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# TECHNICAL EXTENSIONS TO THE O-RAN O2 INTERFACE: IMPLEMENTATION-DERIVED APPROACHES FOR ENHANCED INFRASTRUCTURE MANAGEMENT

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# EXTENDING THE O-RAN O2 INTERFACE: NOVEL APPROACHES TO INFRASTRUCTURE MANAGEMENT

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# INTRODUCTION

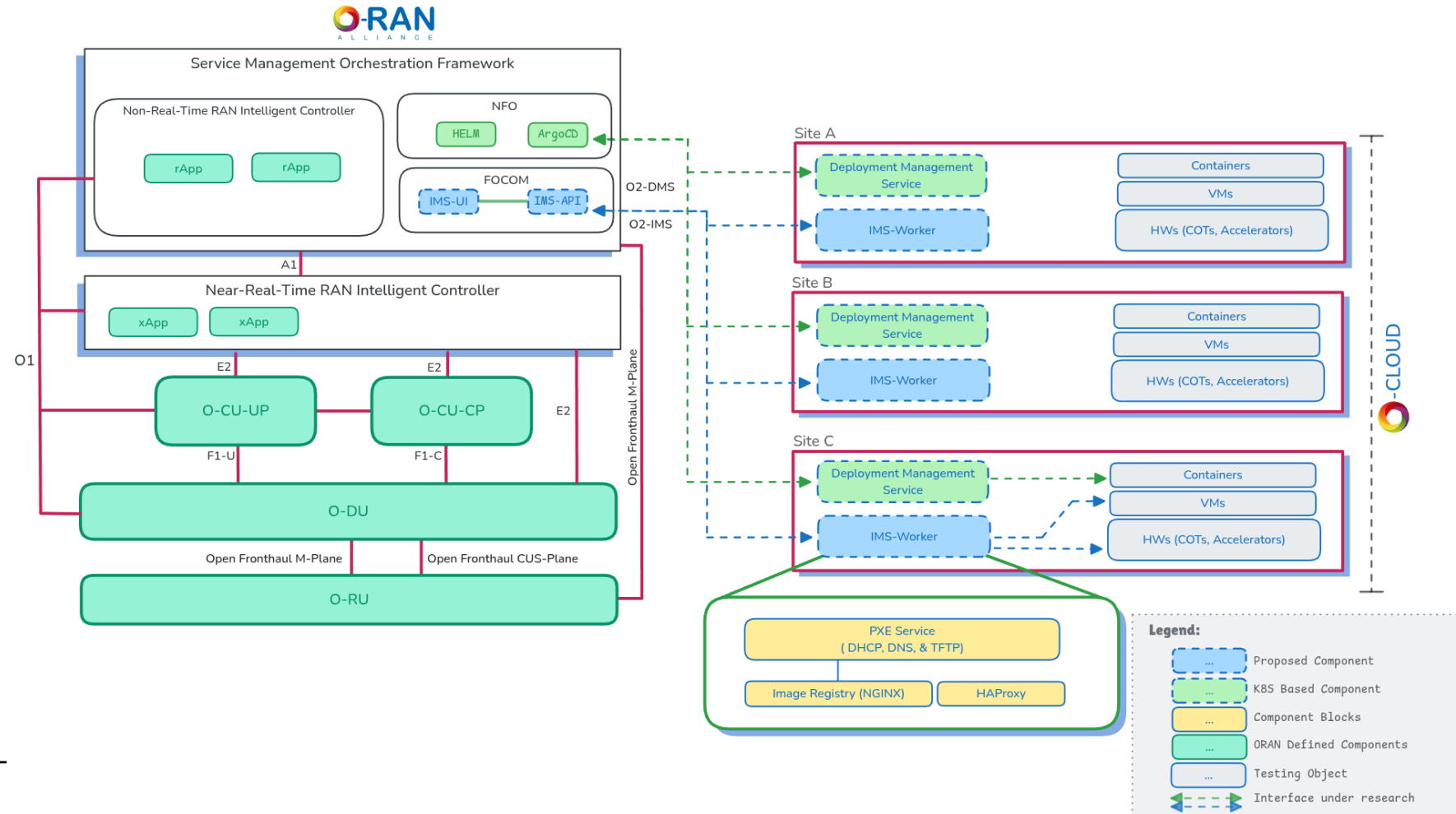
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# ABSTRACT

