LEONORE – Large-Scale Provisioning of Resource-Constrained IoT Deployments

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Motivation

▸ IoT devices provide constrained execution environments with limited processing, storage, and memory resources

- offload parts of application business logic onto these devices
- IoT gateways

▸ Dynamically adapt to inevitable changes such as new requirements or adjustments in regulations

- purchase and sell these application components in an IoT application market

Challenge and Solution

▸ Significant differences in device capabilities

▸ Large number of devices in typical IoT systems

▸ LEONORE

- service oriented infrastructure and toolset for provisioning application components on edge devices in large-scale IoT deployments
- installable application packages are fully prepared
- pull-based and push-based provisioning

Scenario

- Gateways participating in an IoT infrastructure are resource-constrained

- Large-scale deployments comprising thousands of gateways with a wide variety of different supported execution environments

- Requirements of these gateways change over time, which makes updates necessary

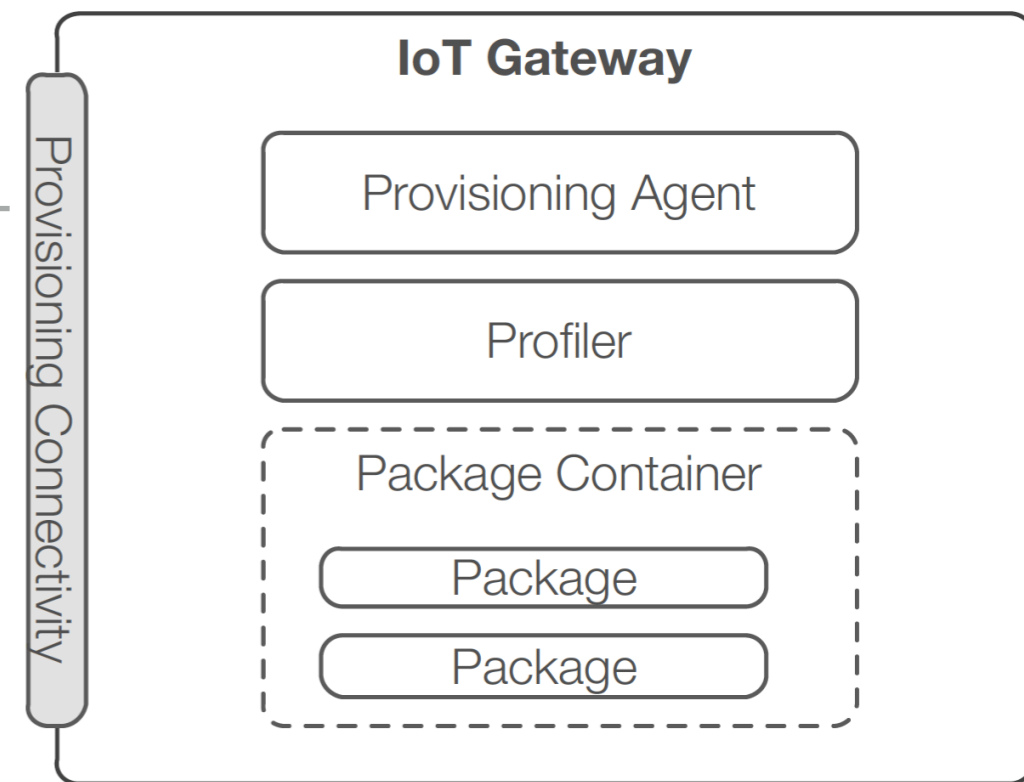- In order to sustain operations all updates need to be efficient and fast

