Spinoff ETH zürich

Building a Cloud Platform for Robots

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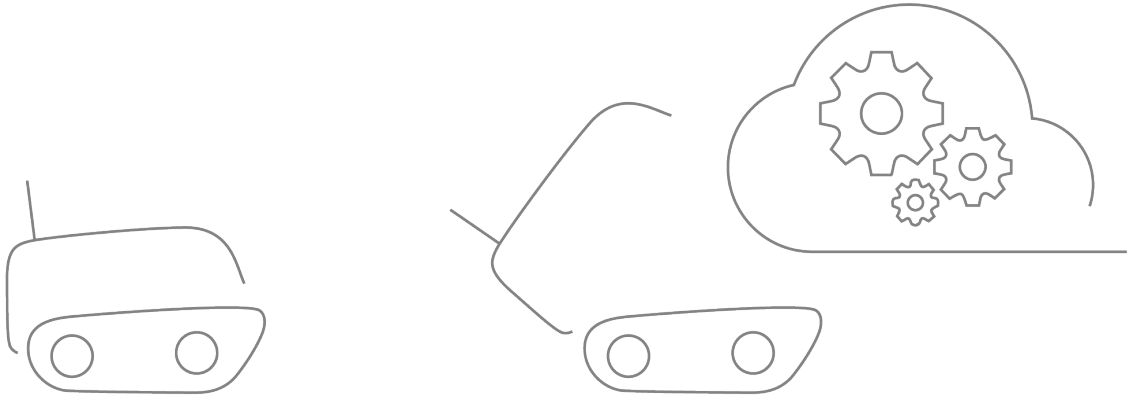
Rapyuta Robotics

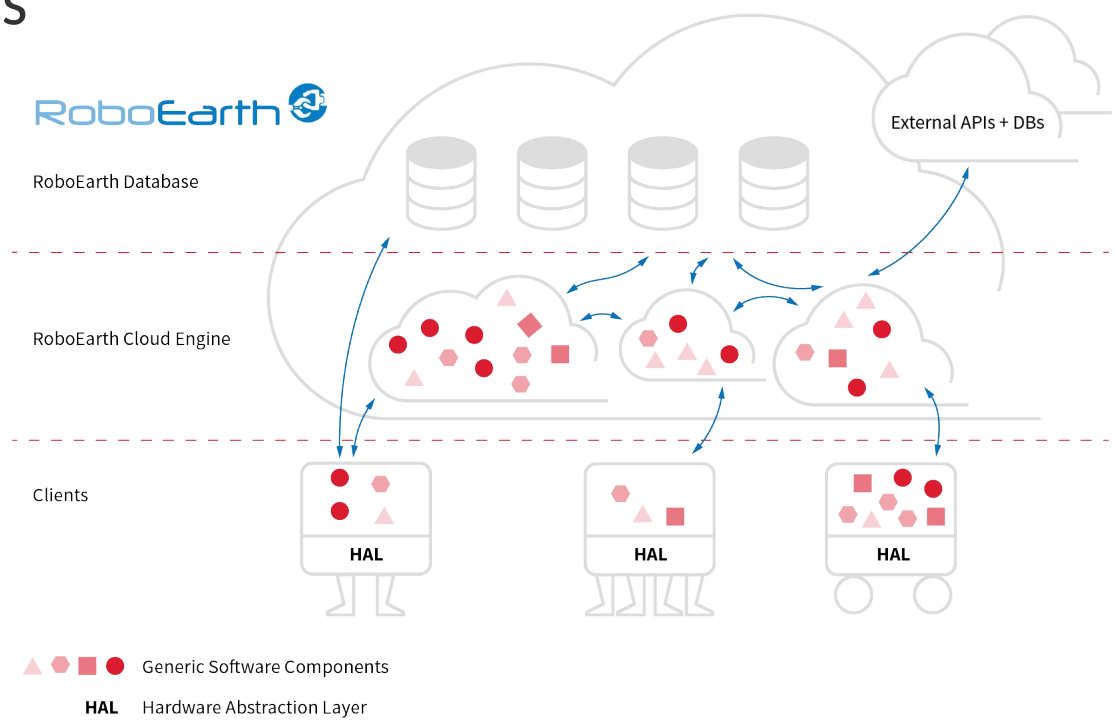
@d_sathe

CloudNativeCon KubeCon

Task Offloading

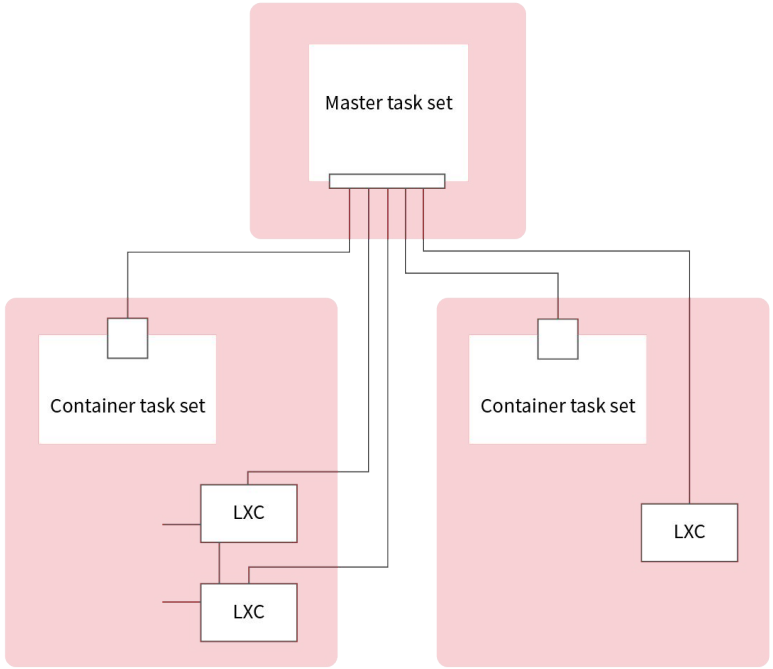


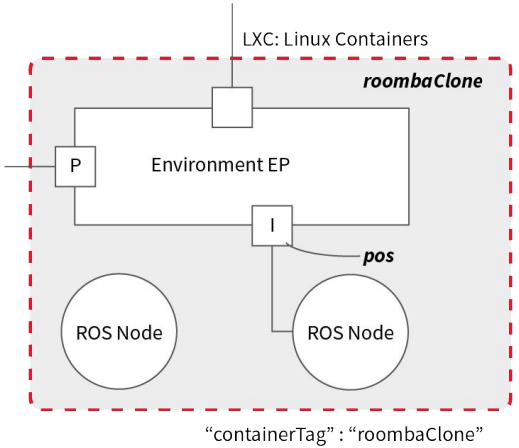
The Genesis



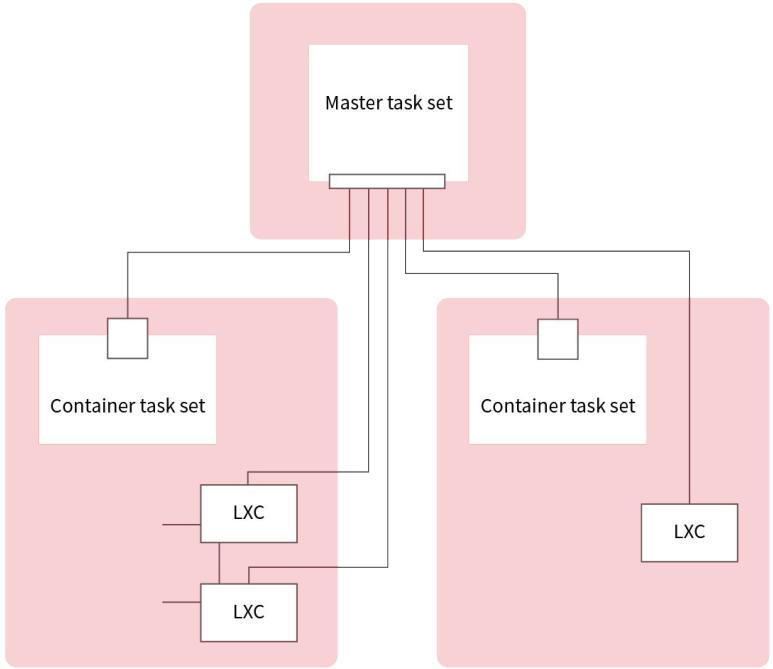
TU/e Technische Universiteit Eindhoven University of Technology Where innovation starts
PHILIPS sense and simplicity
Universität Stuttgart
ETH Eidgenössische Technische Hochschule Zürich Swiss Federal Institute of Technology Zurich
Universidad Zaragoza
TUM Technische Universität München
Universität Bremen

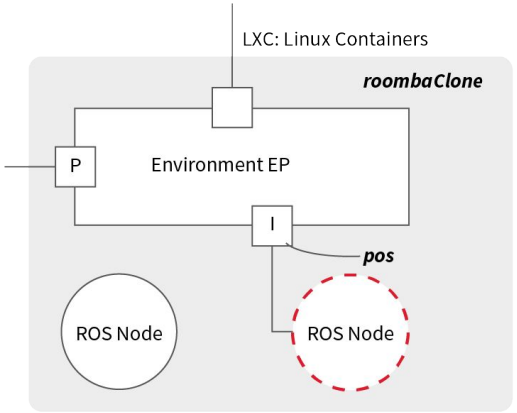
RoboEarth Compute Environment





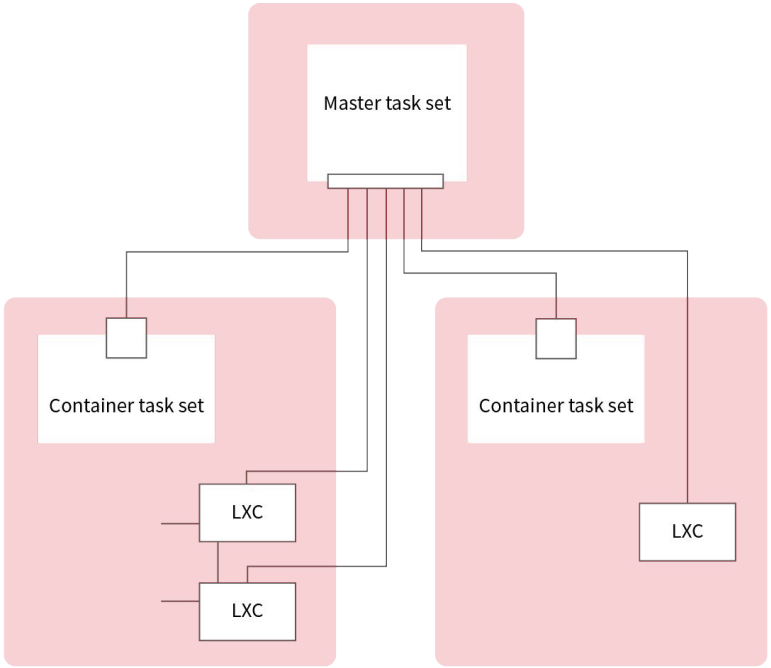
RoboEarth Compute Environment

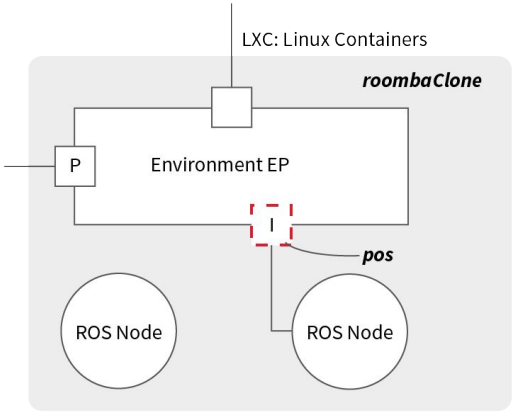





```
"addNodes" : [{
    "containerTag" : "roombaClone",
    "nodeTag"      : "positionRecorder",
    "pkg"          : "testPkg",
    "exe"          : "posRecorder.py"
}],
```

