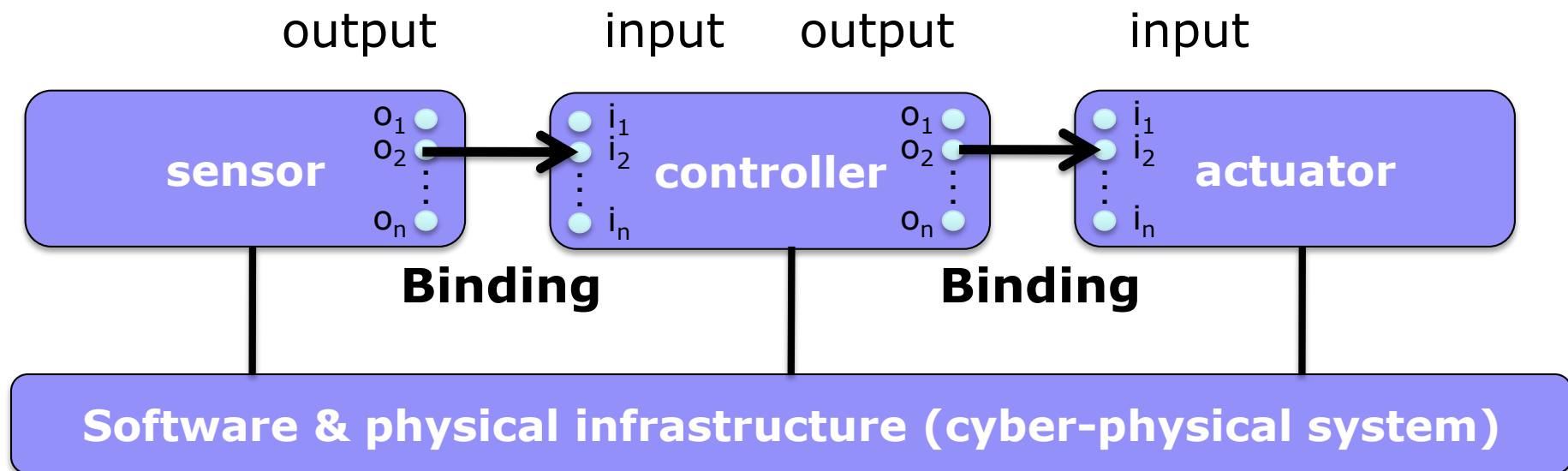# Dynamic Composition and Reconfiguration of Internet-scale Control Systems
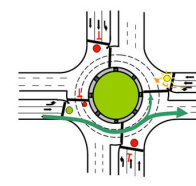
Evangelos Pournaras, Mark Yao and Ron Ambrosio
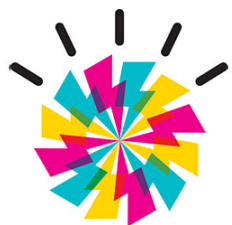
Introduction – Control Systems

> **Power grid:** power plants, transmission lines, consumer devices

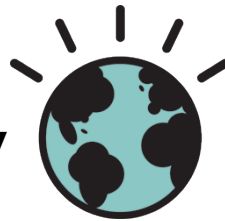> **Transportation systems**: traffic lights, automated vehicles

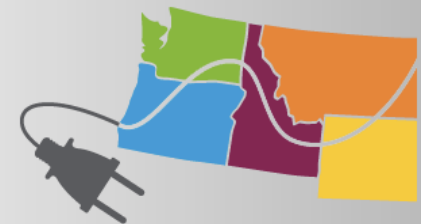# Introduction – Control Systems (Cont.)

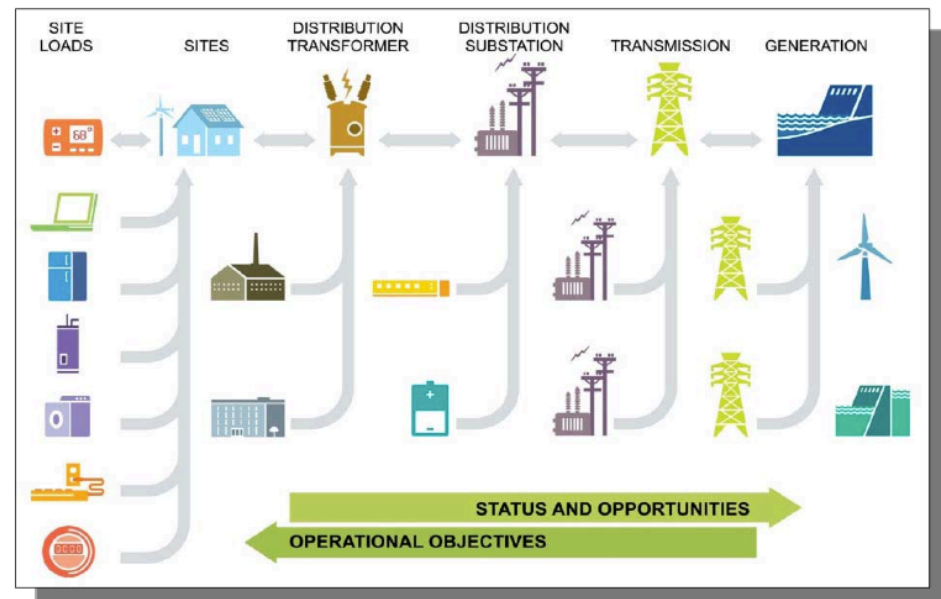**Control systems emerge to large and distributed business ecosystems**