- This thesis presents a systematic analysis and extension of the O-RAN Alliance's O2 interface specification for Infrastructure Management Services (IMS) based on practical implementation experience. The research examines the reference implementation of an IMS module with a worker-based architecture that manages the lifecycle of bare metal servers through to Kubernetes cluster deployment for Network Function Virtualization (NFV) applications.
- The study identifies technical limitations in the current O2 interface specification when applied to production environments, particularly in areas of resource discovery, provisioning scalability, and failure recovery. Through quantitative evaluation of an implemented IMS system that incorporates DHCP, PXE, and TFTP services into a consolidated worker component, the research documents performance metrics across varying deployment scales and configurations.
- The research methodology employs controlled experimental deployments to validate three specific extensions to the O2 interface: an enhanced resource inventory model, a stateful provisioning protocol, and a worker coordination framework. These extensions address identified gaps in the current specification while adhering to the architectural principles established by the O-RAN Alliance.
- The thesis concludes with a technical proposal for standardization of these extensions, including formal interface definitions and state transition diagrams that could be incorporated into future revisions of the O-RAN specifications. This work contributes to the evolution of open telecommunications infrastructure by providing empirically validated improvements to the O2 interface based on practical implementation experience.

# BACKGROUND



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# MCS ON PDF FILE

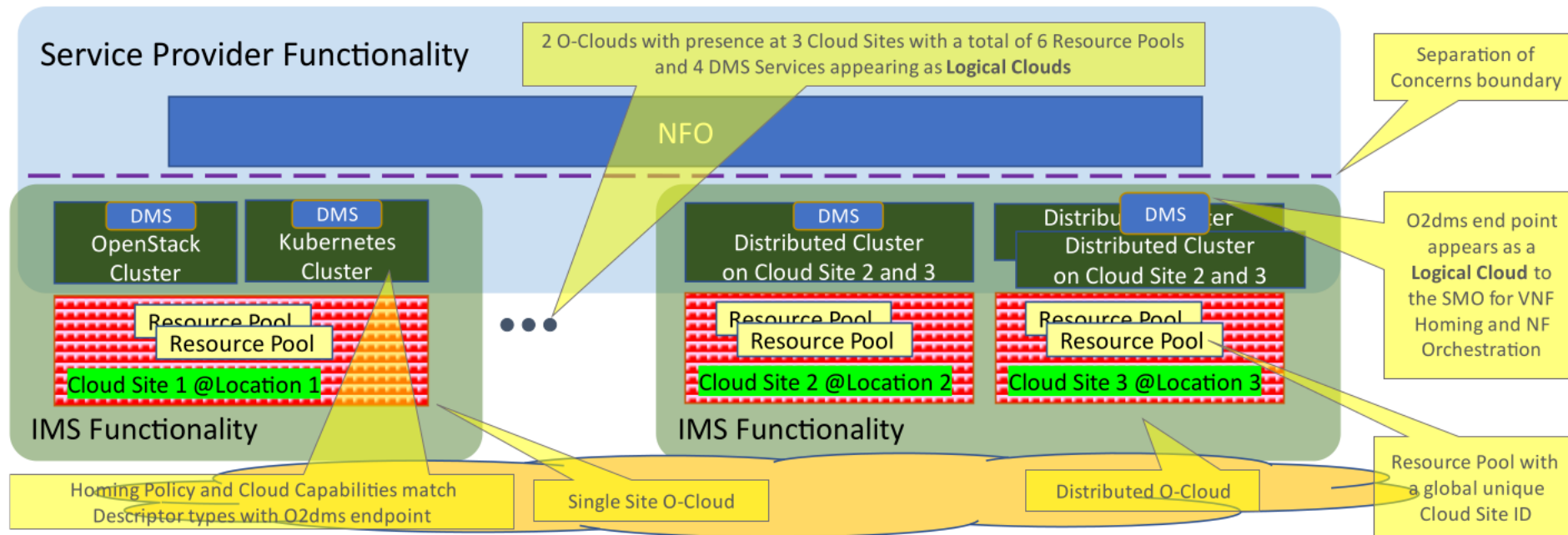
- <https://peridot-fine-08c.notion.site/O2-IMS-Implementation-167d924b024b804787efd2e1bf18db7c?pvs=4>

