IoT Design Patterns: Computational Constructs to Design, Build and Engineer Edge Applications

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Introduction

- There are huge opportunities but considerable challenges in designing IoT applications
  - Provisioning of ultra-low power operation and system design using modular, composable components to smart automation
  - Sensor instrumentation requires an efficient stream data processing
- Propose patterns, which aid system architects in modeling and building context-tailored IoT applications

Pattern Language Conventions

- Pattern language is intended to describe the solution in a way that is easy to digest
- All IoT patterns comprise following semantics
  - Pattern Name
  - Problem
  - Context
  - Motivation Forces
  - Solution Details
  - Sketch

IoT Design Patterns

- Connected devices may use different types of networks and various connectivity patterns
  - Consider design on many different layers
- Automated provisioning, deployment and configuration management of the behavior of edge applications disclosed herein pertain to governance patterns
  - Govern all aspects of edge applications including their provisioning and deployment mechanisms

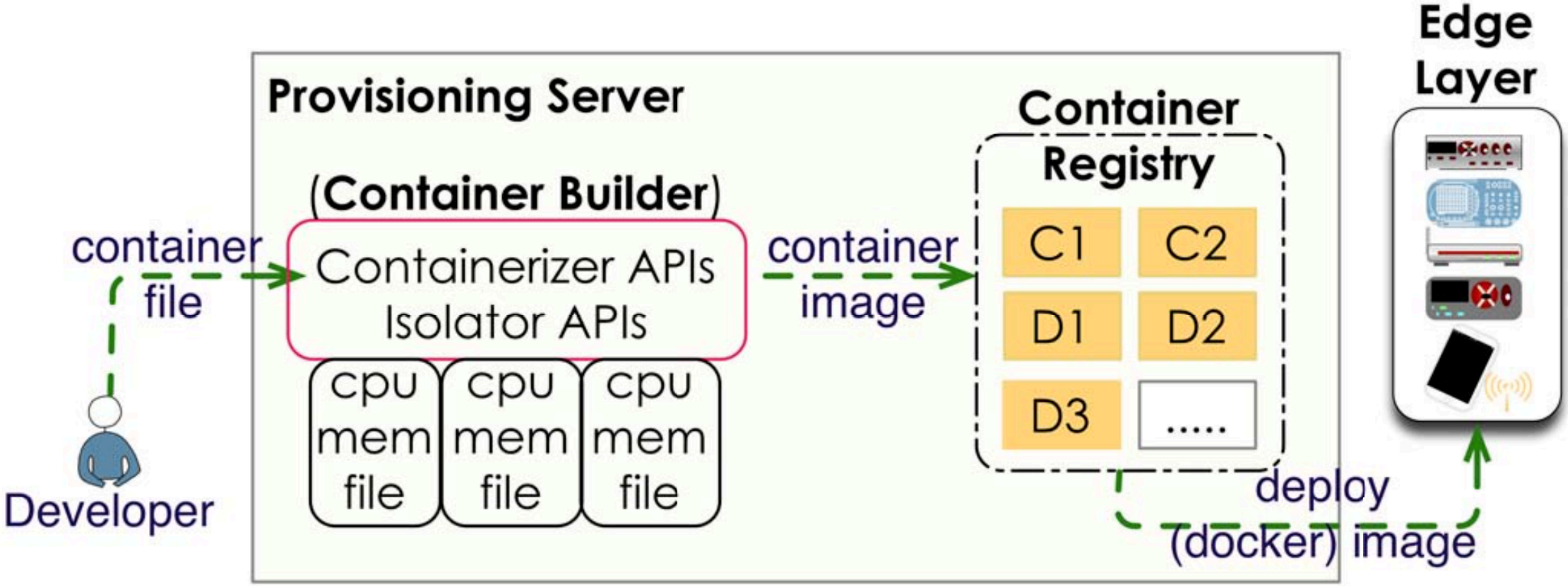
Edge Provision Pattern

- Problem
  - How to ensure all of edge devices are started with a reliable baseline environment, as needed?
  - How to provision all the devices automatically all at once?
- Context
  - IoT devices are usually scattered geographically, sometimes hard to reach and large in number
  - We must be able to reconfigure devices or provision new ones in an efficient way and have pre-configured nodes

