Backend.AI Documentation

Release 24.09.0dev1

Lablup Inc.

Apr 25, 2024

CONTENTS

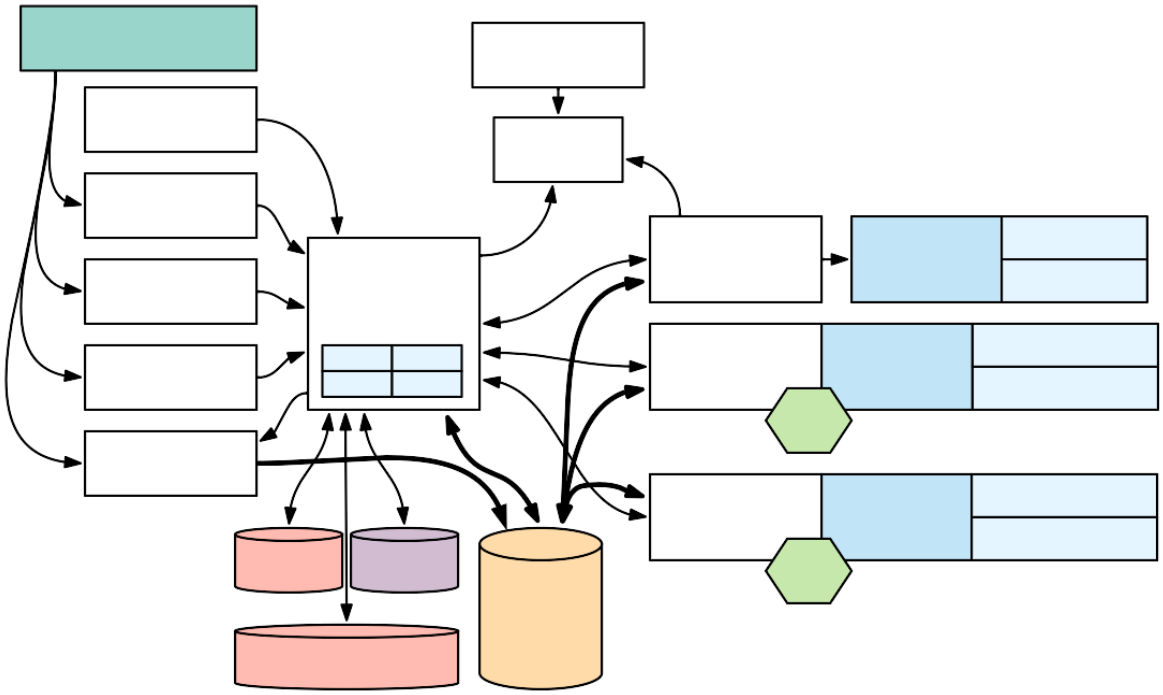
’“”

’

CHAPTER

ONE

BACKEND.AI CONCEPTS



1.1 Service Components

1.1.1 Public-facing services

Manager and Webserver

App Proxy

Storage Proxy

,

FastTrack (Enterprise only)

1.1.2 Resource Management

Sokovan Orchestrator

Agent

“”

1.1.3 Internal services

Event bus

Control Panel (Enterprise only)

Forklift (Enterprise only)

Reservoir (Enterprise only)

Container Registry

’

1.2 Computing

1.2.1 Sessions and kernels

“”.

’

Kernel roles in a cluster session

“” “” “”, “”, “”, …, “” “”

“” “”

1.2.2 Session templates

1.2.3 Session types

Feature	Compute (Interactive)	Compute (Batch)	Inference	System
Code execution	✓			
Service port	✓	✓	✓	✓
Dependencies		✓		
Session result		✓		
Clustering	✓	✓	✓	✓

Interactive compute session

Batch compute session

“”’

Dependencies between compute sessions

Inference session

System session

1.2.4 Scheduling

Session selection strategy

Heuristic FIFO

“”

Dominant resource fairness (DRF)

Agent selection strategy

Concentrated

Dispersed

Custom

1.3 Resource Management

1.3.1 Resource slots

“”.

Resource slot name	Device name	Slot name

Slot type	Meaning	Examples
	“”	

1.3.2 Compute plugins

1.3.3 Resource groups

1.4 User Management

1.4.1 Users

,

1.4.2 Projects

1.5 Cluster Networking

1.5.1 Single-node cluster session

1.5.2 Multi-node cluster session

1.5.3 Detection of clustered setups

,

Environment Variable	Meaning	Examples
	,	

1.6 Storage Management

1.6.1 Virtual folders

“”, “”

User-owned vfolders

Project-owned vfolders

VFolder invitations and permissions

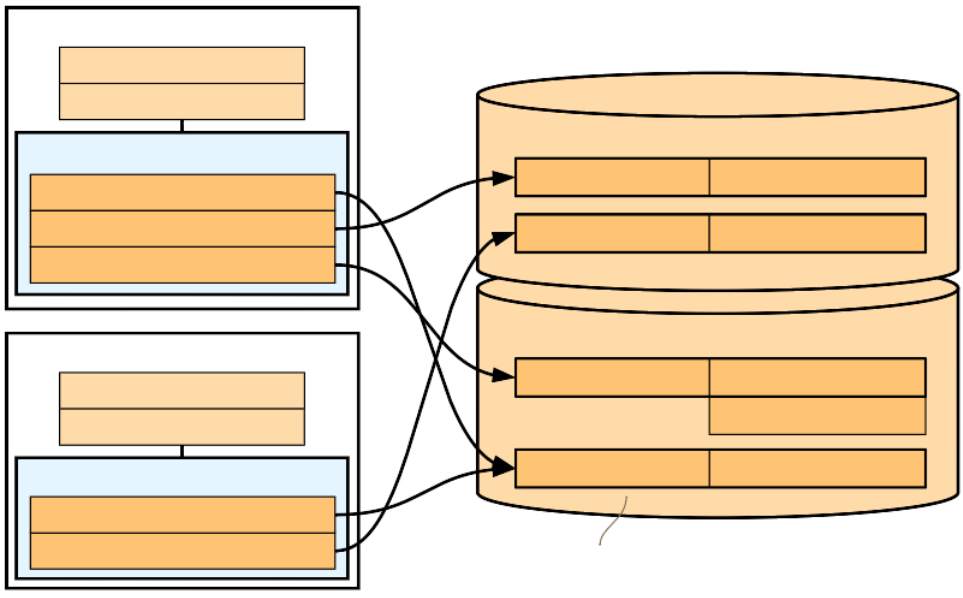
Volume-level permissions

Auto-mount vfolders

,

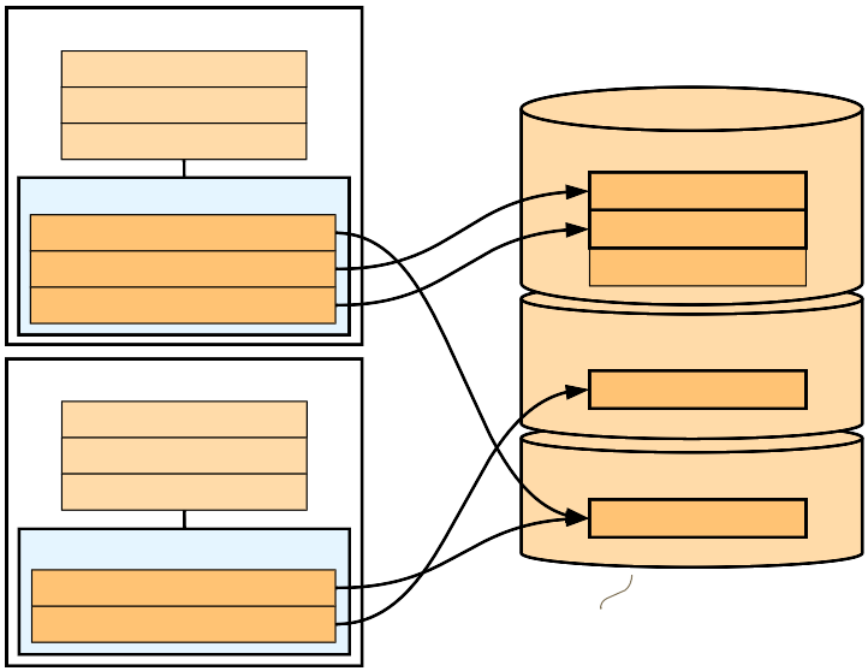
1.6.2 Quota scopes

Storage with per-directory quota



,

Storage with per-volume quota



,

,

1.7 Configuration

1.7.1 Shared config

1.7.2 Local config

1.8 Monitoring

1.8.1 Dashboard (Enterprise only)

1.8.2 Alerts (Enterprise only)

1.9 FAQ

vs. Notebooks

Product	Role	Value

vs. Orchestration Frameworks

Product	Target	Value

vs. Big-data and AI Frameworks

Product	Role	Value

CHAPTER

TWO

INSTALLATION GUIDES

2.1 Install from Source

2.1.1 Setting Up Manager and Agent (single node, all-in-one)

2.1.2 Setting Up Additional Agents (multi-node)

Updating manager configuration for multi-nodes

Installing additional agents in different nodes

“”

2.1.3 Setting Up Accelerators

,

2.1.4 Setting Up Shared Storage

,

2.1.5 Configuring Overlay Networks for Multi-node Training (Optional)

,

2.2 Install from Packages

,

2.2.1 Setup OS Environment

Create a user account for operation

Install Docker engine

Optimize sysctl/ulimit parameters

Prepare required Python versions and virtual environments

Use a standalone static built Python (Recommended)

(Alternative) Use pyenv to manually build and select a specific Python version

Configure network aliases

Mount a shared storage

Setup accelerators

Pull container images

2.2.2 Prepare Database

,

2.2.3 Prepare Cache Service

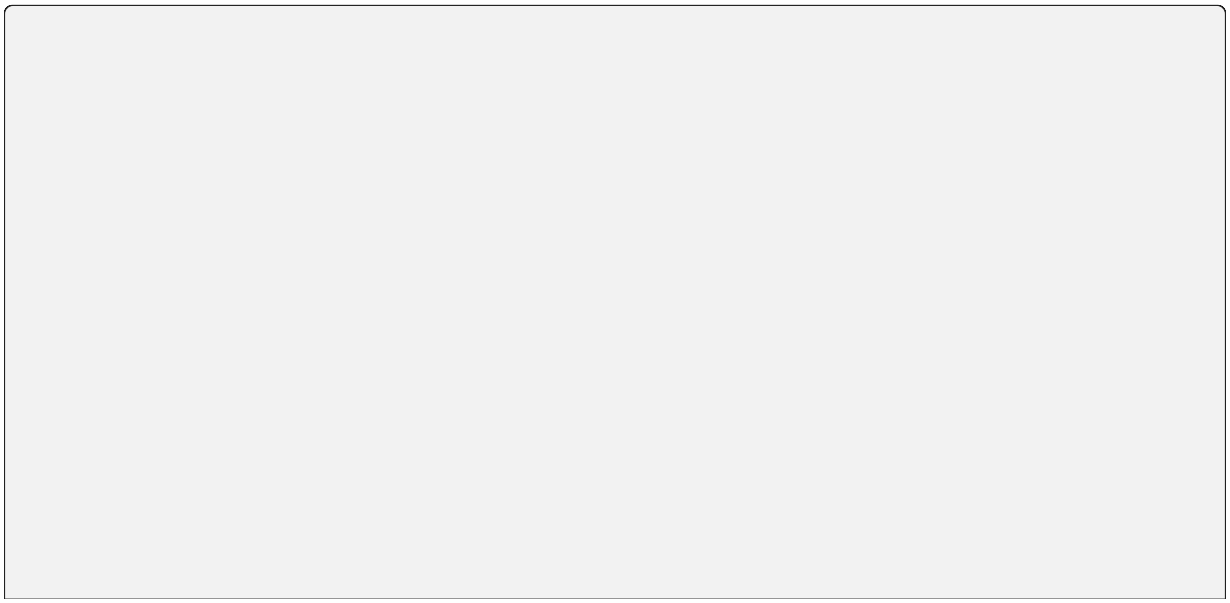
,

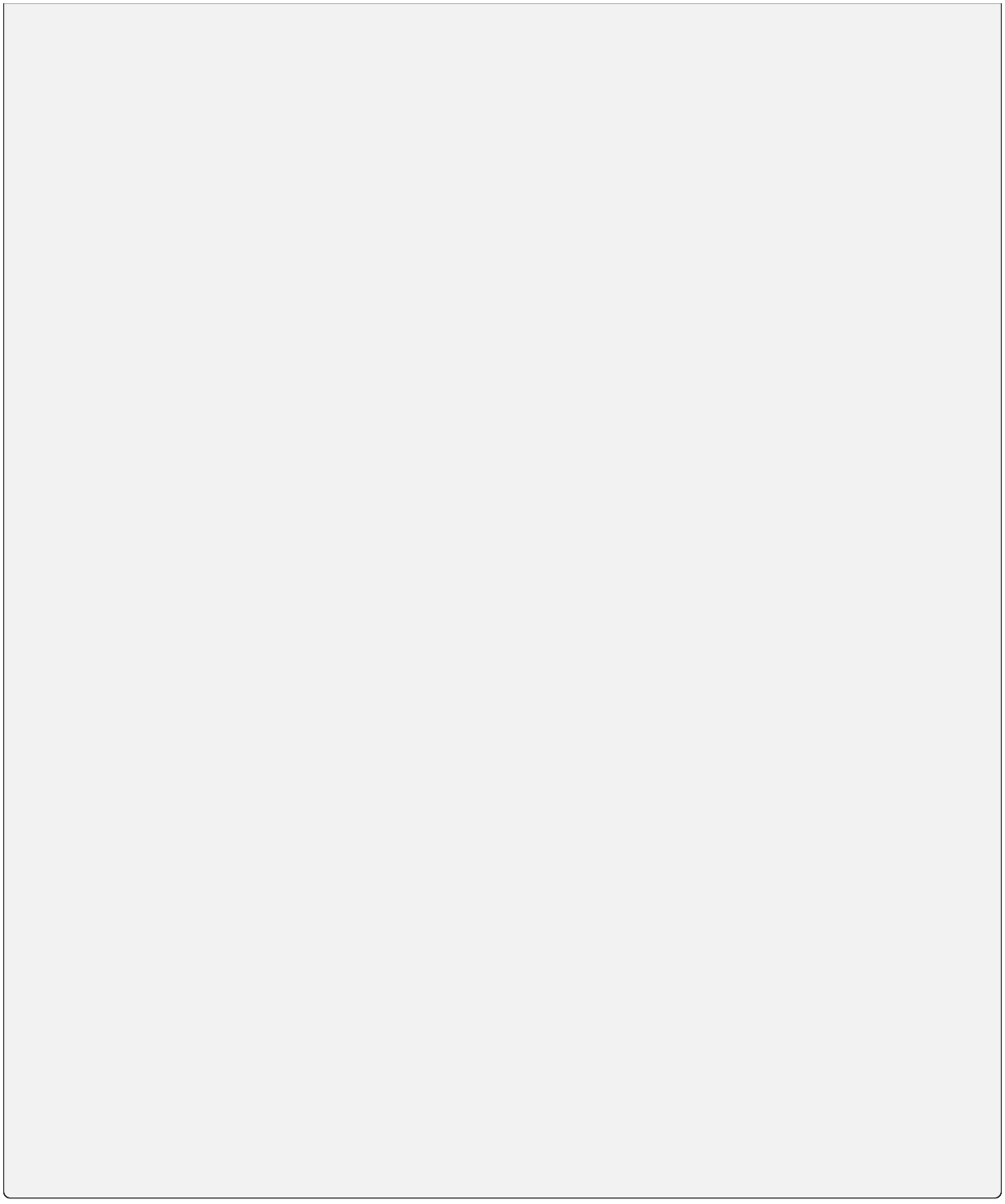
2.2.4 Prepare Config Service

,

2.2.5 Install Backend.AI Manager

Local configuration





Global configuration

,

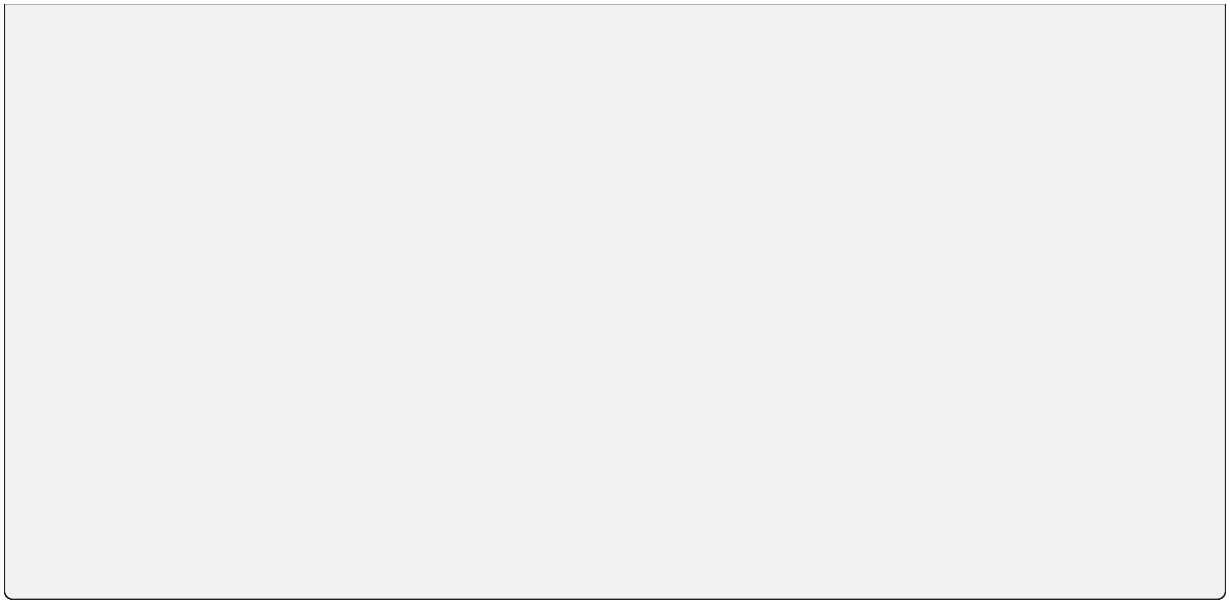
Populate the database with initial fixtures

