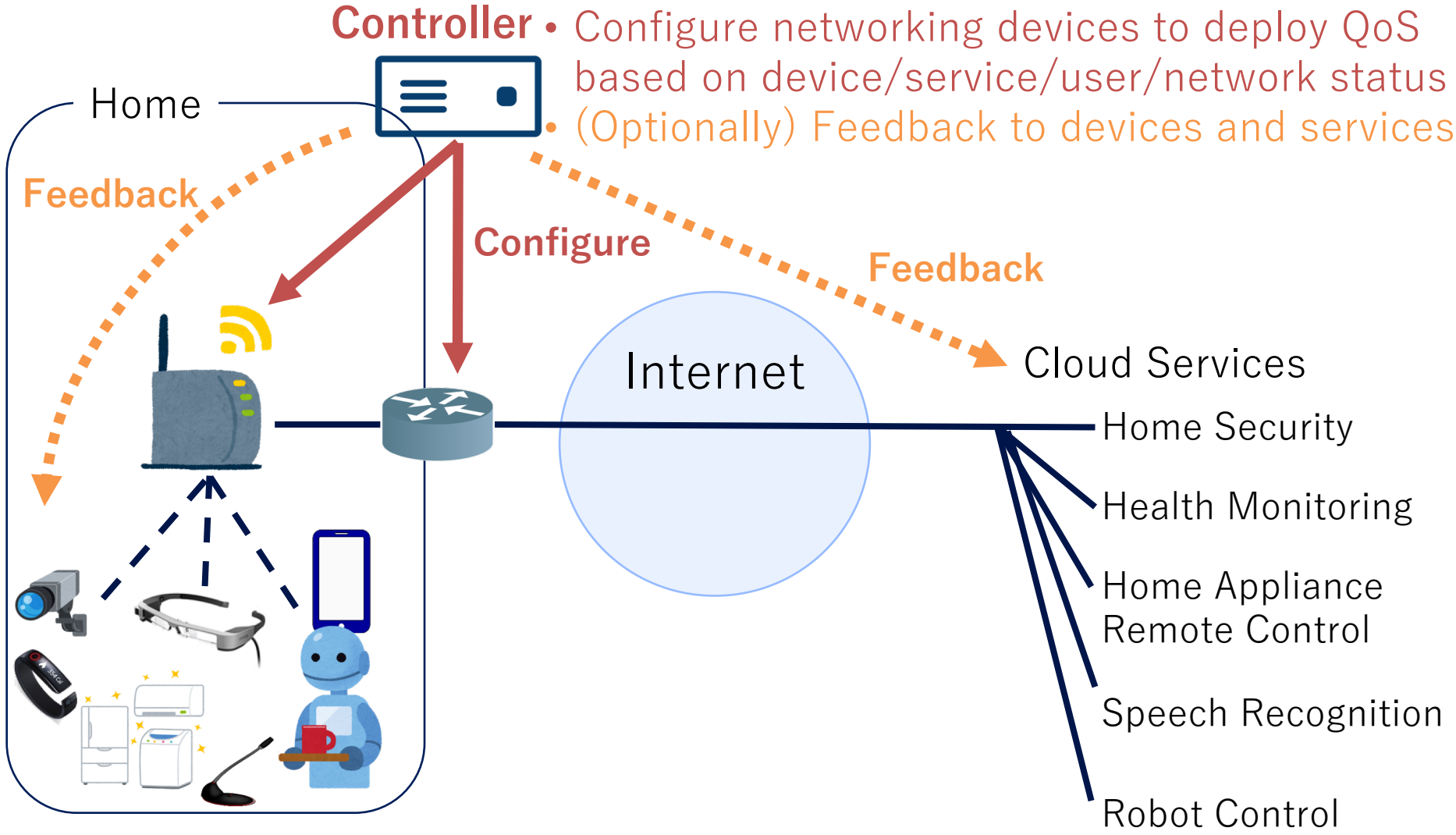
Related Work

- IoT Platforms for data exchange have standard ways to describe devices on the platforms
  - FIWARE – Define devices through device registration
  - W3C Web of Things (WoT) – Thing Description

  - Both are based on Entity – Attribute – Value model
  - We reuse the model as much as possible, and make minor modifications for network control

- Implementation of QoS has been extensively studied for last 10+ years
  - Traffic Engineering, Traffic Shaping/Policing, Scheduling, etc.
  - We use existing mechanisms for applying QoS to traffic. Our focus is how QoS parameters should be configured.