Approach
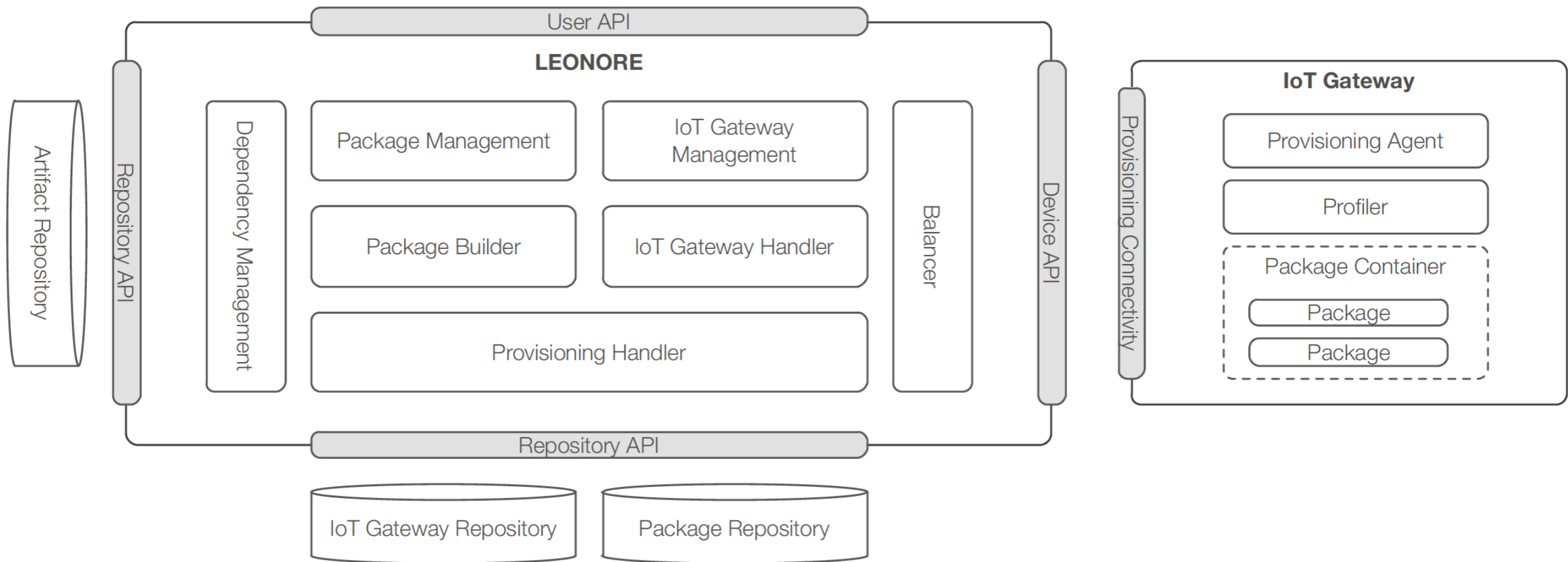
Application Packages

- Usually an application in the IoT domain consists of different application components and supporting files (artifact)
  - id
  - binary folder
  - control folder
  - path file
- Gateways only have to unpack the package and execute the provided installation instructions

IoT Gateway

IoT Gateway

- Provisioning Connectivity
- Provisioning Agent
- Profiler
- Package Container
  - Package
  - Package

▶ a container, hosting application packages

▶ a profiler, monitoring the current status of the gateway

▶ an agent, communicating with the provisioning framework

▶ a connectivity layer, supporting different communication protocols and provisioning strategies

- a pull-based approach, queries the framework for provisioning tasks
- a push-based approach, the framework pushes new updates to the gateway and the agent triggers the local provisioning

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LEONORE – Provisioning Framework

▸ Repositories
  - artifact repository
  - IoT gateway repository
  - package repository