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# BACKGROUND

- The O2 interface is an open logical interface within O-RAN architecture providing secured communication between the SMO and O-Cloud. It enables the management of O-Cloud infrastructures and the deployment life cycle management of O-RAN cloudified NFs that run on O-Cloud. [1]
- The O2 interface is defined in an extensible way that enables new information or functions to be added without necessarily needing to change the protocol or the procedures. This interface enables a multi-vendor environment and is independent of specific implementations of the SMO and O-Cloud. [1]

# BACKGROUND



**Figure 3.2-2 Logical Clouds Example**



# BACKGROUND



O-RAN.WG6.O2-GA&P-R004-v08.00

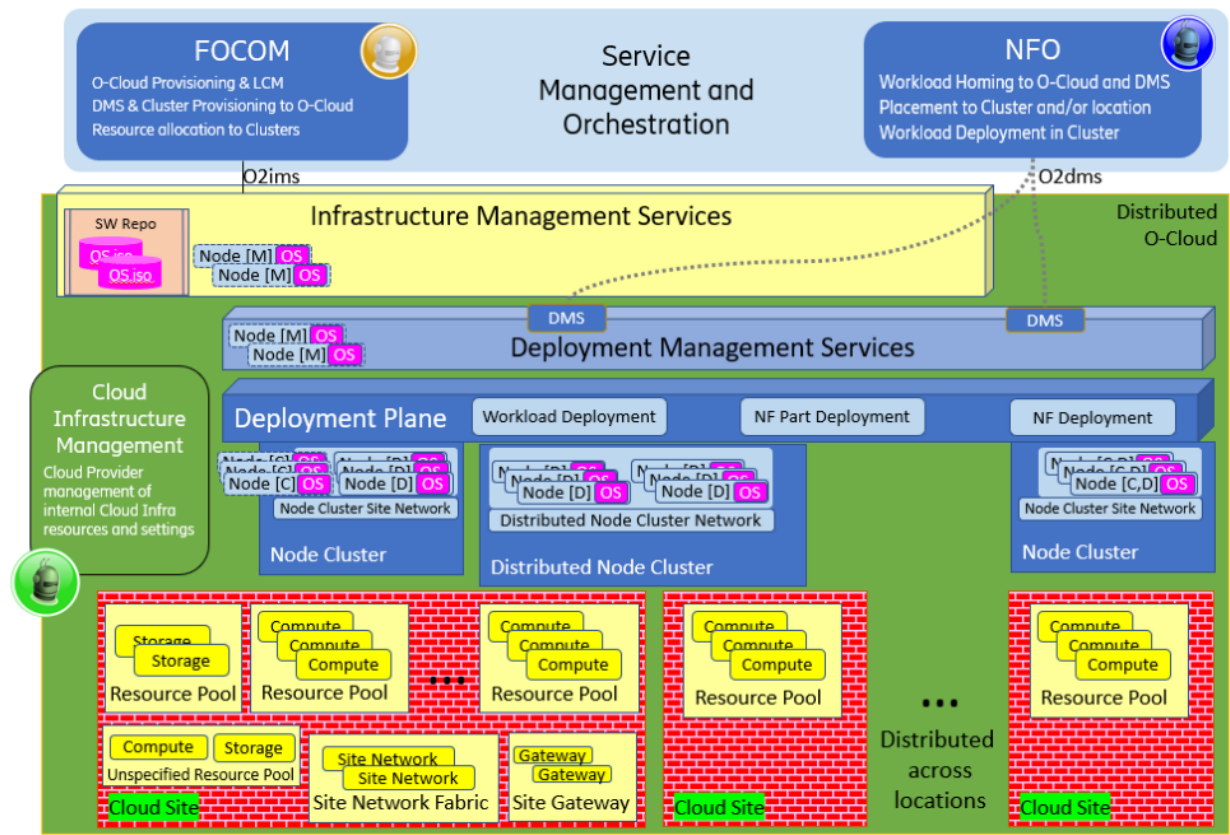
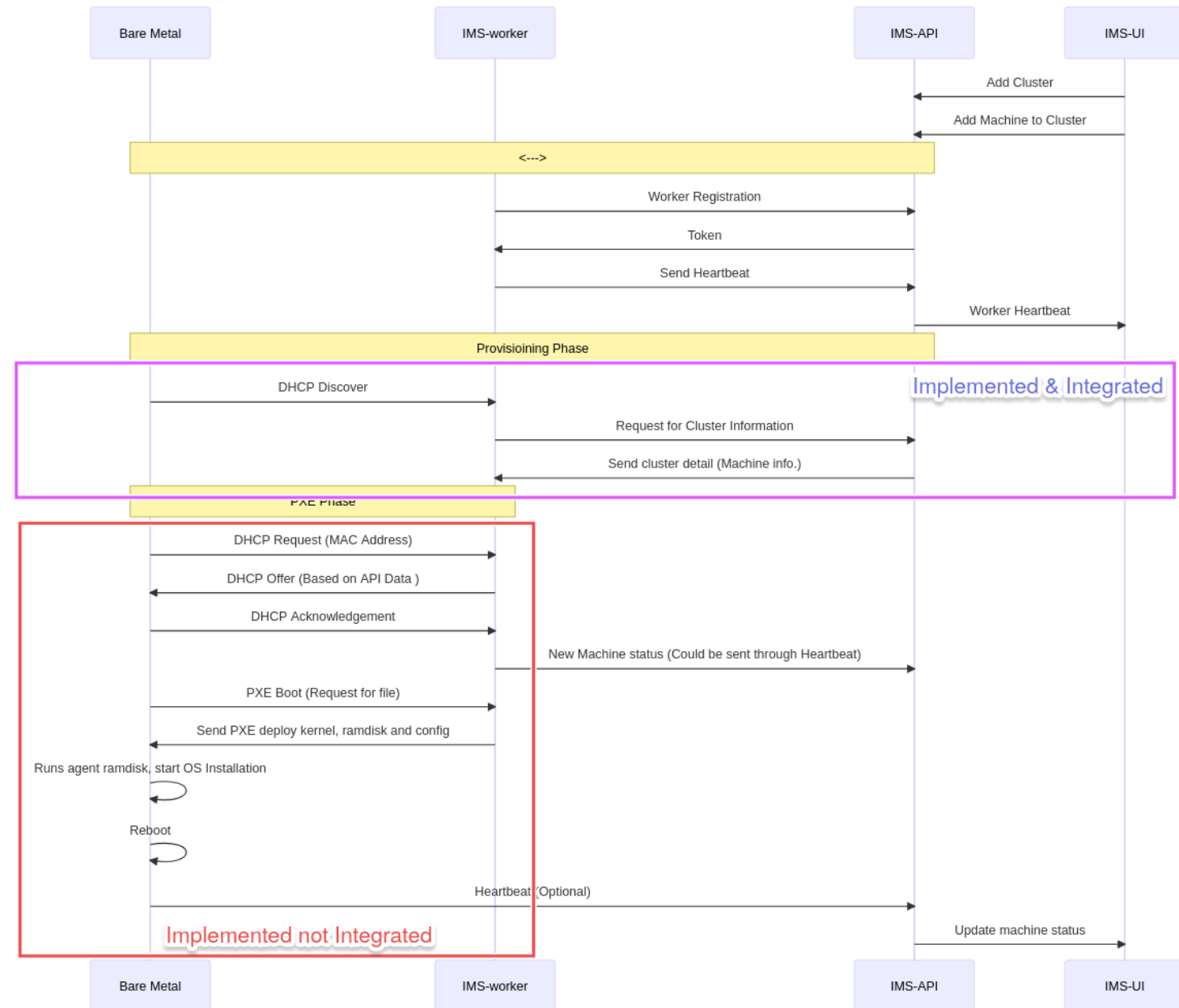