Edge Provision Pattern

- Motivation Forces
  - Replace your technology stack entirely and provision a new environment remotely
  - Add new devices and provision their runtime environment and applications quickly
- Solution Details
  - Container-based virtualization for provisioning
  - Have pre-configured environment with required applications installed
  - Docker images utilize a layered and versioned file system

Edge Provision Pattern Sketch



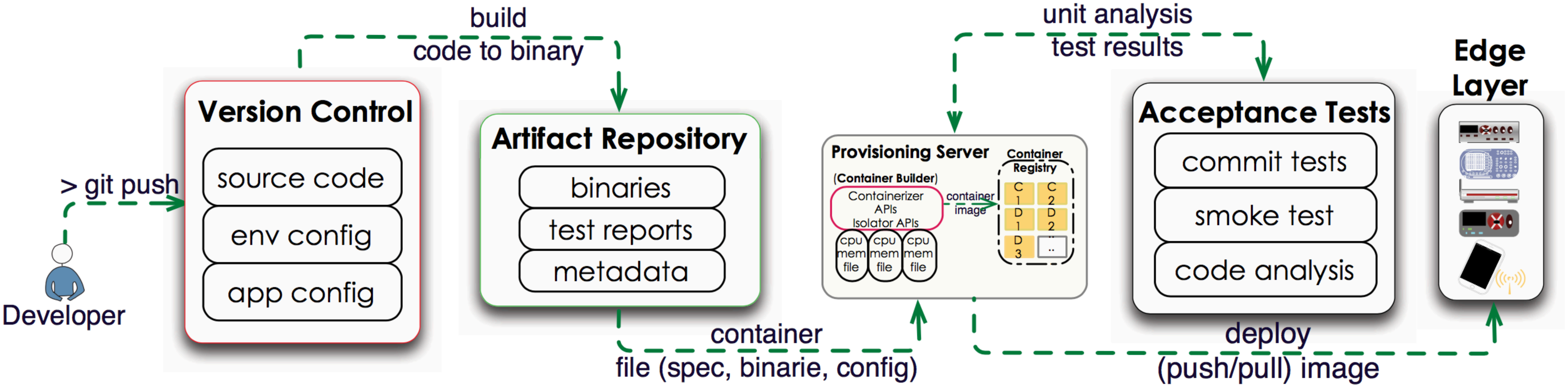
Edge Code Deployment Pattern

- Problem
  - How to deploy code to many IoT devices automatically, quickly and safely, and configure them without being concerned about the long process ?
- Context
  - Deploy the updated code to remote IoT devices quickly. This grants distributing functionality between devices
  - Re-configure the application's environment

Edge Code Deployment Pattern

- Motivation Forces
  - Update the text or graphical features frequently or change the duration of ad display
  - It is best to only deliver the changes
  - The tools for deploying the code to devices should be transparent to the developers
- Solution Details
  - Version control systems
  - The deployment pipeline is started with each commit, and changes in the source code are published to all edge devices