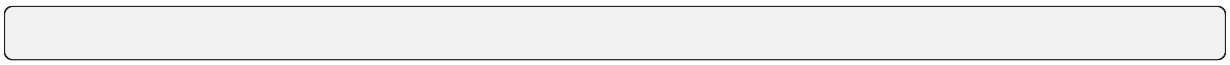
Sync the information of container registry

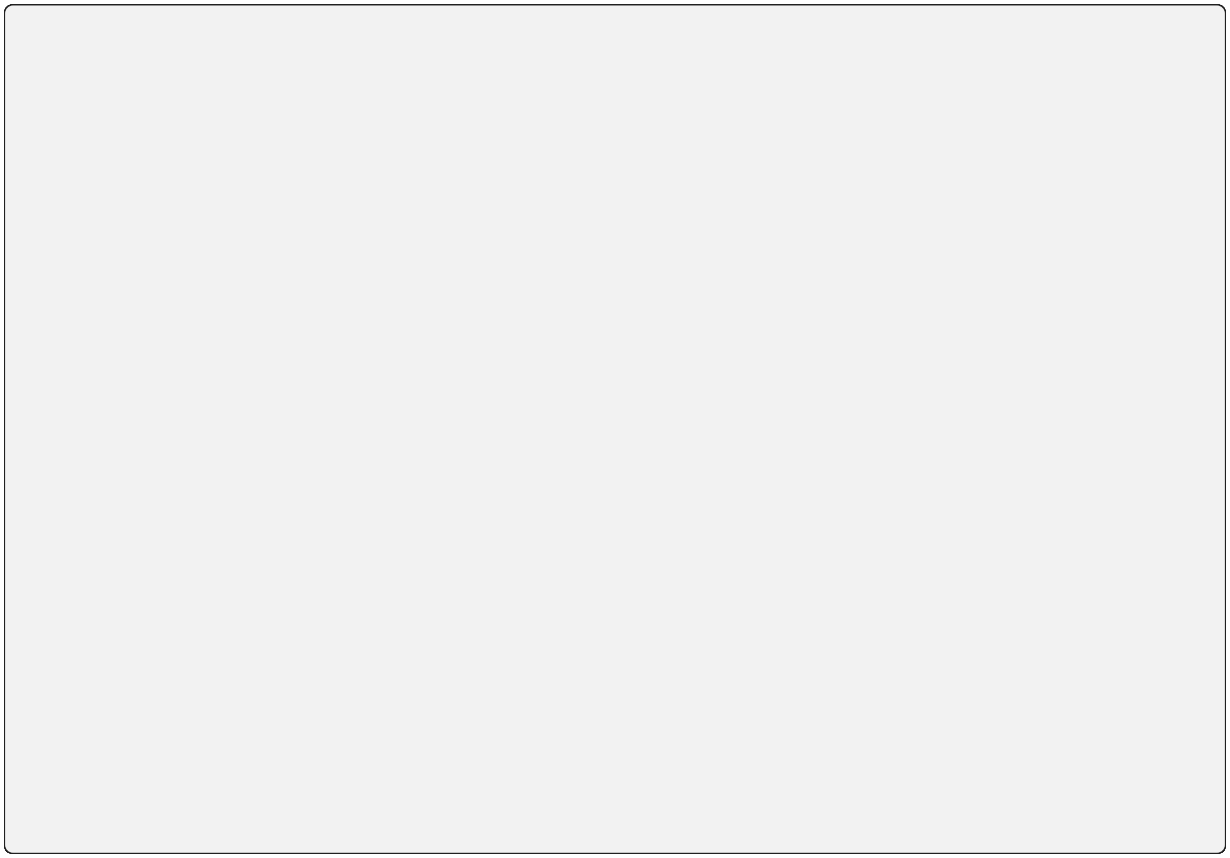
,

Run Backend.AI Manager service

Register systemd service







2.2.6 Install Backend.AI Agent

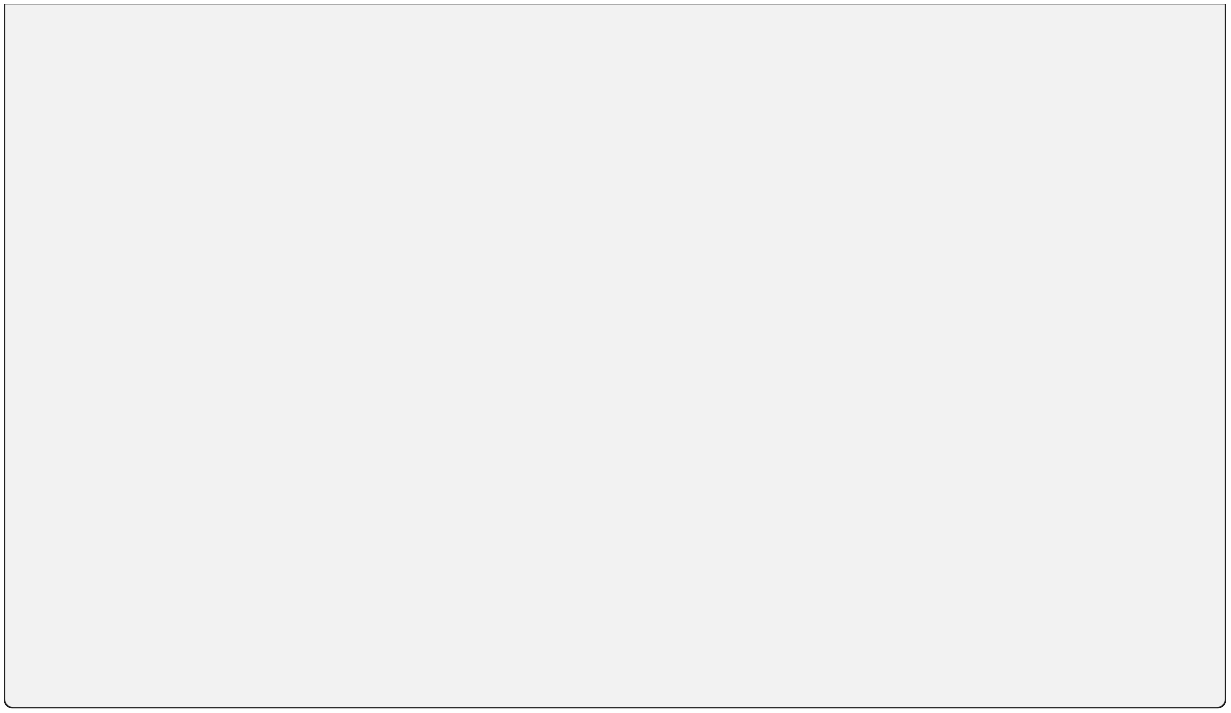
Setting Up Accelerators

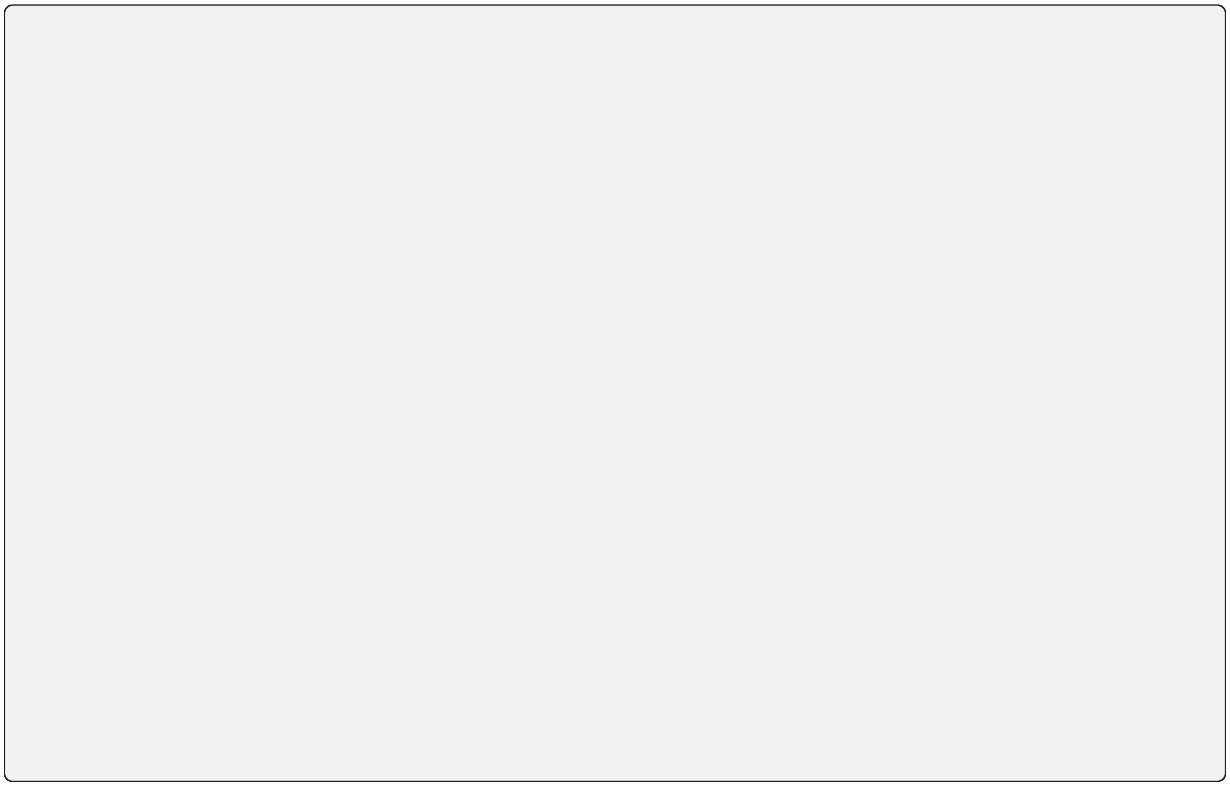
,

Local configuration

Run Backend.AI Agent service

Register systemd service





2.2.7 Install Backend.AI Storage Proxy

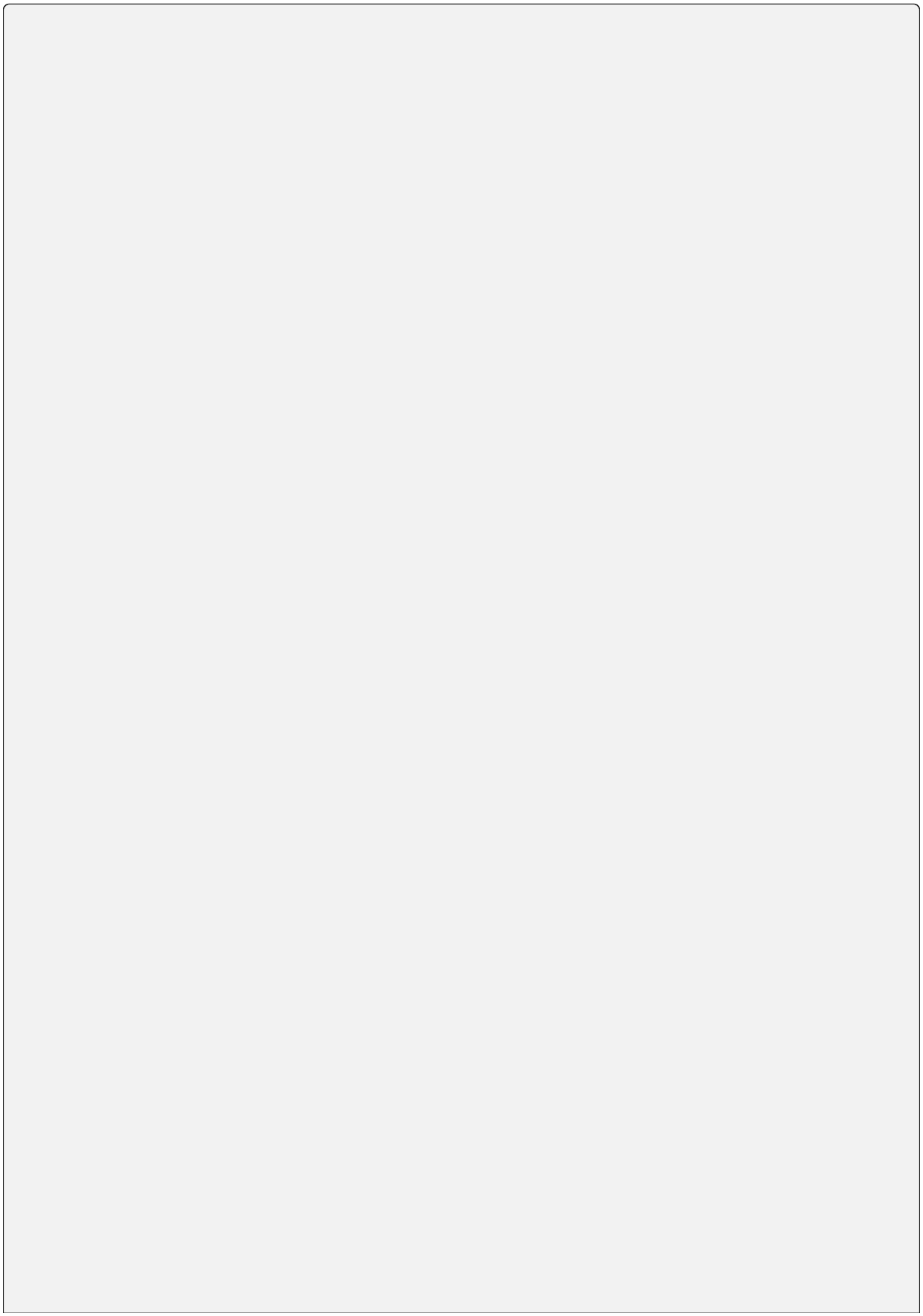
Local configuration

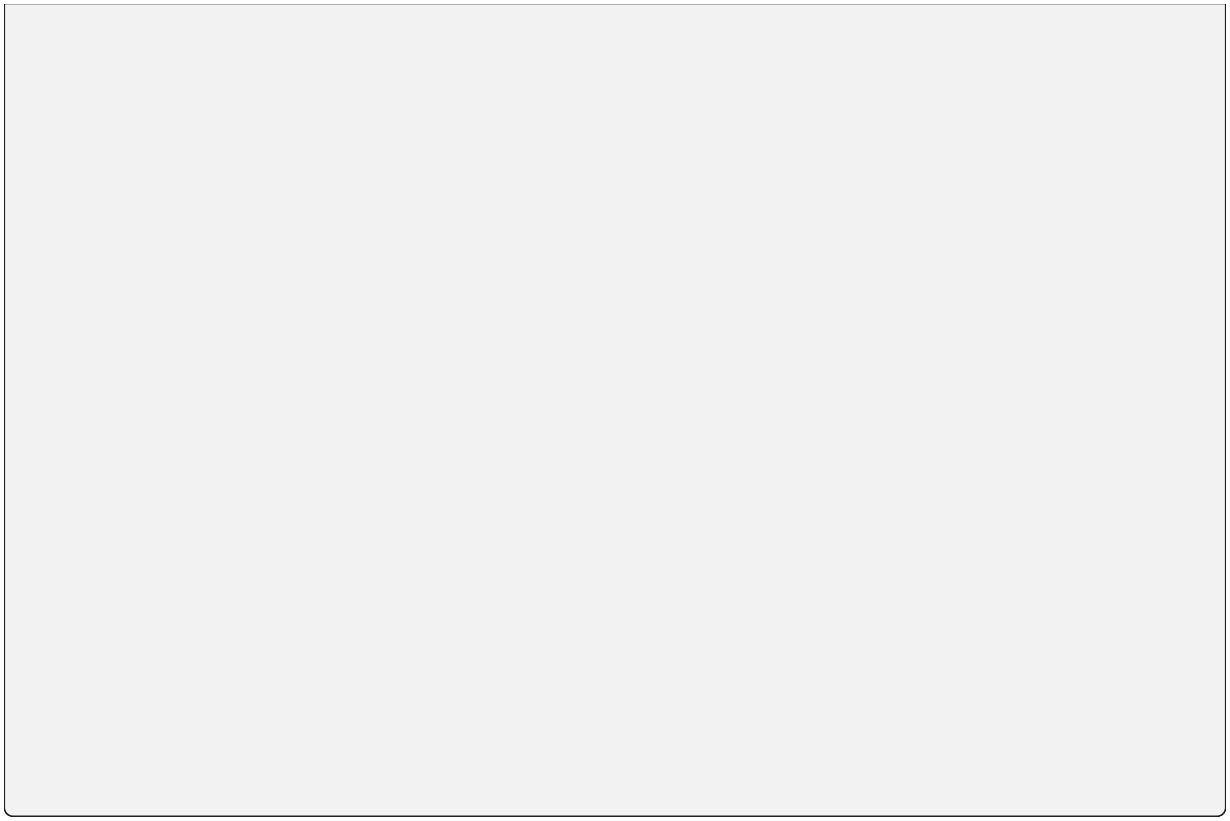
Run Backend.AI Storage Proxy service

Register systemd service

2.2.8 Install Backend.AI Webserver

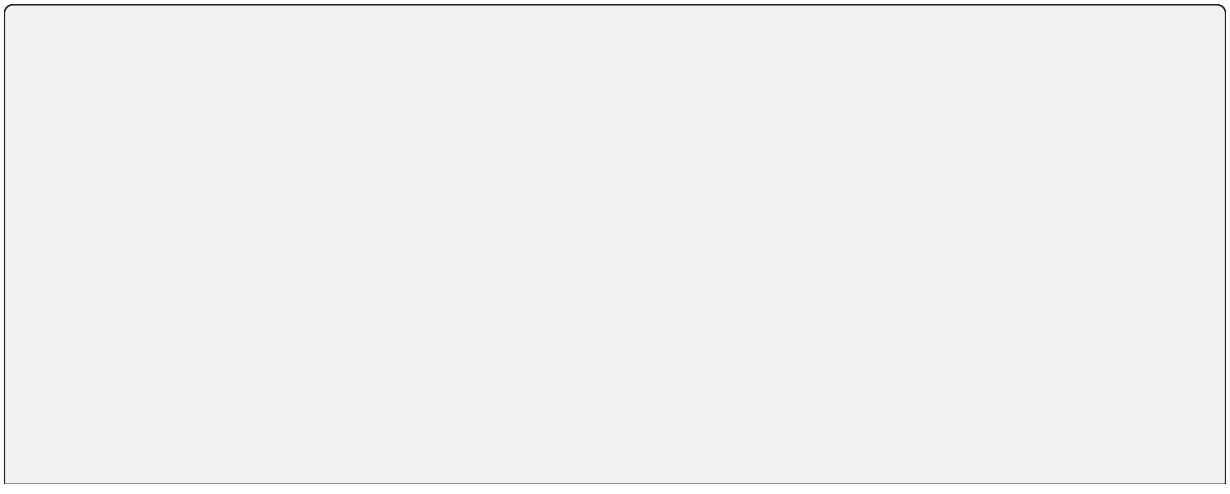
Local configuration

