eSAAM 2023

on Cloud to Edge Continuum

# Tool Support for Architectural Pattern Selection and Application in Cloud-Centric Service-Oriented IDEs

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Ludwigsburg, Germany

## Software Architecture Design

- **High-level structure of system components & their interactions**
- **High impact on quality, success & management of software**
- **Architectural patterns & styles**
  - Principles & best practices for software architecture design
  - Guidelines & templates for structuring & organizing software systems
  - Common vocabulary to describe software architecture
  - E.g., event-driven architecture, layered architecture, microservices

## Software Architecture Design

- **Choosing the right architectural pattern**
  - Strengths, drawbacks, technical knowledge
  - Impact on quality attributes (“-abilities”), requirements, constraints
  - Project requirements, constraints & limitations
  - System complexity, scalability needs
  - Team expertise, trade-offs
  - Industry best practices
- **Traditional methods**
  - Architectural pattern catalogs, architectural decision records
  - Architecture tradeoff analysis, decision matrices
  - Expert consultation, reference architectures

# Architectural Decision Tool Support

- **Modeling and diagramming**
  - UML-based software modeling
  - Architectural diagrams
  - E.g., Enterprise Architect (Sparx Systems), IBM Rational Software Architect, Archimate Toolset, Eclipse Papyrus
- **Architectural decision modeling framework (O. Zimmermann)**
- **Quality attribute analysis**
  - Performance & security analysis
  - Scalability & maintainability assessment
  - Cost & change impact analysis
  - E.g., ARIS (Software AG), IBM Rational Rhapsody, QualiWare, Determine
- **ML techniques to learn from architectural decisions (Mahabaleshwar)**
- **Decision studio web tool for technology selection & architectural patterns (Farshidi et al.)**
- **Code generation from architectural models**
  - From UML or other notations
  - Scaffolding & project organization tools

# A Framework for Architectural Pattern Selection and Application

- **Architectural pattern decision support feature for IDE integration**
- **Architectural pattern selection**
  - Knowledge base
    - Application domain
    - Application type
    - Quality attributes / non-functional requirements
    - Development & deployment requirements
    - Architectural features
  - Evaluation & ranking
    - Based on existing literature on pattern analyses (Farshidi et al. 2020, Richards 2022)
    - Scoring system assigning weights to patterns in context of knowledge base
- **Architectural pattern application**
  - GitHub repository templates for project & code organization
- **Integrated into the cloud-native SmartCLIDE IDE**

# Supported Architectural Patterns

- **Layered architecture**
  - Distinct layers for presentation, application logic, data storage
- **Event-driven architecture (EDA)**
  - Systems communicate through events (trigger actions or reactions)
- **Microkernel architecture**
  - Essential core (the microkernel) and various optional modules
- **Microservices architecture**
  - Small independent services that communicate over APIs
- **Service-oriented architecture (SOA)**
  - Loosely coupled, reusable services communicating via interfaces
- **Space-based architecture (SBA)**
  - Distributes data & processing across a network of interconnected, distributed spaces

# Application Domain

| Application Domain | Associated Architectural Patterns |
|---|---|
| Web-based systems | EDA, layered, microservices, SOA, SBA |
| Web services | Microservices, SOA, SBA |
| Service-based systems | Microservices, SOA |
| Distributed systems | EDA, layered, microkernel, microservices, SOA, SBA |
| Cloud computing applications | Microservices, SOA |
| Mobile applications | Layered, microservices, SOA, SBA |
| Compiler design | Layered |
| CASE and related developer tools | EDA, layered, microkernel, microservices, |
| Database systems | EDA, layered, microservices |
| Context-aware systems | EDA, layered, microservices, SOA |
| Adaptable systems | Microkernel, microservices |
| Enterprise application integration | EDA, microservices, SOA |
| Customer relationship management | EDA, layered, microservices, SOA |
| Information management and decision support system | EDA, layered, SOA |
| Transaction processing | EDA, layered, microservices, SOA |

# Application Type

| Application Type | Associated Architectural Patterns |
|---|---|
| Web application / website with small components | Microservices, SOA |
| Large scale web application like e-commerce or social website development | EDA, layered, microservices, SOA, SBA |
| General desktop application | Layered |
| Application with a simple business logic that does not need to scale out | EDA, layered |
| Enterprise or business application with traditional IT departments and processes | Layered, SOA |
| Application with fixed set of core functionalities and a dynamic set of functionalities that need frequent updates | Microkernel, microservices |
| Large, complex, enterprise-wide systems that require integration with many heterogeneous applications | EDA, microservices, SOA |
| Application with many shared components, particularly components across the enterprise | EDA, microservices, SOA |
| Application with immense and rapidly growing data systems | EDA, microservices, SBA |
| Application with different platforms | Microservices, SOA |
| Application that requires strict standards of testability | Layered |

# Quality Attributes / NFRs

| Quality Attributes / Non-functional Requirements | Associated Architectural Patterns |
|---|---|
| Maintainability | All six |
| Performance / Efficiency | EDA, microservices, SOA, SBA |
| Portability | All six |
| Reliability | All six |
| Security | All six |

# Architectural Knowledge

| Development & Deployment Requirements | Associated Architectural Patterns |
|---|---|
| High ease of development / quick development with fewer developers | Layered, microservices |
| Ease of rewriting and updating parts of the application | EDA, microkernel, microservices, SOA |
| Development teams that are spread out | Microservices |
| Adding special functionality, modules or extensions without modifying the original application | Microkernel, microservices |
| High ease of deployment | Microkernel, microservices |
| Rapid, frequent and independent deployment | Microservices |
| Quick response to a constantly changing environment | EDA, microkernel, microservices, SBA |
| Reusability of integrations and components sharing | EDA, microservices, SOA |

# Architectural Features

| Architectural Features | Associated Architectural Patterns |
|---|---|
| Asynchronous communication / data flow | EDA, layered, microservices, SBA |
| Synchronous communication / data flow | Layered, microkernel, microservices, SOA |
| Loose coupling | EDA, microservices, SOA |
| Independent services | Microservices |
| Separation of concerns | Layered, microkernel, microservices, SOA |
| Plug-in components | Microkernel |
| Dynamic composition | EDA, microkernel, SOA, SBA |
| High volume data | EDA, microservices, SBA |