▸ Package Management

▸ Dependency Management

▸ Package Builder

▸ IoT Gateway Management and IoT Gateway Handler

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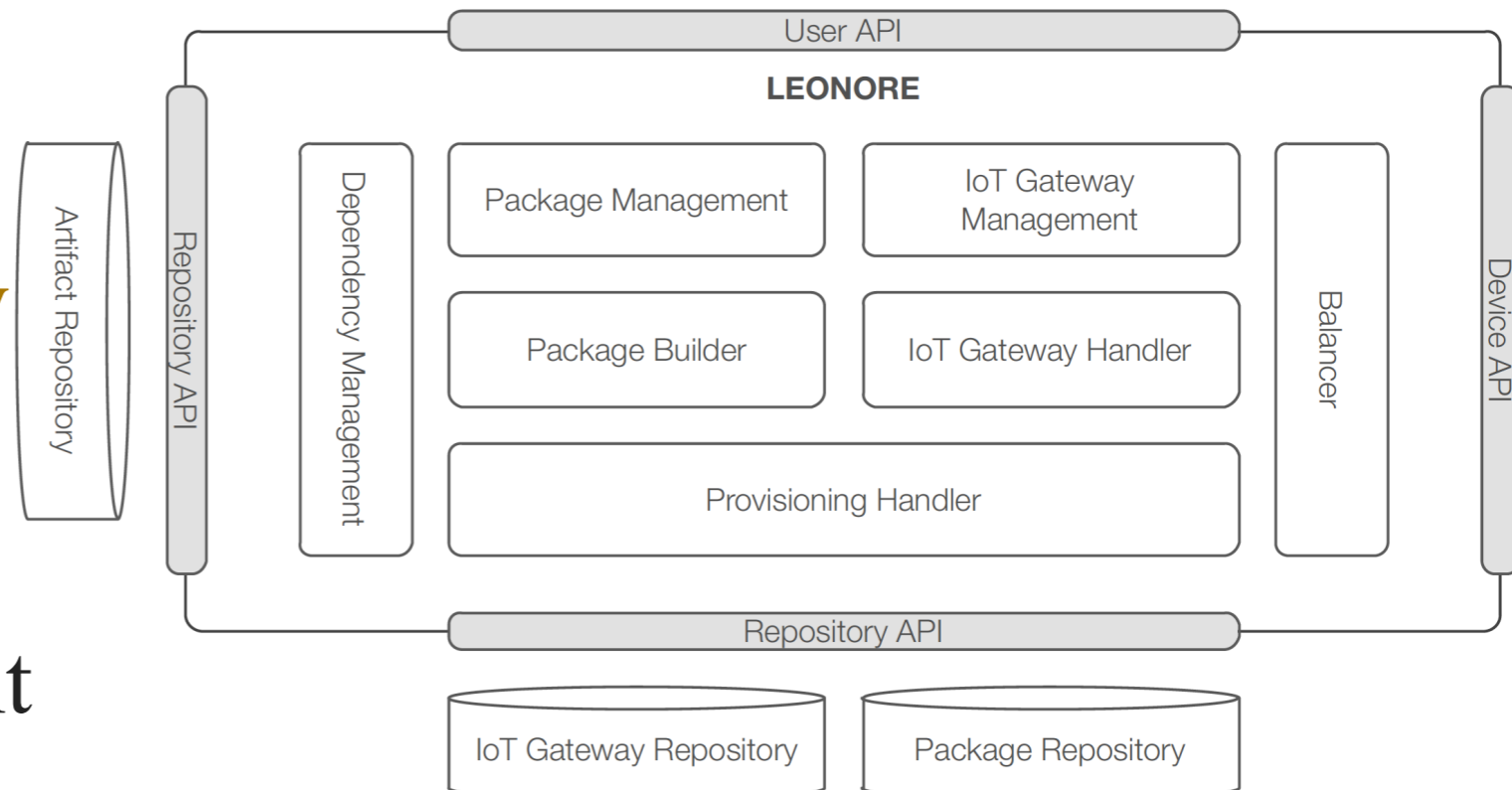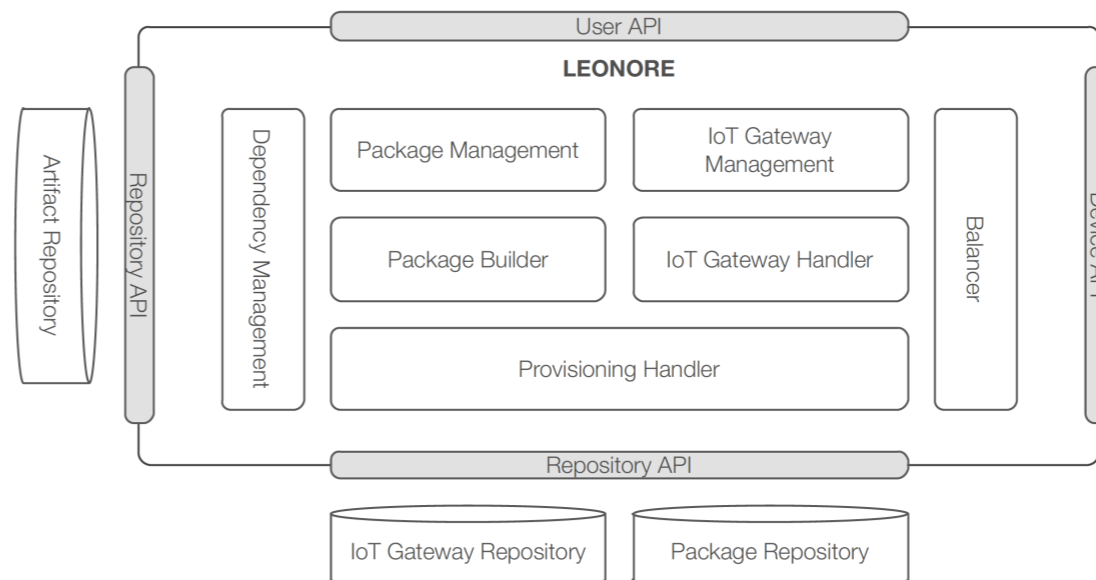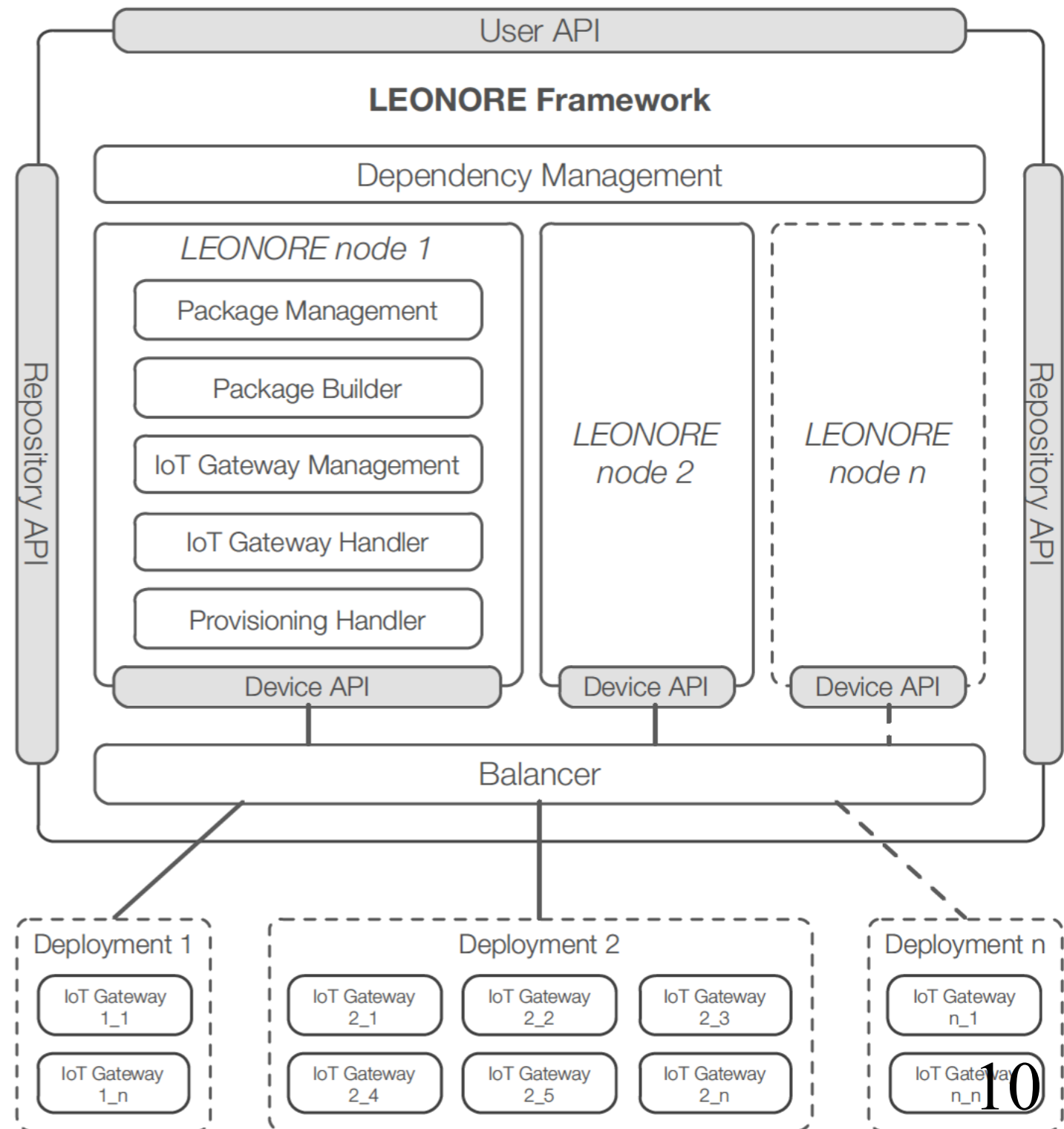
LEONORE – Provisioning Framework