Edge Code Deployment Pattern Sketch



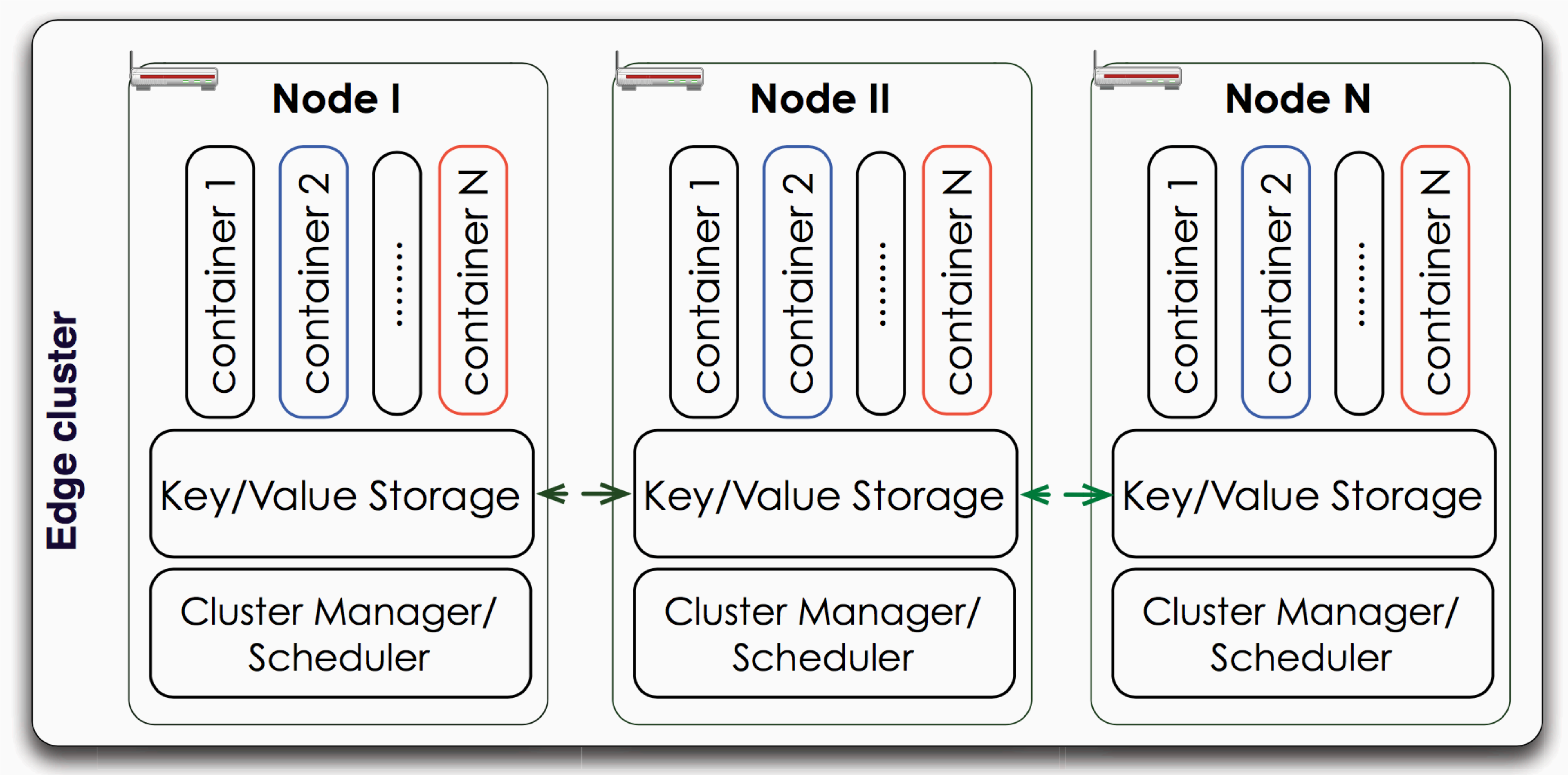
Edge Orchestration Pattern

- Problem
  - How to orchestrate IoT devices remotely?
  - How can edge cluster nodes discover services?
- Context
  - The cluster manage nodes to check their health state, their services state to reconfigure them
  - Run services in the cluster on certain nodes and enable them to discover the services they need and re-configure themselves accordingly
  - Edge nodes should be able to advertise services they provide

Edge Orchestration Pattern

- Motivation Forces
  - We need a declarative way to deploy home automation system without configuring and installing each component separately on every device
- Solution Details
  - Containers' compose-oriented technology enables us to deploy composite applications
  - Service discovery mechanisms can be leveraged by nodes to find each other
  - [key,value] stores