Environment Assumption: Where and How Controller Works



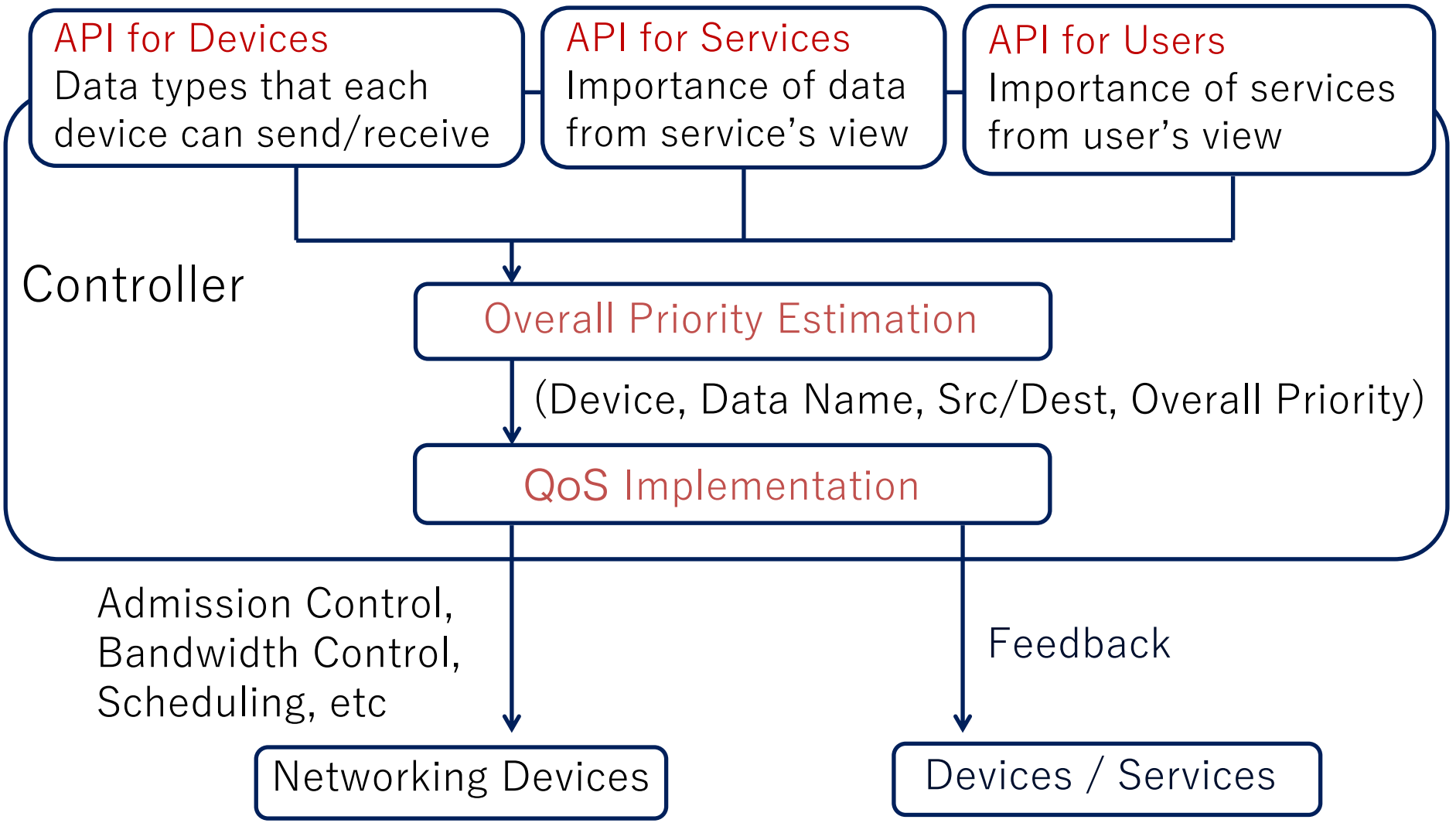
Input to Controller

No one knows the overall situation,
but each party knows partial information that is related to