Figure 3.1-1 O-Cloud Services, Interfaces, and High-Level Concepts

# RESEARCH OBJECTIVES

- Design and implement O2 IMS compliant system
- Develop scalable infrastructure management solution
- Validate against O-RAN Alliance specifications
- Contribute to open-source O-RAN ecosystem



# O-RAN STANDARDS & SPECIFICATIONS

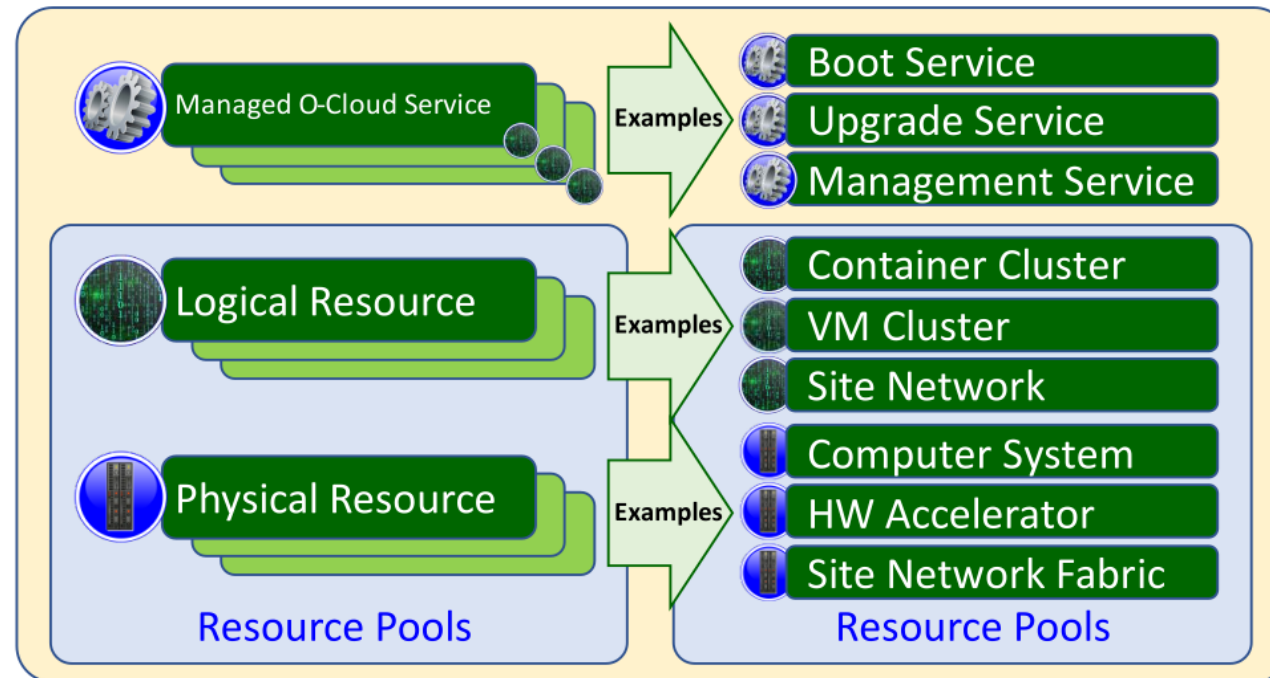


Figure 3.4-1 Diagram of kinds of Resources and examples of Resources

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# O-RAN STANDARDS & SPECIFICATIONS

3.3.6.2.3 Type: AlarmSubscriptionInfo	Fully Compliant	
3.3.6.3 Simple data types and enumerations		
3.3.6.3.1 Introduction	Noted	
3.3.6.3.2 Simple data types	Noted	
3.3.7 Error handling		
3.3.7.1 General	Noted	
3.3.7.2 Protocol errors	Noted	
3.3.7.3 Application errors	Noted	
3.3.8 Security	Noted	
3.4 O2ims_InfrastructureProvisioning Service API	N/A	Spec. content is FFS
3.5 O2ims_InfrastructureSoftwareManagement Service API	N/A	Spec. content is FFS
3.6 O2ims_InfrastructureLifecycleManagement Service API		
3.6.1 Description	Noted	
3.6.2 API version	Noted	
3.6.3 REST resources structure and methods	N/A	Spec. content is FFS
3.6.4 REST resources	N/A	Spec. content is FFS
3.6.5 Notifications	Noted	
3.6.5.1 General	Fully Compliant	
3.6.5.1.1 OCloud Available Notification Description	Noted	
3.6.5.1.2 Target URI	Fully Compliant	
3.6.6 Data Model	Noted	
3.6.6.1 REST resource data types	N/A	Spec. content is FFS
3.6.6.2 Structured data types	N/A	Spec. content is FFS
3.6.6.3 Simple data types and enumerations	Noted	
3.6.6.3.1 Introduction	Noted	