▸ Provisioning Handler

- Chooses the suitable provisioning strategy according to the information provided by the IoT gateway management

- Then the handler triggers the building of gateway-specific application packages by invoking the package builder

- Once the builder creates the packages, the provisioning handler executes the provisioning strategy

LEONORE – Provisioning Framework

▸ Balancer

● scale components by replicating them and therefore distributing the workload across multiple computing resources

● components that should be scaleable are grouped together in so-called LEONORE nodes


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Provisioning of Application Packages
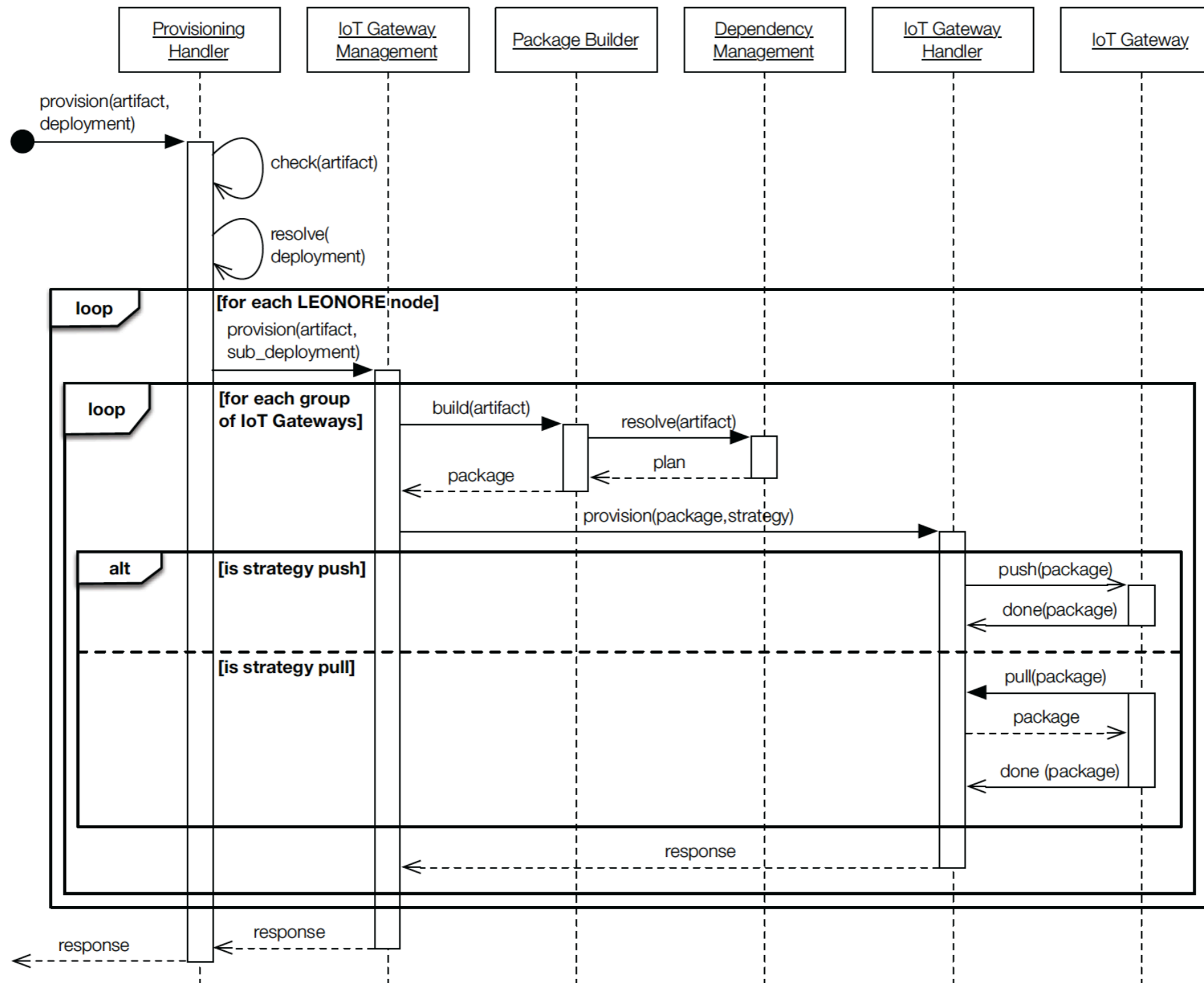
Evaluation

- Pull-base approach
  - gateway's agent pulls the provisioning framework for new tasks in a configurable interval
  - generates increased load on the framework
- Push-base approach
  - gateway's agent only registers the gateway once at the framework and then remains idle until the framework pushes an update
- 2 applications
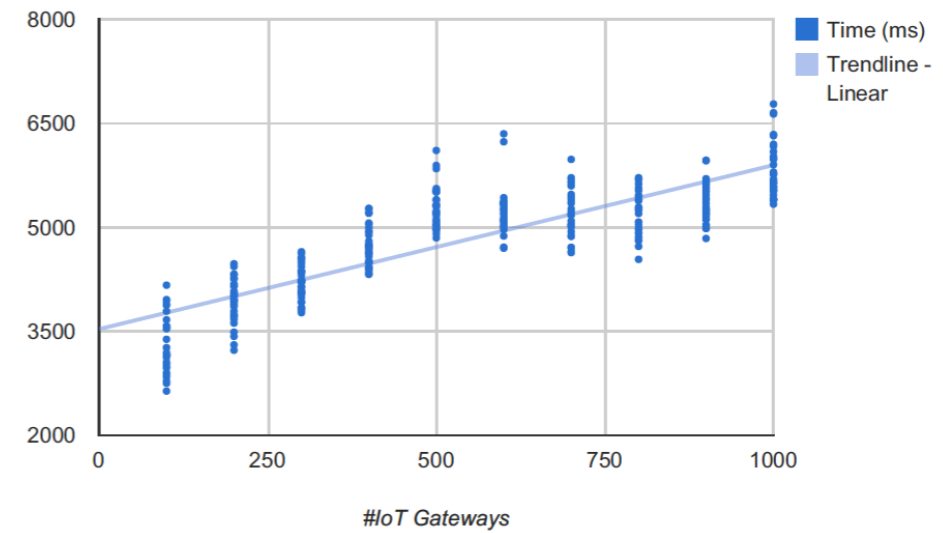 - SVM, 120KB
  - Java8, 12MB