	Know	Don't know
IoT Devices (Device Vendors)	Device Details (Traffic volume, Choices of data types)	How data is used Importance of data
Services (Service Providers)	Importance of data for providing the service	Importance of services for the life of users
Users	Importance of each service	Implementation details on services and devices

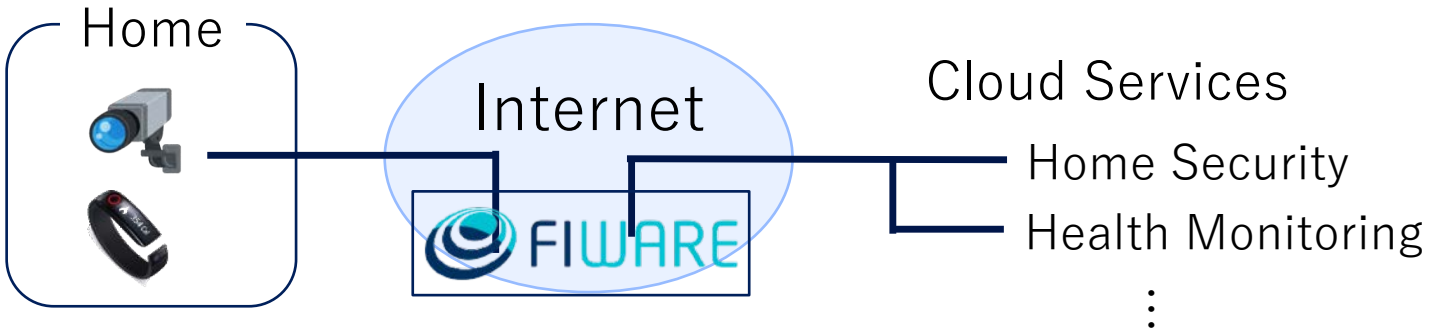
Controller provides different interfaces for each party to receive the partial information

Proposed Controller Architecture

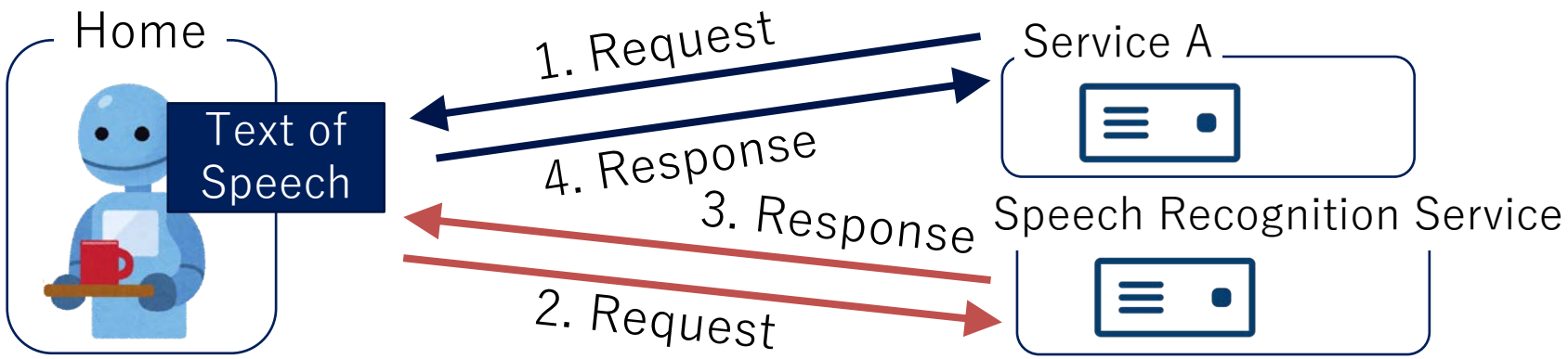


Things to Consider When Desigining API

- IoT data exchange platforms, like FIWARE
  - Data is transferred via the platforms
  - Destination visible at the home gateway is the platform