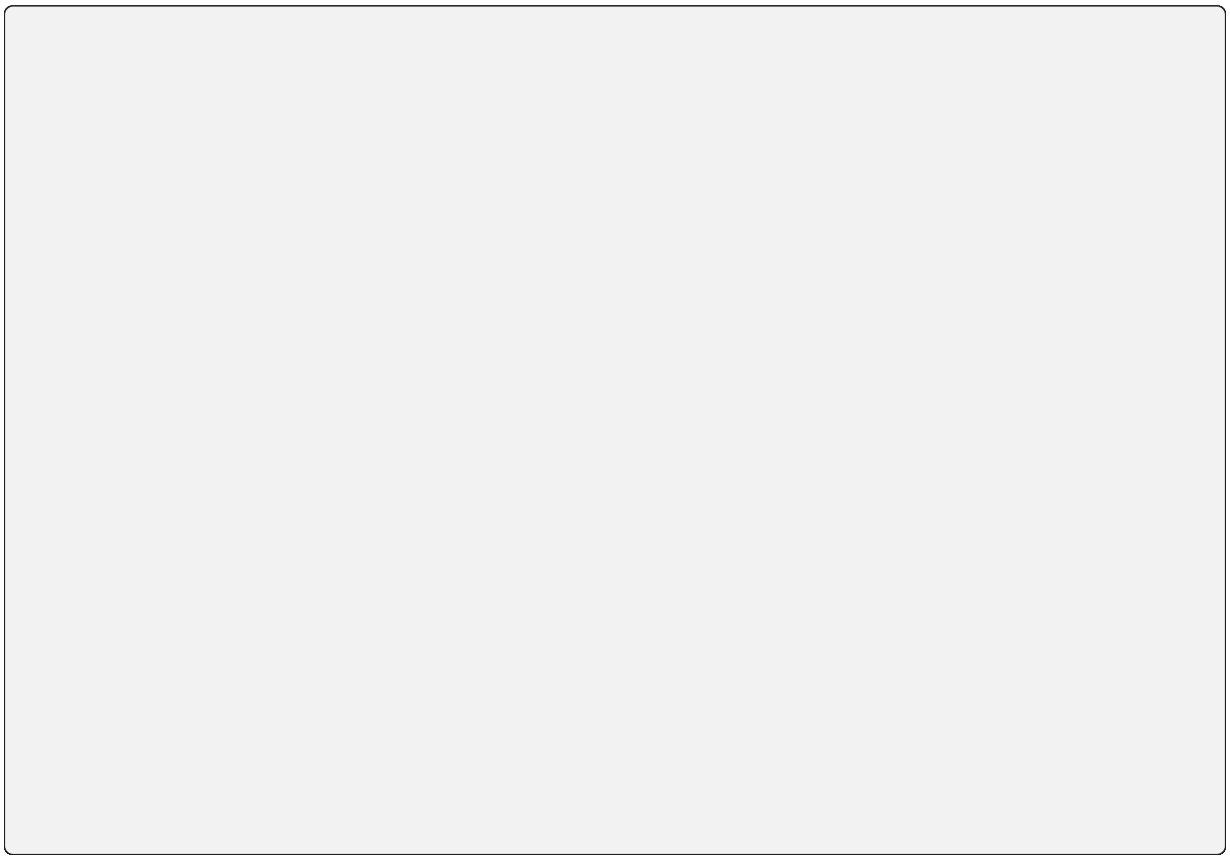




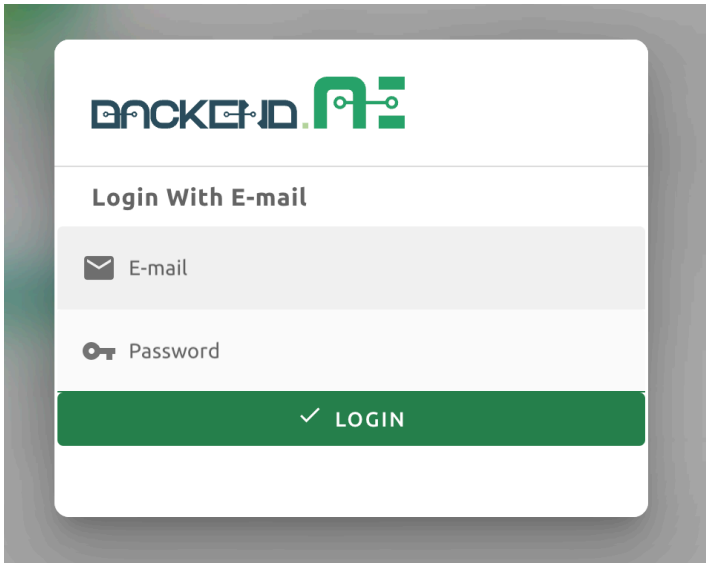
Run Backend.AI Webserver service

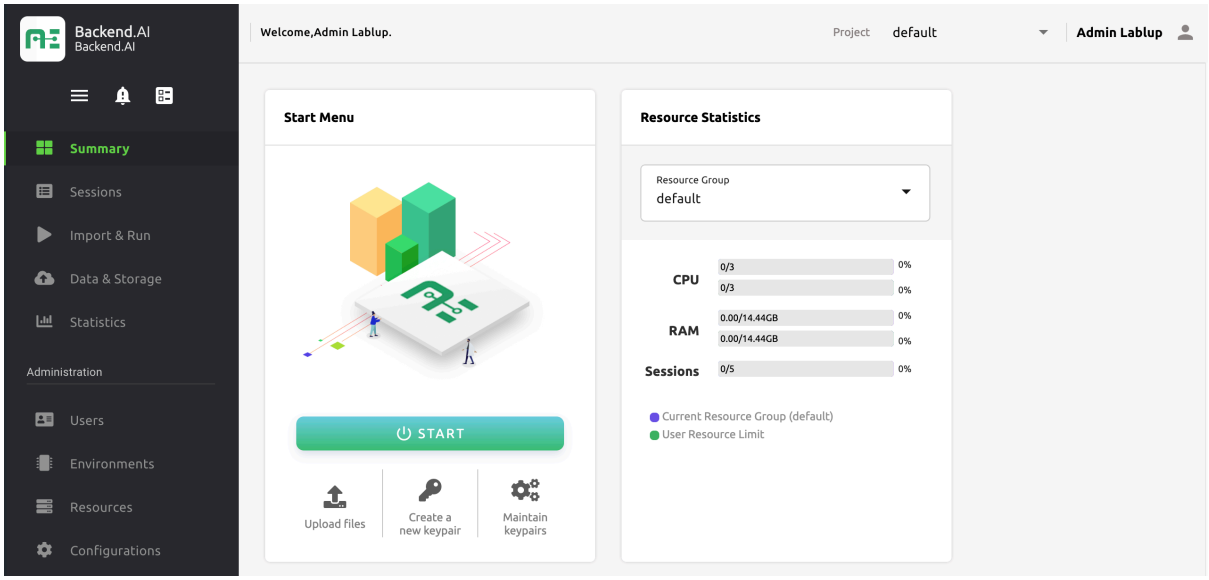
Register systemd service



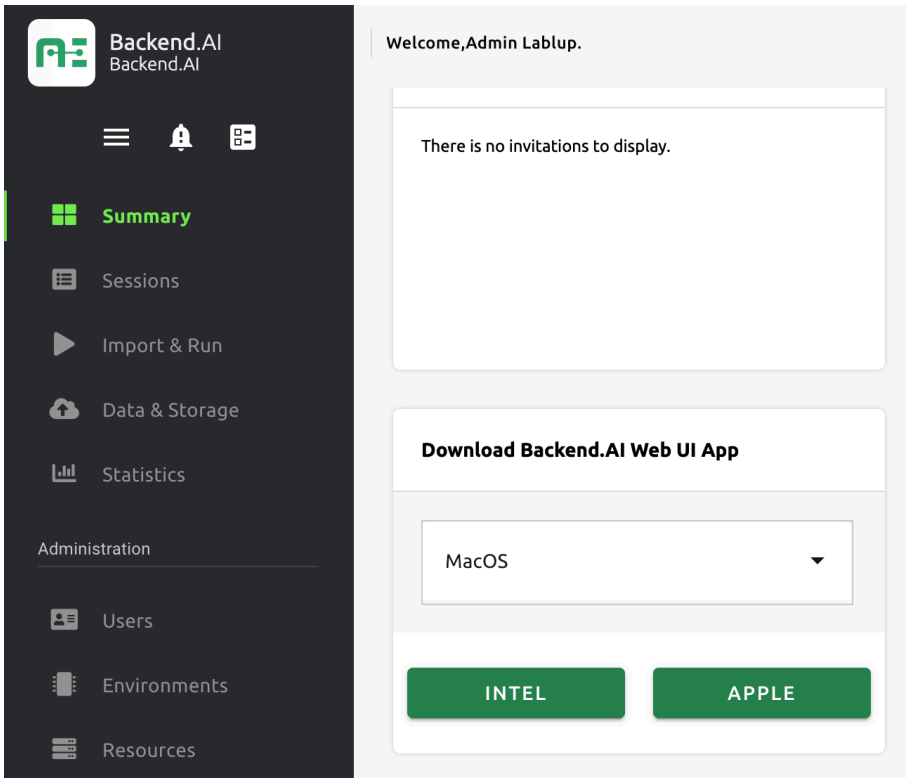


Check user GUI access via web





“”



2.3 Install on Clouds

2.4 Install on Premise

2.5 Install monitoring and logging tools

2.5.1 Guide variables

Name	Description

2.5.2 Install Datadog agent

2.5.3 Install Raven (Sentry client)

2.6 Upgrade existing Backend.AI cluster

2.6.1 Performing minor upgrade

,

Upgrading Backend.AI Manager

Upgrading other Backend.AI components

Others

2.6.2 Performing major upgrade

Example of allowed upgrade paths

...

...

Example of forbidden upgrade paths

...