# Architectural Pattern Application

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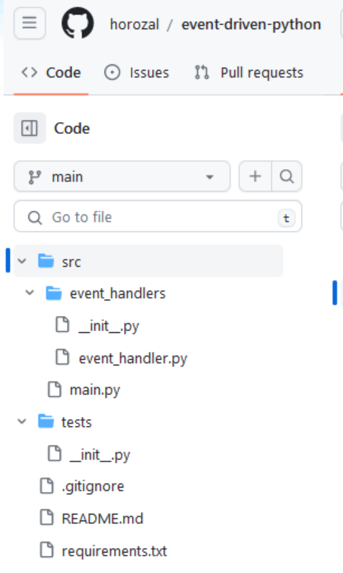
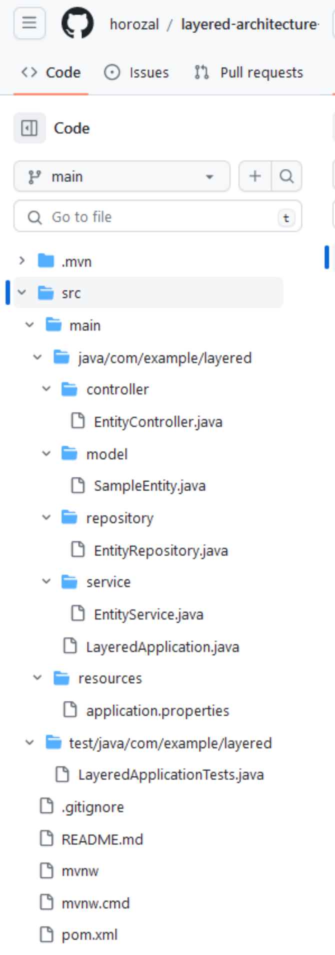
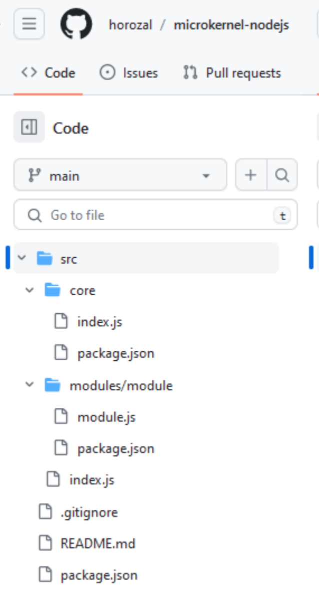
- **18 GitHub repository templates**
  - Frameworks: Java Spring Node.js Python
  - Template for each architectural pattern & framework



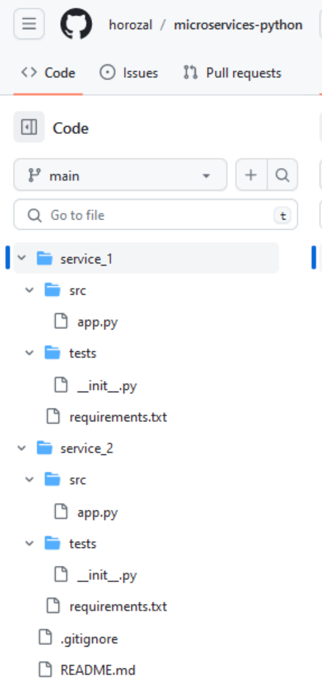
```
horozal / event-driven-python
Code  Issues  Pull requests
Code
main
Go to file
src
  event_handlers
    __init__.py
    event_handler.py
  main.py
tests
  __init__.py
.gitignore
README.md
requirements.txt
```



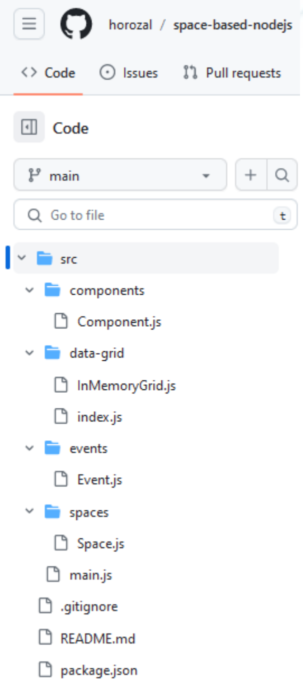
```
horozal / layered-architecture
Code  Issues  Pull requests
Code
main
Go to file
.mvn
src
  main
    java/com/example/layered
      controller
        EntityController.java
      model
        SampleEntity.java
      repository
        EntityRepository.java
      service
        EntityService.java
      LayeredApplication.java
    resources
      application.properties
  test/java/com/example/layered
    LayeredApplicationTests.java
.gitignore
README.md
mvnw
mvnw.cmd
pom.xml
```



```
horozal / microkernel-nodejs
Code  Issues  Pull requests
Code
main
Go to file
src
  core
    index.js
    package.json
  modules/module
    module.js
    package.json
  index.js
.gitignore
README.md
package.json
```

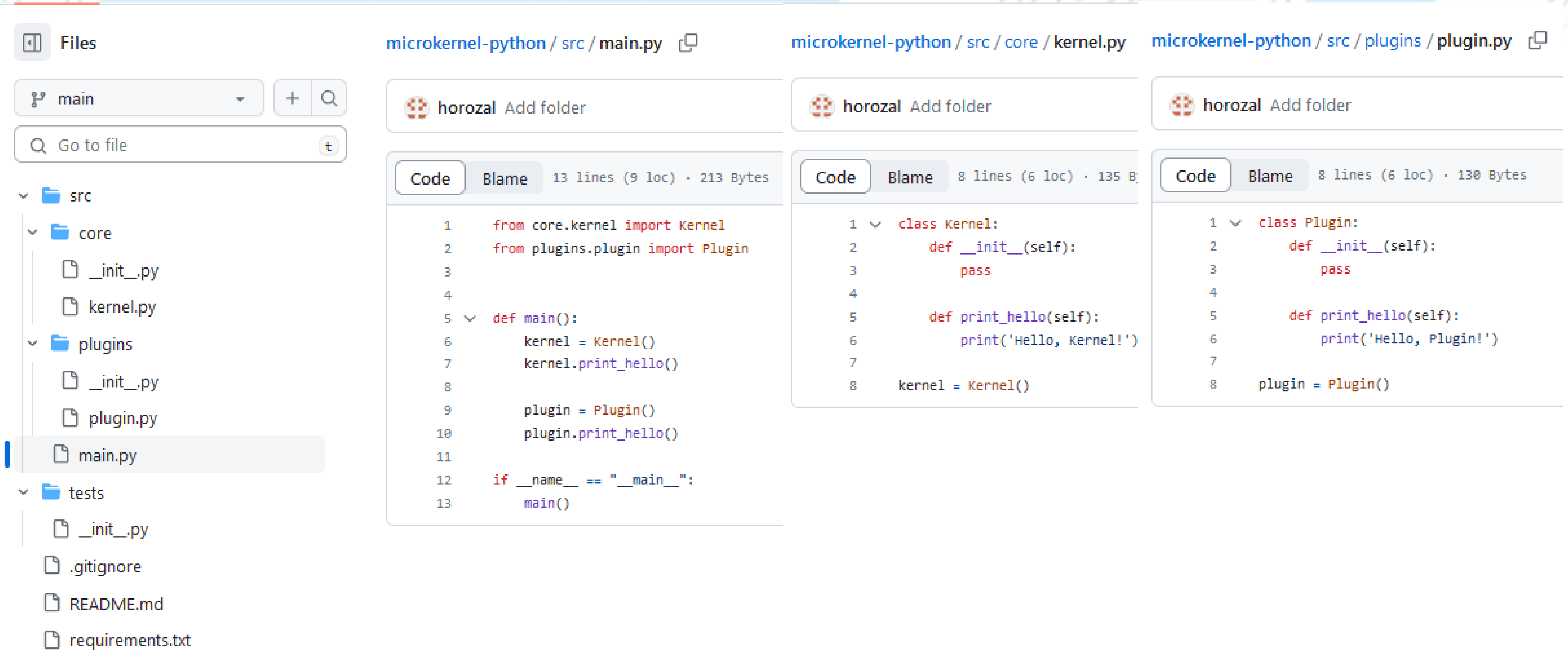


```
horozal / microservices-python
Code  Issues  Pull requests
Code
main
Go to file
service_1
  src
    app.py
  tests
    __init__.py
  requirements.txt
service_2
  src
    app.py
  tests
    __init__.py
  requirements.txt
.gitignore
README.md
```



```
horozal / space-based-nodejs
Code  Issues  Pull requests
Code
main
Go to file
src
  components
    Component.js
  data-grid
    InMemoryGrid.js
    index.js
  events
    Event.js
  spaces
    Space.js
  main.js
.gitignore
README.md
package.json
```