Setup

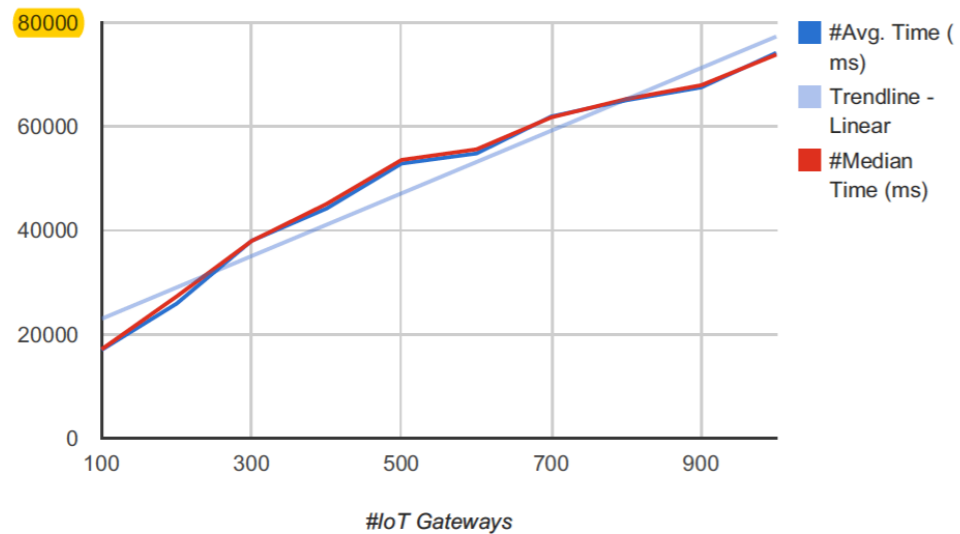▸ OpenStack

- Docker image is used to virtualize and mimic the physical gateway
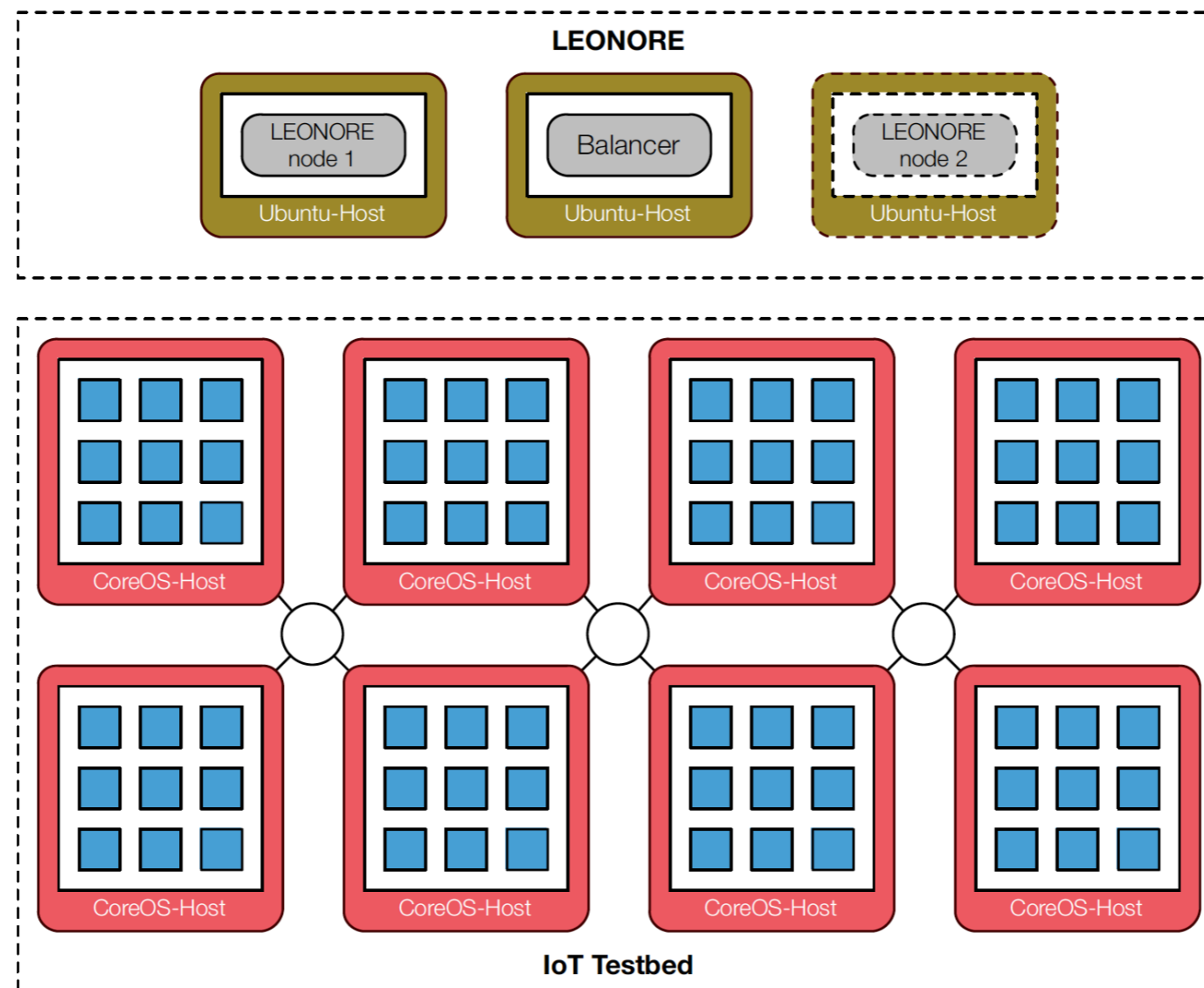
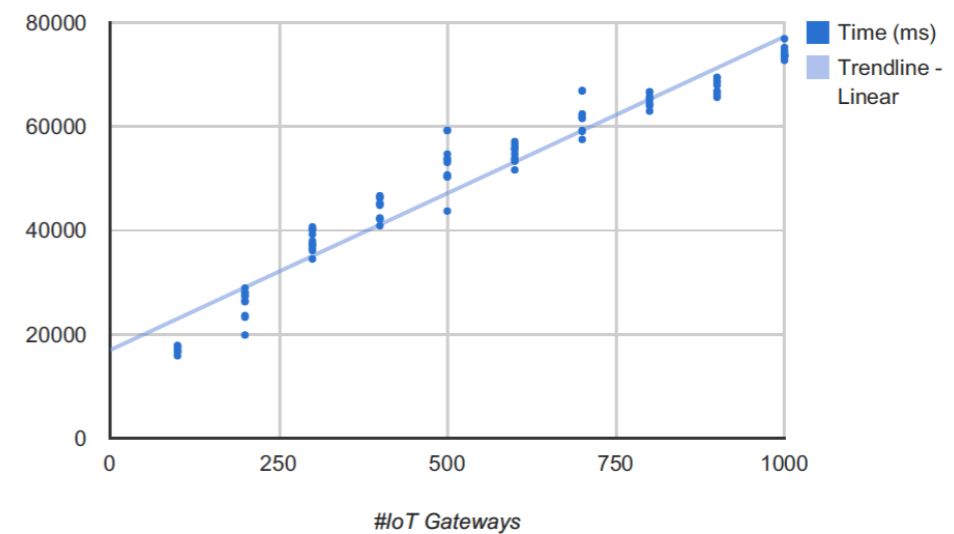# Scenario 1: 100 - 1000 IoT Gateways (pull)