Upgrading Backend.AI Manager

Upgrading other Backend.AI components

Others

2.7 Environment specifics: WSL v2

2.7.1 Configuration of Docker Desktop for Windows

→ →

2.7.2 Configuration of WSL

2.7.3 Installation of Backend.AI

CHAPTER

THREE

USER GUIDES

3.1 Install User Programs in Session Containers

3.1.1 Install packages with linuxbrew

Creating a user linuxbrew directory

,

Installing linuxbrew

,

Testing linuxbrew

Setting linuxbrew environment variables automatically

Example: Installing and testing htop

,

,

,

3.1.2 Install packages with miniconda

Creating a user miniconda-required directory

,

miniconda test

```
```

Example: Installing and testing htop

,

,

```
```

,

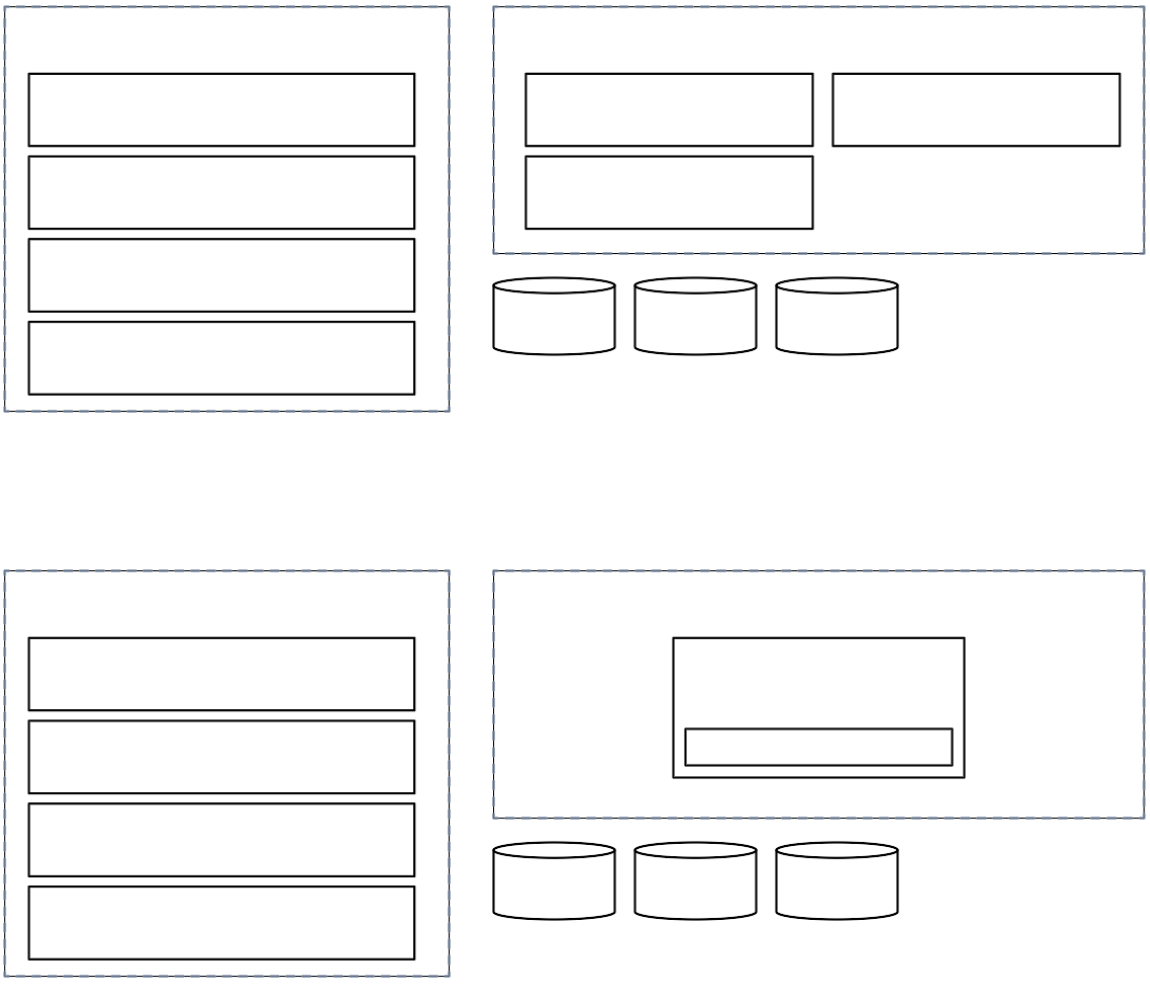
```
```

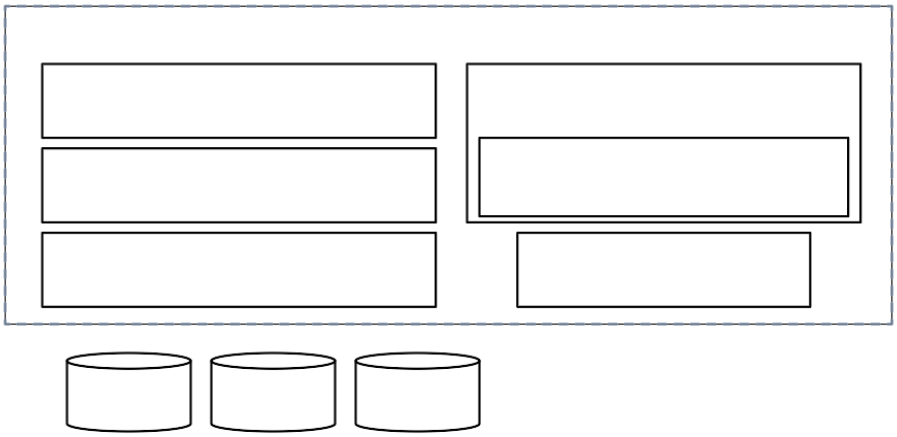
CHAPTER

FOUR

DEVELOPER GUIDES

4.1 Development Setup





4.1.1 Installation from Source

Prerequisites

Running the install-dev script

,

Verifying Installation

,

✓
✓
✓

Resetting the environment

,

Daily Workflows

4.2 Daily Development Workflows

4.2.1 About Pants

Key concepts

Inspecting build configurations

4.2.2 Running lint and check

4.2.3 Running formatters

4.2.4 Running unit tests

4.2.5 Running integration tests

4.2.6 Building wheel packages

4.2.7 Using IDEs and editors

,

,

VSCode

,

Setting ID	Recommended value

Setting ID	Example value

Vim/NeoVim

Switching between branches

“”

4.2.8 Running entrypoints

4.2.9 Working with plugins

4.2.10 Writing test cases

“”

,

4.2.11 Writing documentation

,

4.2.12 Advanced Topics

Adding new external dependencies

Merging lockfile conflicts

```
```

Resetting Pants

```
```

’

```
```

Resolve the error message ‘Pants is not abailable for your platform’, When installing Backend.AI with pants

‘’

```
_____
```

Resolving missing directories error when running Pants

Changing or updating the Python runtime for Pants

Debugging test cases (or interactively running test cases)

Installing a subset of mono-repo packages in the editable mode for other projects

,

```
```

,

Boosting the performance of Pants commands

```
```

```
```

```
```

Making a new release

“”.

“” “”

,

```
```

Backporting to legacy per-pkg repositories

4.3 Adding New Kernel Images

4.3.1 Overview

4.3.2 Kernel Runner

“”.

’“”

Image Prerequisites

’

4.3.3 Metadata Labels

“” “”. “”

,

4.3.4 Service Ports

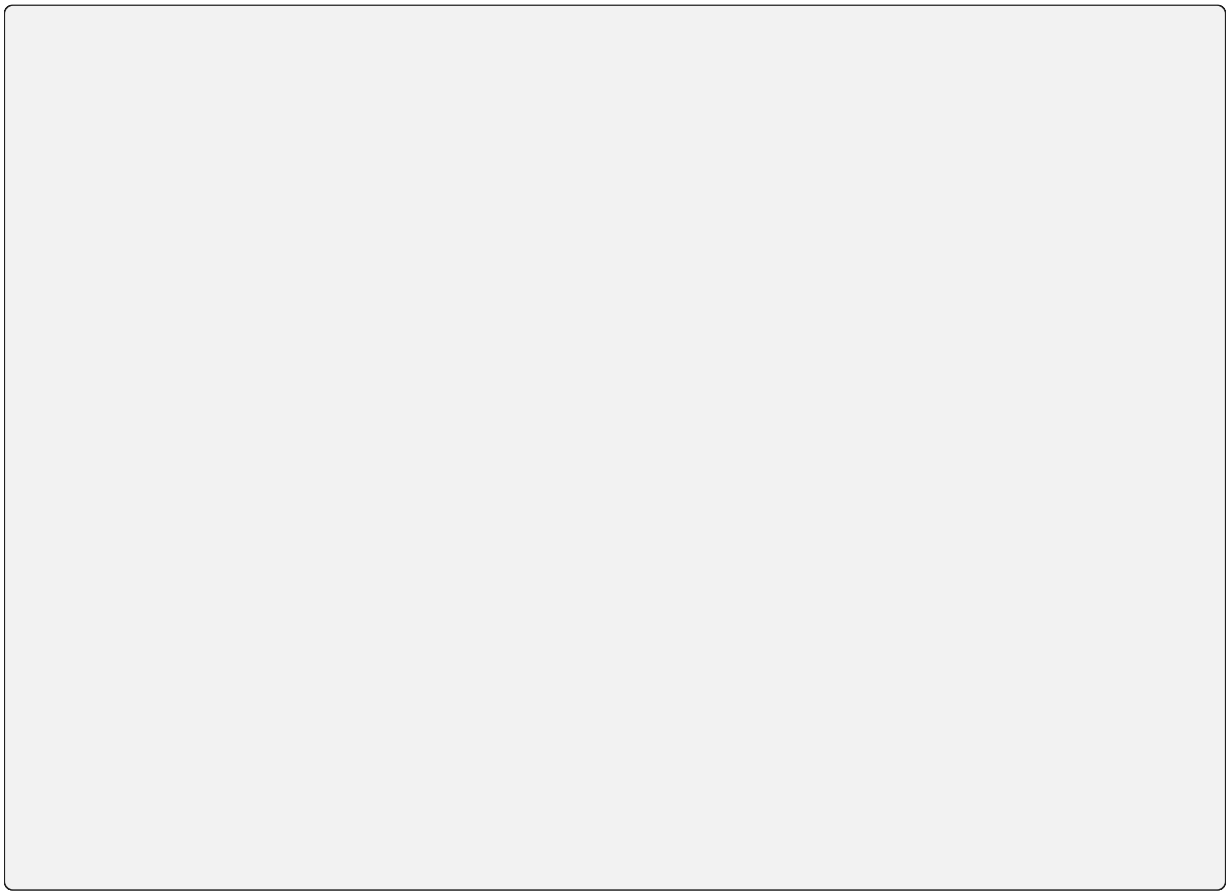
“”

Port Mapping Declaration

Service Definition DSL

’

“”



“” ’

Available predefined variables

Available prestart actions

“”.

Action Name	Arguments	Return
	: “”	
	: “”	
	:	
	:	
	:	

Interpretation of URL template

’

4.3.5 Jail Policy

Adding Custom Jail Policy

4.3.6 Example: An Ubuntu-based Kernel

4.3.7 Custom startup scripts (aka custom entrypoint)

4.3.8 Implementation details

The query mode I/O protocol

’

’

The pseudo-terminal mode protocol

“”

“” “”

’

“”

4.4 Using Mocked Accelerators

4.4.1 Configuring the mock-accelerator plugin

’’

4.4.2 Activating the mock-accelerator plugin

,

4.5 Version Numbering

,

4.6 Upgrading

CHAPTER

FIVE

MIGRATION GUIDES

5.1 Upgrading from 20.03 to 20.09

5.2 Migrating from the Docker Hub to cr.backend.ai

“” “...”

CHAPTER

SIX

BACKEND.AI MANAGER REFERENCE

6.1 Manager API Common Concepts

6.1.1 API and Document Conventions

HTTP Methods

Parameters in URI and JSON Request Body

HTTP Status Codes and JSON Response Body

JSON Field Notation

Example	Meaning

JSON Value Types

,

Type	Description

API Versioning

6.1.2 JSON Object References

Paging Query Object

Key	Typ	Description

Paging Info Object

Key	Typ	Description

KeyPair Item Object

Key	Typ	Description

KeyPair Properties Object

Key	Typ	Description

Key	Typ	Description

Service Port Object

Key	Typ	Description

Batch Execution Query Object

Key	Typ	Description
		,

Execution Result Object

Key	Typ	Description
		“”

Console Item Object

Key	Typ	Description

Execution Result File Object

Key	Typ	Description

Container Stats Object

Key	Typ	Description

Creation Config Object

Key	Typ	Description
		,

Resource Slot Object

Key	Typ	Description
		“”, “”, “”, “”, “”, “”, “”,
		$2^{53} - 1$
		“” “”.
		“”
		“”

Resource Preset Object

Key	Typ	Description
		‘’, ‘’, ‘’,

Virtual Folder Creation Result Object

Key	Typ	Description

Virtual Folder List Item Object

Key	Typ	Description
		’“”, “”, “” “” “”
		“” “”.

Virtual Folder Item Object

Key	Typ	Description
		’
		“” “”.

Virtual Folder File Object

Key	Typ	Description
		’
		’

Virtual Folder Invitation Object

Key	Typ	Description
		’

Key	Typ	Description
		“” “
		’

6.1.3 Authentication

Access Tokens and Secret Key

Common Structure of API Requests

HTTP Headers	Values
	’

Common Structure of API Responses

HTTP Headers	Values

Signing API Requests

Generating a signing key

Generating a string to sign

Attaching the signature

Example Requests and Responses

Success example for checking the latest API version

Failure example with a missing authorization header

6.1.4 Rate Limiting

,

HTTP Headers	Values

“”.

6.2 Manager REST API

6.2.1 Session Management

Creating Session

Parameters

Parameter	Typ	Description
		“”.
		“”

Response

HTTP Status Code	Description
	’

Fields	Typ	Values

Getting Session Information

Parameters

Parameter	Typ	Description

Response

HTTP Status Code	Description

Key	Typ	Description
	’	

Destroying Session

Parameters

Parameter	Typ	Description

Response

HTTP Status Code	Description

Key	Typ	Description

Restarting Session

Parameters

Parameter	Typ	Description

Response

HTTP Status Code	Description

6.2.2 Code Execution (Query Mode)

Executing Snippet

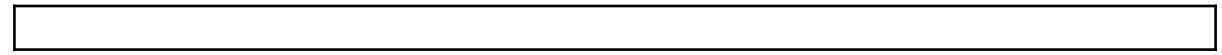
Parameters

Parameter	Typ	Description

Response

HTTP Status Code	Description

Fields	Typ	Values



Auto-completion

Parameters

Parameter	Typ	Description

Response

HTTP Status Code	Description

Fields	Typ	Values

Interrupt

Parameters

Parameter	Typ	Description

Response

HTTP Status Code	Description

6.2.3 Code Execution (Batch Mode)

Uploading files

Parameters

Response

HTTP Status Code	Description

Executing with Build Step

Parameters

Parameter	Typ	Description

Response

HTTP Status Code	Description

Fields	Typ	Values

Listing Files

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Fields	Type	Values

Downloading Files

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

6.2.4 Code Execution (Streaming)

Code Execution

Terminal Emulation

Parameters

Parameter	Typ	Description

Client-to-Server Protocol

Standard input stream

Terminal resize

Ping

Restart

Server-to-Client Protocol

Standard output/error stream

Server-side errors

6.2.5 Event Monitoring

Session Lifecycle Events

Parameters

Parameter	Typ	Description
		,
		,

Responses

Event Name	Description

Field Name	Description

Background Task Progress Events

Parameters

Parameter	Typ	Description

Responses

Event Name	Description

Field Name	Typ	Description

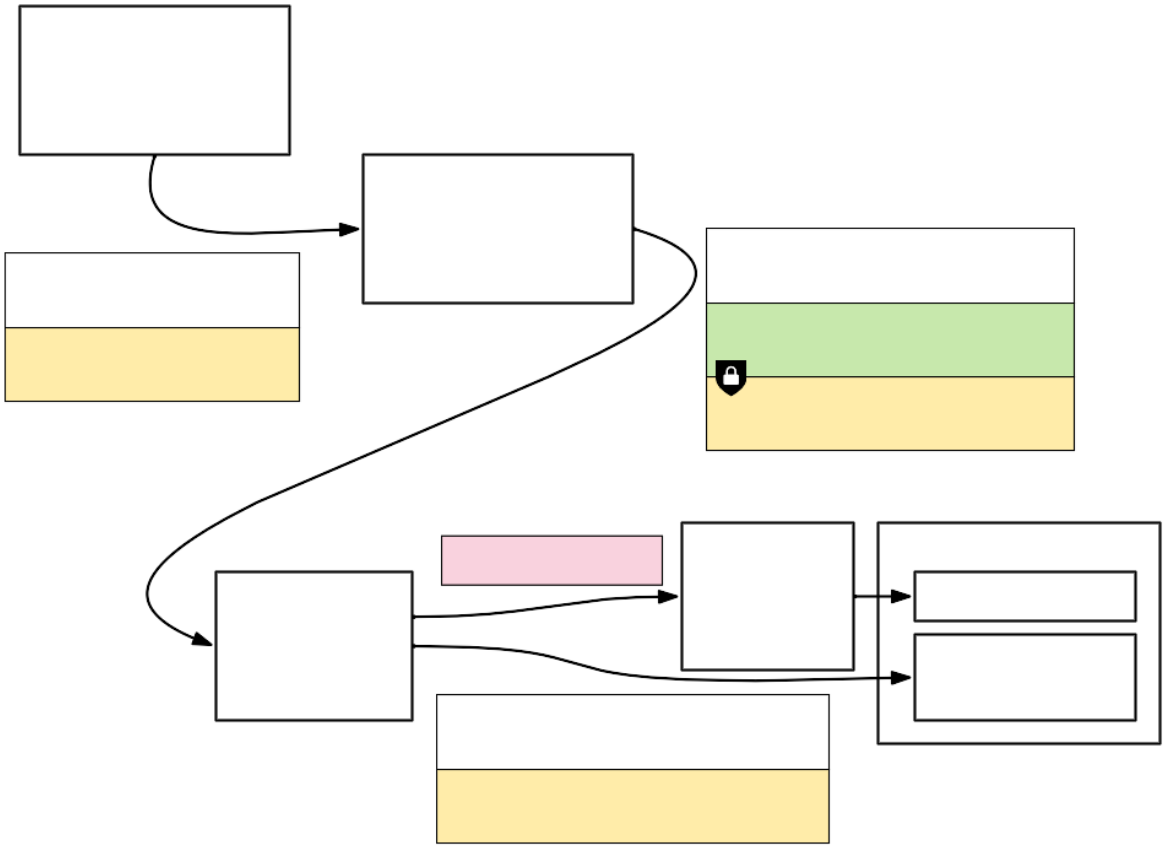
“”

6.2.6 Service Ports (aka Service Proxies)

“”

’

’



Service Proxy (HTTP)

Parameters

Parameter	Typ	Description

Service Proxy (TCP)

Parameters

Parameter	Typ	Description

6.2.7 Resource Presets

Listing Resource Presets

Parameters

Response

HTTP Status Code	Description

Fields	Typ	Values

Checking Allocatability of Resource Presets

,

Parameters

Response

HTTP Status Code	Description

Fields	Typ	Values
		“”.
		“”.
		“”
		’’

6.2.8 Virtual Folders

Listing Virtual Folders

Parameters

Parameter	Typ	Description

Response

HTTP Status Code	Description

Fields	Typ	Values

Listing Virtual Folder Hosts

Parameters

Response

HTTP Status Code	Description

Fields	Type	Values

Creating a Virtual Folder

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Fields	Typ	Values

Getting Virtual Folder Information

Parameters

Parameter	Typ	Description

Response

HTTP Status Code	Description

Fields	Typ	Values

Deleting Virtual Folder

Parameters

Parameter	Description

Response

HTTP Status Code	Description

Rename a Virtual Folder

Parameters

Parameter	Typ	Description

Response

HTTP Status Code	Description

Listing Files in Virtual Folder

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Fields	Type	Values

Uploading a File to Virtual Folder

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Fields	Type	Values

Creating New Directory in Virtual Folder

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Downloading a File or a Directory from a Virtual Folder