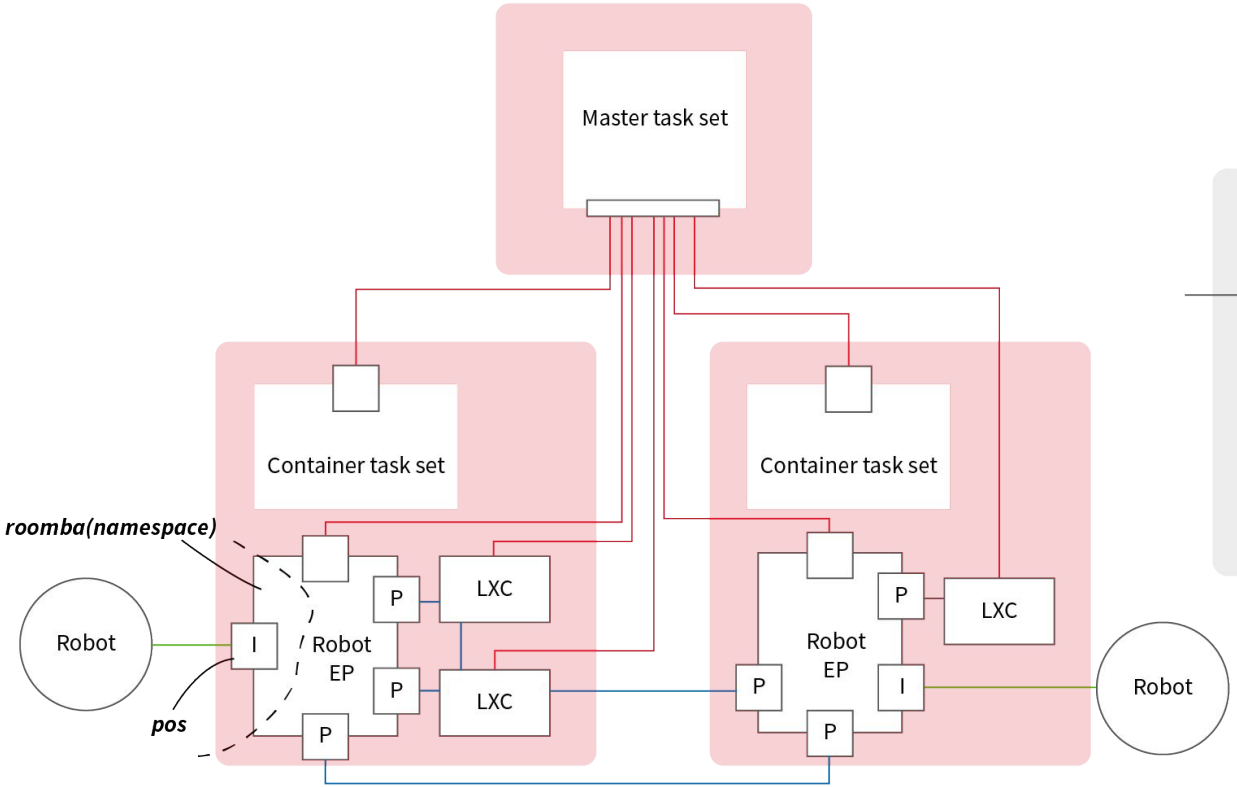
RoboEarth Compute Environment

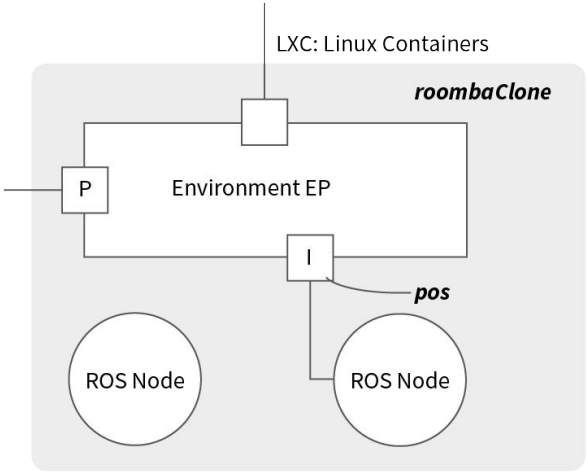





```
"addInterfaces" : [{
  "endpointTag"   : "roombaClone",
  "interfaceTag"  : "pos",
  "interfaceType" : "PublisherInterface",
  "className"     : "geometry_msgs/Pose2D",
  "addr"          : "/posPub"
}]
```

Networking in RoboEarth





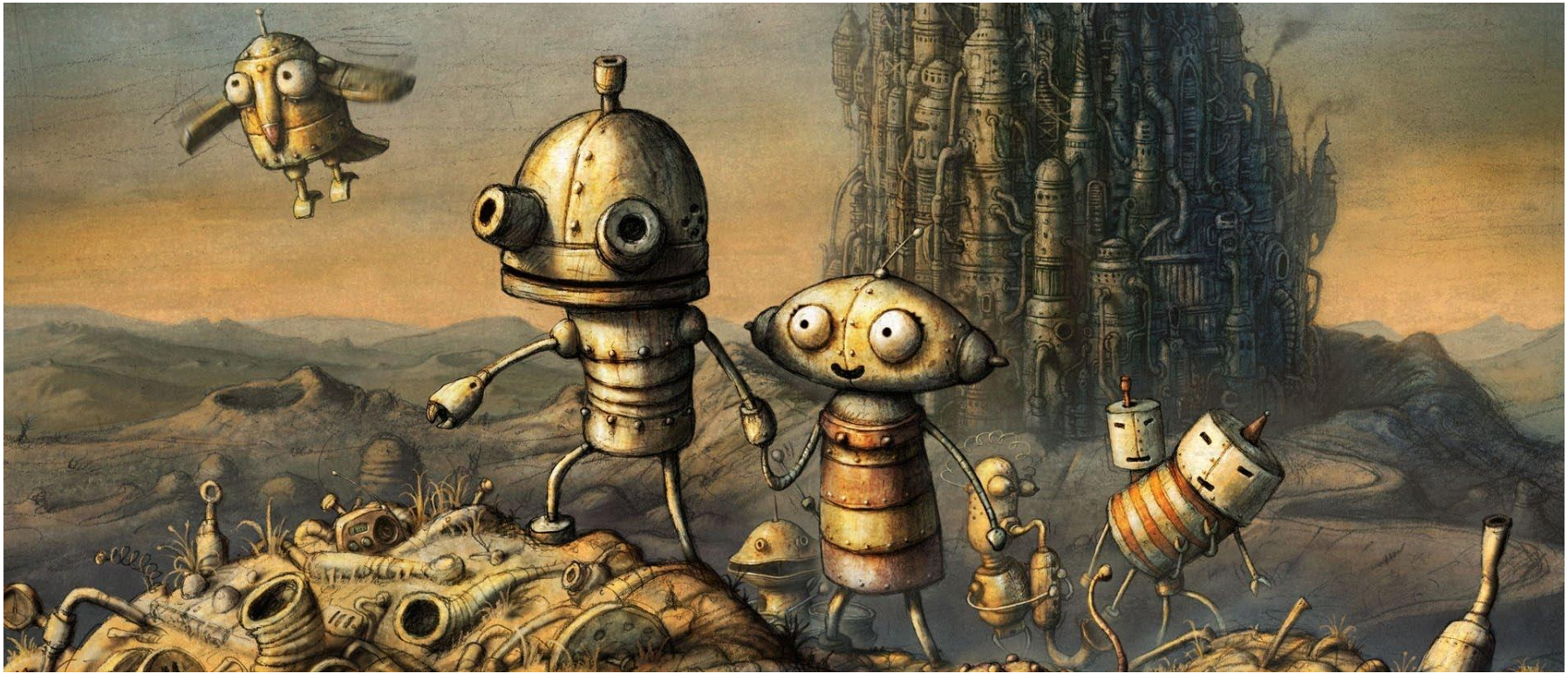
* NAT + proprietary protocol or raw sockets over GRE-tunnels and Openvswitch
* Websockets
* Proprietary RCE Protocol

It worked!