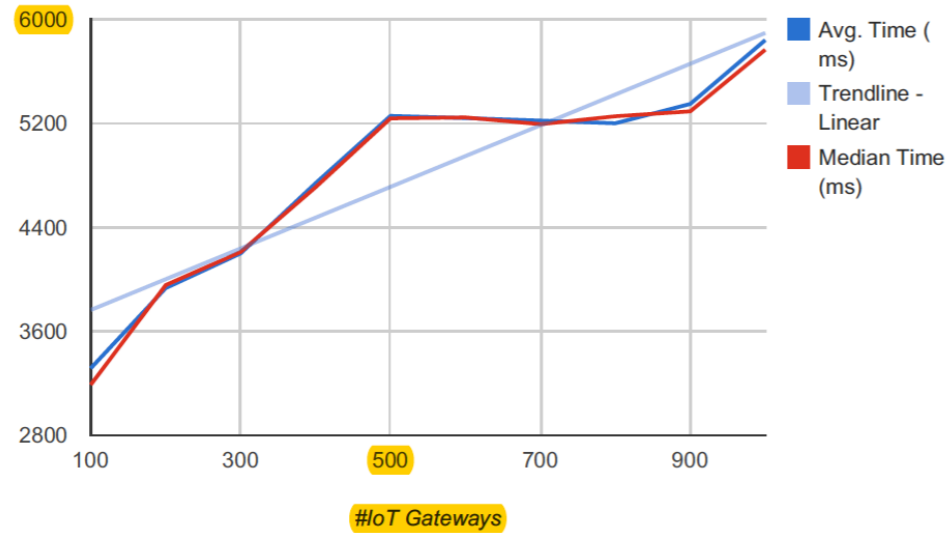
(a) Evaluation Results for SVM
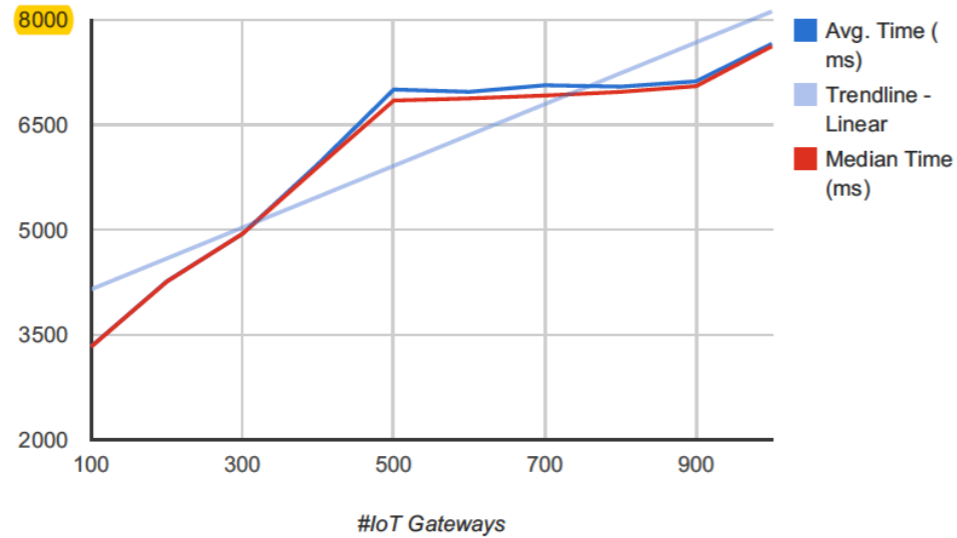
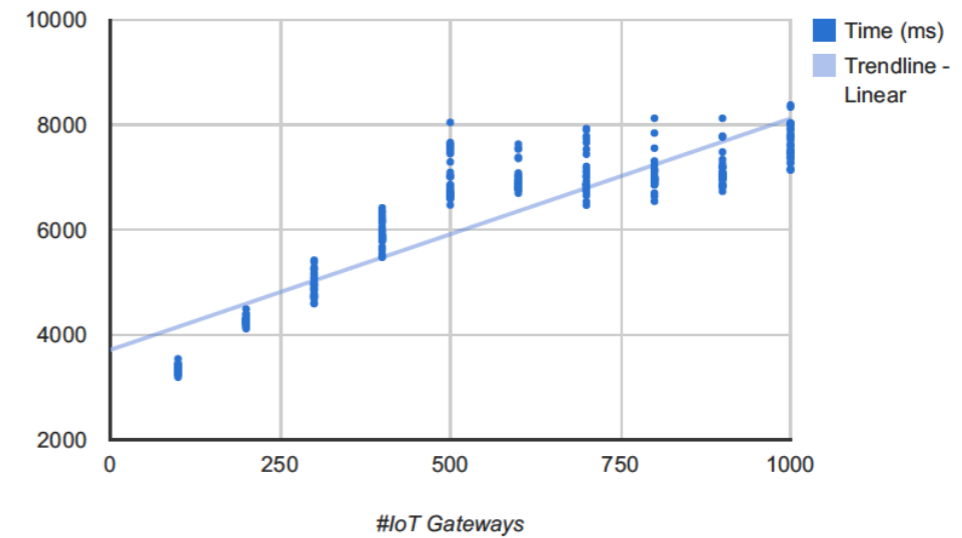(b) Evaluation Results for SVM - Scatter