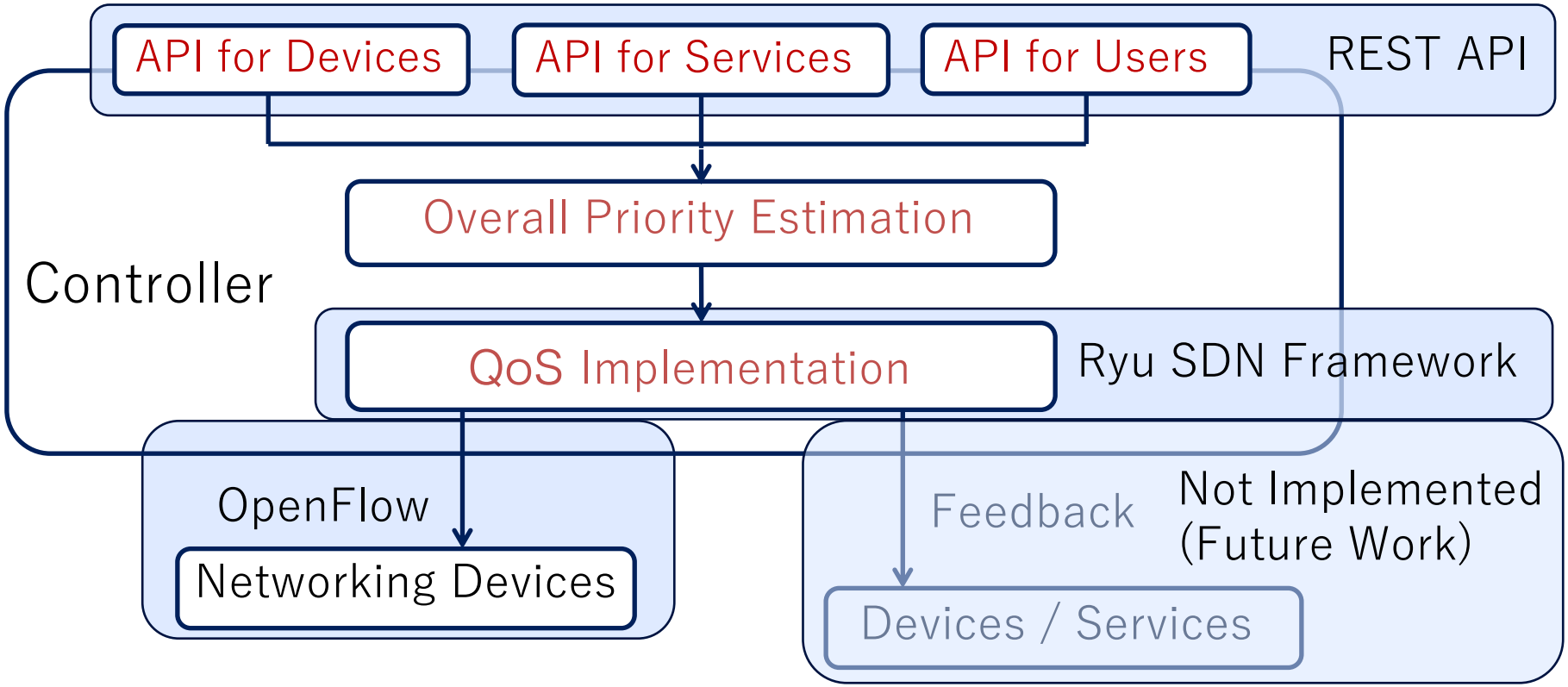
- Cloud-integrated Devices:
  - Device interacts with cloud services when it accepts a request