# Repository Templates



microkernel-python / src / main.py

horozal Add folder

Code Blame 13 lines (9 loc) · 213 Bytes

```python
from core.kernel import Kernel
from plugins.plugin import Plugin


def main():
    kernel = Kernel()
    kernel.print_hello()

    plugin = Plugin()
    plugin.print_hello()

if __name__ == "__main__":
    main()
```

microkernel-python / src / core / kernel.py

horozal Add folder

Code Blame 8 lines (6 loc) · 135 By

```python
class Kernel:
    def __init__(self):
        pass

    def print_hello(self):
        print('Hello, Kernel!')

kernel = Kernel()
```

microkernel-python / src / plugins / plugin.py

horozal Add folder

Code Blame 8 lines (6 loc) · 130 Bytes

```python
class Plugin:
    def __init__(self):
        pass

    def print_hello(self):
        print('Hello, Plugin!')

plugin = Plugin()
```

# Implementation

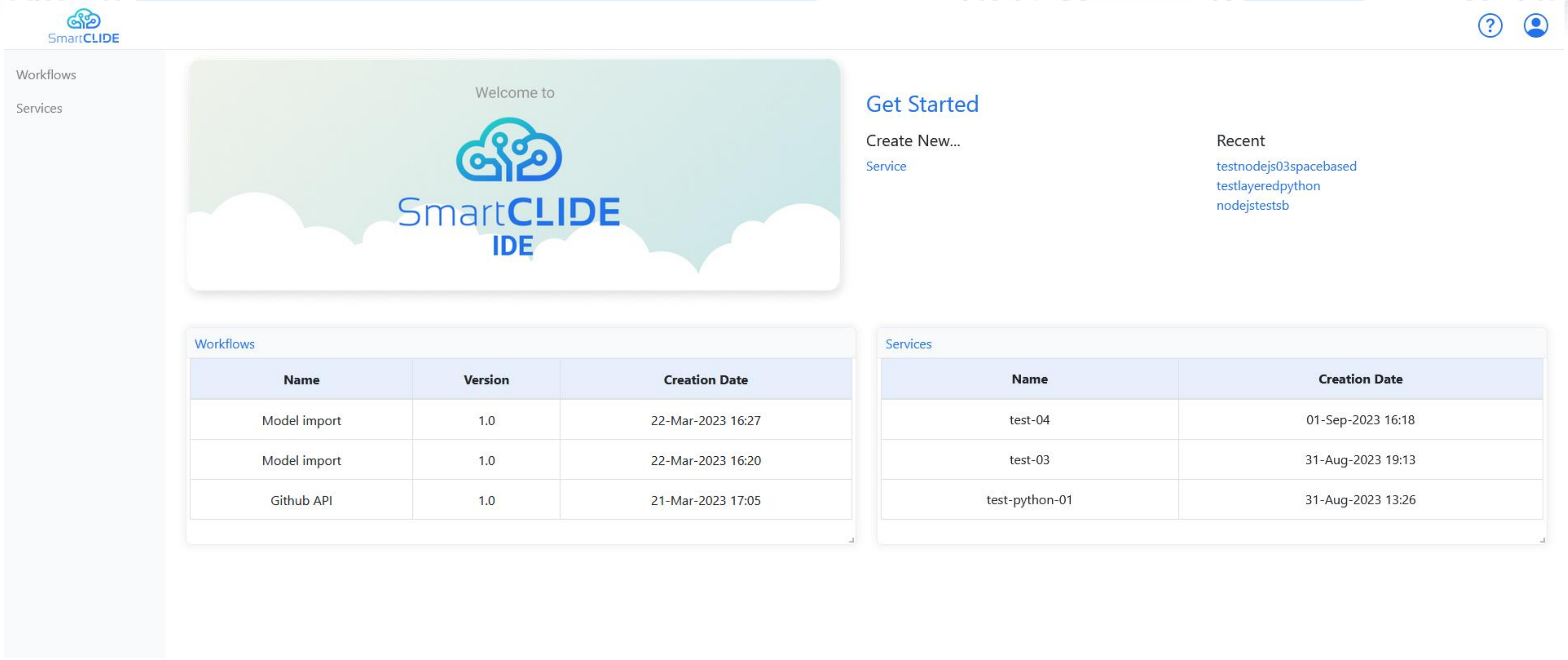
- **Backend REST API in Java Spring**
  - Retrieve survey content
  - Select architectural pattern
  - Select repository template
- **Independent of survey content & evaluation values**
  - JSON format for survey content & evaluation values
  - Reconfigurable

# SmartCLIDE Project

- **H2020 EU-funded project (2020-2023)**
  - https://smartclide.eu/
- **Novel cloud-native IDE**
  - https://ide.che.smartclide.eu/
  - Based on Eclipse Theia
  - Life cycle support (development, testing, deployment, run-time)
  - Collaborative discovery, creation, composition, testing, deployment of services in the cloud
  - Source code monitoring
  - CI/CD integration
- **4 industry pilots for validation & assessment**
  - Real-time communication platform (Wellness Telecom, Spain)
  - Social security application (Netcompany-Intrasoft, Luxembourg)
  - IoT web catalog (Unparallel, Portugal)
  - Project management solution (CONTACT Software, Germany)
- **Open sourced under Eclipse Foundation**
  - Eclipse OpenSmartCLIDE

SmartCLIDE

# SmartCLIDE IDE



Get Started

Create New...