IBM Smarter Energy Smarter Planet

Pacific Northwest SMART GRID DEMONSTRATION PROJECT

➢ A 5-year US project of $178 millions

➢ Model and control in different levels

➢ Renewables, reliability, consumers flexibility

➢ 60000 metered customers

Problem Overview

Static composition and reconfiguration of Internet-scale control systems
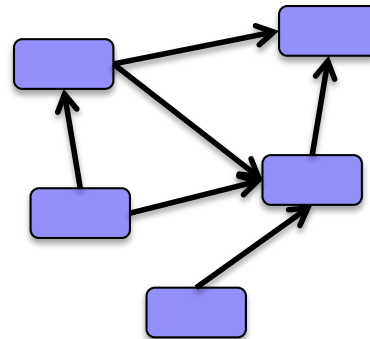
Problem Overview

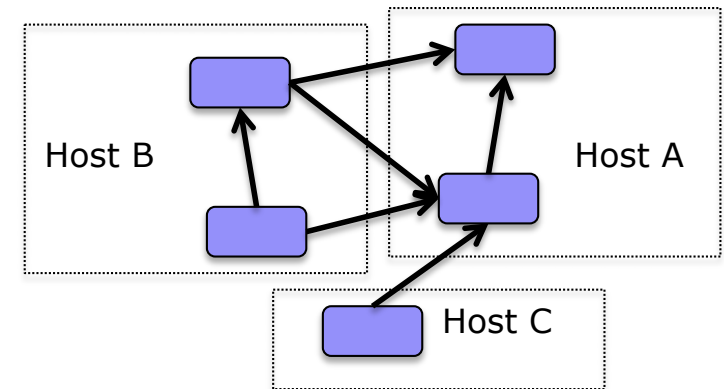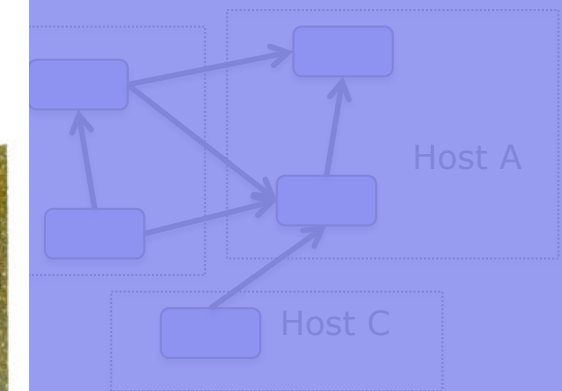Static composition and reconfiguration of Internet-scale control systems

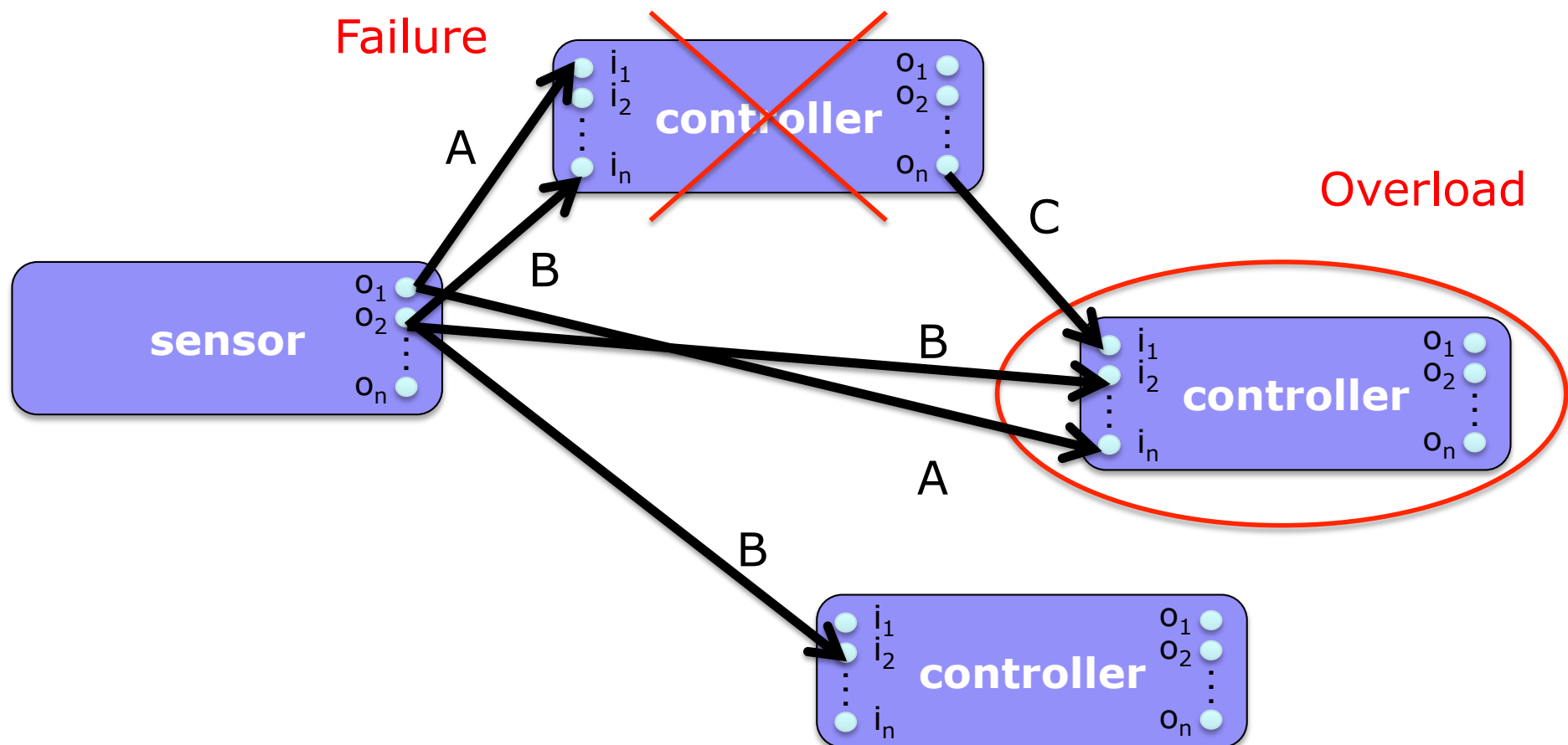**Gap: Offline approach in dynamic distributed systems**