API Design at a Glance

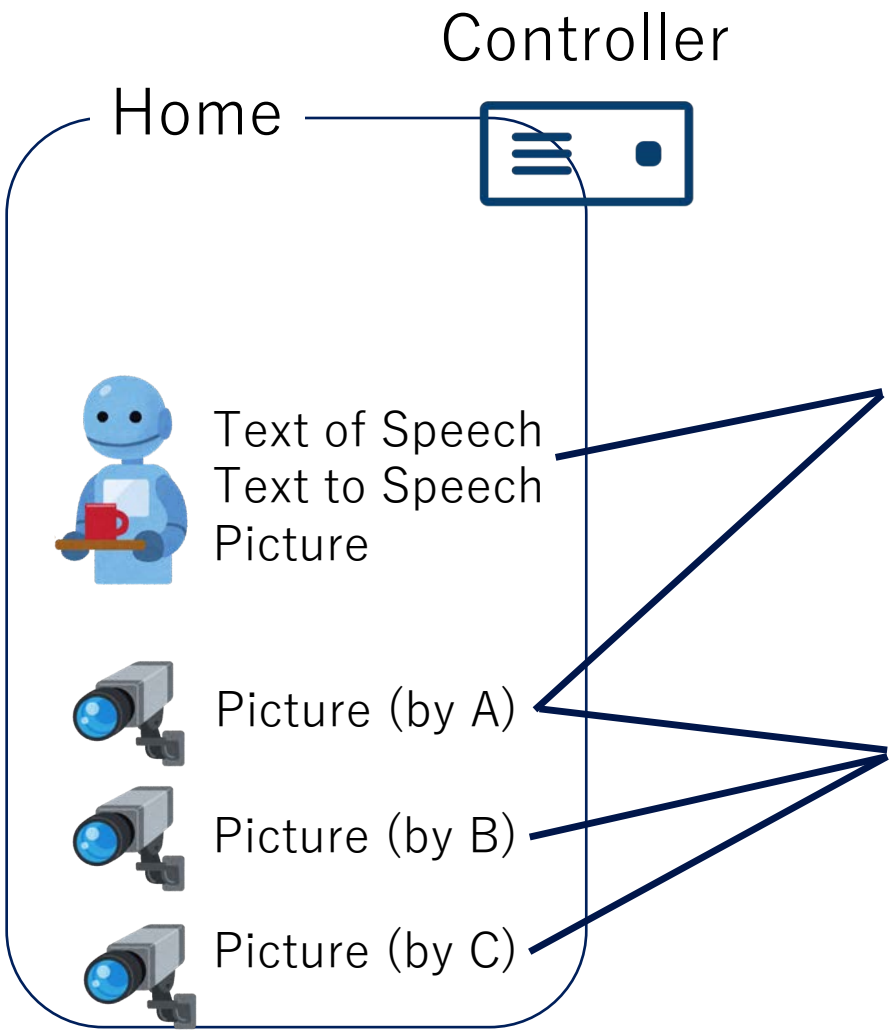
- API for Devices
  - Properties and Commands that a device provides
  - Destination (if autonomously sending data to others, e.g. FIWARE)
  - IoT Coflow (properties/commands, destination)
- API for Services
  - (User, Device, Property, Service Endpoint (URL, IP address, etc), Priority to provide service)
  - Service Endpoint can be keywords, e.g. FIWARE
    - Controller internally translates to pre-configured URL
- API for Users
  - (Service, Priority of Services for their life)
  - Devices owned by Users, and Device Endpoint (IP address, etc)

Prototype Implementation



- All types of priorities in three levels (tentative)
- Overall Priority Estimation:
  - Prioritize traffic to provide service that are important for users
- Currently limited to admission control

An Example Use Case Scenario



Cloud Services

Companion Robot

- Retrieve text of speech from robot
- Send text to speech to robot based on the text of speech and facial expression (Picture)

Home Monitoring

- Retrieve pictures from multiple cameras, and find suspicious activities
- Picture (by B) is less important than Picture (by A and C) because area covered by B overlaps with A and C