Service

Recent

testnodejs03spacebased

testlayeredpython

nodejstestsb

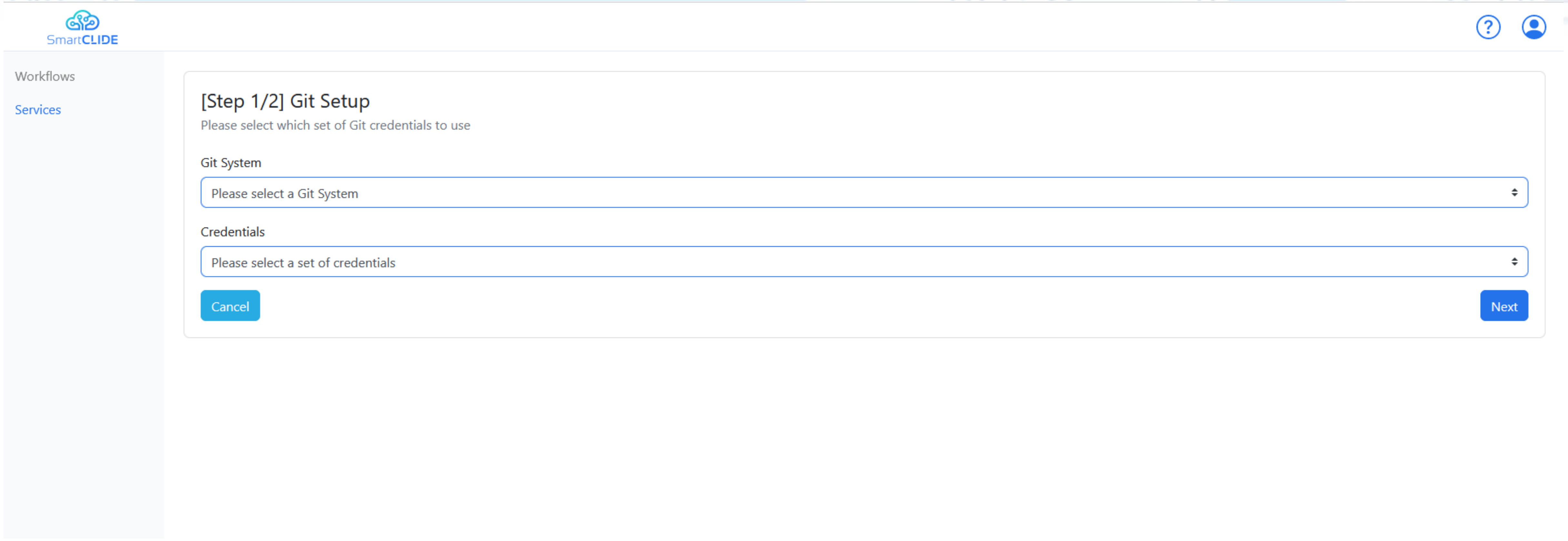
Workflows

| Name | Version | Creation Date |
|---|---|---|
| Model import | 1.0 | 22-Mar-2023 16:27 |
| Model import | 1.0 | 22-Mar-2023 16:20 |
| Github API | 1.0 | 21-Mar-2023 17:05 |

Services

| Name | Creation Date |
|---|---|
| test-04 | 01-Sep-2023 16:18 |
| test-03 | 31-Aug-2023 19:13 |
| test-python-01 | 31-Aug-2023 13:26 |

# SmartCLIDE IDE



[Step 1/2] Git Setup

Please select which set of Git credentials to use

Git System: Please select a Git System

Credentials: Please select a set of credentials

# SmartCLIDE IDE

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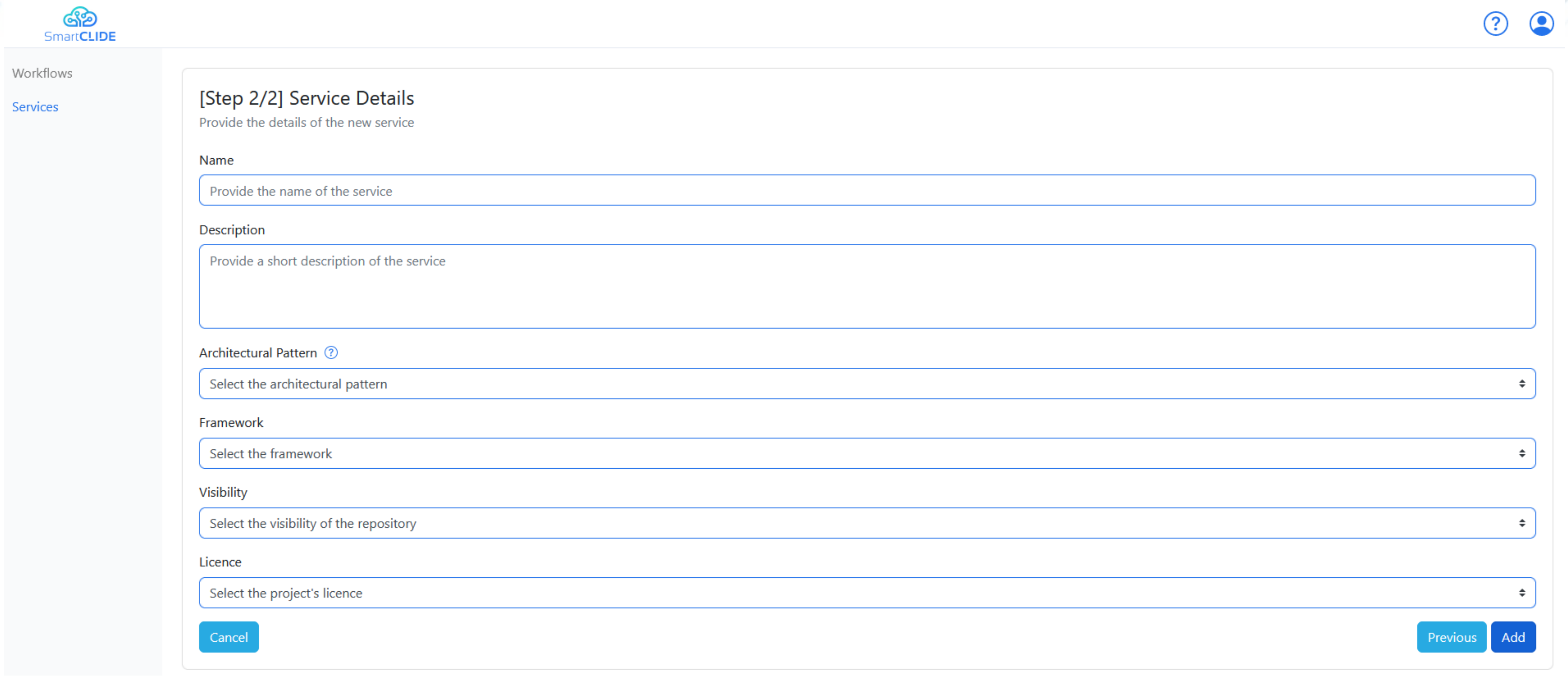