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Fields	Type	Values

Deleting Files in Virtual Folder

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Rename a File in Virtual Folder

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Listing Invitations for Virtual Folder

Parameters

Response

HTTP Status Code	Description

Fields	Typ	Values

Creating an Invitation

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Fields	Typ	Values

Accepting an Invitation

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Rejecting an Invitation

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Fields	Typ	Values

Listing Sent Invitations

Parameters

Response

HTTP Status Code	Description

Fields	Typ	Values

Updating an Invitation

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Fields	Typ	Values

Leave an Shared Virtual Folder

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Fields	Typ	Values

Listing Users Share Virtual Folders

,

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Fields	Typ	Values

Updating the permission of a shared virtual folder

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Fields	Typ	Values

Share a Group Virtual Folder to an Individual Users

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Fields	Typ	Values

Unshare a Group Virtual Folder from Users

Parameters

Parameter	Type	Description

Response

HTTP Status Code	Description

Fields	Typ	Values

Clone a Virtual Folder

Parameters

Parameter	Type	Description

Response

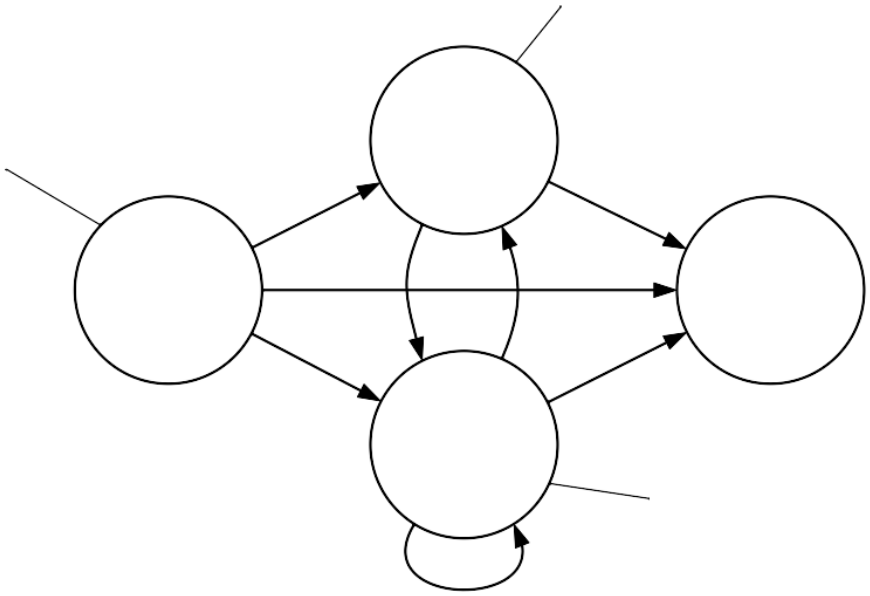
HTTP Status Code	Description

Fields	Typ	Values

Fields	Typ	Values

6.2.9 Code Execution Model

,



“”

’

6.2.10 Handling Console Output

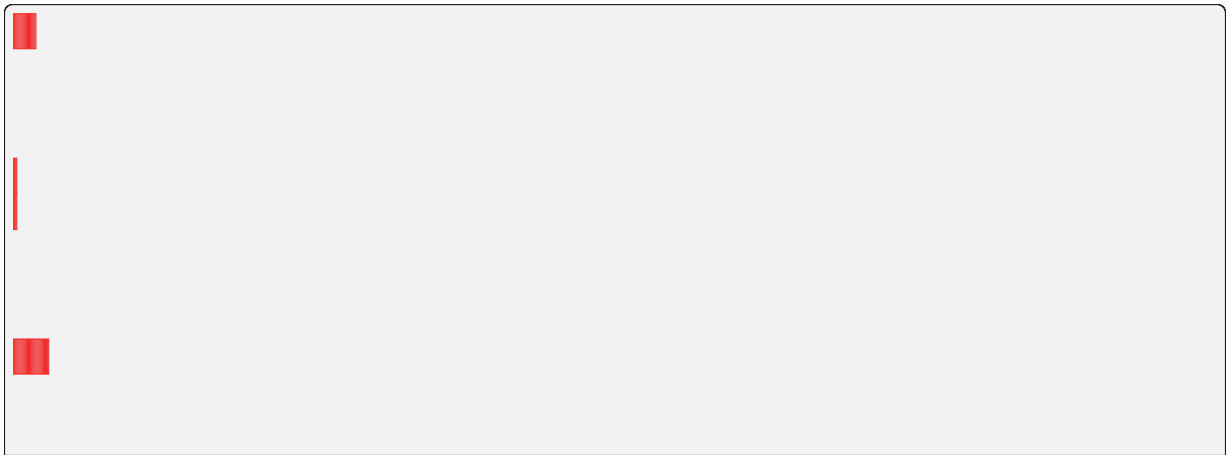
’