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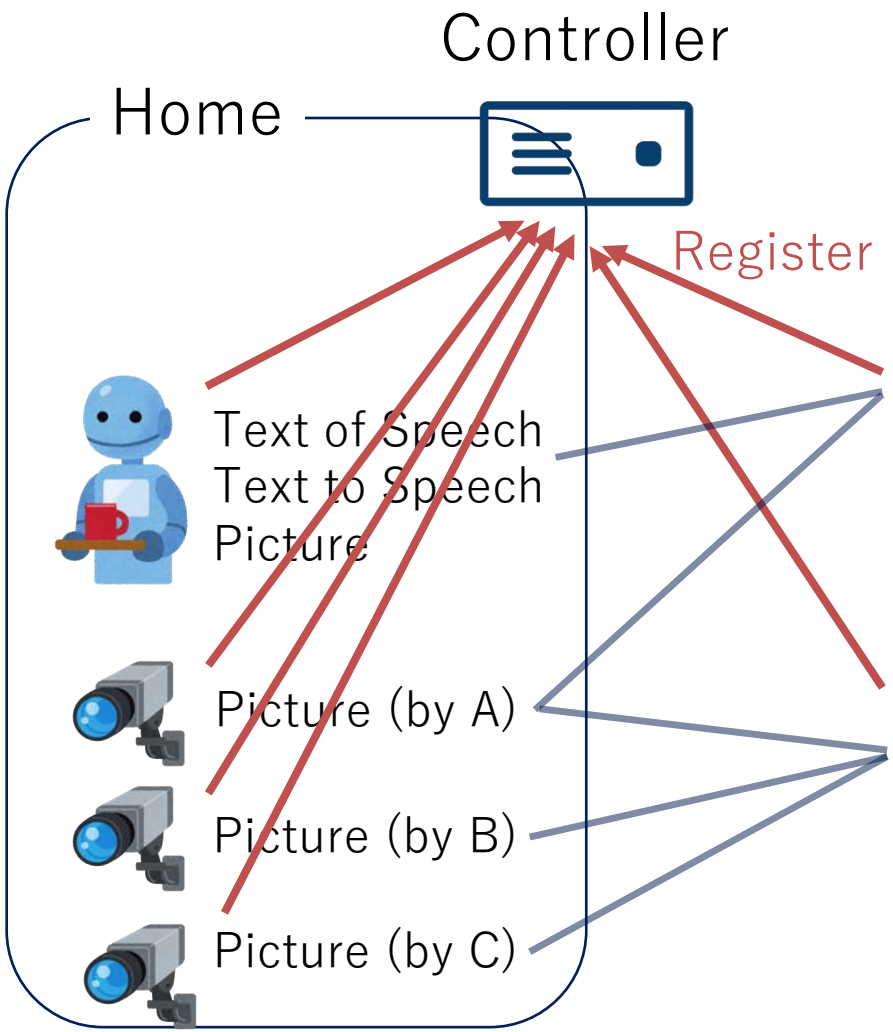