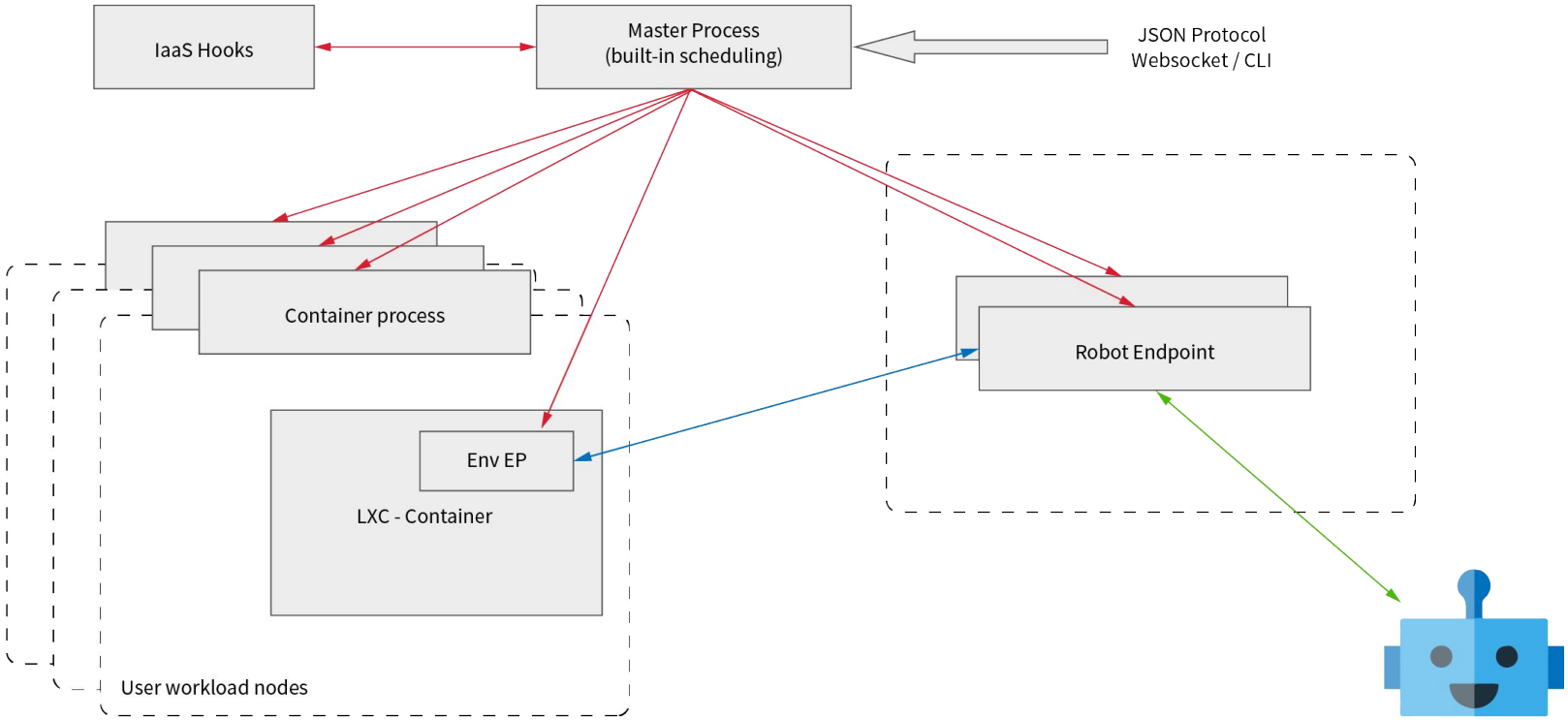
Collaborative 3D mapping

Dynamic mobile manipulation

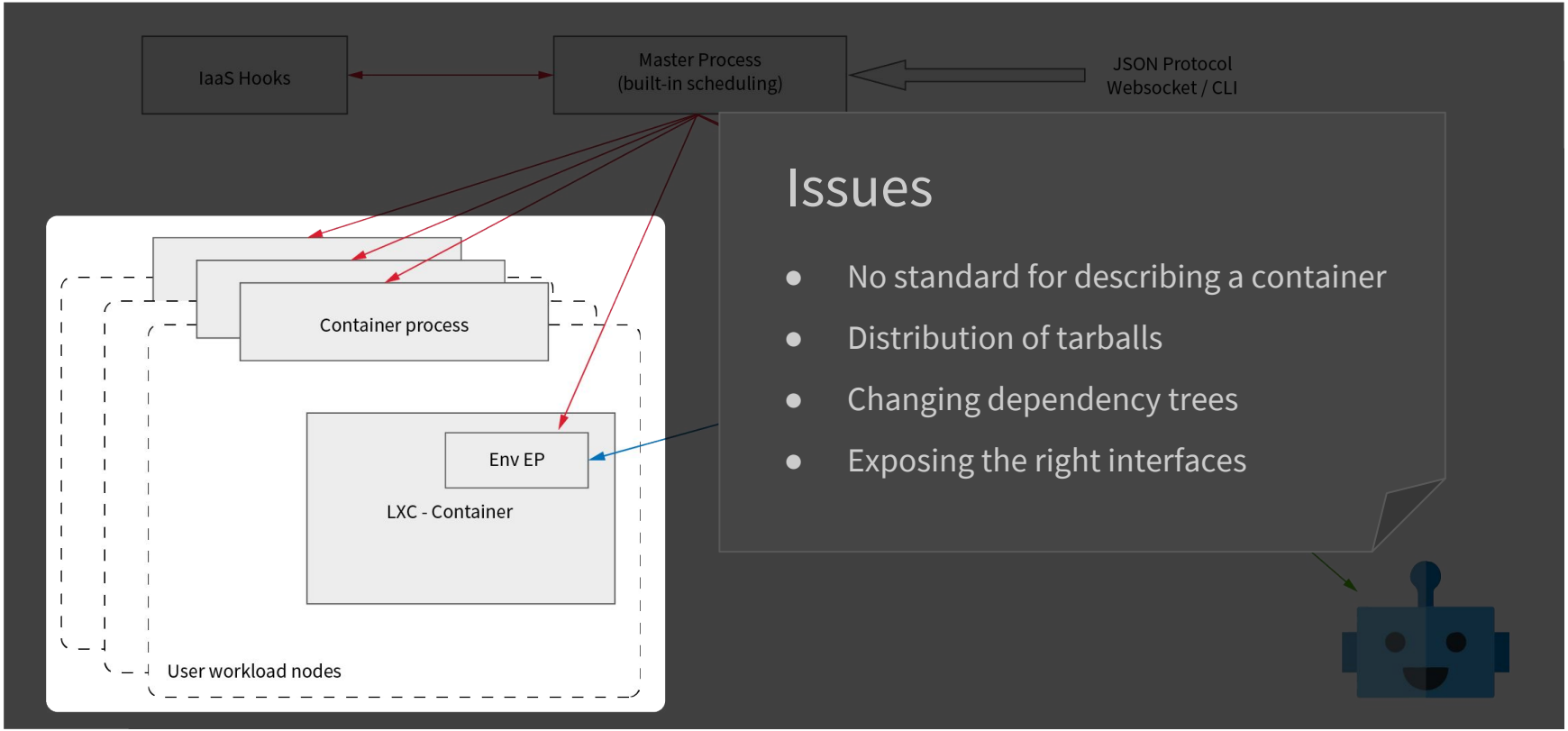
Re-imagining the platform



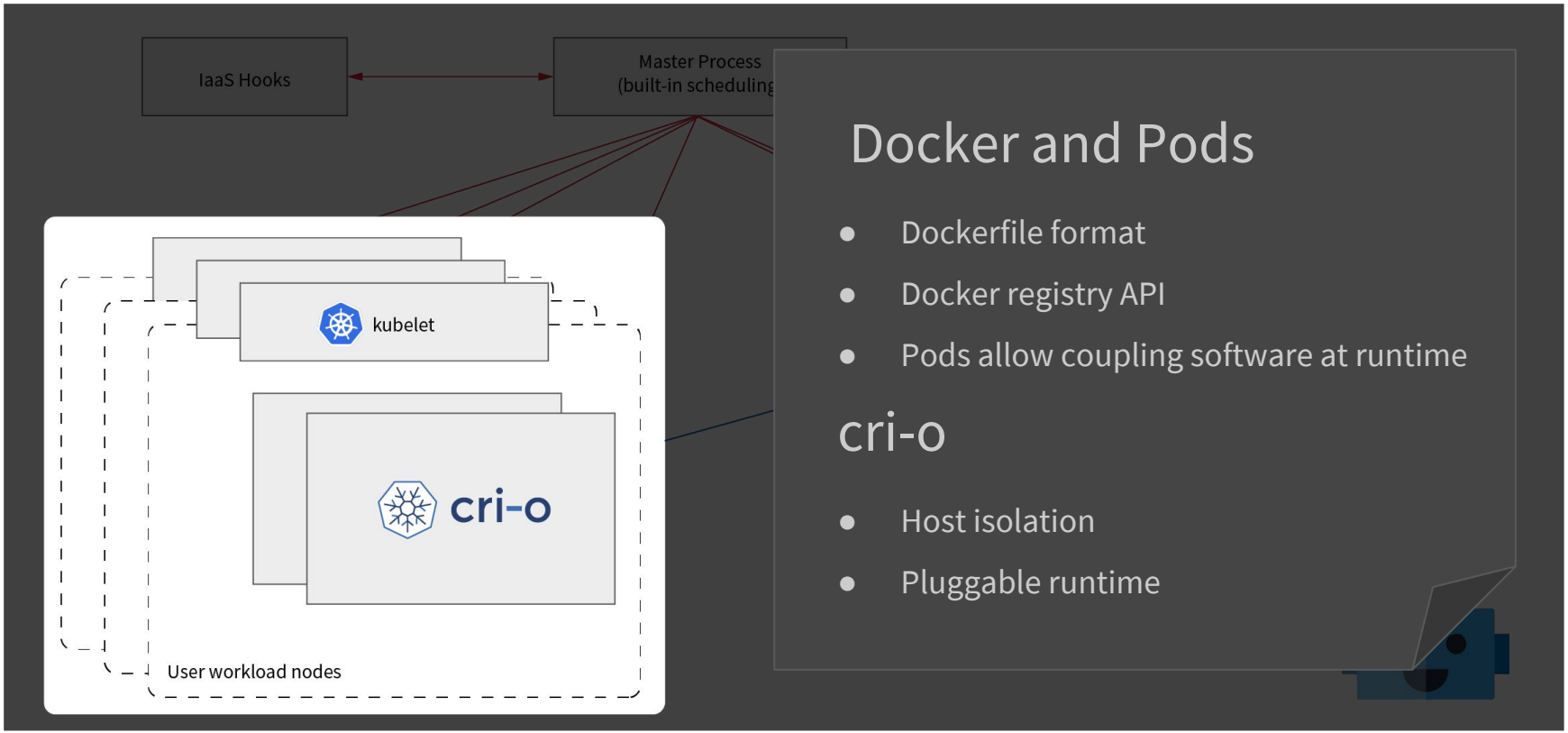
RoboEarth Architecture Overview



Containerization



Containerization



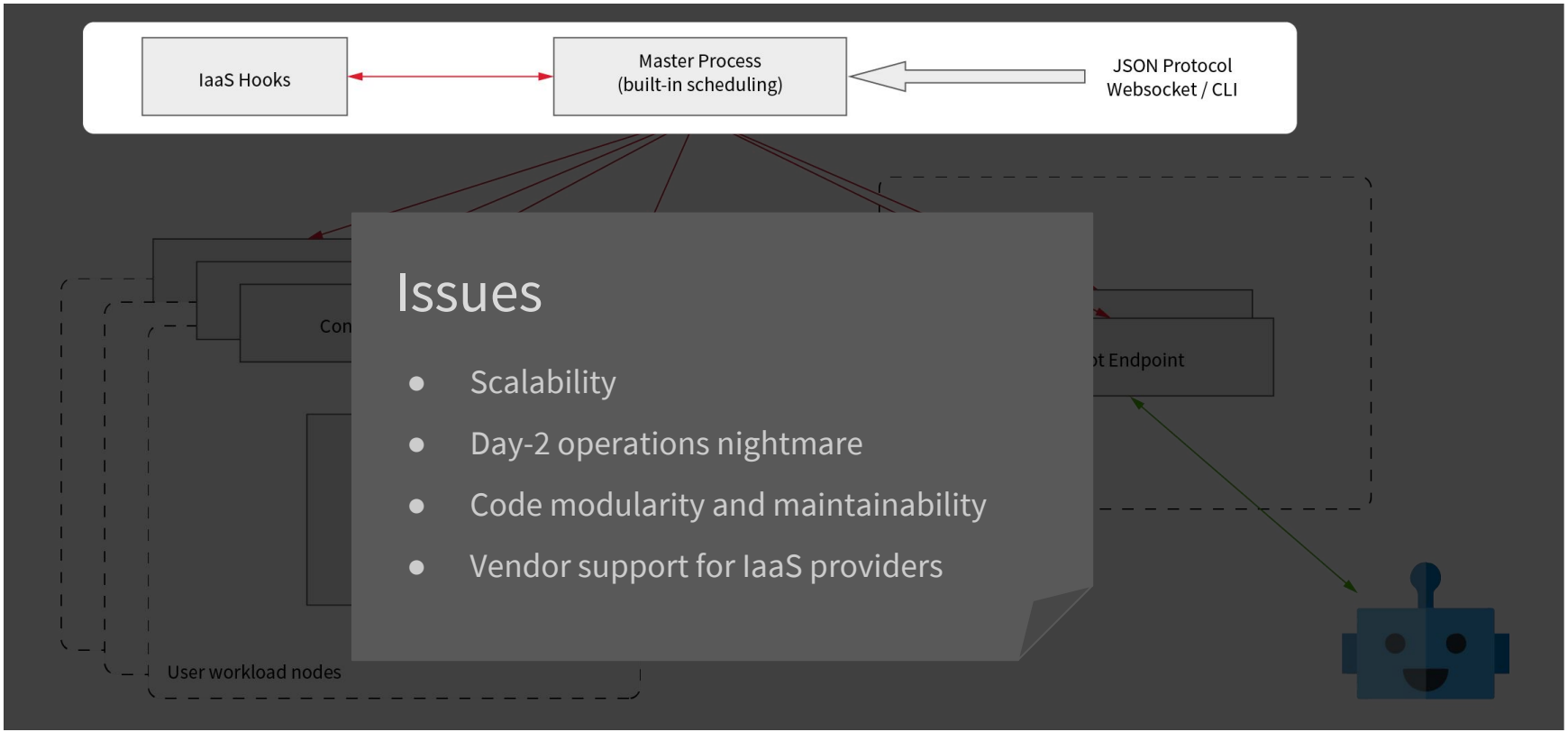
Docker and Pods