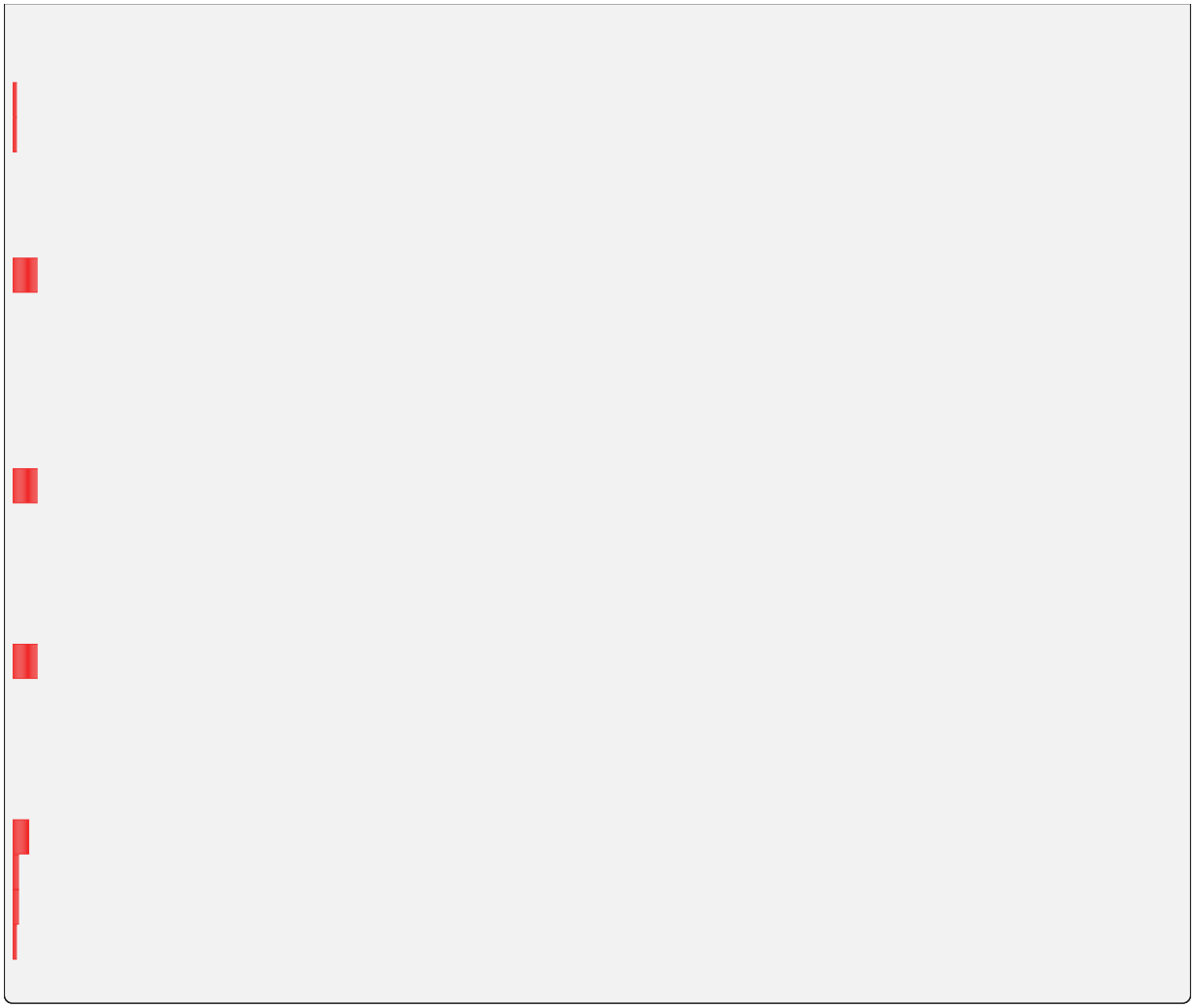
6.3 Manager GraphQL API

6.3.1 Domain Management

Query Schema

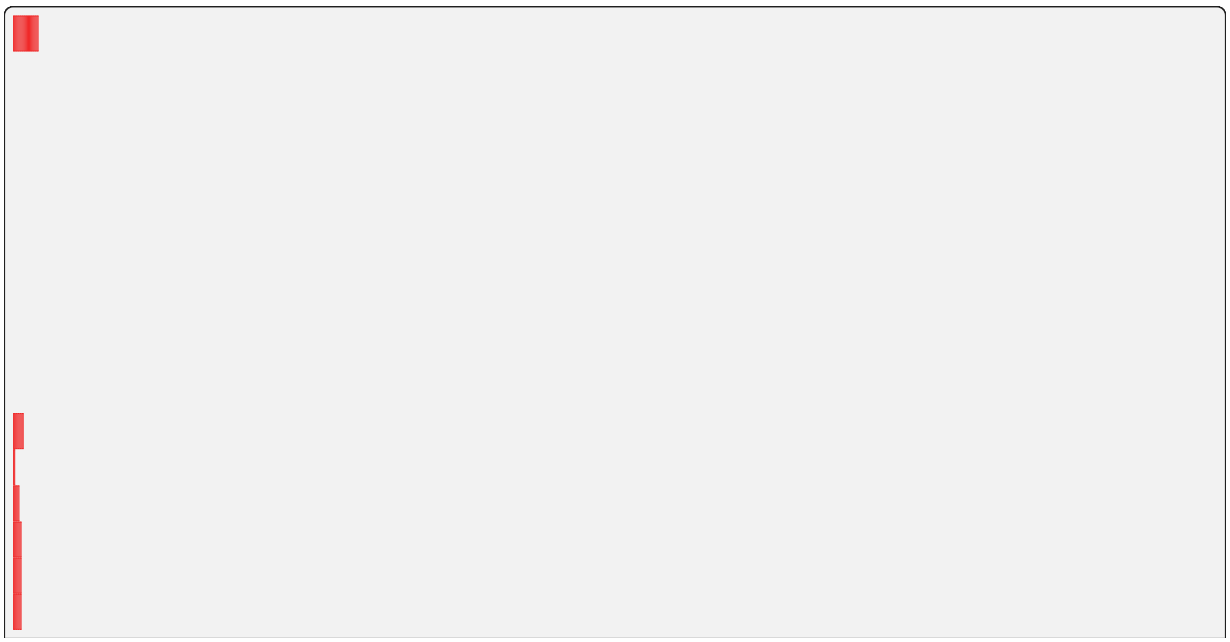
Mutation Schema





6.3.2 Scaling Group Management

Query Schema



Mutation Schema

6.3.3 Resource Preset Management

Query Schema

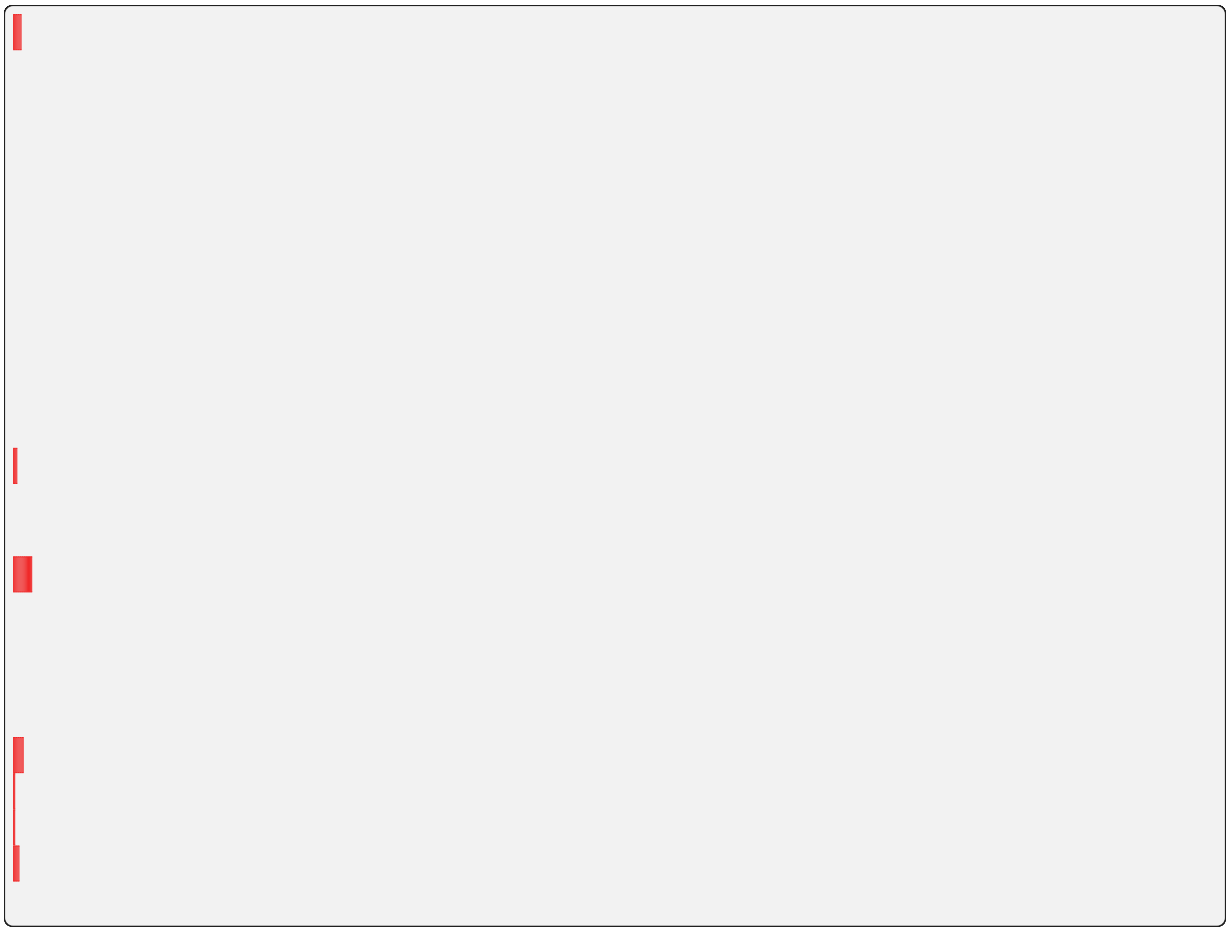
Mutation Schema

6.3.4 Agent Monitoring

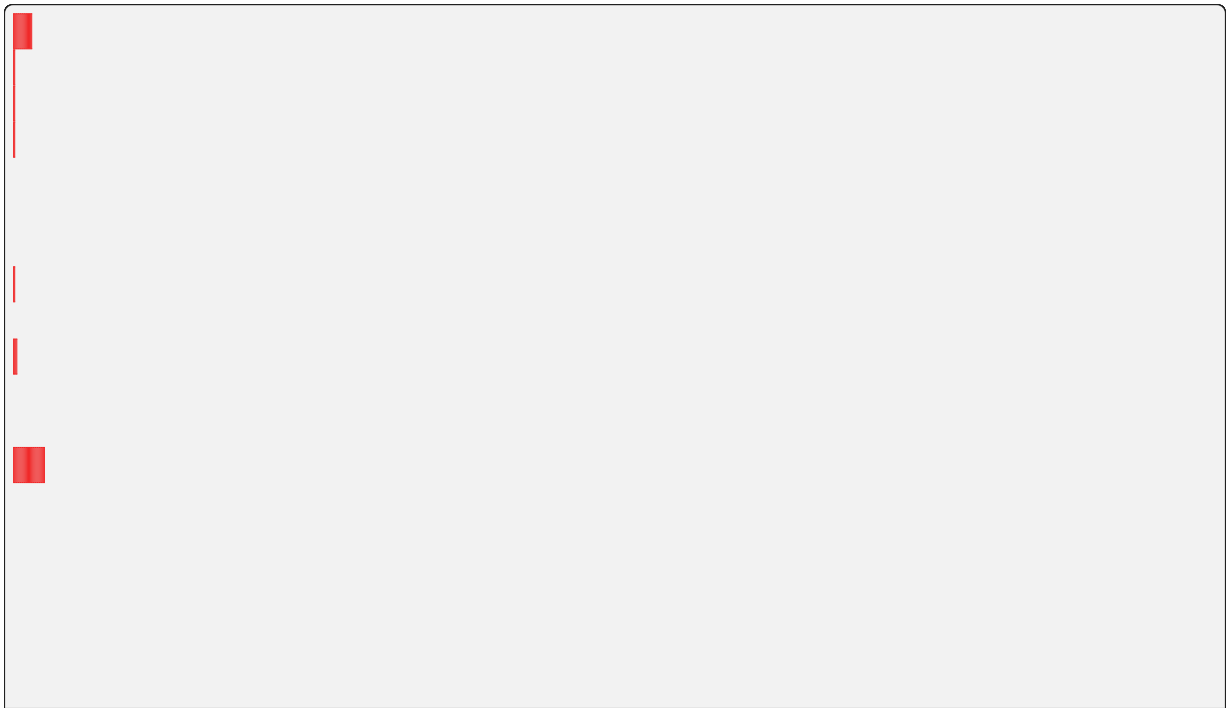
Query Schema

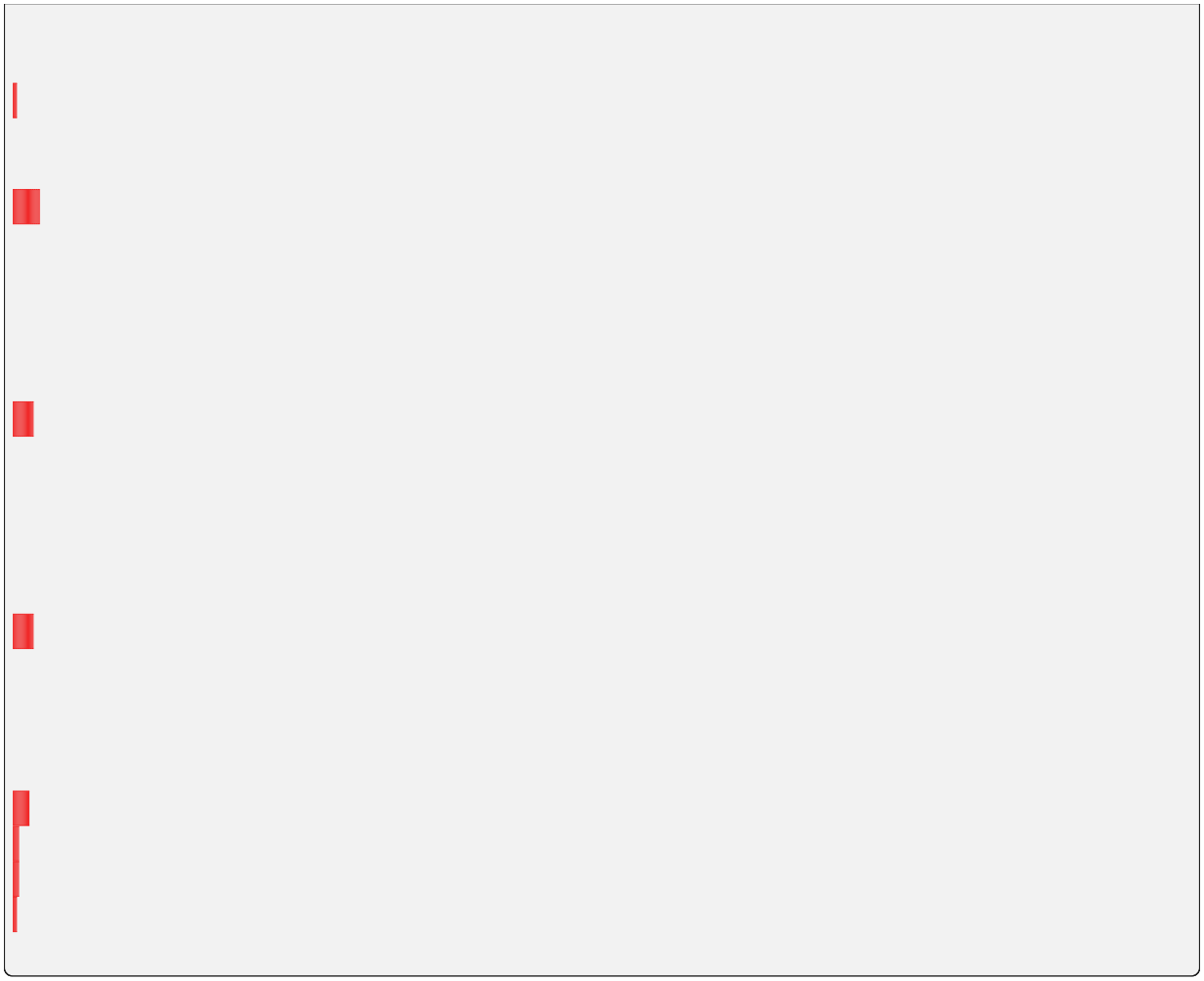
6.3.5 User Management

Query Schema



Mutation Schema





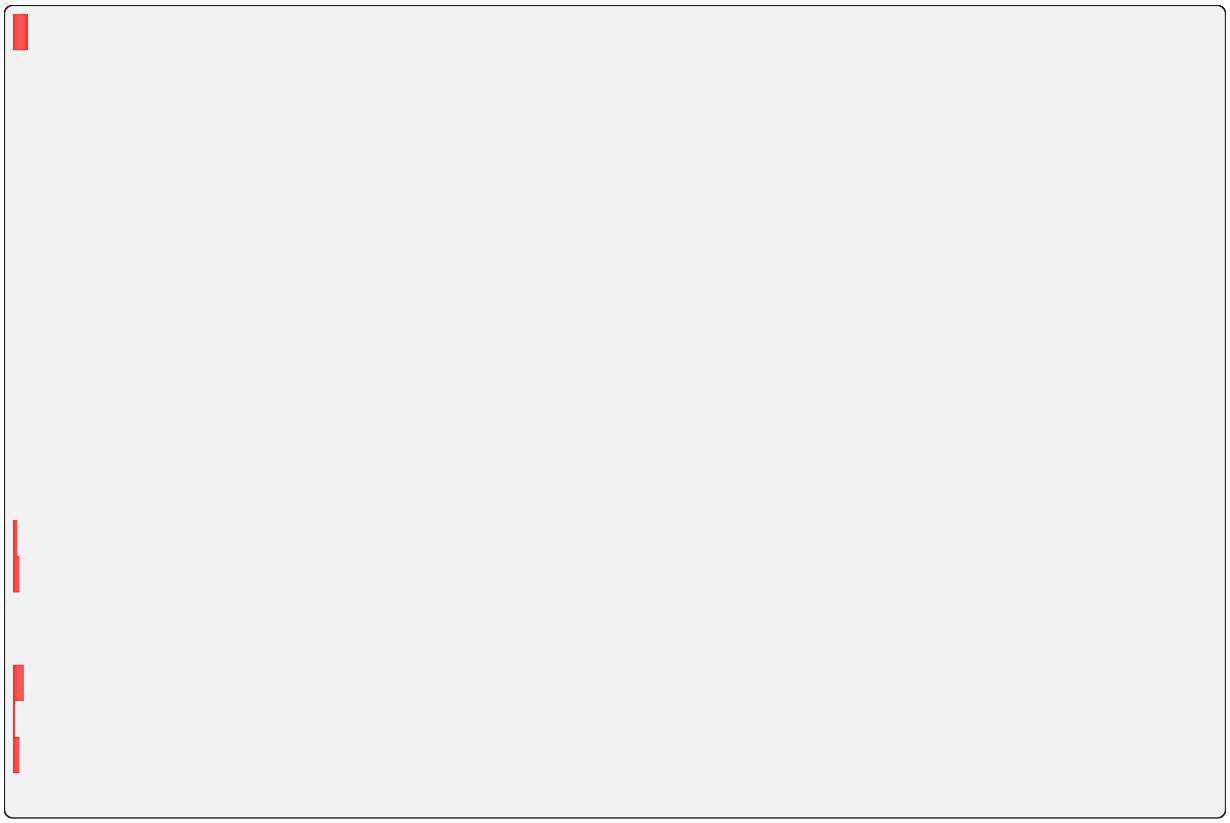
6.3.6 Group Management

Query Schema

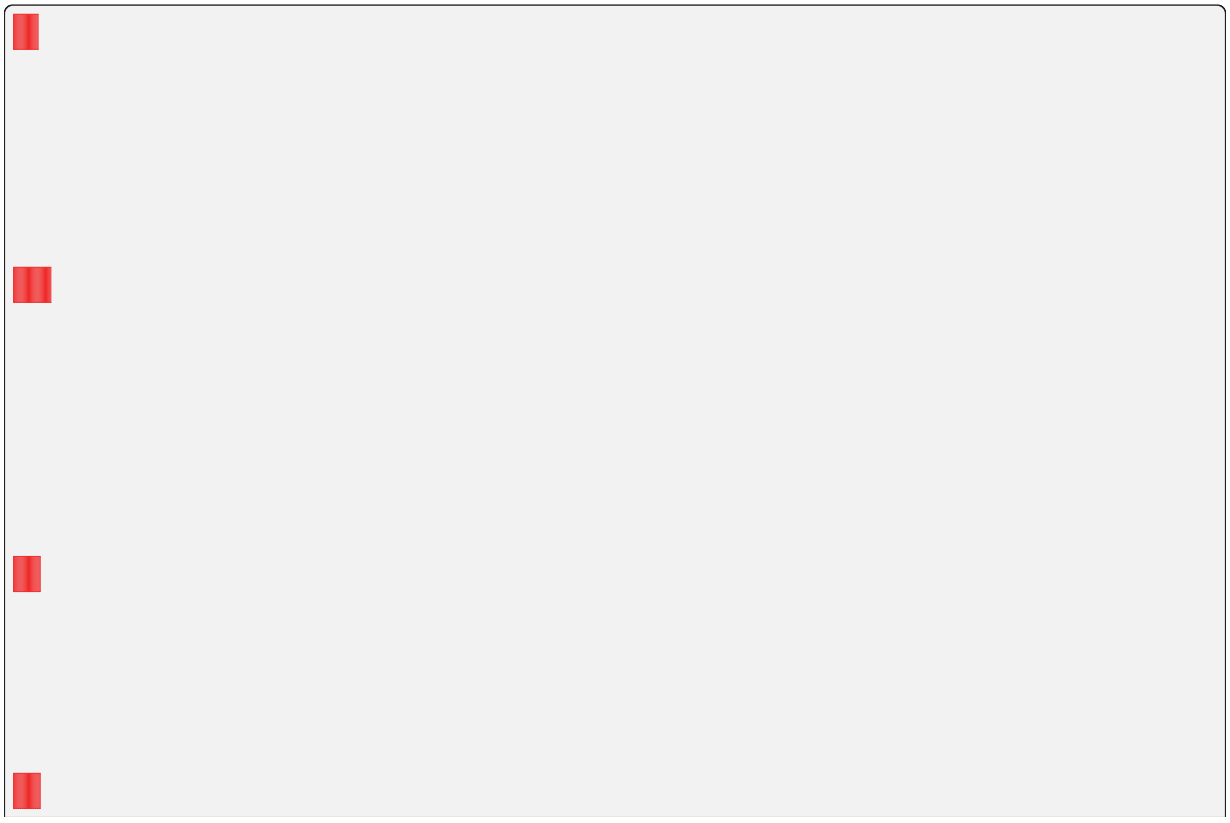
Mutation Schema

6.3.7 KeyPair Management

Query Schema



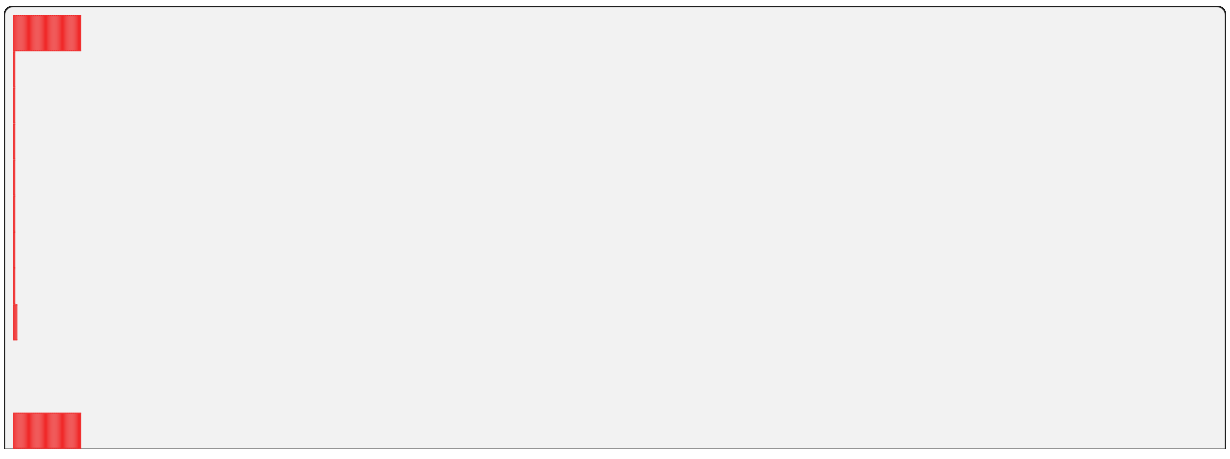
Mutation Schema

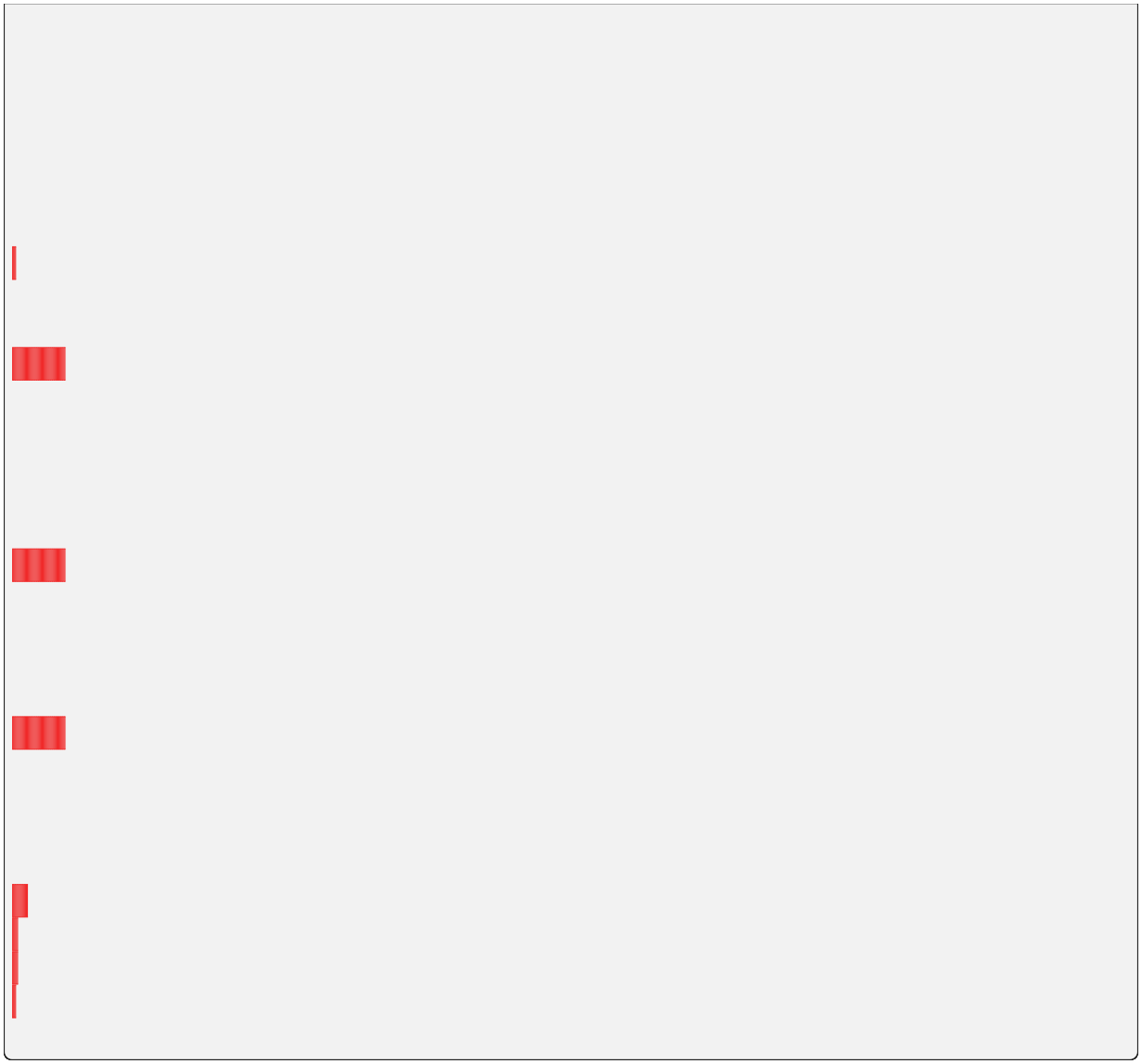


6.3.8 KeyPair Resource Policy Management

Query Schema

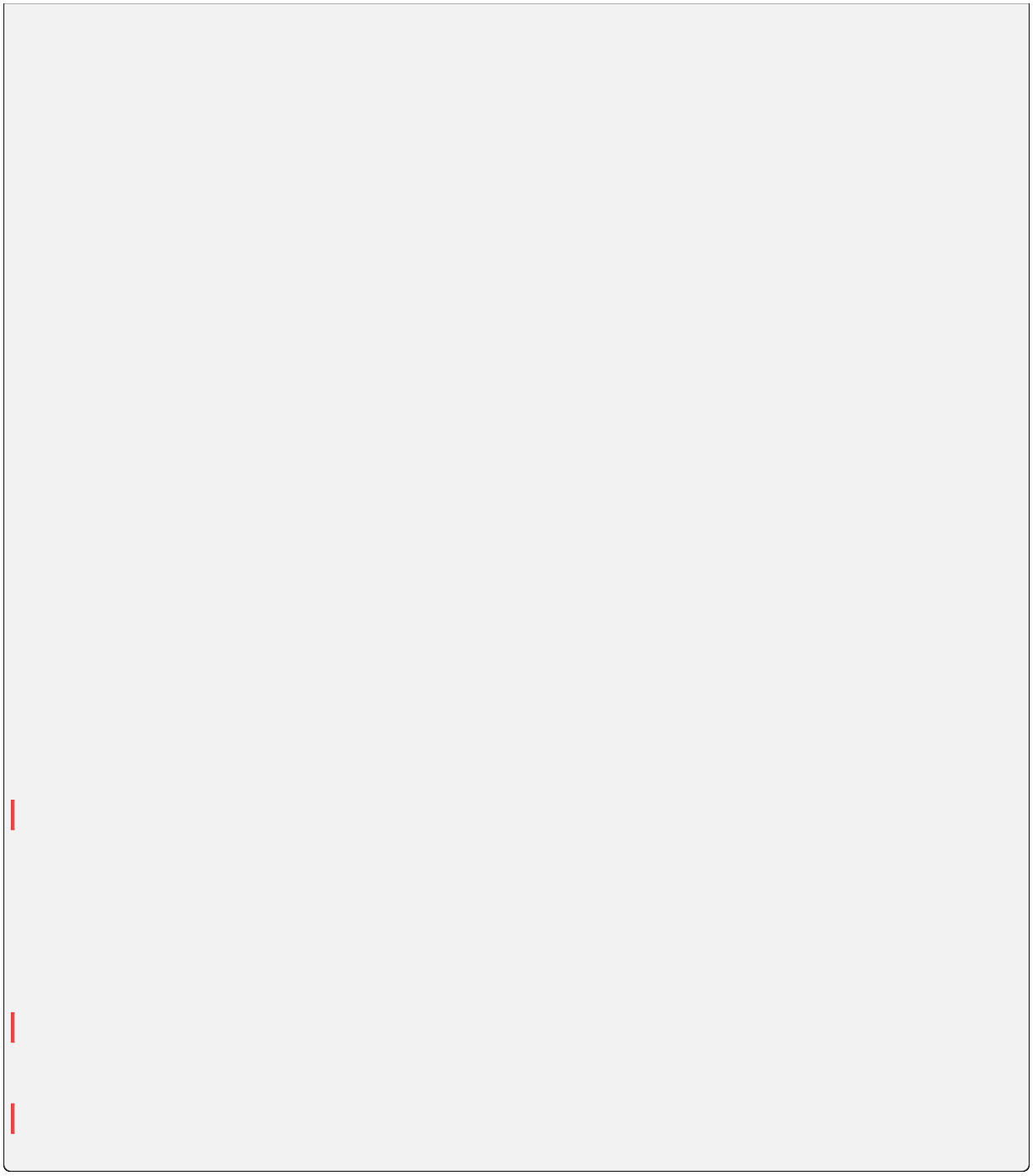
Mutation Schema

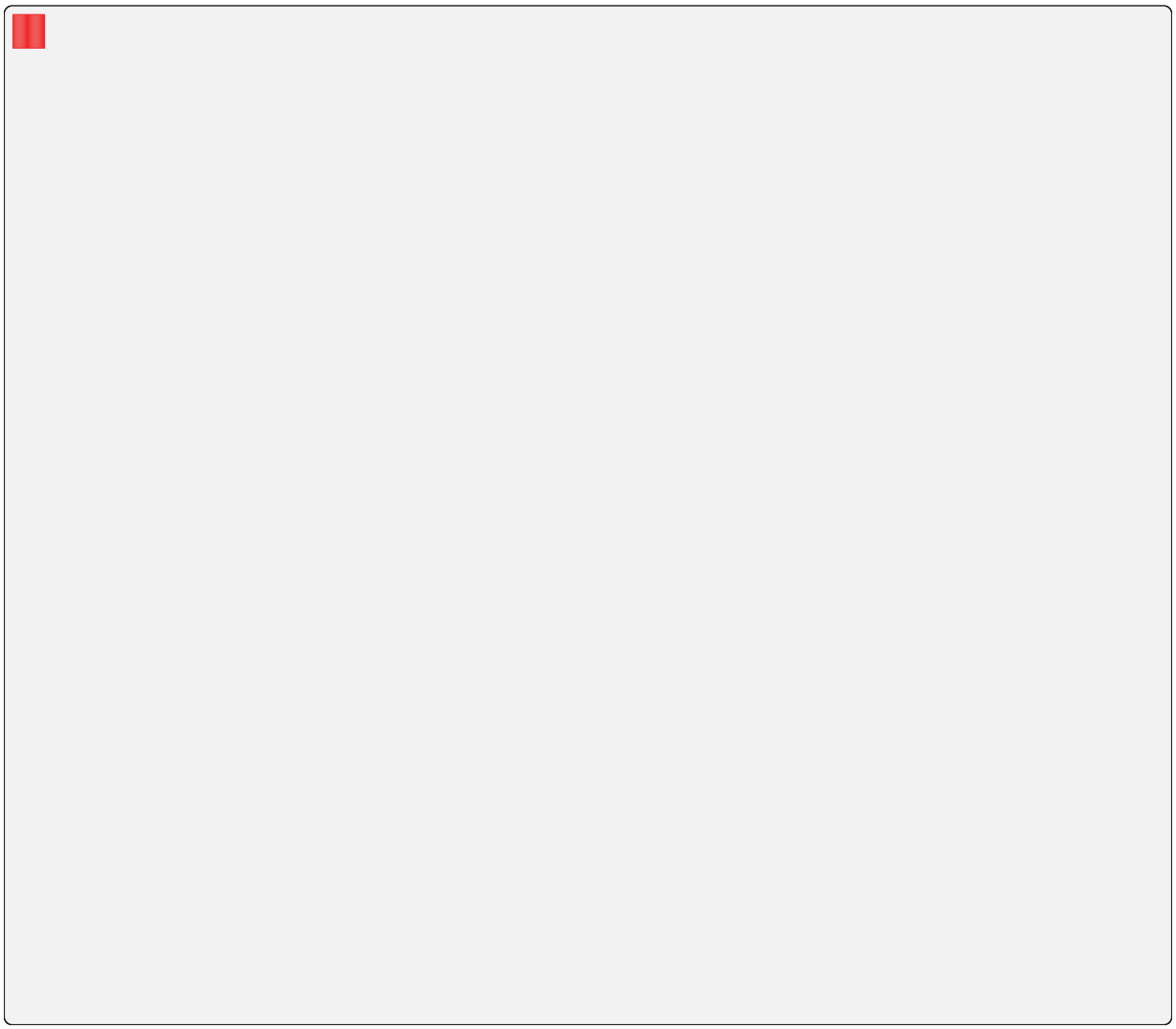




6.3.9 Compute Session Monitoring

Query Schema

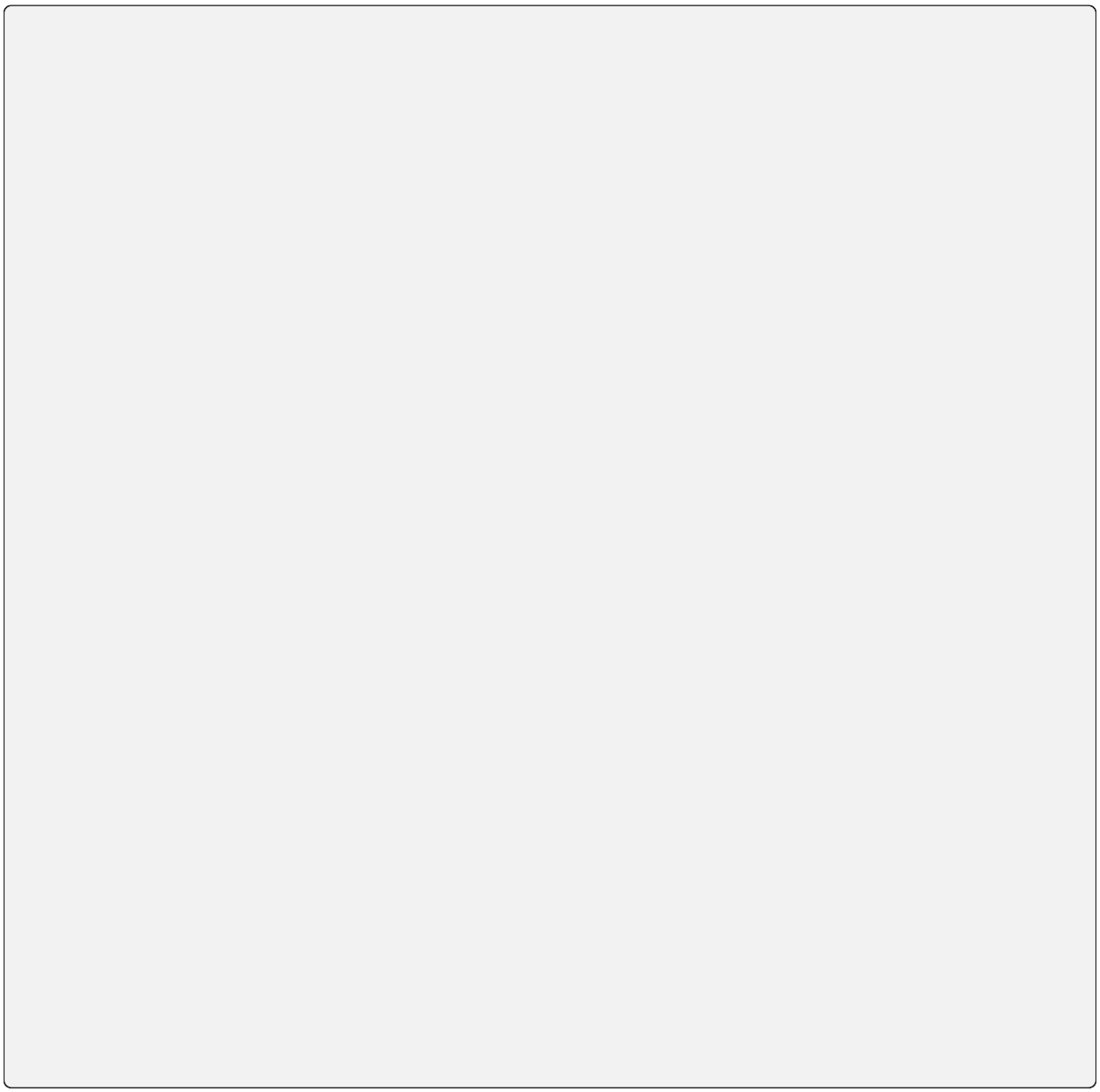




Query Example

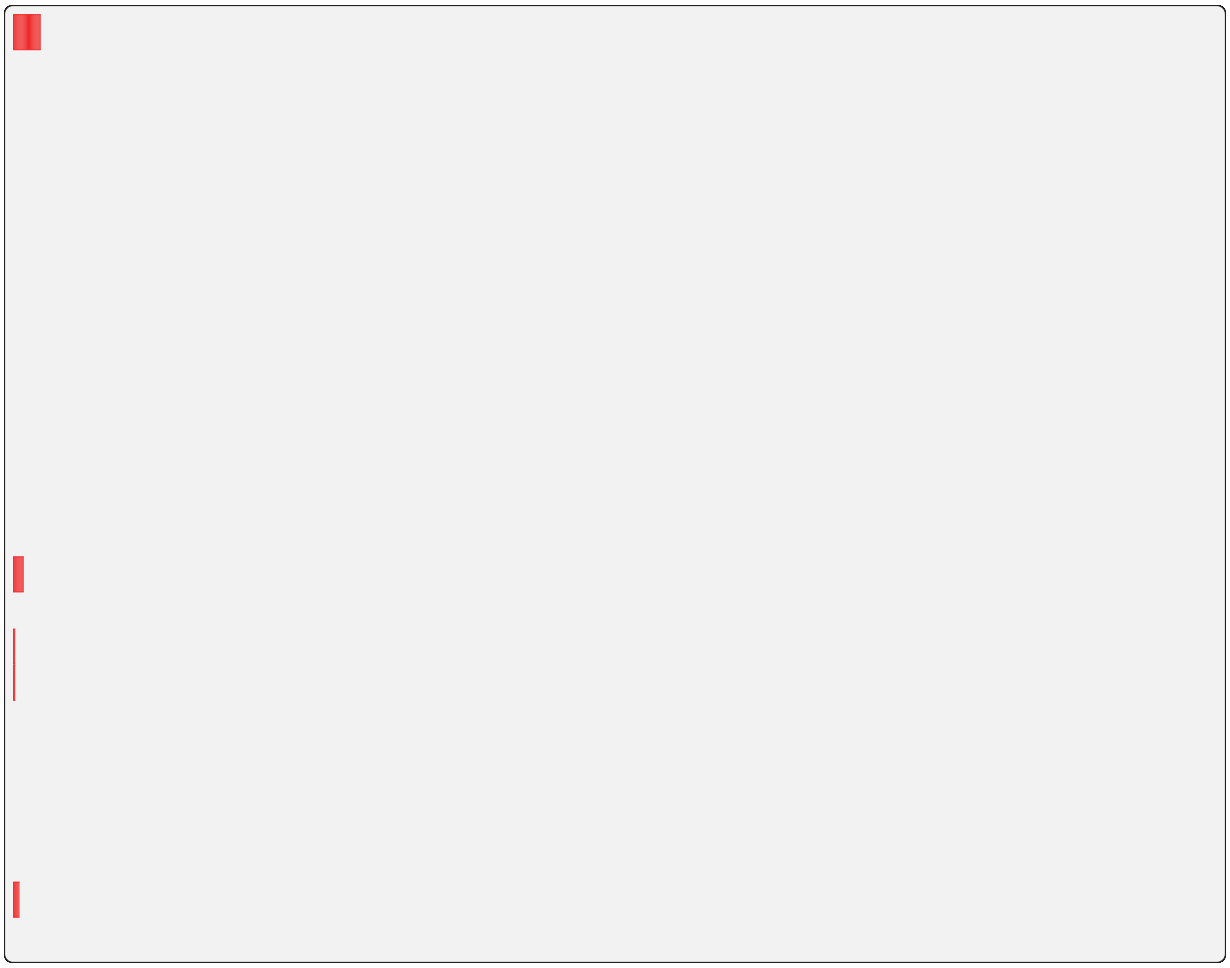
API Parameters

API Response



6.3.10 Virtual Folder Management

Query Schema

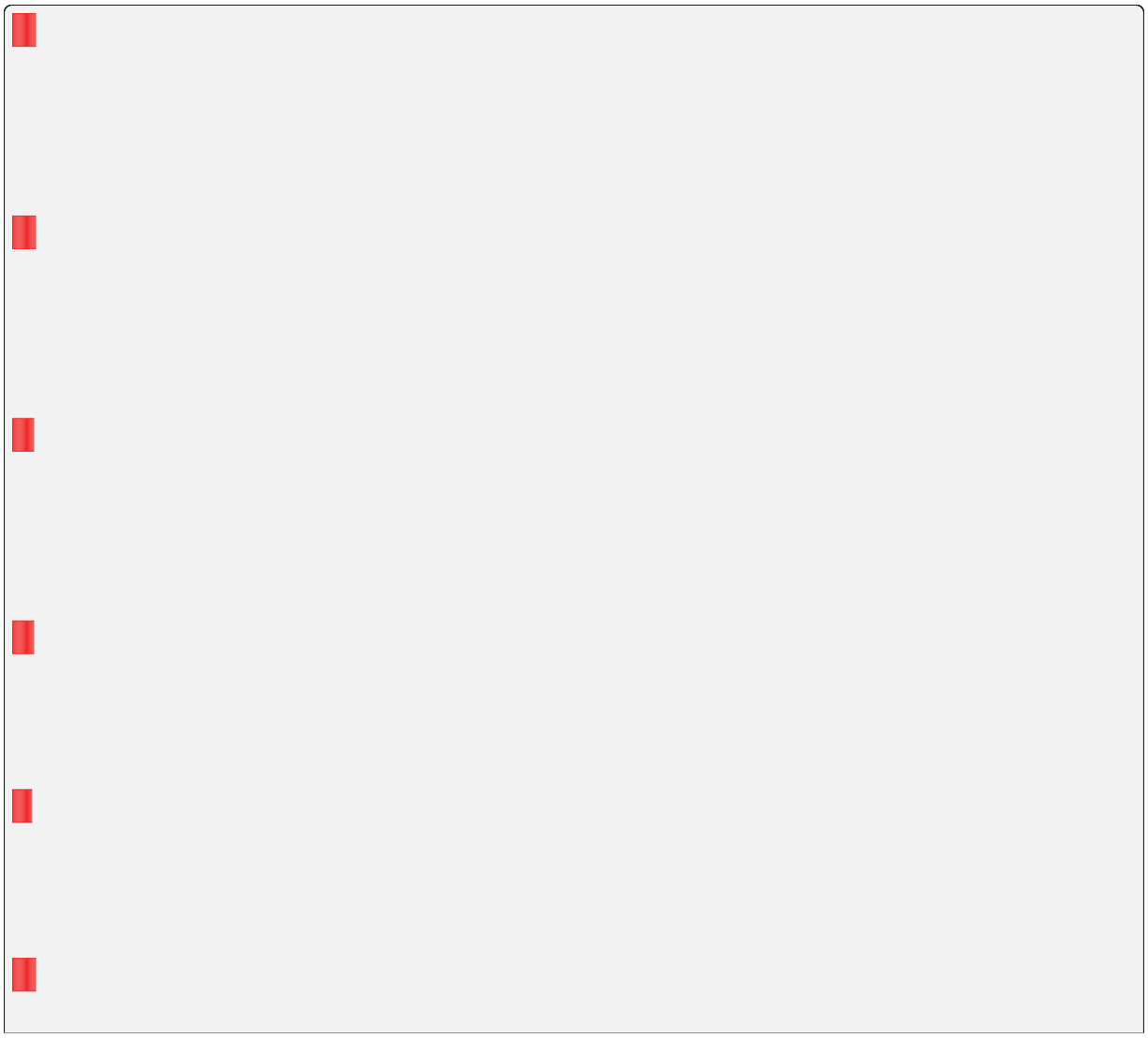


6.3.11 Image Management

Query Schema

,,