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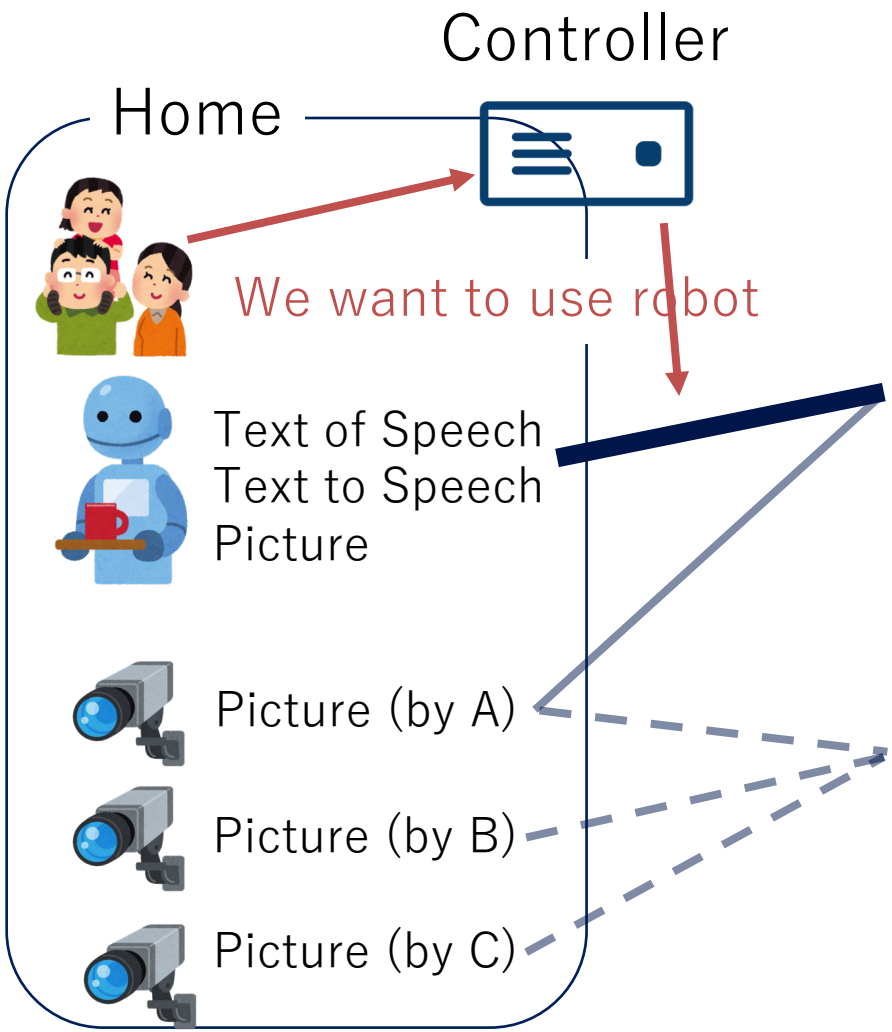

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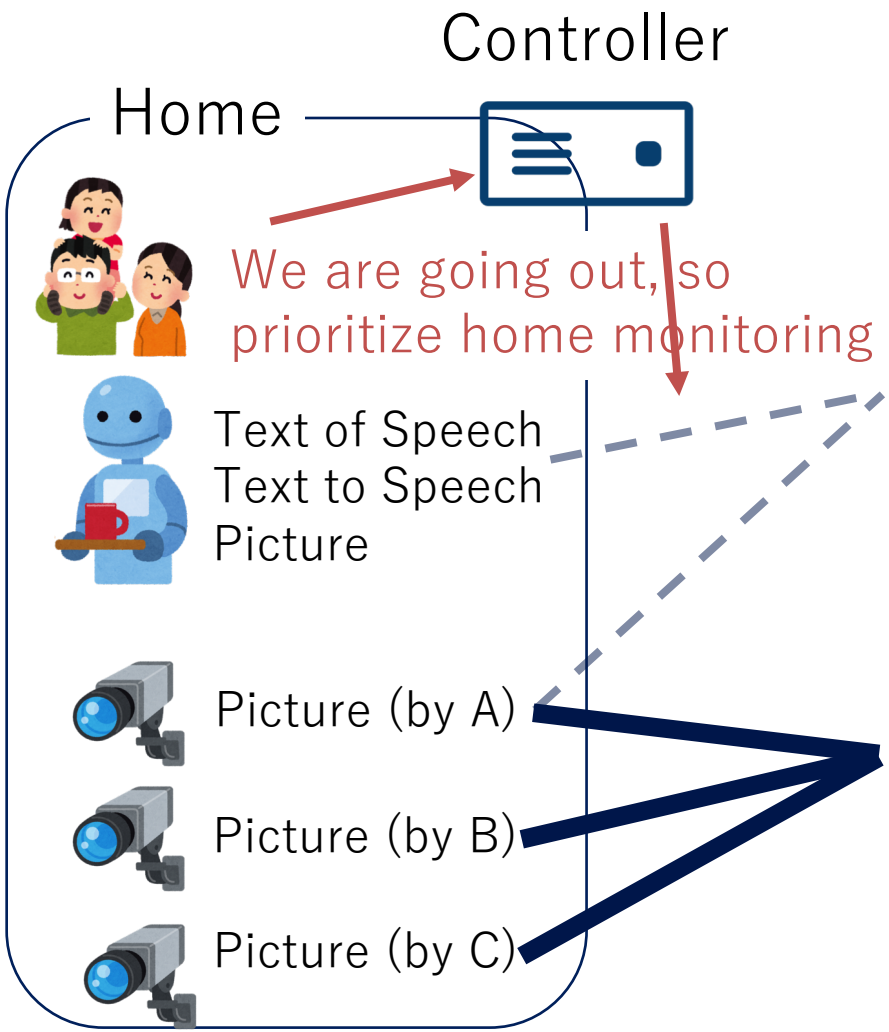