Load-balancing?

Domain-expert develo... ...stem administrator

algorithms

Host A

Host C

Research Question

How can Internet-scale control systems be composed and reconfigured dynamically during runtime?

Key Components

Discovery

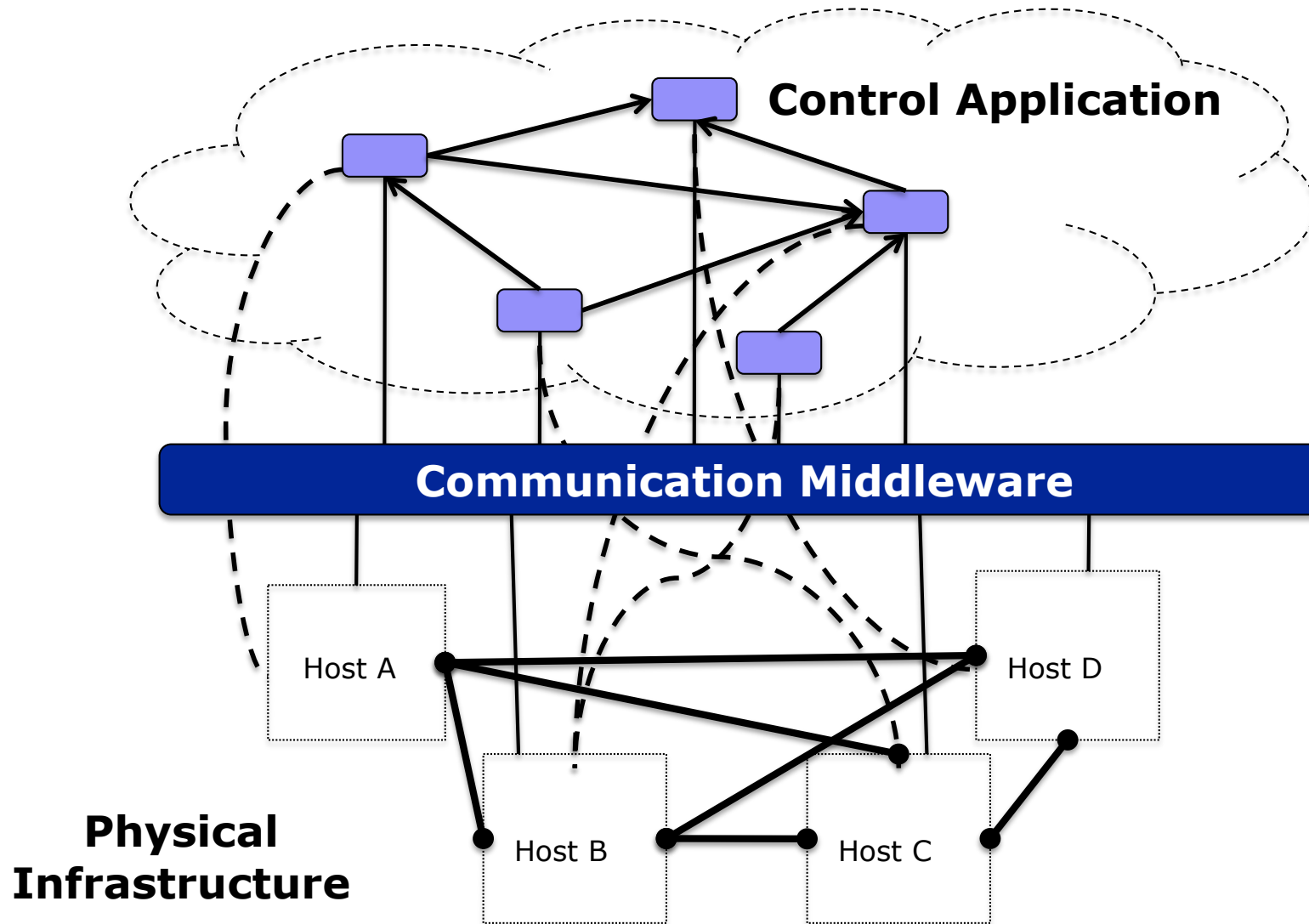Search for possible I/Os of online control elements