- Dockerfile format
- Docker registry API
- Pods allow coupling software at runtime

cri-o

- Host isolation
- Pluggable runtime

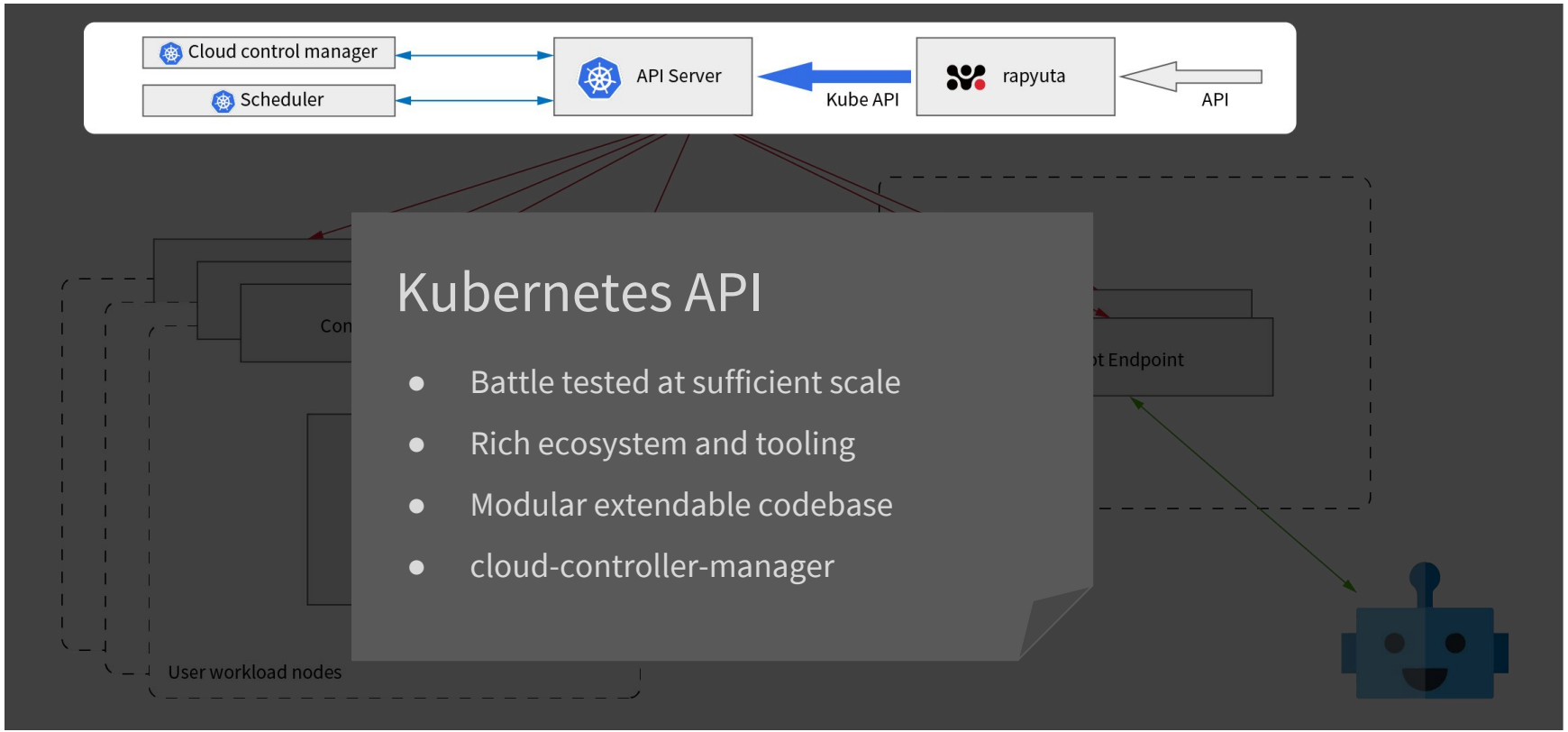
Control Plane



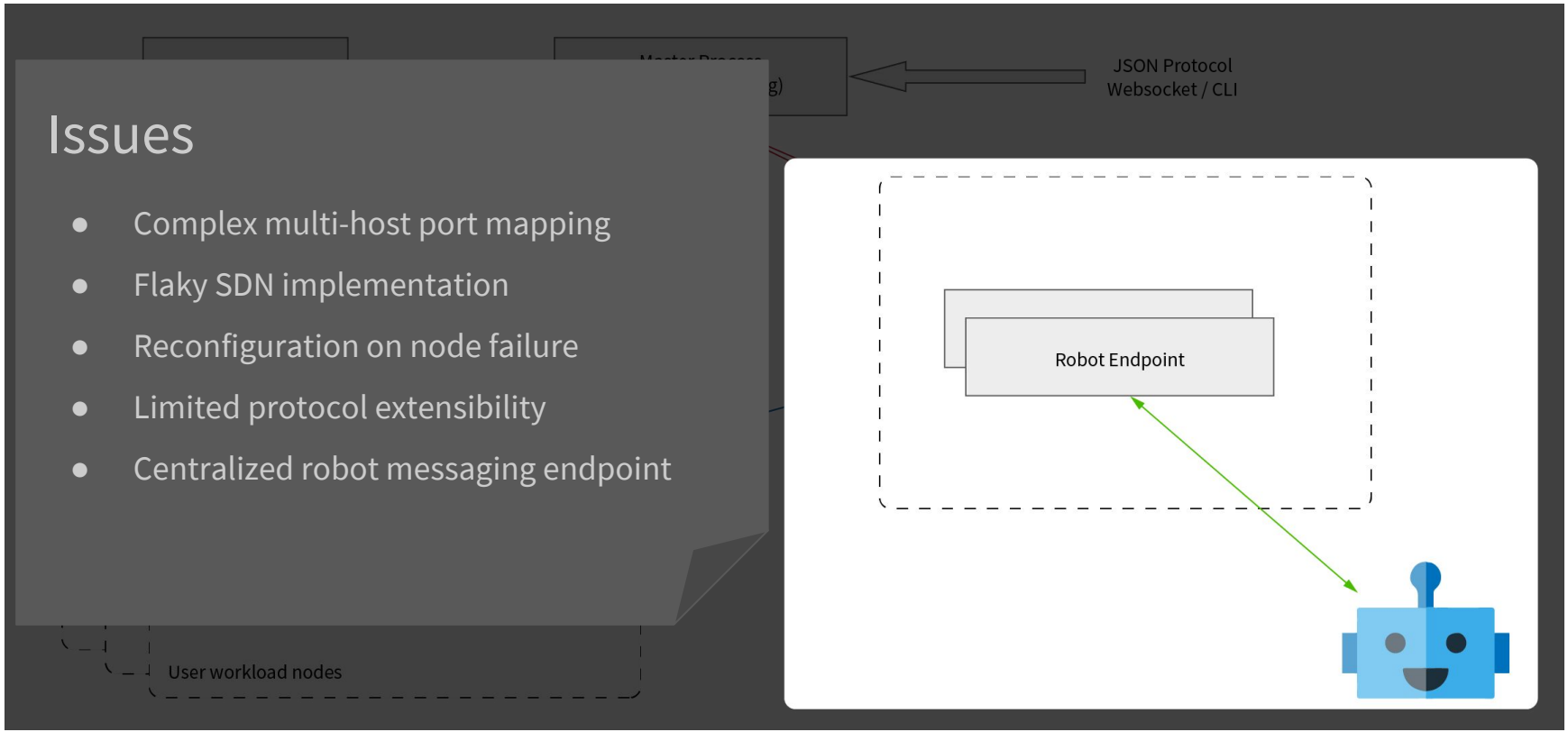
Issues

- Scalability
- Day-2 operations nightmare
- Code modularity and maintainability
- Vendor support for IaaS providers