Edge Orchestration Pattern Sketch



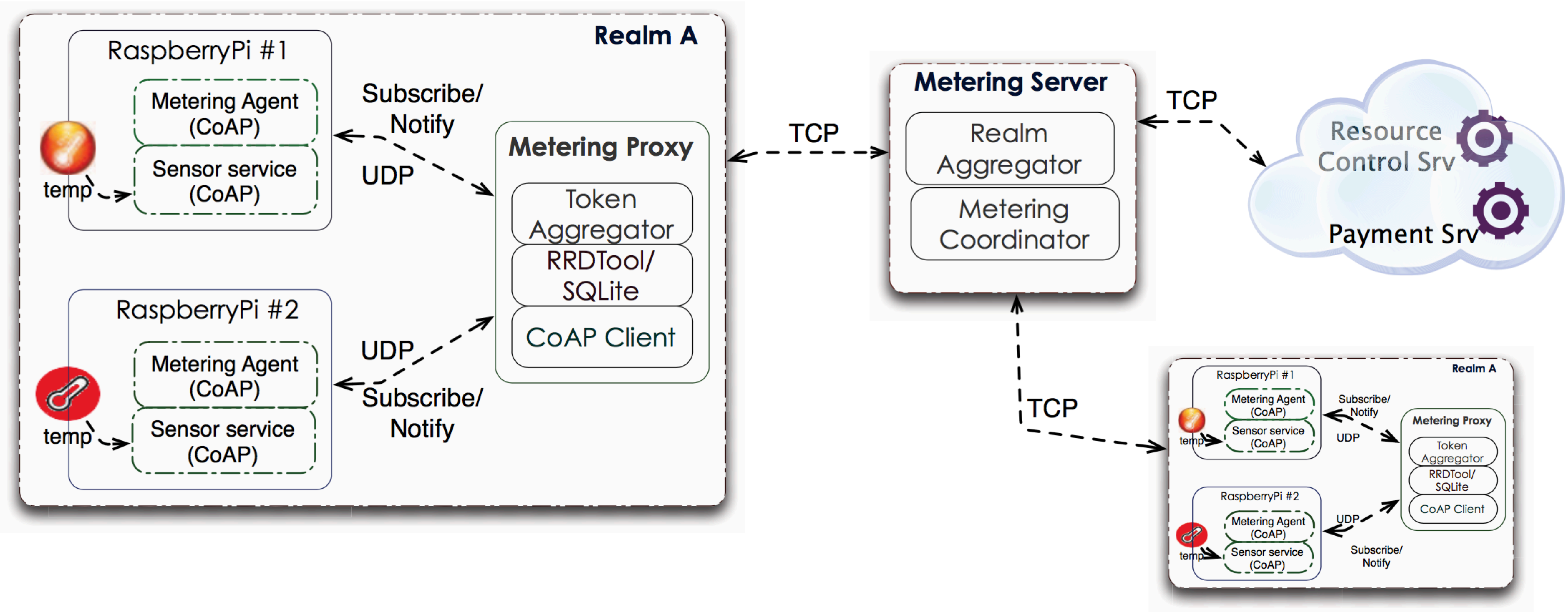
Edge Diameter of Things (DoT) Pattern

- Problem
  - How to monitor and meter the actual usage of IoT deployment units in real-time in order to monetize them?
  - How the IoT composite application resource usage can be charged against a specific user balance?
- Context
  - The need for defining some metrics for service and resource usage, which in turn, can be used to measure the consumption of the service and to price it

Edge Diameter of Things (DoT) Pattern

- Motivation Forces
  - Measure the rate of actual resource and service utilization, as near real-time as possible
- Solution Details
  - Define a specific agreement called metering plan, offered by the provider and accepted by the client
  - Parses the plan and calculates the U3 (Used Unit Update) rate for each constituent service in the plan.

Edge Diameter of Things Pattern Sketch



Conclusion

- Defined four design patterns enabling IoT architects to construct edge applications
- They will focus more on patterns to be used for elasticity, resiliency and Software Defined Networking (SDN) patterns for edge computing