Decision-making

Select I/Os of control elements based on application criteria

Configuration

Setup local and remote I/O information routing

Distributed middleware

Distributed middleware

Configuration?

Control Application

Decision-making?

Discovery?

Communication Middleware

Low integration

Low abstraction

Host A

Host D

Physical Infrastructure

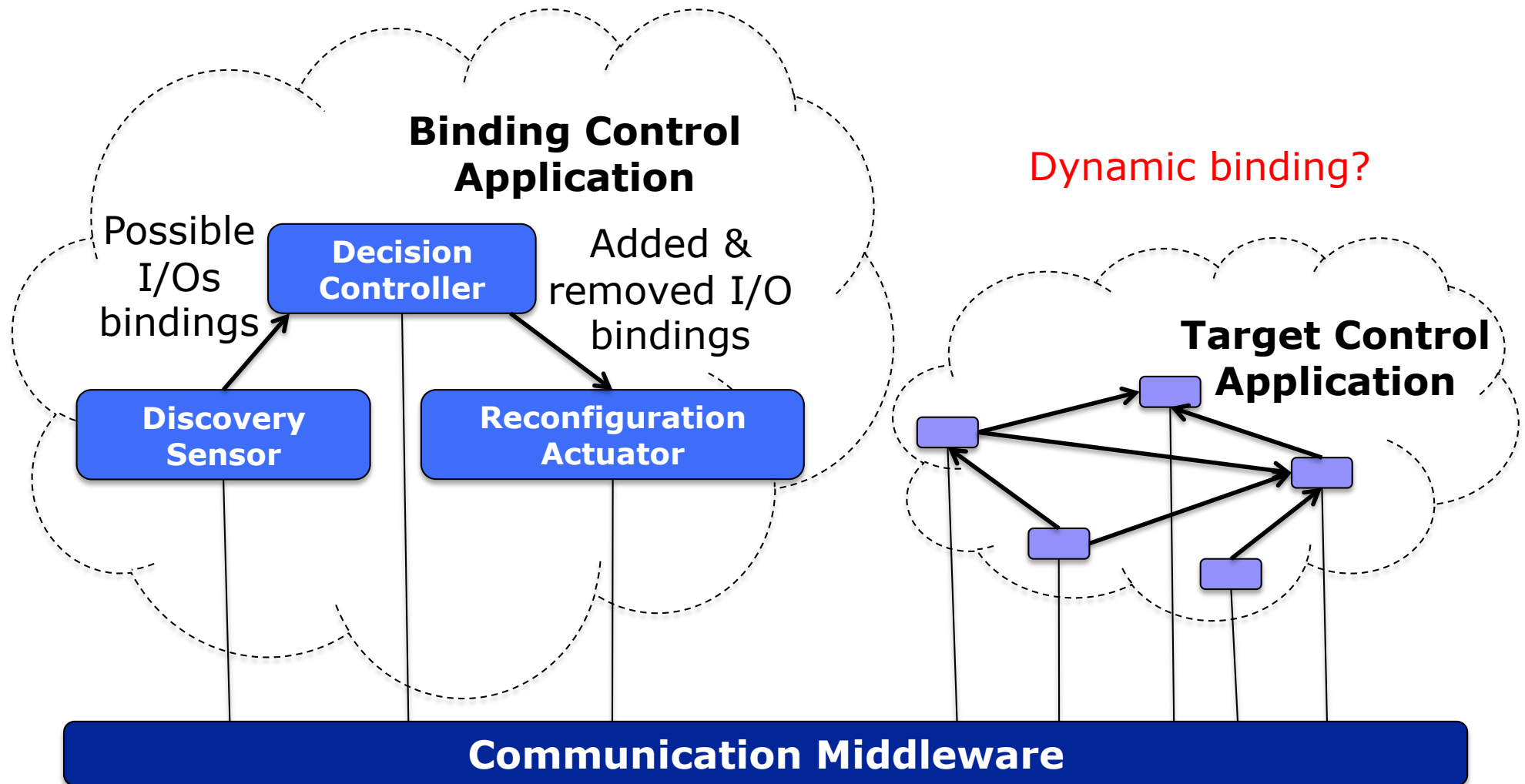Host B

Host C

Low applicability
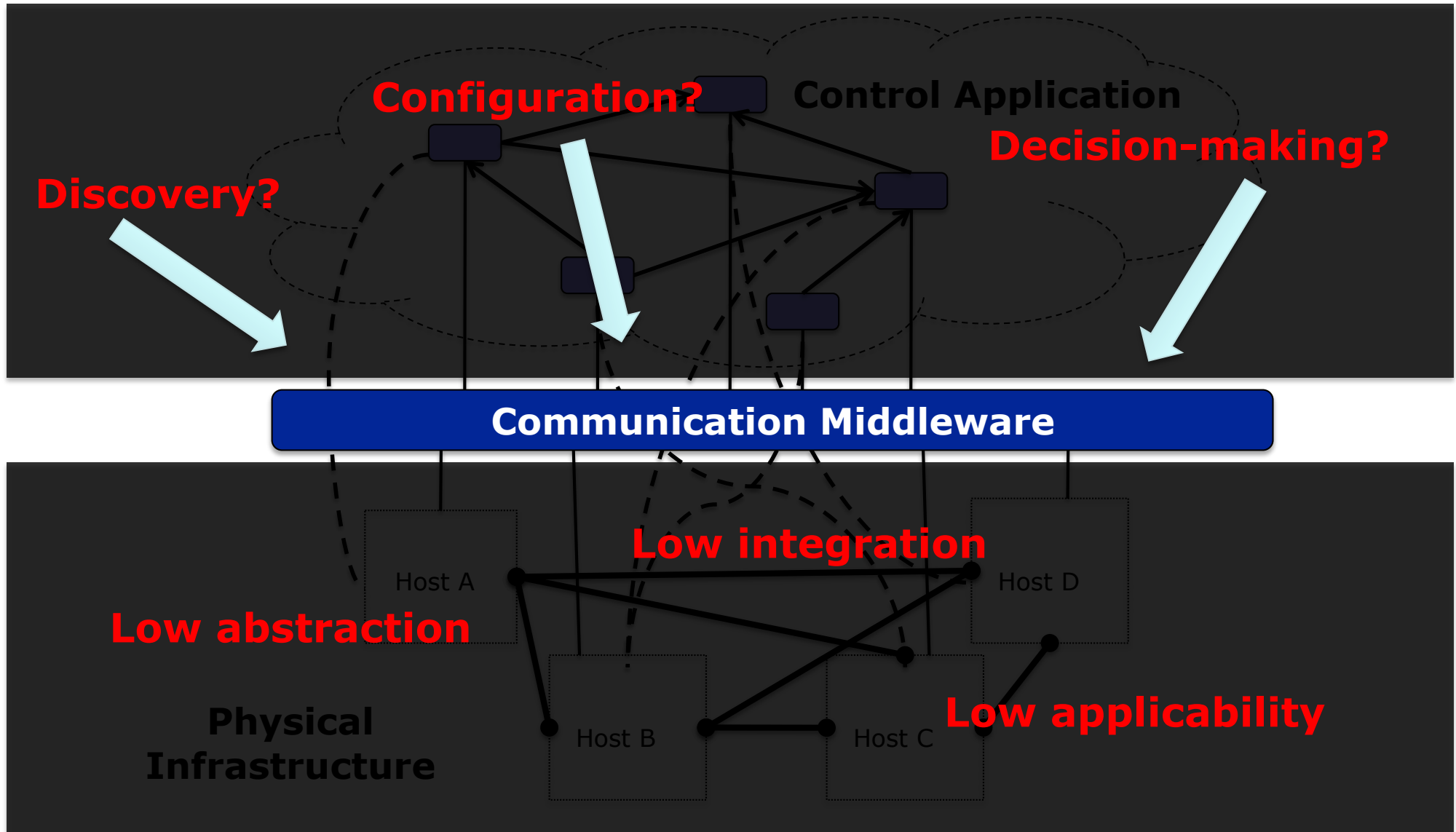
Approach

A model of dynamic composition and reconfiguration in
distributed control applications
designed as a distributed control application!