Control Plane



Networking



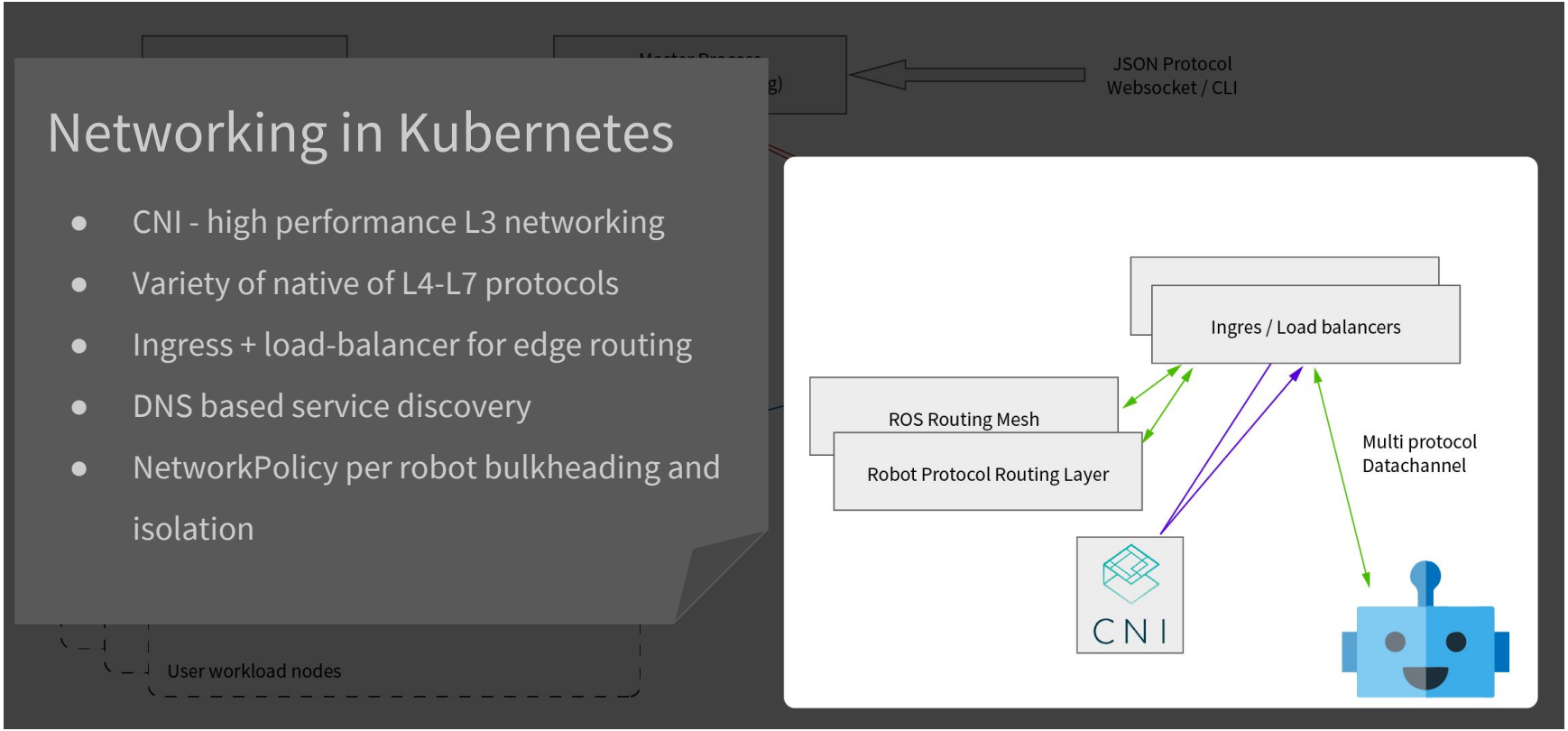
Issues

- Complex multi-host port mapping
- Flaky SDN implementation
- Reconfiguration on node failure
- Limited protocol extensibility
- Centralized robot messaging endpoint

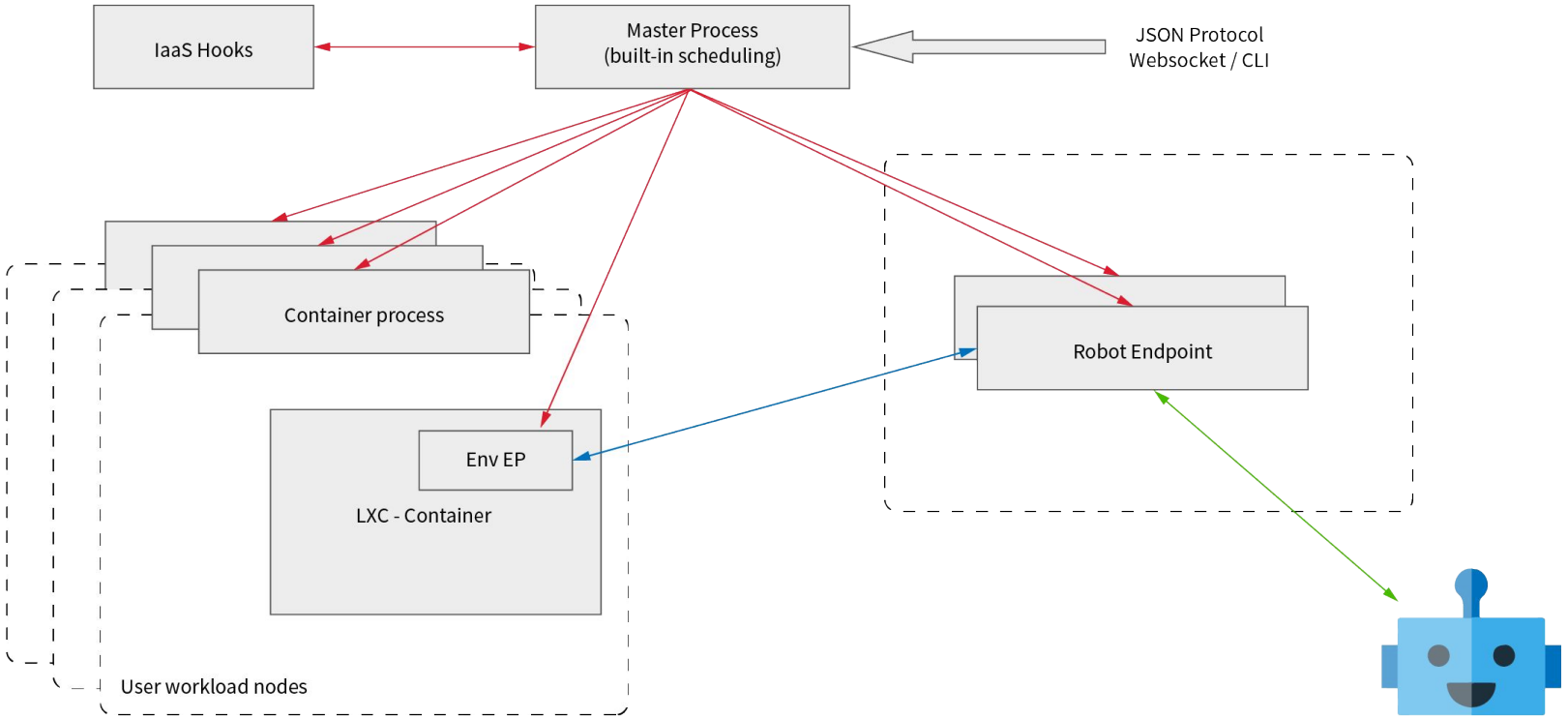
Networking

Networking in Kubernetes

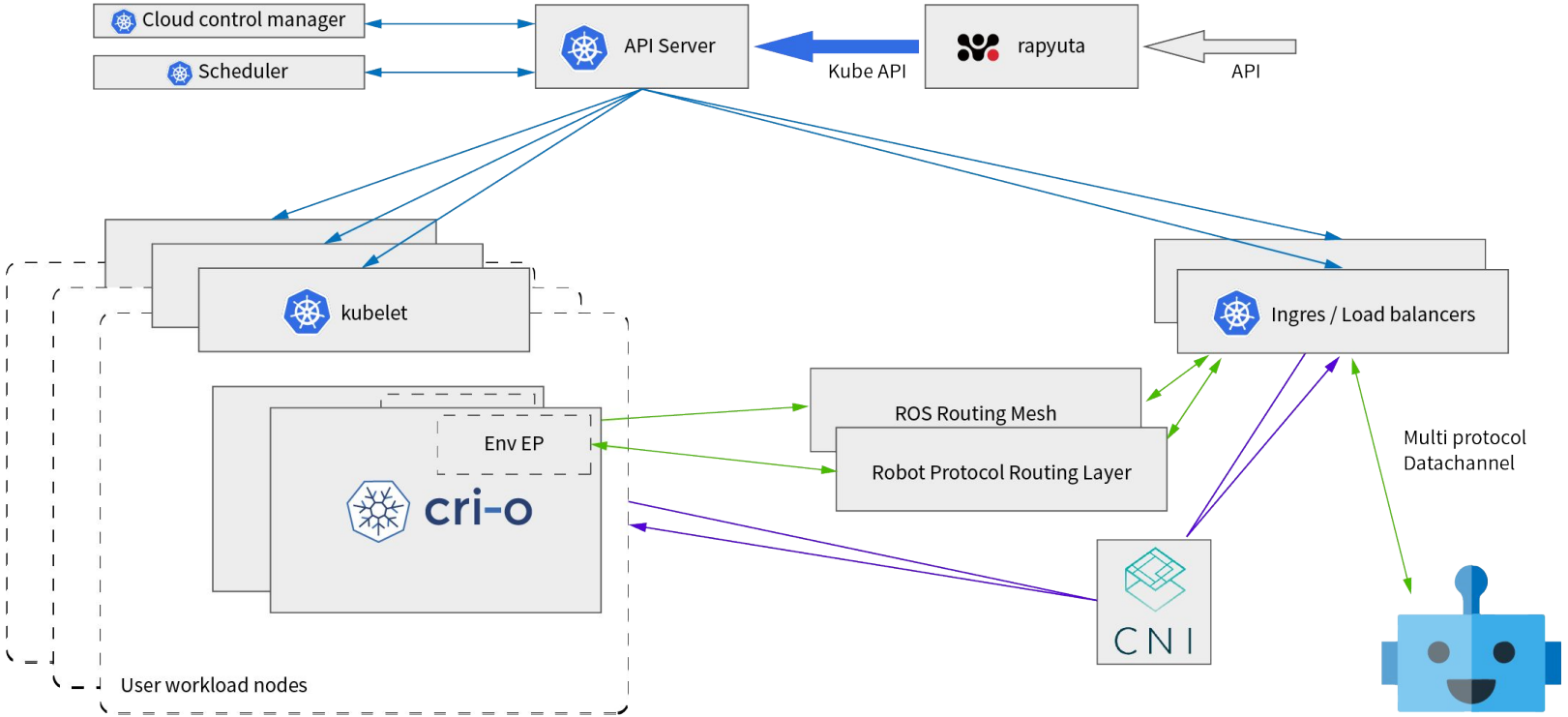
- CNI - high performance L3 networking
- Variety of native of L4-L7 protocols
- Ingress + load-balancer for edge routing
- DNS based service discovery
- NetworkPolicy per robot bulkheading and isolation