SmartCLIDE

Workflows

Services

[Step 2/2] Service Details

Provide the details of the new service

Name

Provide the name of the service

Description

Provide a short description of the service

Architectural Pattern

Select the architectural pattern

Framework

Select the framework

Visibility

Select the visibility of the repository

Licence

Select the project's licence

Cancel

Previous Add

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# Architectural Pattern Selection in SmartCLIDE IDE

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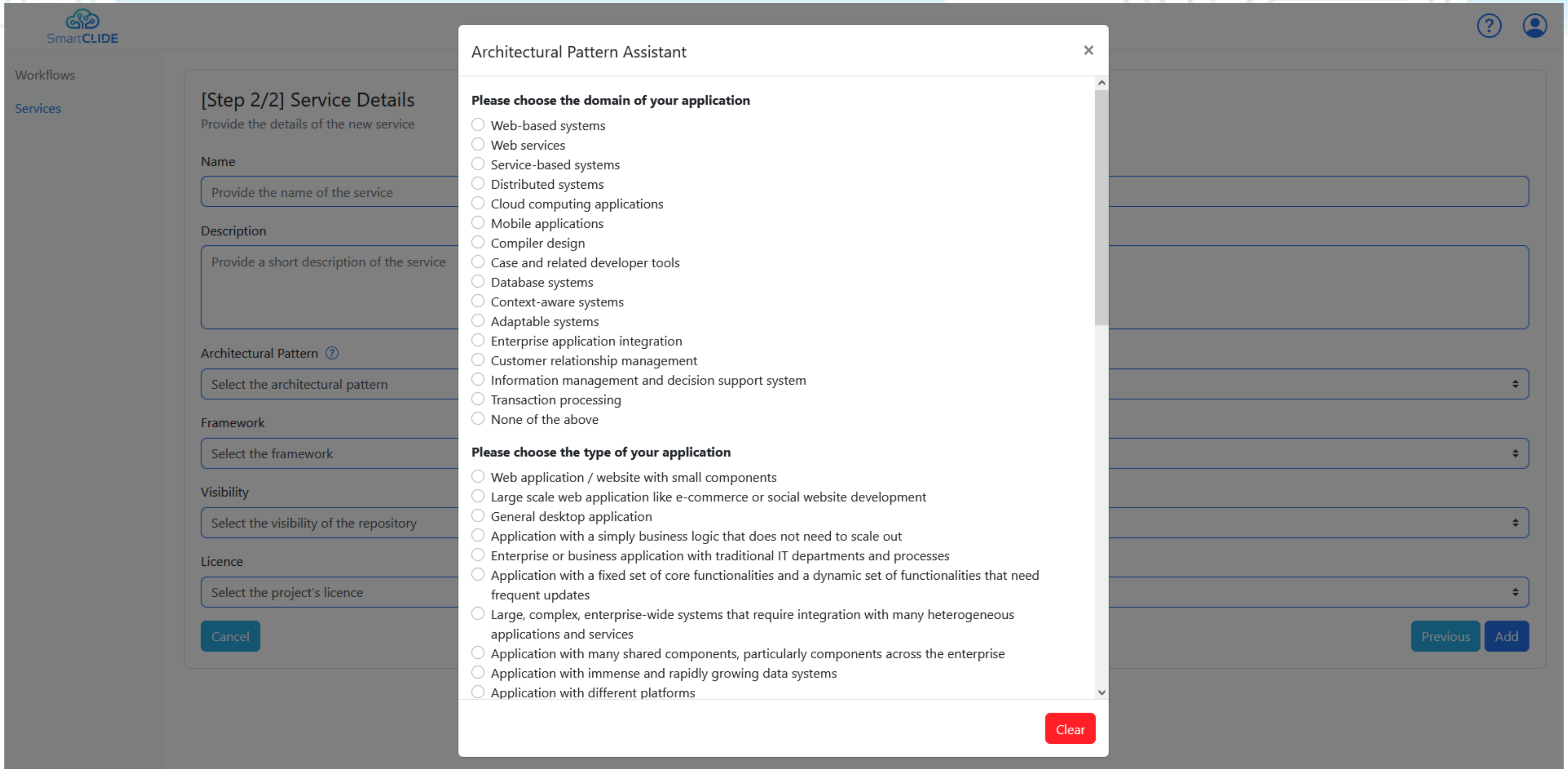
SmartCLIDE
Workflows
Services
[Step 2/2] Service Details
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Architectural Pattern
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Cancel
Previous
Add
Clear

Architectural Pattern Assistant

**Please choose the domain of your application**

- ◯ Web-based systems
- ◯ Web services
- ◯ Service-based systems
- ◯ Distributed systems
- ◯ Cloud computing applications
- ◯ Mobile applications
- ◯ Compiler design
- ◯ Case and related developer tools
- ◯ Database systems
- ◯ Context-aware systems
- ◯ Adaptable systems
- ◯ Enterprise application integration
- ◯ Customer relationship management
- ◯ Information management and decision support system
- ◯ Transaction processing
- ◯ None of the above

**Please choose the type of your application**

- ◯ Web application / website with small components
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- ◯ Application with a simply business logic that does not need to scale out
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- ◯ Application with a fixed set of core functionalities and a dynamic set of functionalities that need frequent updates
- ◯ Large, complex, enterprise-wide systems that require integration with many heterogeneous applications and services
- ◯ Application with many shared components, particularly components across the enterprise
- ◯ Application with immense and rapidly growing data systems
- ◯ Application with different platforms