(c) Evaluation Results for JVM
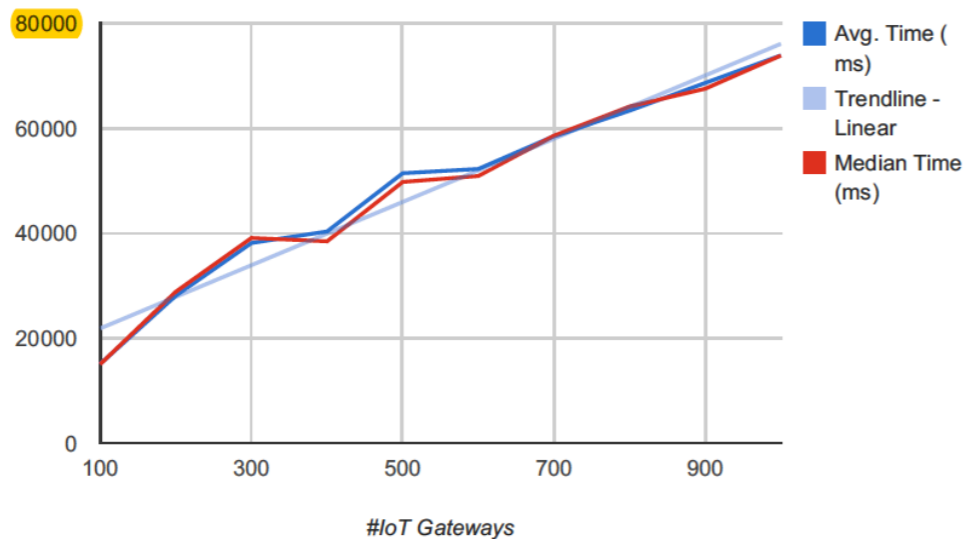
(d) Evaluation Results with for JVM - Scatter

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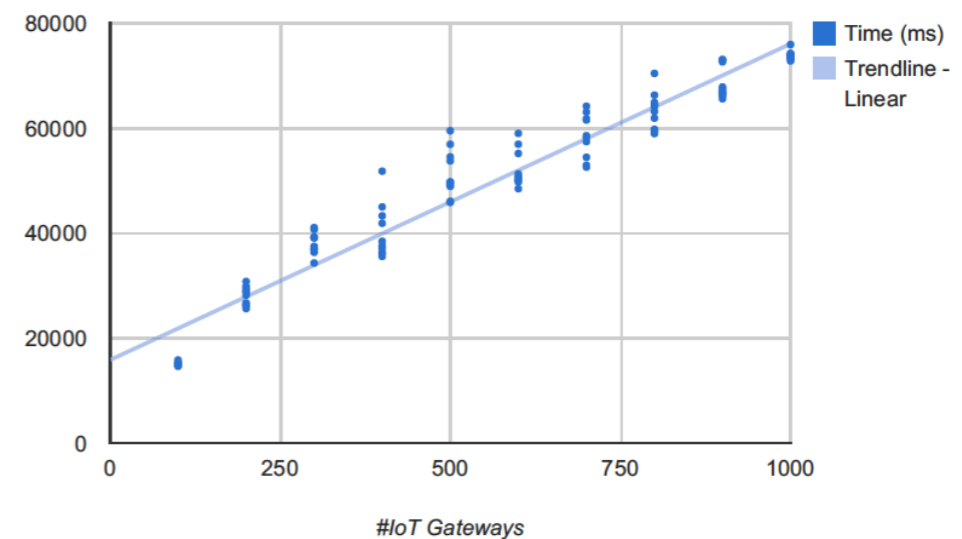
Scenario 1: 100 - 1000 IoT Gateways (push)