The Onset


IaaS Hooks
Master Process
(built-in scheduling)
JSON Protocol
Websocket / CLI
Container process
Robot Endpoint
Env EP
LXC - Container
User workload nodes

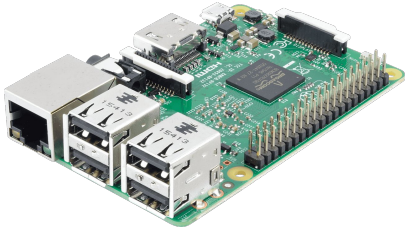
The Culmination



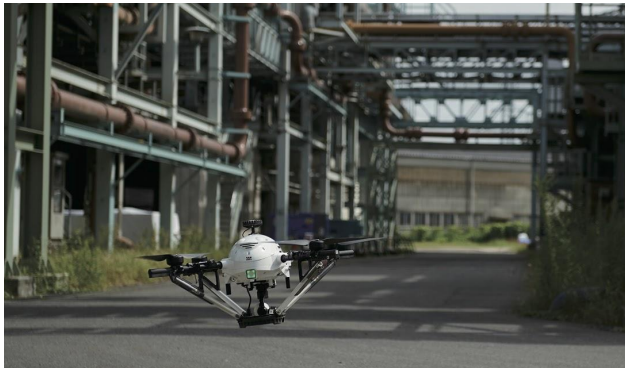
Breaking out of the Datacenter

A few challenges

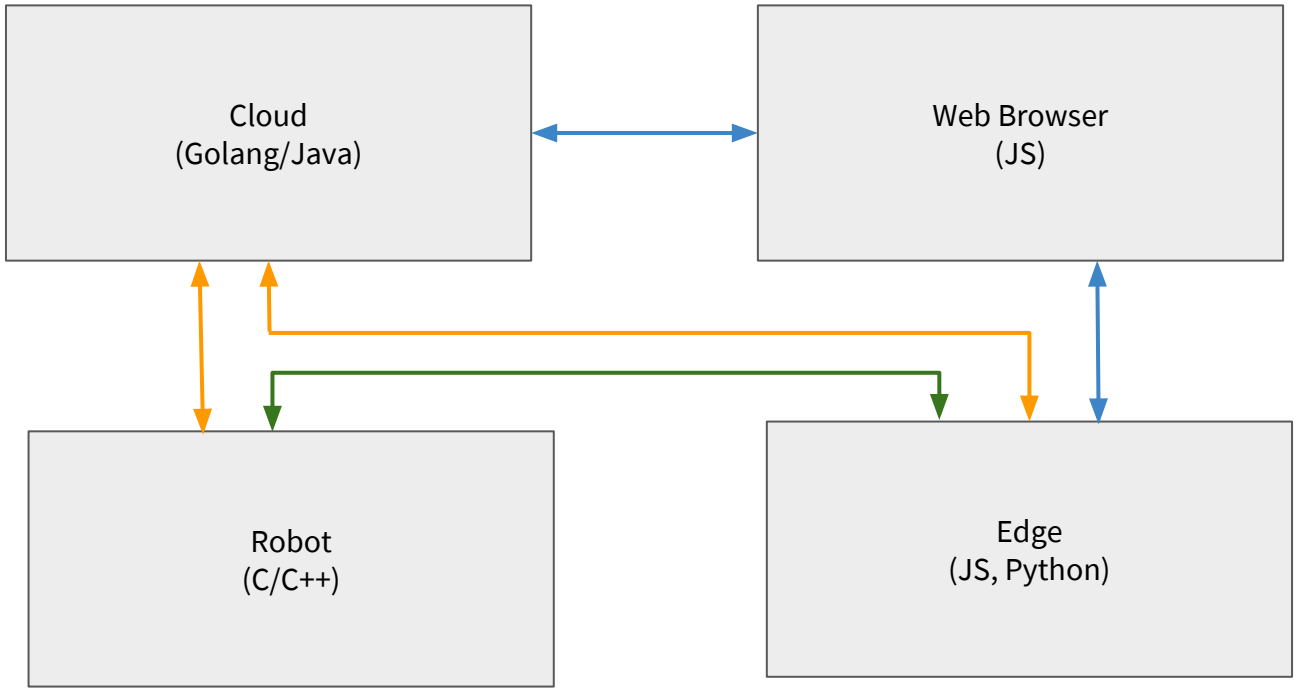
- Heterogeneous compute architectures
- Network reliability
- Configuration management and reproducibility
- Latency and temporal variations




Installation > Tsukuba > Patrol-02 > Real Time
Rapyuta Robotics
EMERGENCY LAND
19min
800 m
360°
2D Scan
Flight status
Endurance
25 min
remaining
Waypoint
2 / 5
123 m to next waypoint
1,300 m from home
35°40'34.5"N 139°47'07.3"E



The Anatomy of a Robotics Application



“kubectl is the new SSH…If you’re using kubectl to deploy from your laptop you’re missing the point. If you’re doing it right no one should know you’re using Kubernetes.”

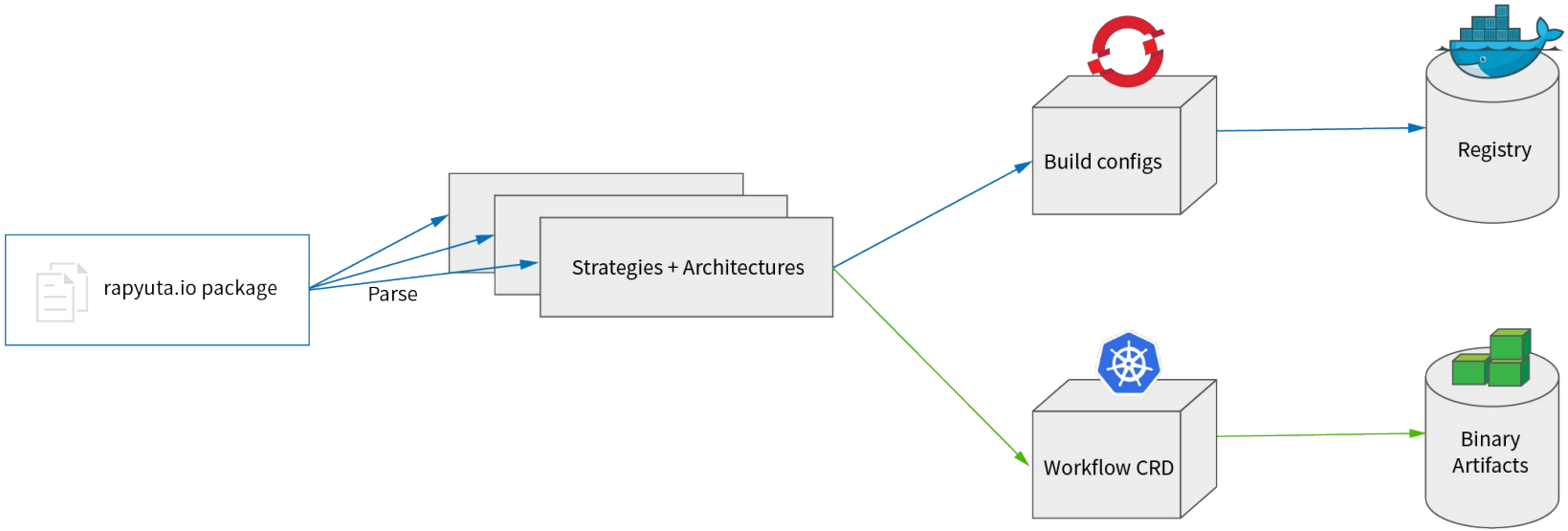
A Platform Package

- Must run anywhere
- Should have a unified declarative description
- Should have a unified set of API and Tools

Package Manifest

```
{
  "apiVersion":"v1.0.0",
  "name":"cloud_pub_sub",
  "plans":[{
     "name":"default",
     "components":[{
         "name":"listener",
         "cloudInfra":{ "replicas":1},
         "requiredRuntime":"cloud",
         "executables":[{"docker":"rapyutians/listener, "cmd":["roslaunch listener listener.launch"]}],
     },{
         "name":"talker",
         "requiredRuntime":"device",
         "executables":[{
             "git":"https://github.com/rapyuta/talker", "cmd":["roslaunch talker talker.launch"]
         }],
     }
}
```