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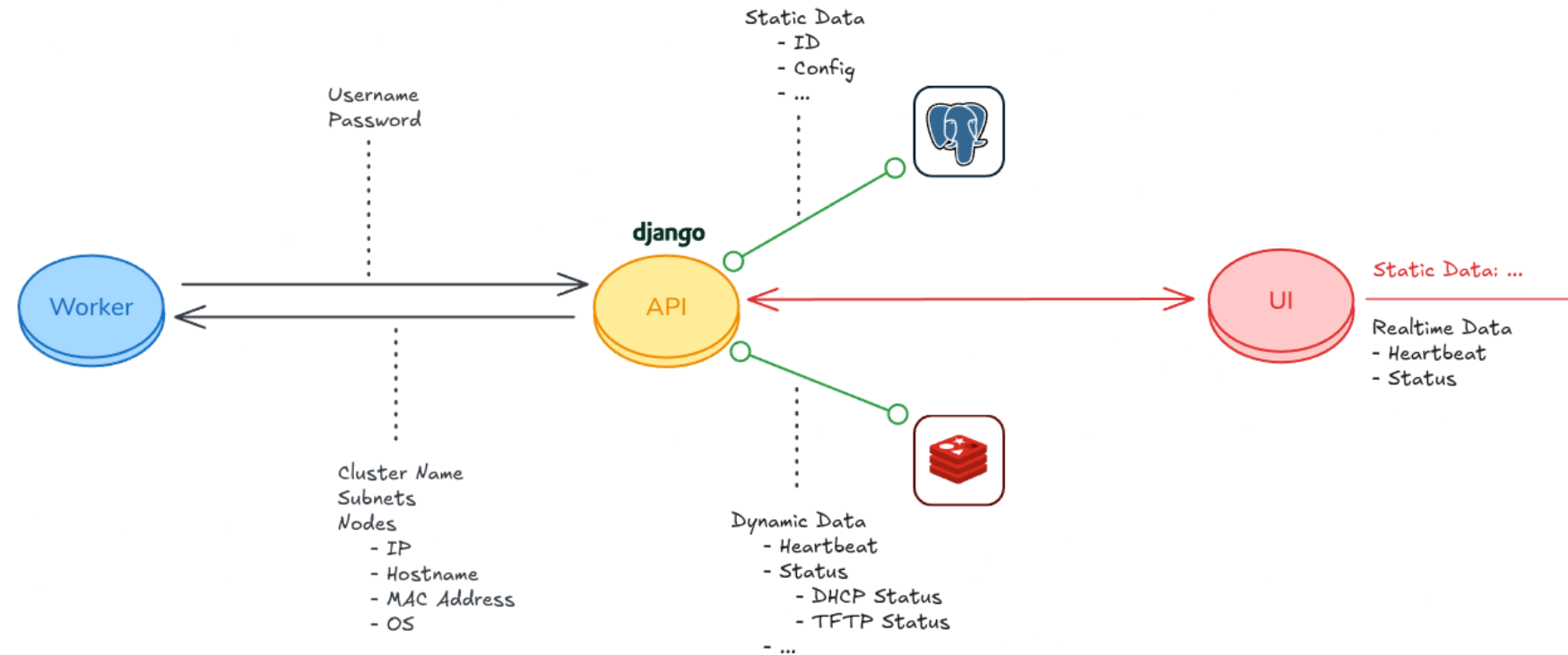
# O-RAN STANDARDS & SPECIFICATIONS

Table 2.1.1-1 O2ims Services to API mapping

Service Name	Clause	Description	apiName
O2ims_InfrastructureInventory Services	3.2	Service for querying the O-Cloud resources and management services.	O2ims-infrastructureInventory
O2ims_InfrastructureMonitoring Services	3.3	Service for configuring telemetry reporting of O-Cloud infrastructure resources.	O2ims-infrastructureMonitoring
O2ims_InfrastructureProvisioning Services	FFS	Service for configuring the O-Cloud infrastructure resources and management services.	FFS
O2ims_InfrastructureSoftware Management Services	FFS	Services for software inventory and updating the software used for O-Cloud infrastructure resources and management services.	FFS
O2ims_InfrastructureLifecycle Management Services	3.6	Services related to O-Cloud infrastructure lifecycle management and events.	O2ims-infrastructureLifeCycleManagement

# RELATED TECHNOLOGIES

- DHCP/TFTP for network boot
- Database systems for lease management
- RESTful APIs and microservices
- Container orchestration