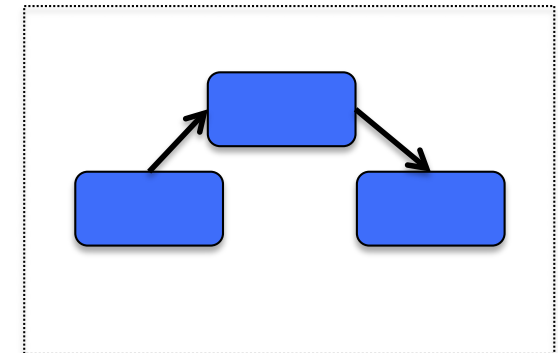No need to reinvent the wheel
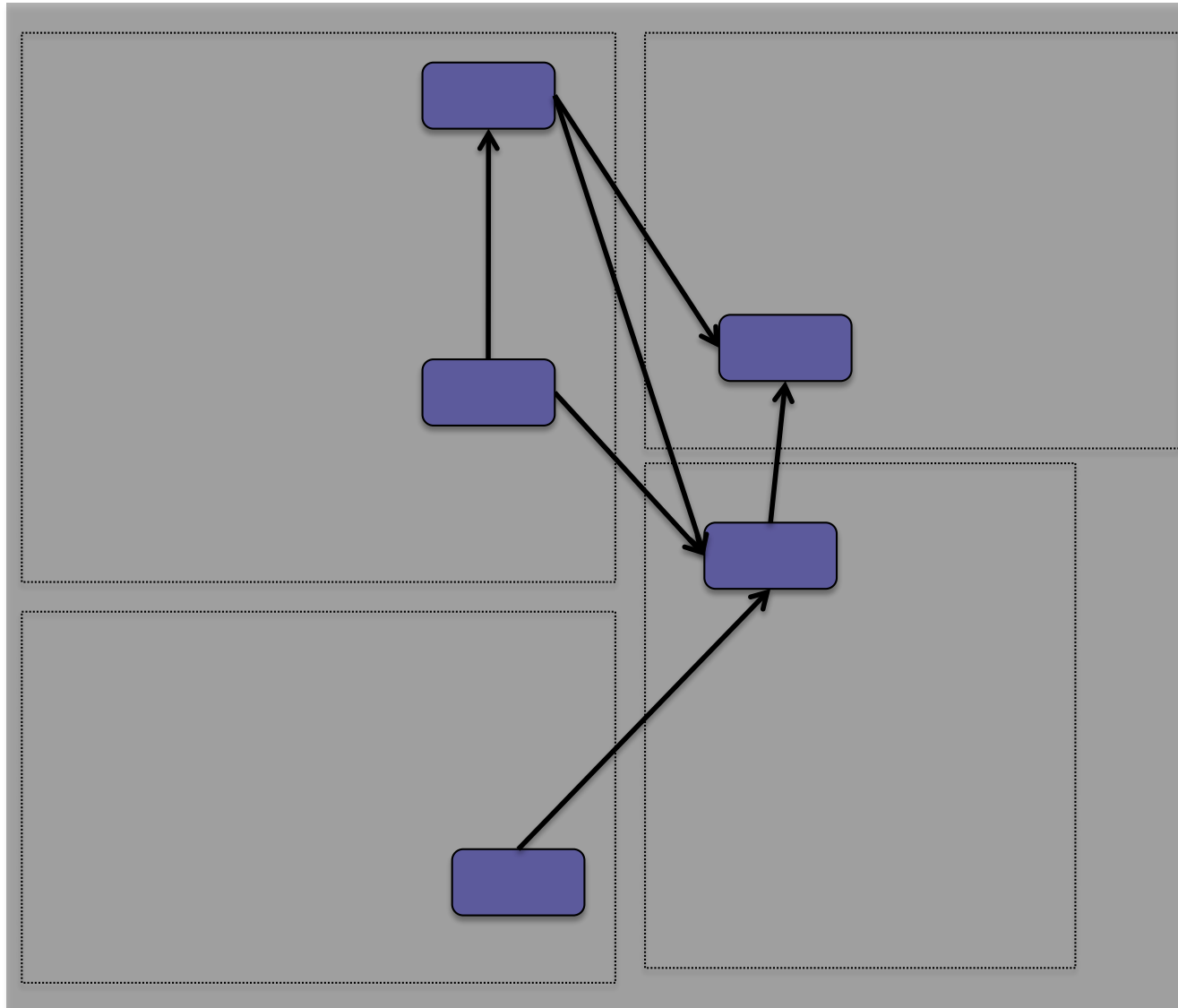
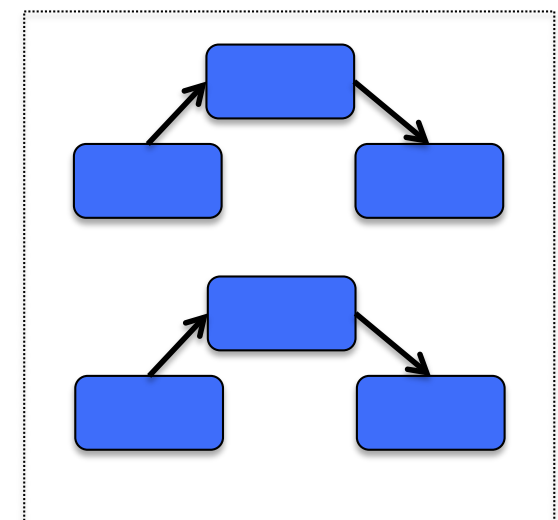# The Binding Control Model