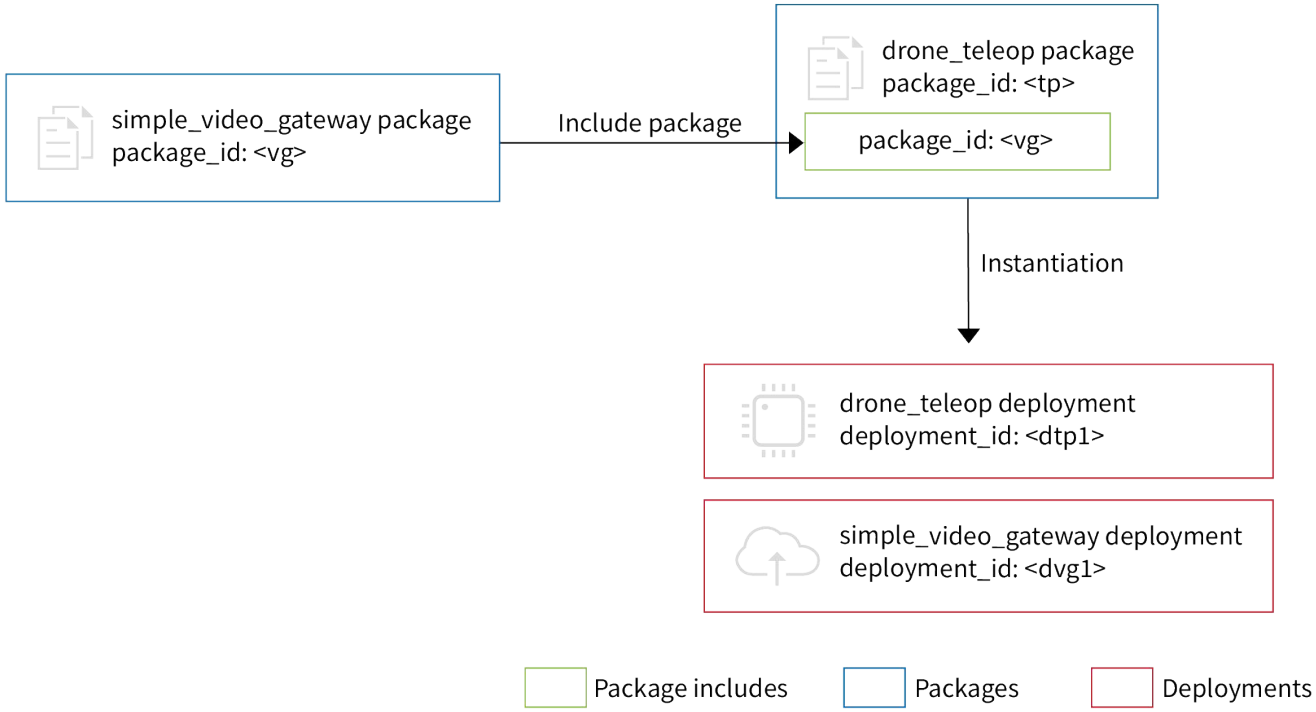
MultiArch-Build Engine



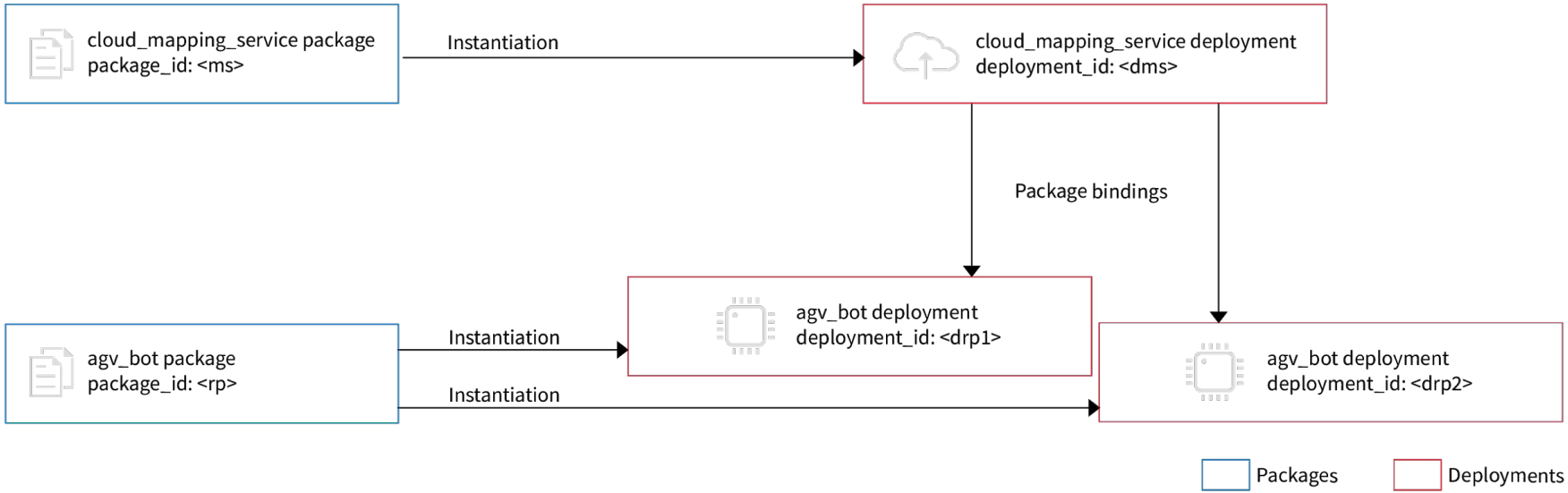
Composing Applications from Packages

- Uniform tools lead to uniform lifecycle management
- Permit coupling of packages to build more complex applications
- Allow users to pick and choose packages and components from a private/public catalog
- Decouple development teams, organisations and skill-sets

Package Composition



Package Composition

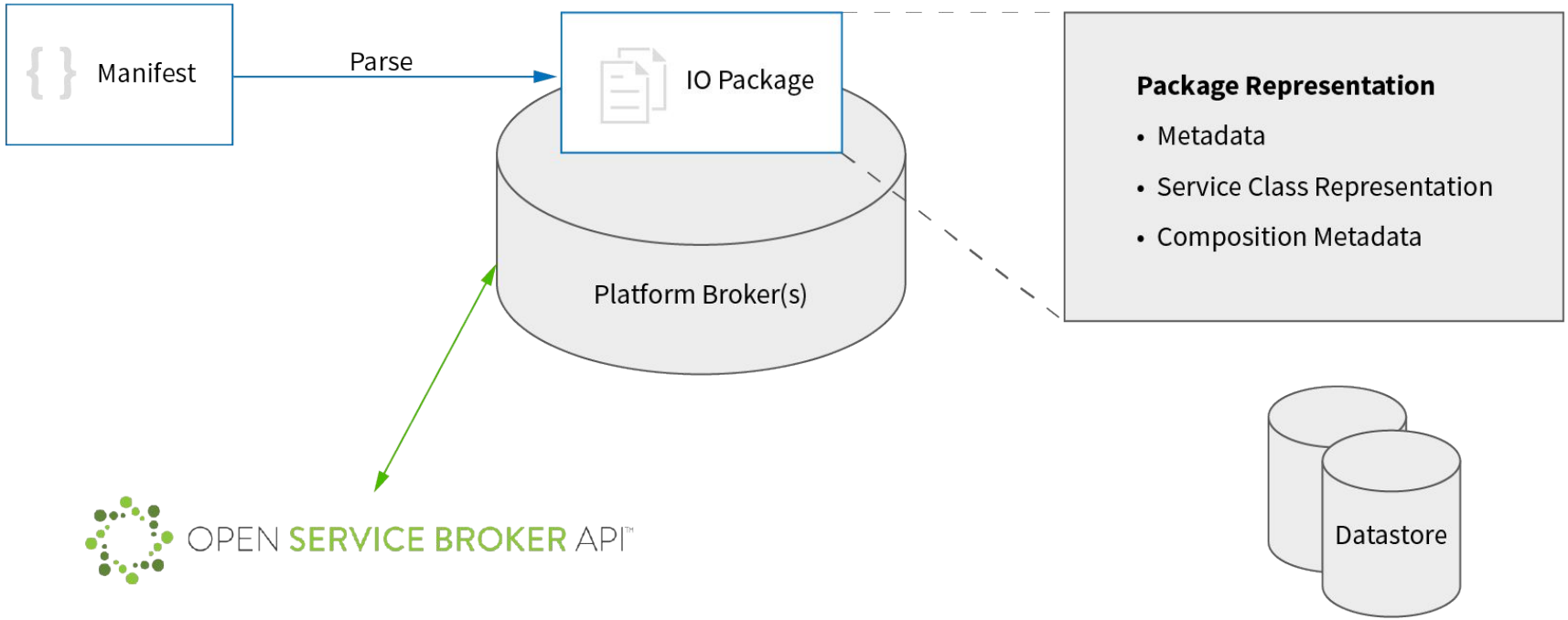


Open Service Broker API

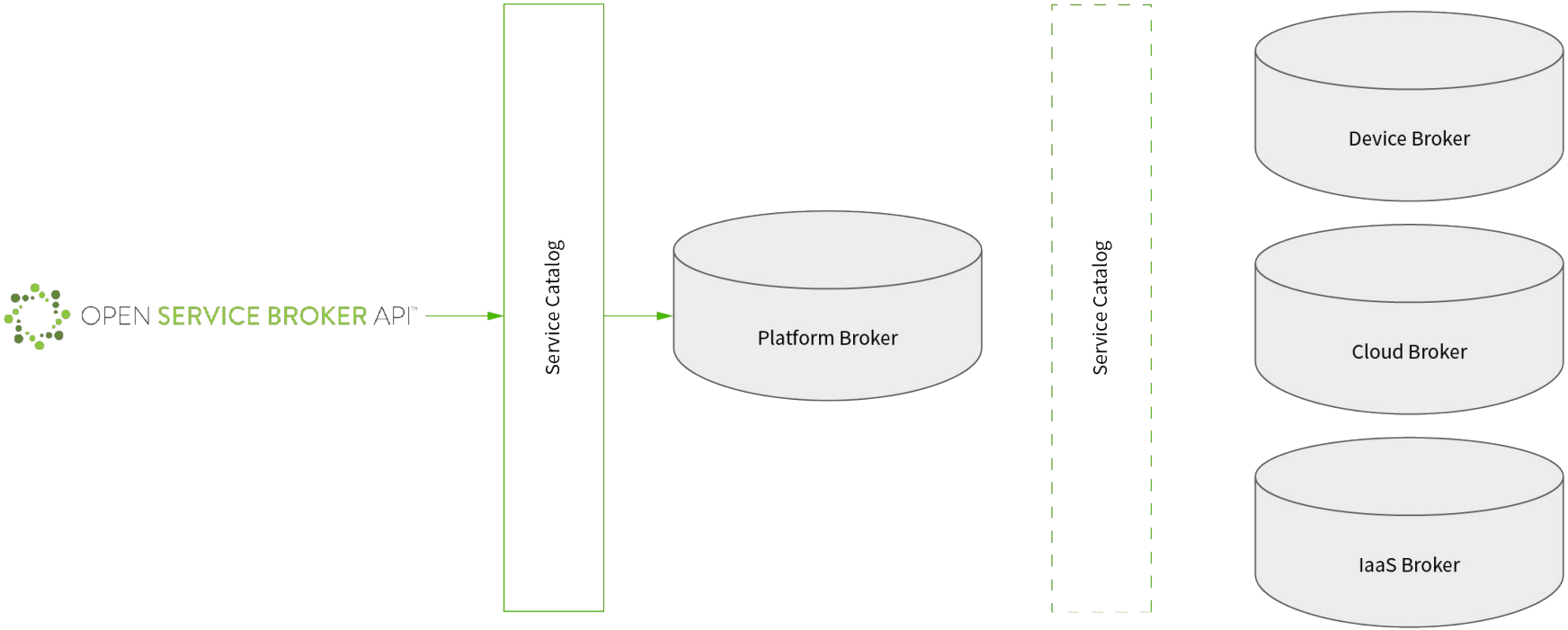
GetCatalog
Provision
Bind
Update
Unbind
Deprovision