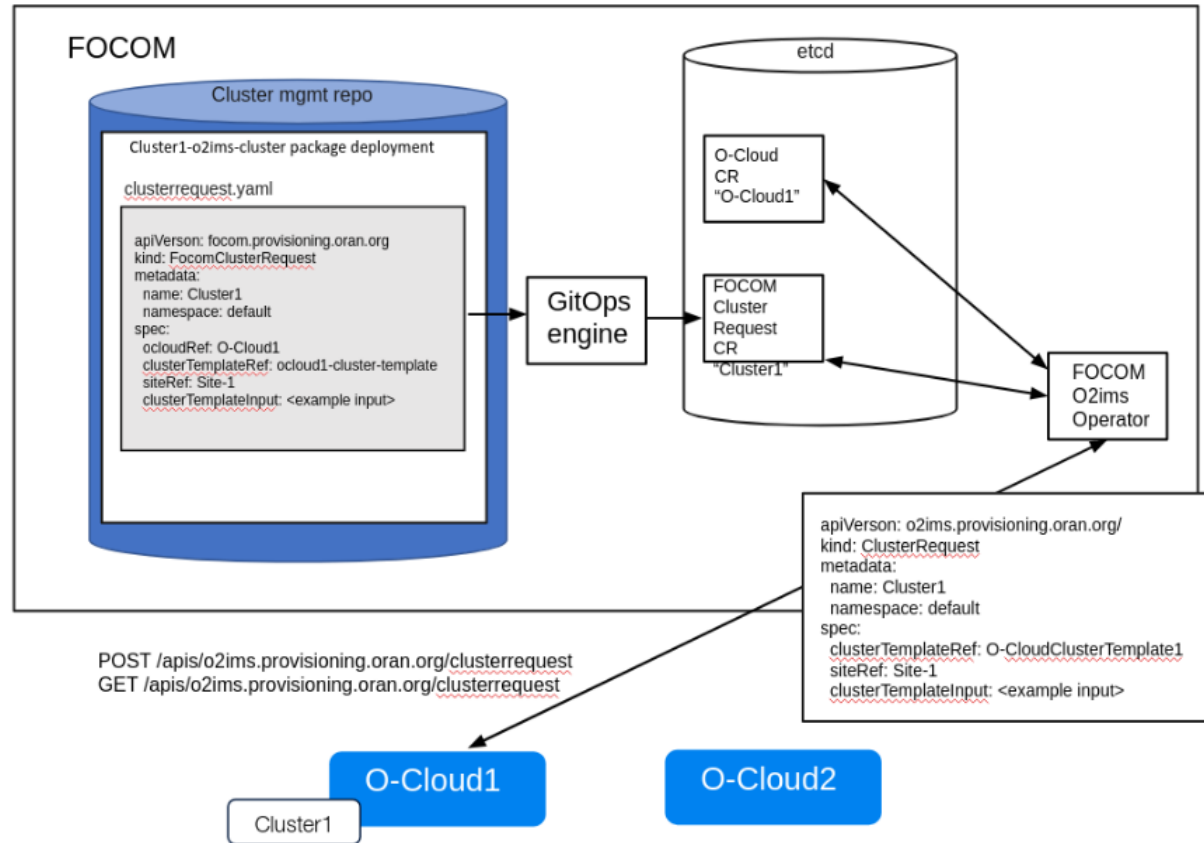


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# NEPHIO: IMPLEMENTATION APPROACH

- O-Cloud Clusters are the primary method of allocating cloud resources (e.g., O-Cloud Nodes, Networks) to be used during deployments of O-RAN NFs.
- The O-RAN WG6 O2ims Provisioning working group has now introduced the concept of a template for O-Cloud Node Cluster and Infrastructure deployment in O-RAN.WG6.O2-GA&P-R003-v06.00.docx.
- Within FOCOM a corresponding SMO-level O-Cloud Template information record is kept. The role of the FOCOM is to support integration towards multiple O-Clouds, each with its own catalog of supported O-Cloud Templates. The FOCOM O-Cloud Template information record contains a reference to the supporting O-Cloud IMS end point

# NEPHIO: O2 API





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# NEPHIO: 02 IMS OPERATOR

- Code: <https://github.com/nephio-project/nephio/tree/main/operators/o2ims-operator>
- What they already done
  - Template Declaration for Infrastructure Resources
  - Active API functions for IMS
  - Support for IMS deployment on existing clusters
- **Where can we contribute:**
  - Baremetal Support for non clustered environments
  - Implement Infra Controllers

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# STARLINGX:

- What they already done
  - Integration with existing infrastructure controller OpenStack Ironic for baremetal
  - Template Declaration for Infrastructure Resources
- What can we offer
  - Baremetal support for non OpenStack environment (not every deployment need a cluster)
  - Implement Infra Controllers

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# REFERENCE

[1]. O2 Interface General Aspects and Principles, October 2024, O-RAN Alliance

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