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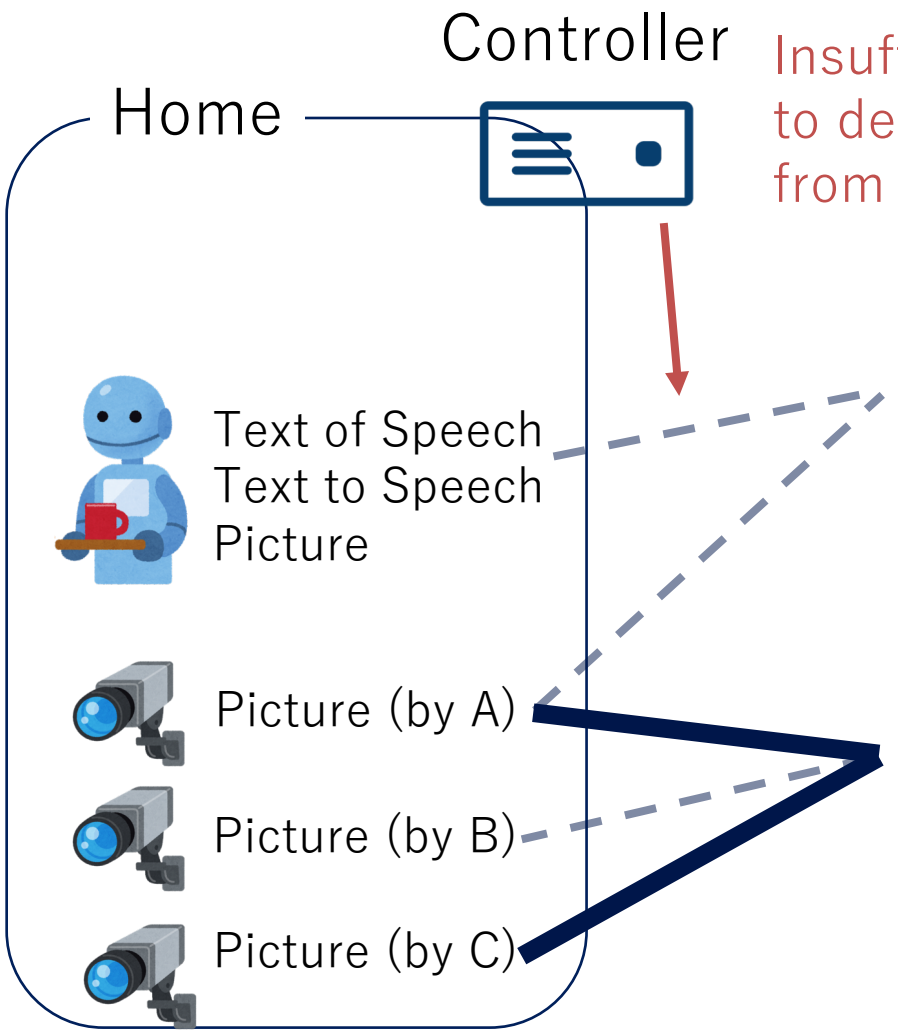

Insufficient Bandwidth
to deliver pictures
from three cameras

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Concluding Remarks and Future Work

- Traffic should be controlled in home network where many IoT devices and services are deployed
- Problematic because no one knows which traffic is important
- Our controller architecture try to solve the problem by:
  - Receive partial information from parties involved
  - Automatically estimates the overall priority of each traffic

- Future work
  - More sophisticated estimation algorithm
  - Verification of appropriateness by real applications
    - API, priority, etc
  - More solid prototype implementation for deployment