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# Architectural Pattern Selection in SmartCLIDE IDE

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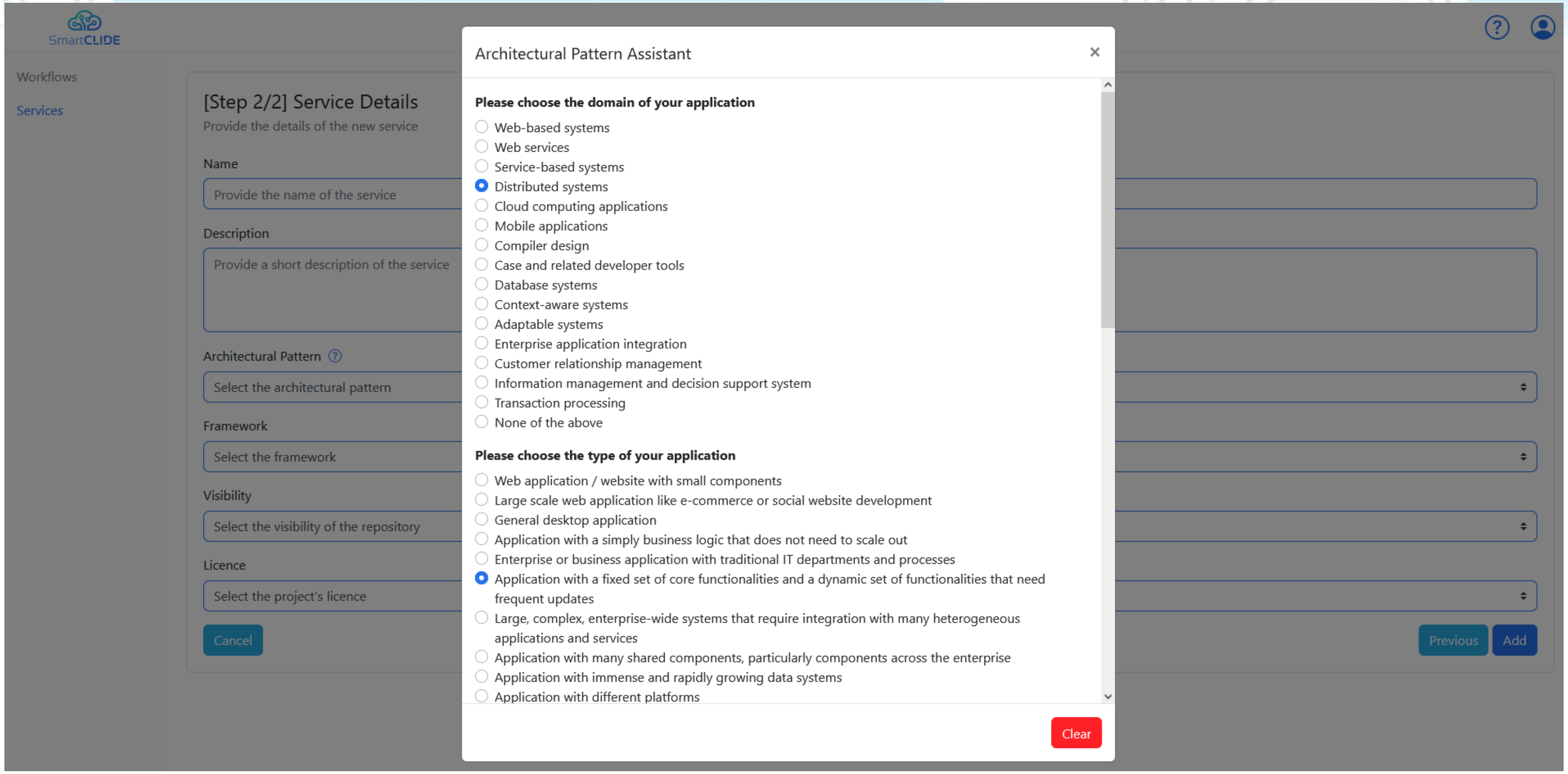

[Step 2/2] Service Details
Provide the details of the new service

Name: Provide the name of the service

Description: Provide a short description of the service

Architectural Pattern: Select the architectural pattern

Framework: Select the framework

Visibility: Select the visibility of the repository

Licence: Select the project's licence

Architectural Pattern Assistant

**Please choose the domain of your application**

- Web-based systems
- Web services
- Service-based systems
- [✓ Distributed systems]
- Cloud computing applications
- Mobile applications
- Compiler design
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- Adaptable systems
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# Architectural Pattern Selection in SmartCLIDE IDE

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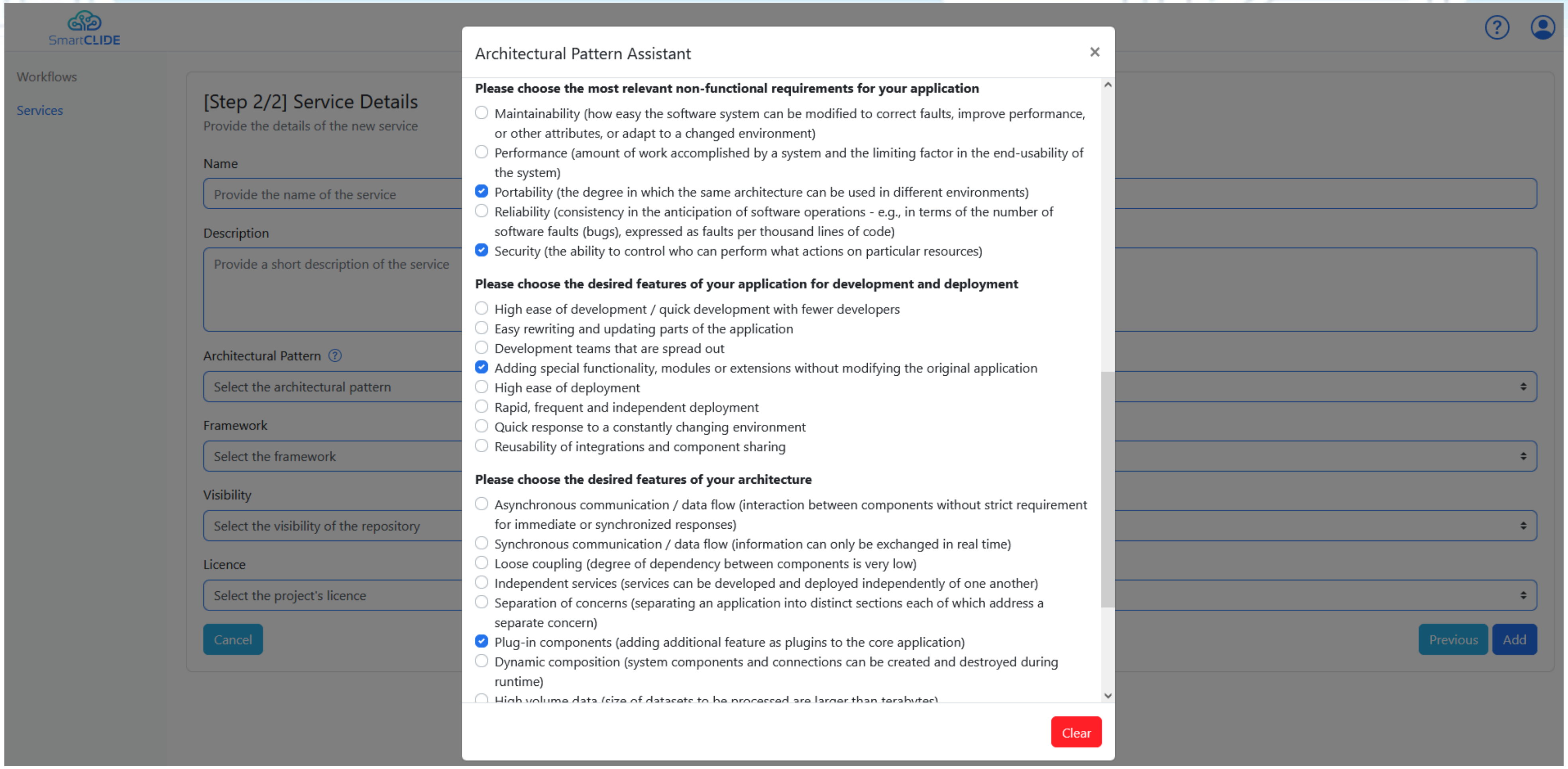