(a) Evaluation Results for SVM

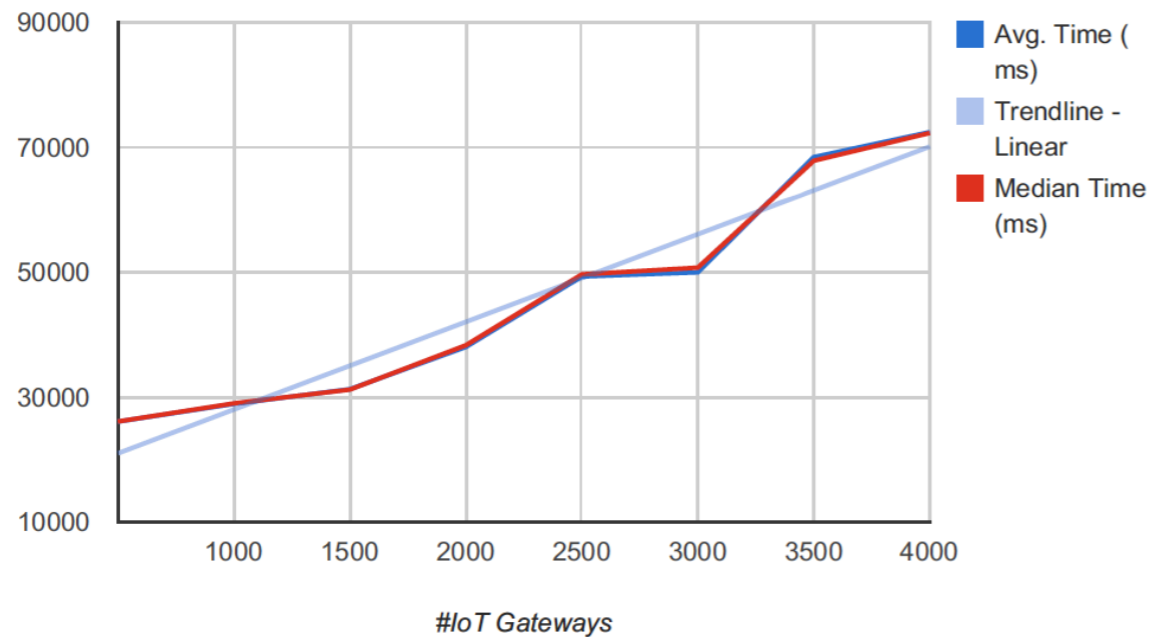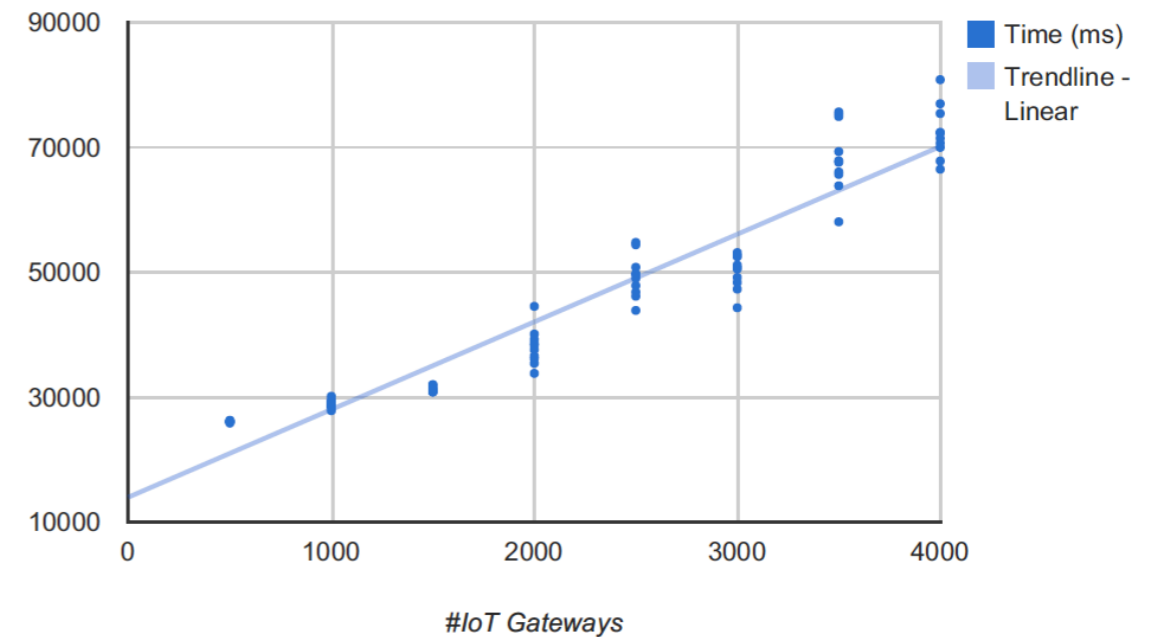(b) Evaluation Results for SVM - Scatter

(c) Evaluation Results for JVM

(d) Evaluation Results with for JVM - Scatter

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Scenario 2: 500 - 4000 IoT Gateways

(a) Evaluation Results for SVM with Pushing

(b) Evaluation Results for SVM with Pushing - Scatter

Conclusion

‣ LEONORE

- service oriented infrastructure and toolset for provisioning application components on edge devices in large-scale IoT deployments
- installable application packages are fully prepared
- pull-based and push-based provisioning