Mutation Schema



6.3.12 Basics of GraphQL

HTTP Request Convention

Field Naming Convention

Common Object Types

“”

Pagination Convention

,

Custom Scalar Types

’“” “”

Authentication

Versioning

6.4 Backend.AI REST API Reference

CHAPTER

SEVEN

BACKEND.AI AGENT REFERENCE

CHAPTER

EIGHT

BACKEND.AI STORAGE PROXY REFERENCE

CHAPTER

NINE

BACKEND.AI CLIENT SDK FOR PYTHON

’“”

9.1 Installation

9.1.1 Linux/macOS

9.1.2 Windows

9.1.3 Verification

“”

“”,

9.2 Client Configuration

,

9.3 Command Line Interface

9.3.1 Configuration

Session Mode

✓
✓

API Mode

```
```

Checking out the current configuration

```
```

9.3.2 Compute Sessions

Listing sessions

```
```

```
```

Option	Included Session Status

Option	Included Session Fields

Running simple sessions

,

Running sessions with accelerators

Terminating or cancelling sessions

9.3.3 Container Applications

Starting a session and connecting to its Jupyter Notebook

“” “”

Accessing sessions via a web terminal

Accessing sessions via native SSH/SFTP

“”

,

9.3.4 Storage Management

“”“”

Creating vfolders and managing them

“”:

File transfers and management

```

```

```

```

’

```

```

```

```

```

```

Running sessions with storages

“” “”

```

```

‘’

Creating default files for kernels