[Step 2/2] Service Details
Provide the details of the new service

Name
Provide the name of the service

Description
Provide a short description of the service

Architectural Pattern
Select the architectural pattern

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Select the framework

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Select the visibility of the repository

Licence
Select the project's licence

Architectural Pattern Assistant

**Please choose the most relevant non-functional requirements for your application**

- ☐ Maintainability (how easy the software system can be modified to correct faults, improve performance, or other attributes, or adapt to a changed environment)
- ☐ Performance (amount of work accomplished by a system and the limiting factor in the end-usability of the system)
- ☑ Portability (the degree in which the same architecture can be used in different environments)
- ☐ Reliability (consistency in the anticipation of software operations - e.g., in terms of the number of software faults (bugs), expressed as faults per thousand lines of code)
- ☑ Security (the ability to control who can perform what actions on particular resources)

**Please choose the desired features of your application for development and deployment**

- ☐ High ease of development / quick development with fewer developers
- ☐ Easy rewriting and updating parts of the application
- ☐ Development teams that are spread out
- ☑ Adding special functionality, modules or extensions without modifying the original application
- ☐ High ease of deployment
- ☐ Rapid, frequent and independent deployment
- ☐ Quick response to a constantly changing environment
- ☐ Reusability of integrations and component sharing

**Please choose the desired features of your architecture**

- ☐ Asynchronous communication / data flow (interaction between components without strict requirement for immediate or synchronized responses)
- ☐ Synchronous communication / data flow (information can only be exchanged in real time)
- ☐ Loose coupling (degree of dependency between components is very low)
- ☐ Independent services (services can be developed and deployed independently of one another)
- ☐ Separation of concerns (separating an application into distinct sections each of which address a separate concern)
- ☑ Plug-in components (adding additional feature as plugins to the core application)
- ☐ Dynamic composition (system components and connections can be created and destroyed during runtime)
- ☐ High volume data (size of datasets to be processed are larger than terabytes)

# Architectural Pattern Selection in SmartCLIDE IDE

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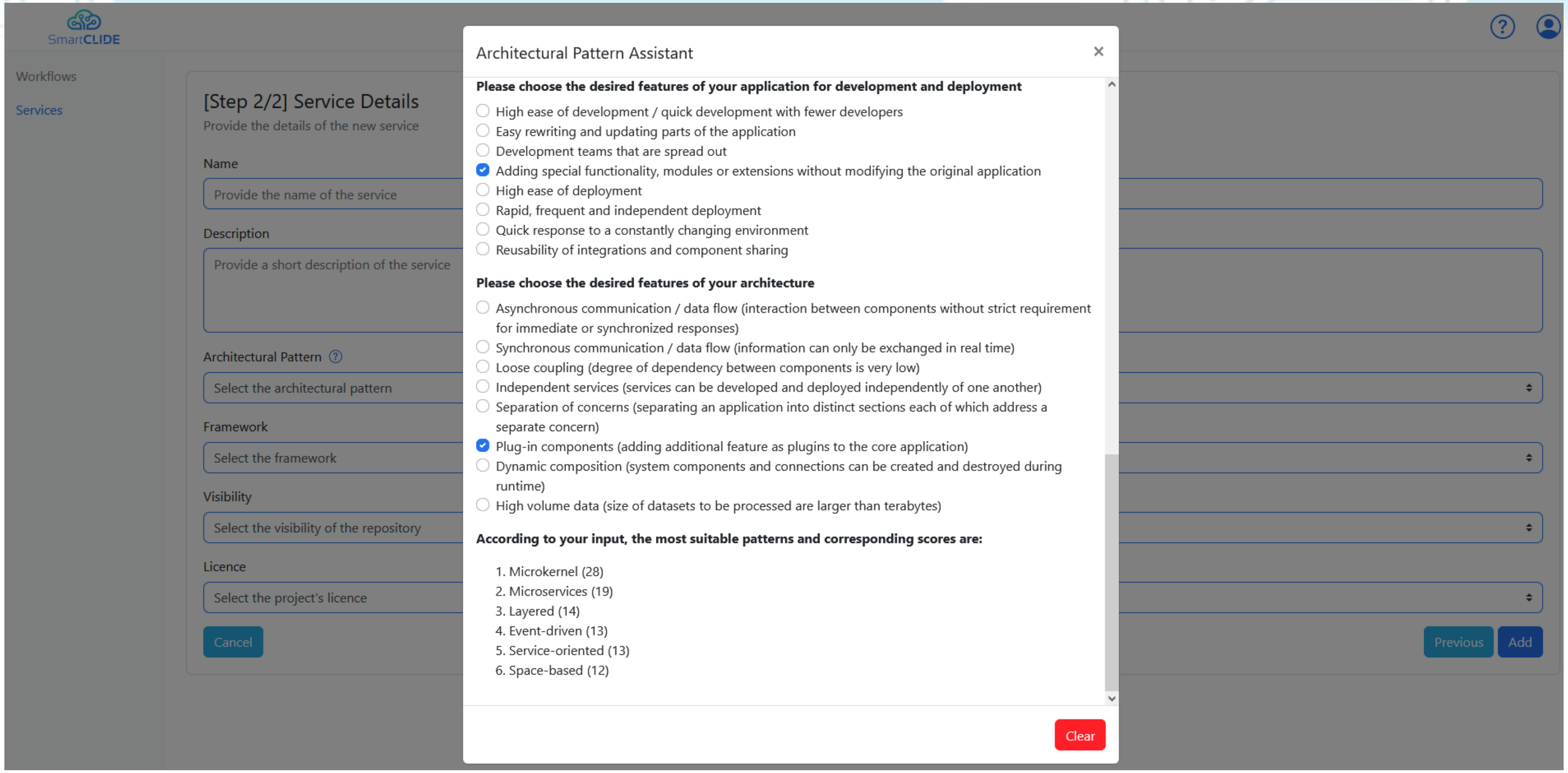
SmartCLIDE
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Select the framework
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Cancel
Previous
Add