Credentials

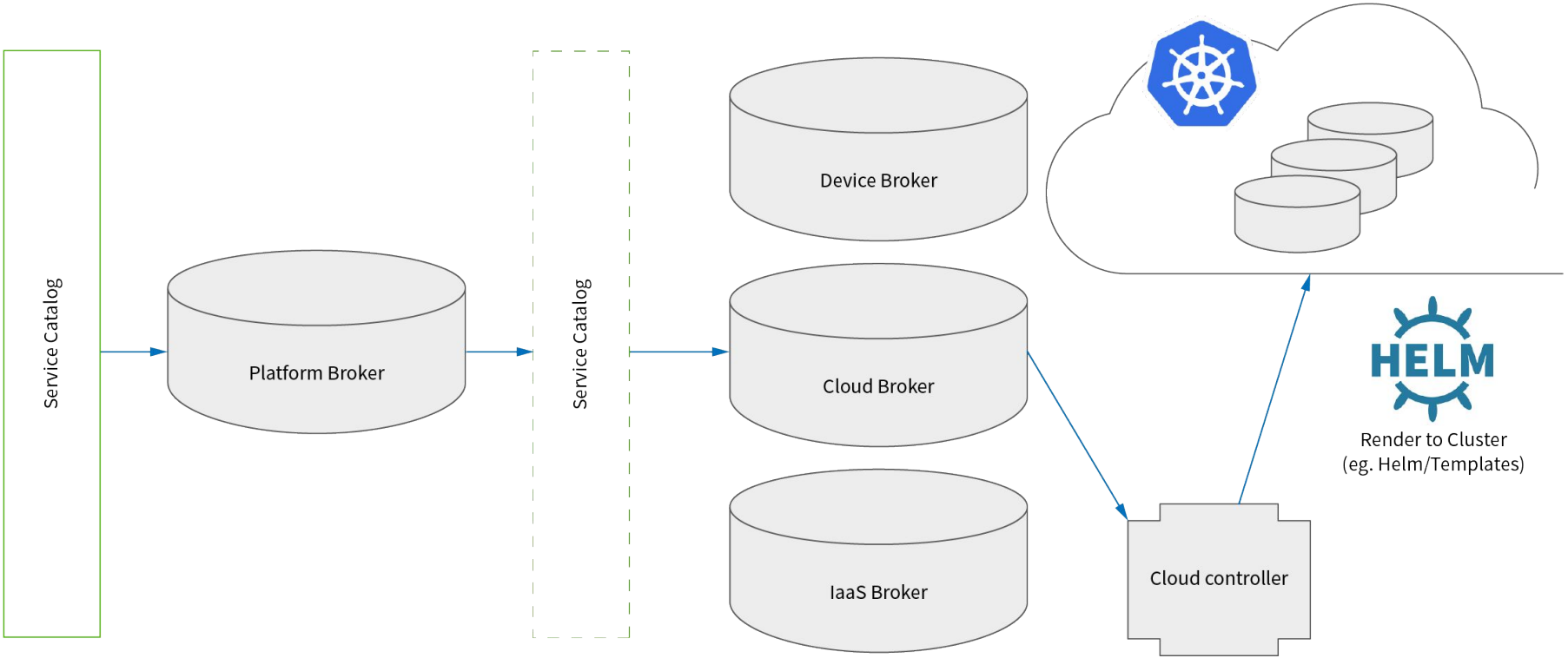
Package Representation



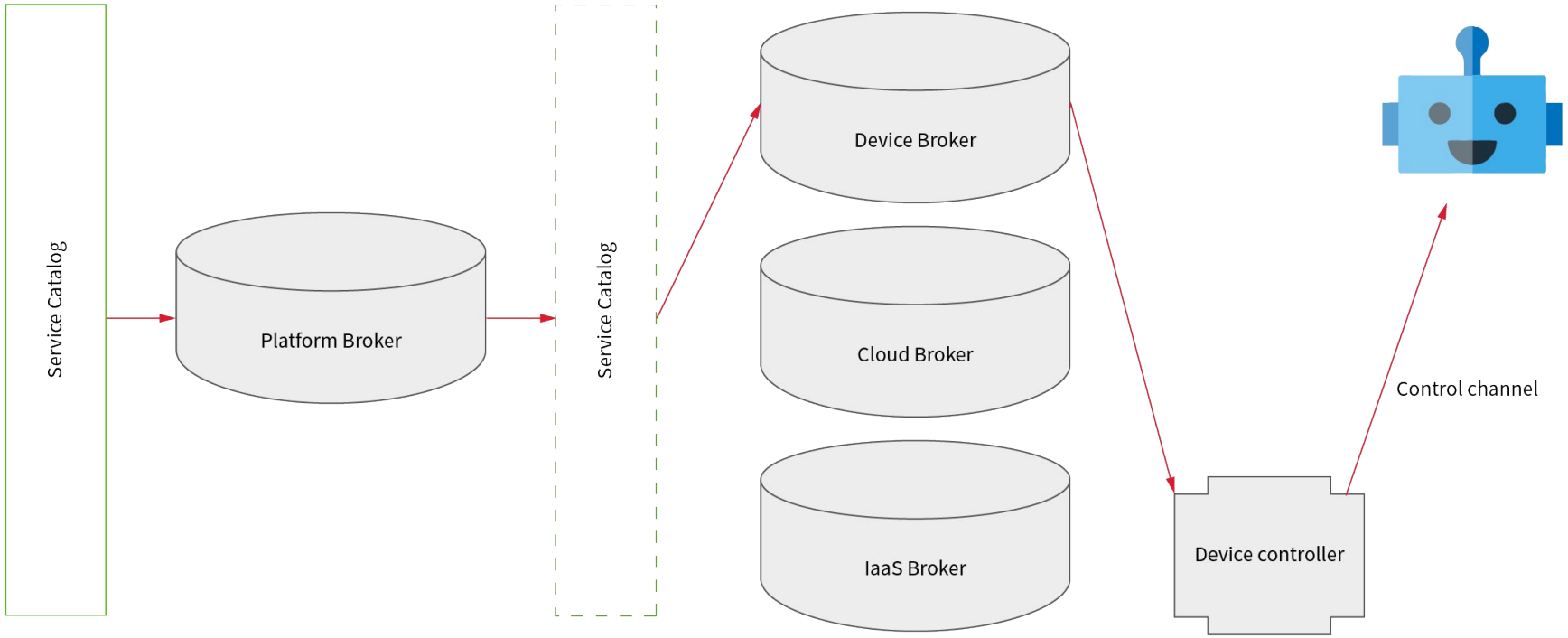
The Platform Broker



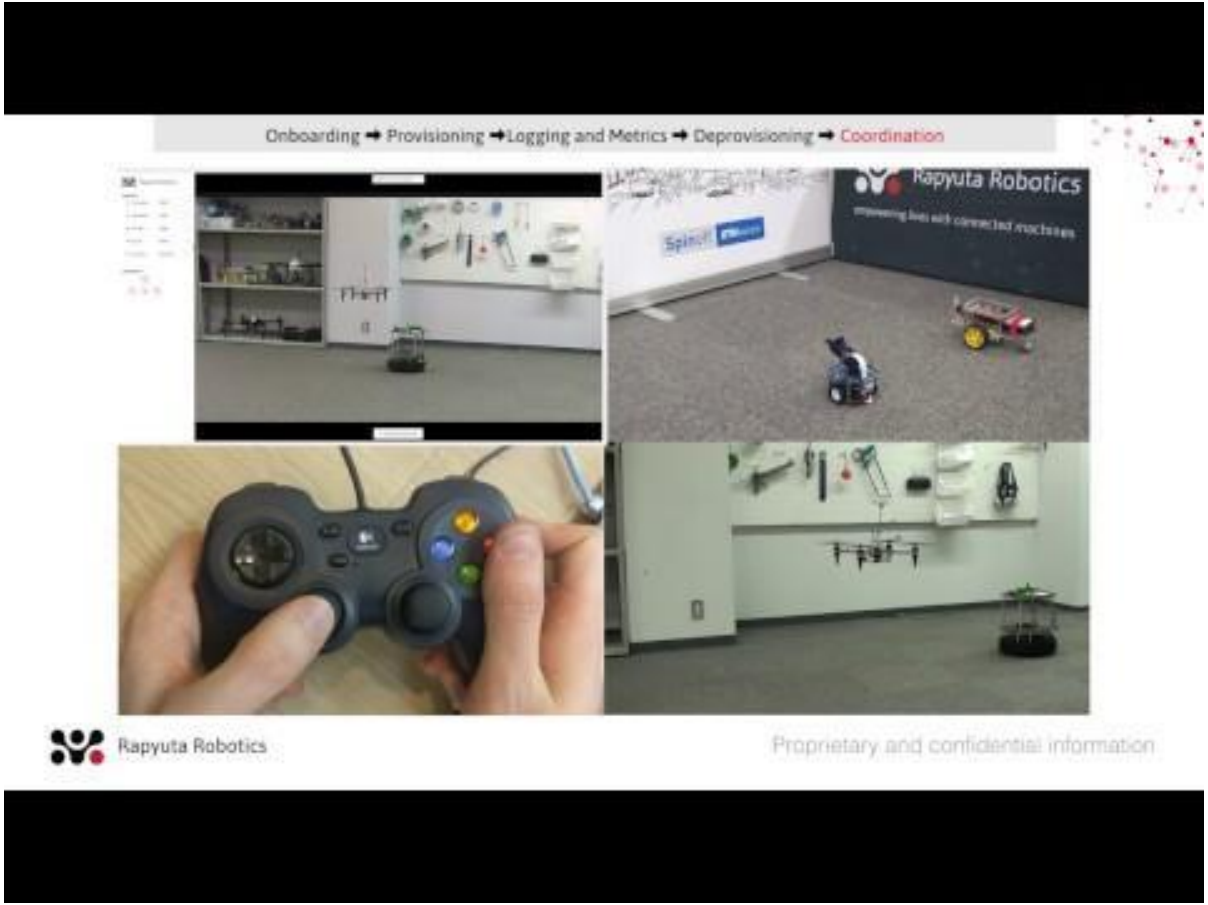
The Platform Broker



The Platform Broker



Dynamic multi-robot orchestration



Foreglimpse

- VirtualKubelet
- Custom Resource Definitions
- Improvements to CNI, KubeProxy to eBPF
- TUF Conformance

Acknowledgements

Zürcher Hochschule
für Angewandte Wissenschaften

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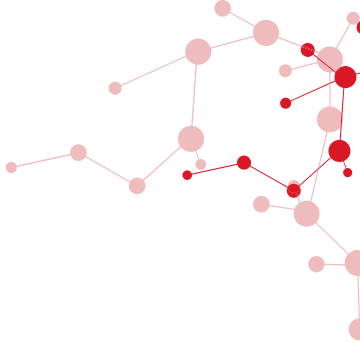
aw

Service Engineering
Research Area
ICCLAB
SPLAB

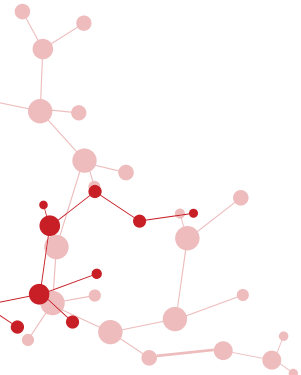
Rapyuta Robotics

CloudNativeCon

KubeCon



Questions?



CloudNativeCon KubeCon