‘’, ’

```

```

9.3.5 Advanced Code Execution

Running concurrent experiment sessions

“”.

Expression	Interpretation
	’

’

9.3.6 Session Templates

Creating and starting session template

Full syntax for task template

9.4 Developer Guides

9.4.1 Client Session

Client Session Objects

,

9.4.2 Examples

Initialization of the API Client

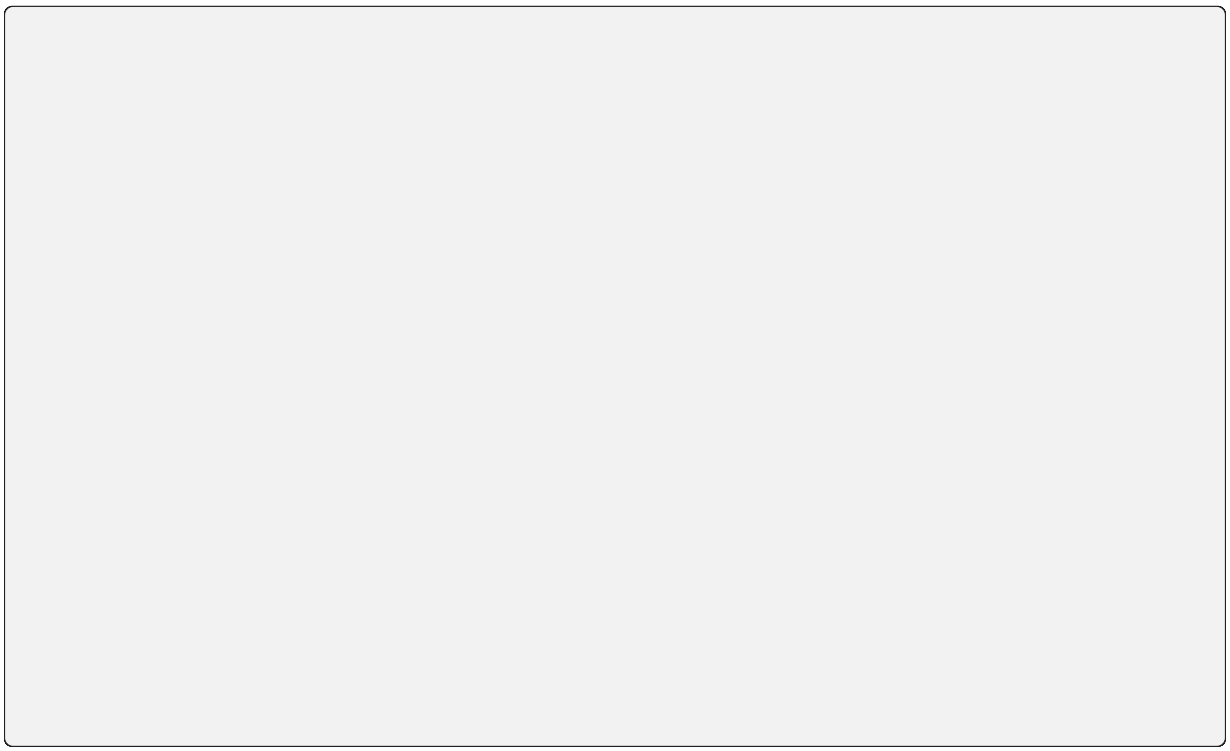
Implicit configuration from environment variables

Explicit configuration

Asyncio-native API session

Working with Compute Sessions

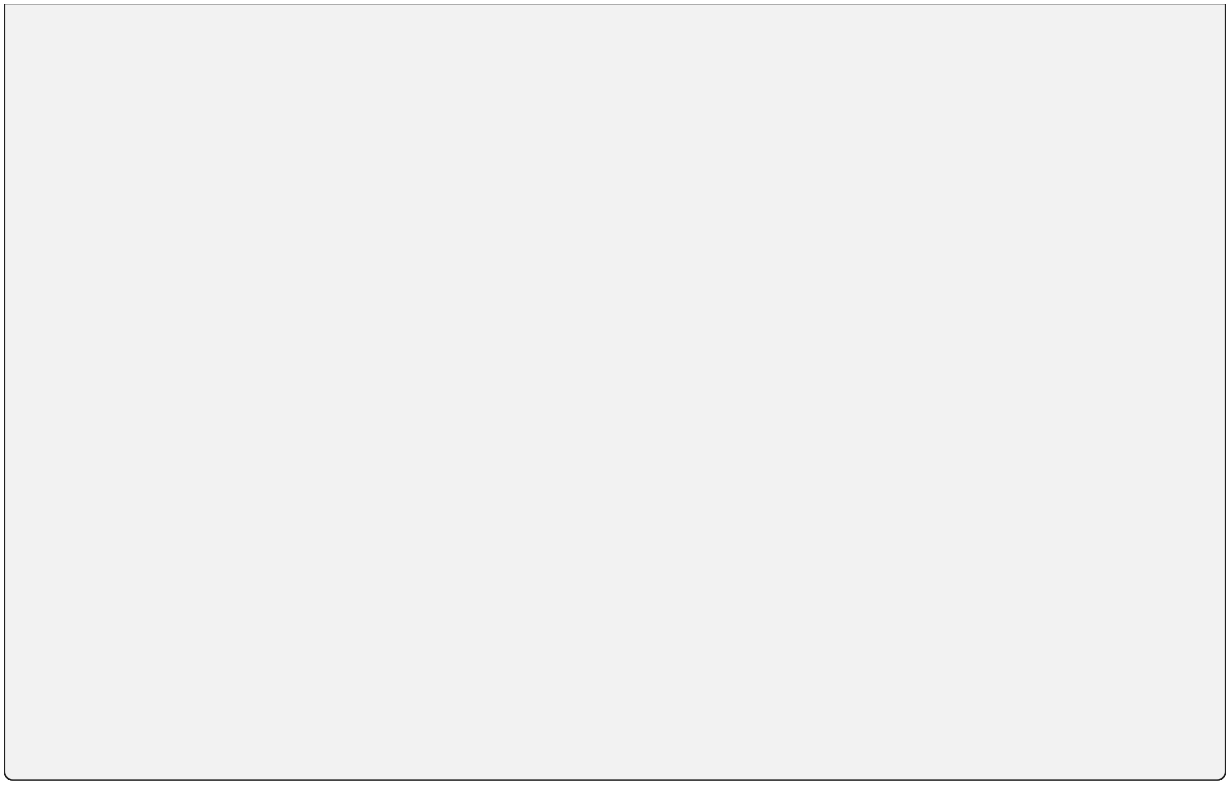
Listing currently running compute sessions



Creating and destroying a compute session

Accessing Container Applications

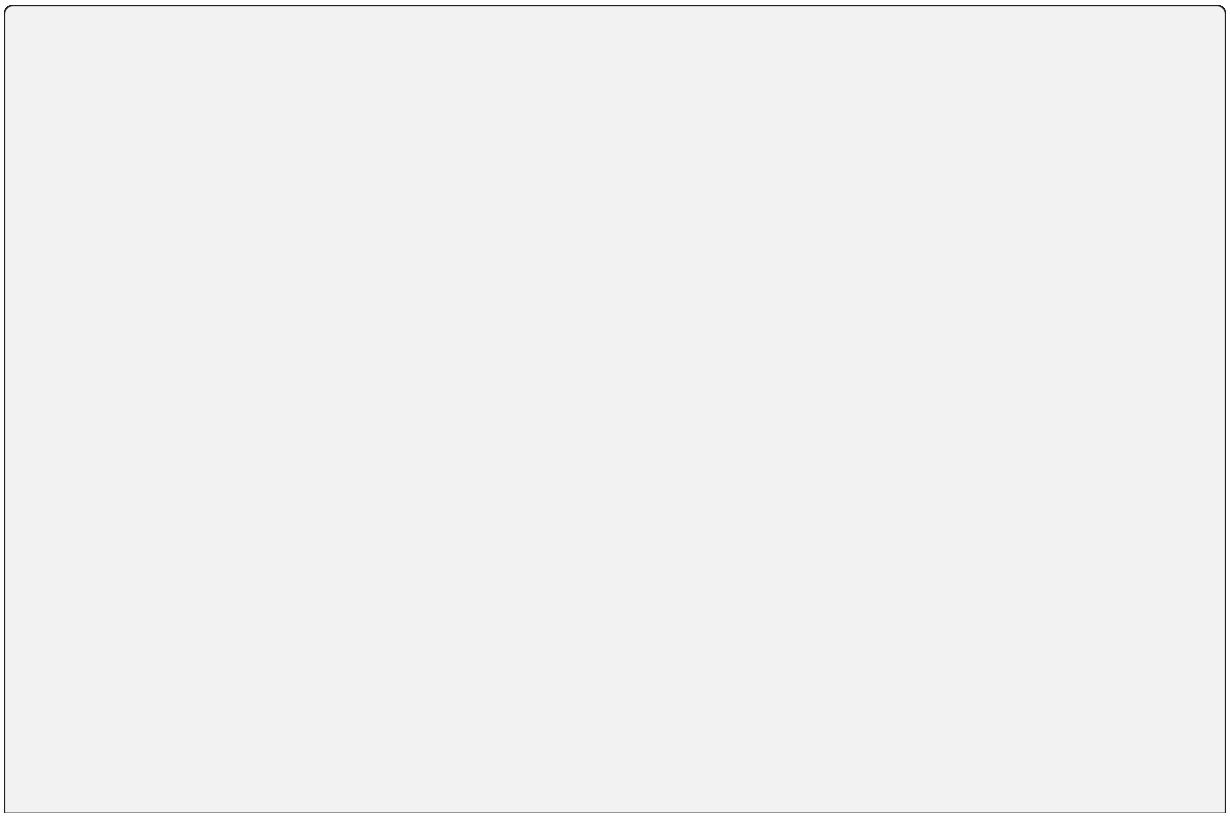
The API



Code Execution via API

Synchronous mode

Snippet execution (query mode)

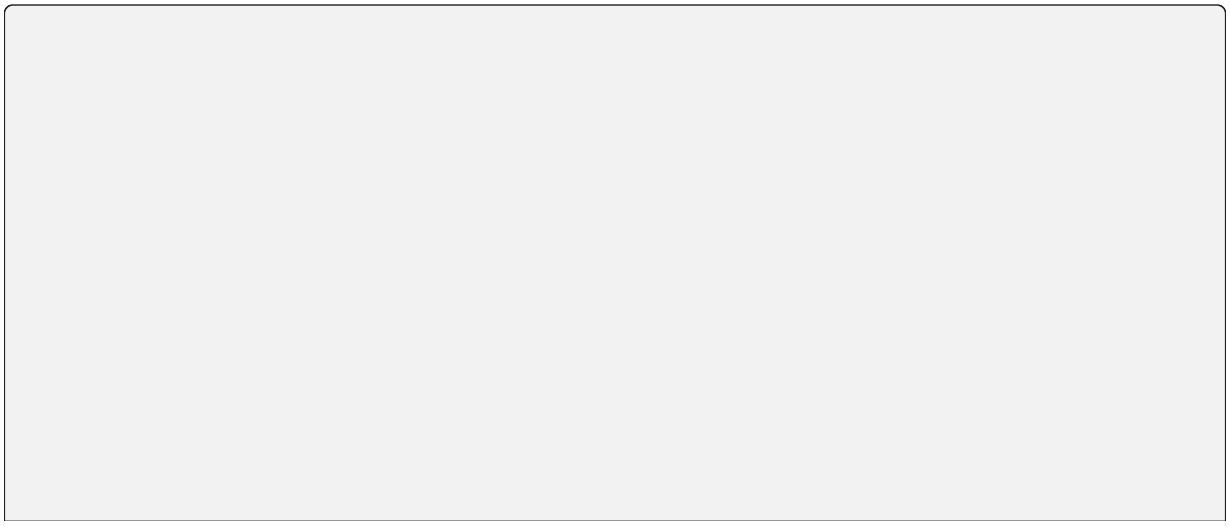


Script execution (batch mode)

Handling user inputs

Handling multi-media outputs

Asynchronous mode



Working with model service

Starting model service

Making request to model service endpoint

9.4.3 Testing

Unit Tests

How to run

Integration Tests

“”

Prerequisite

How to run

9.5 High-level Function Reference

9.5.1 Admin Functions

9.5.2 Agent Functions

9.5.3 Auth Functions

,

,

,

9.5.4 Configuration