Architectural Pattern Assistant

**Please choose the desired features of your application for development and deployment**

- [ ] High ease of development / quick development with fewer developers
- [ ] Easy rewriting and updating parts of the application
- [ ] Development teams that are spread out
- [✓] Adding special functionality, modules or extensions without modifying the original application
- [ ] High ease of deployment
- [ ] Rapid, frequent and independent deployment
- [ ] Quick response to a constantly changing environment
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**Please choose the desired features of your architecture**

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- [ ] Separation of concerns (separating an application into distinct sections each of which address a separate concern)
- [✓] Plug-in components (adding additional feature as plugins to the core application)
- [ ] Dynamic composition (system components and connections can be created and destroyed during runtime)
- [ ] High volume data (size of datasets to be processed are larger than terabytes)

**According to your input, the most suitable patterns and corresponding scores are:**

1. Microkernel (28)
2. Microservices (19)
3. Layered (14)
4. Event-driven (13)
5. Service-oriented (13)
6. Space-based (12)

Clear

# Architectural Pattern Selection in SmartCLIDE IDE

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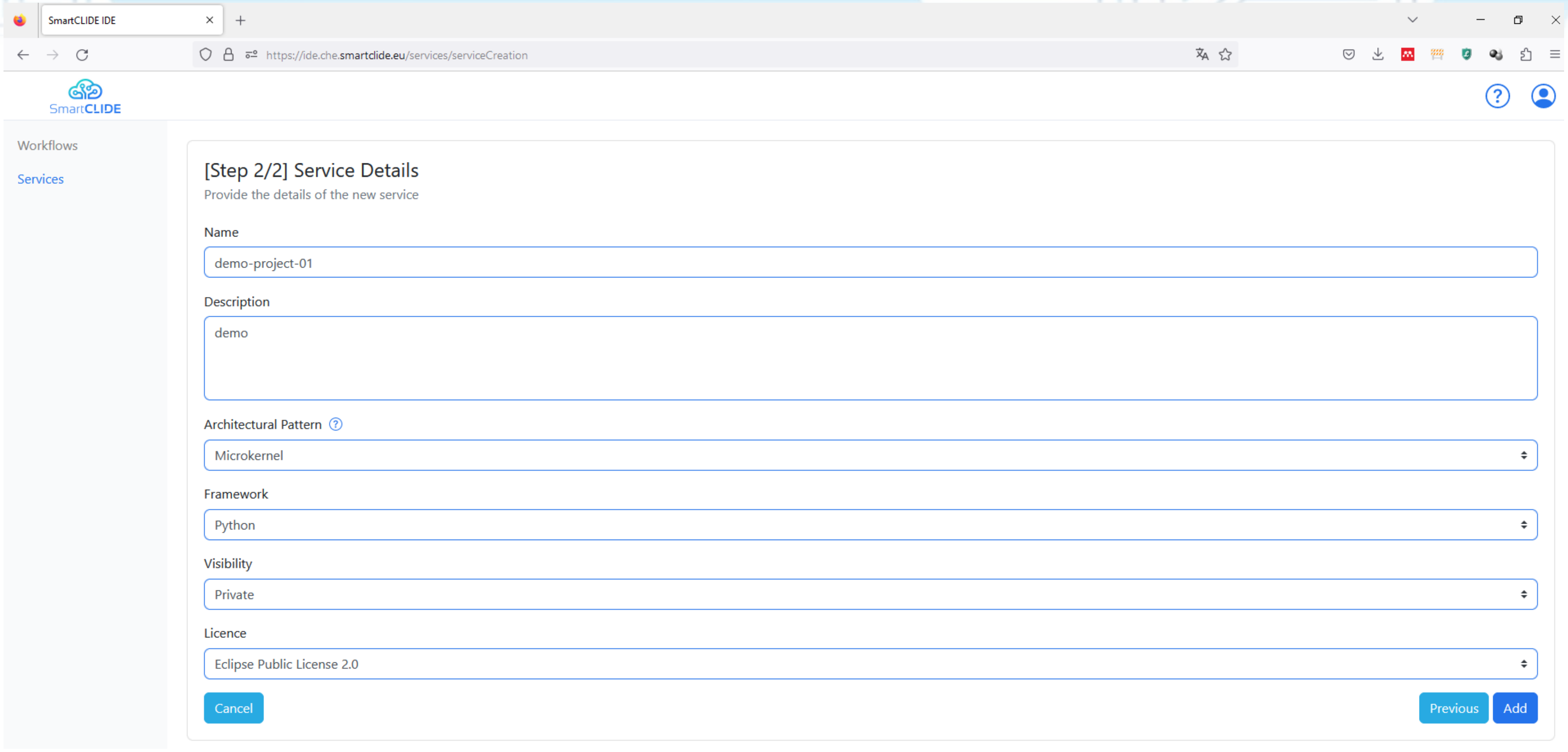

[Step 2/2] Service Details

Provide the details of the new service

Name: demo-project-01

Description: demo

Architectural Pattern: Microkernel

Framework: Python

Visibility: Private

Licence: Eclipse Public License 2.0

Oct. 17, 2023

Ludwigsburg, Germany

## Future Work

- Increase # of patterns supported
- Support pattern combinations
- Improve survey content & evaluation
- Add explanation to pattern suggestions
- Add alternative structures to repository templates

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## on Cloud to Edge Continuum

SmartCLIDE

https://ide.che.smartclide.eu/

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Organized by:

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