Model Granularity

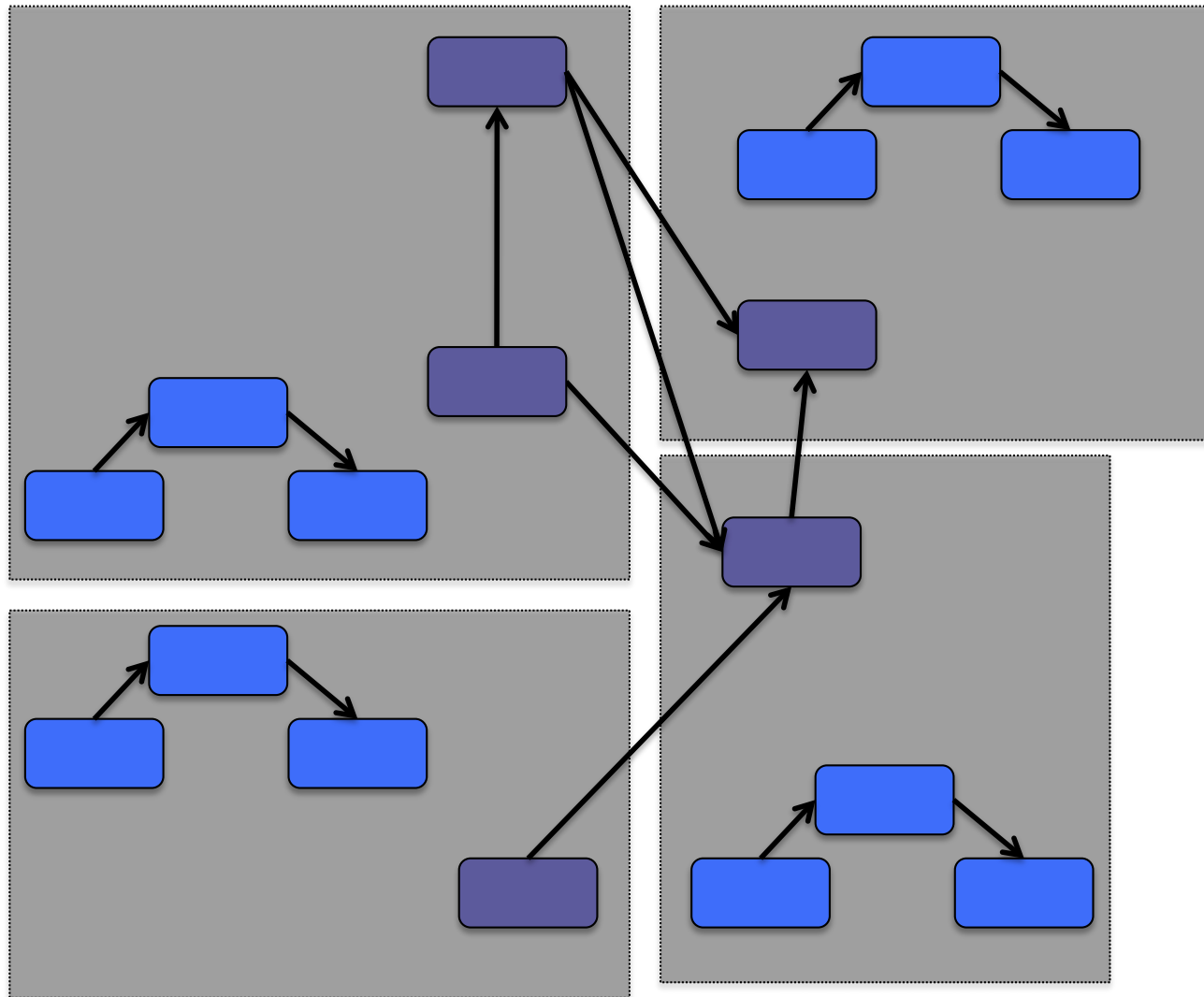Application element

Binding control element

System-level

Model Granularity
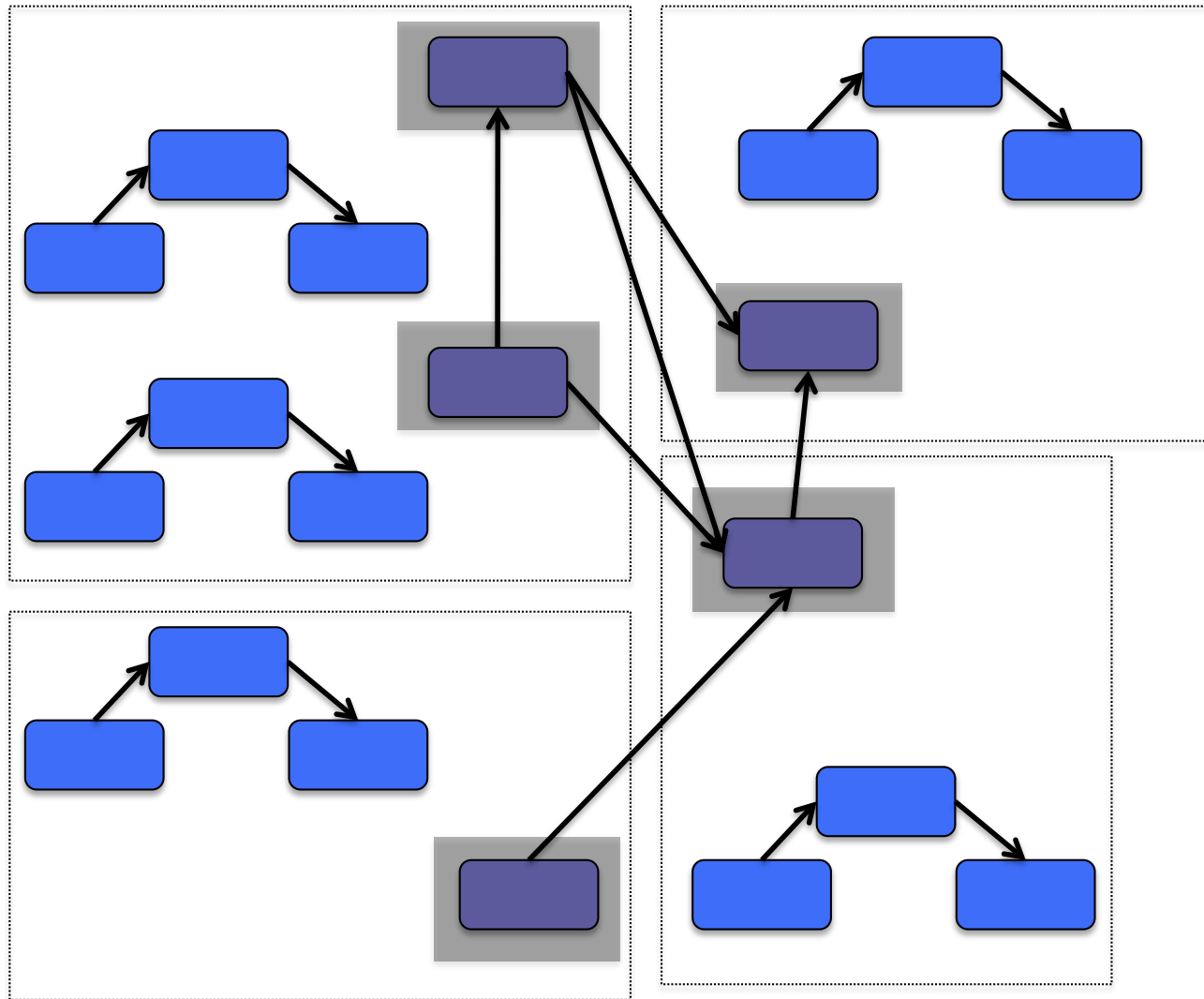
Application element
Binding control element

Node-level

Model Granularity

Application element

Binding control element

Element-level

Applicability

IBM software infrastructure & core demonstration project technology

Lightweight – Java Mobile Edition (JME)

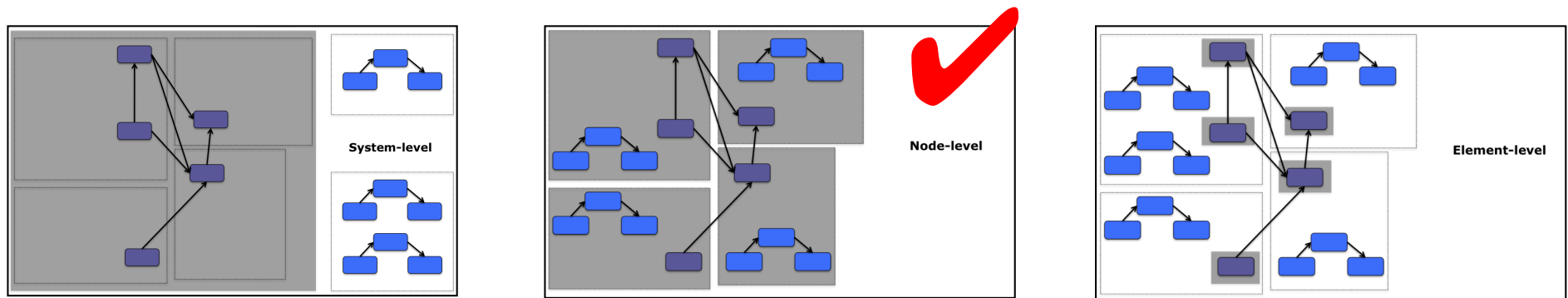Publish-subscribe system

Internet-scale Control System - iCS

Synchronous & asynchronous remote middleware communication

Multiple network adapters

XML files: binding map & network map

Applicability (Cont.)

Scenario: Update the binding map without the network map

Discovery sensor: gossiping protocol

Decision controller: Fitness function or administrative rules

Reconfiguration actuator: Adapt the publish-subscribe system

Conclusions

➢ Distributed control systems emerge to highly complex ecosystems

➢ **Composition and reconfiguration as a control application**

➢ We can do more than changing or introducing a middleware

➢ **Higher abstraction, integration and applicability**

➢ Bridging the gap between developers

➢ New business opportunities and models

Future Work

Quantitative comparison of different granularity levels in iCS

Evaluation of more complex composition and reconfiguration scenarios

Questions?