MORPHEMIC

Use cases definition and preparation

Modelling and Orchestrating heterogeneous Resources and Polymorphic applications for Holistic Execution and adaptation of Models In the Cloud

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Executive summary

This deliverable outlines the design of the use cases scenarios, including their description, the scenario requirements and targets, the infrastructures and platforms that will be utilized.
In this report, different scenarios are outlined explaining how MORPHEMIC will handle each individual use case within the project. This includes both the detailed descriptions of the requirements and the required technology / offerings of MORPHEMIC. We outline the methodological approach that was taken in this project in the development and description of the use cases scenarios. We also describe the primary MORPHEMIC usage scenarios and the use cases level scenarios. The primary audience of this document are the technical partners and the use case owners. Another audience are the target users and potential customers of all the implemented use cases in their respective application domains (i.e., 5G, brain imaging, and computational fluid dynamics). A wider communication will be accomplished by using our document as a foundation for the user guides which will be developed for each community based on the case studies provided. Moreover, the deliverable is important for technical audiences, including platform administrators, application developers, testers, etc., since it provides requirements and scenarios that can be utilized to build validation tests for the MORPHEMIC outcomes and identify their added value in different contexts.

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20/09/2021	3.1	ISW	PMB reading 2nd review

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Glossary

Acronyms	
AI	Artificial Intelligence
CAMEL	Cloud Application Model Language
CAPEX	Capital Expenditures
CFD	Computational Fluid Dynamics
COTS	Commercial Of-the-Shelve
CP	Control Plane
CPU	Central Processing Unit
CTO	Chief Technology Officer
CU	Central Unit
CU-CP	Central Unit – Control Plane
CU-UP	Central Unit – User Plane
DPDK	Data Plane Development Kit
DTI	Diffusion Tensor Imaging
DU	Data Unit
DWI	Diffusion-Weighted Imaging
FPGA	Field Programmable Gate Array
GPU	Graphics Processing Unit
HPC	High Performance Computing
MAC	Media Access Control
ML	Machine Learning
MNO	Mobile Network Operators
MRI	Magnetic Resonance Imaging
MVNO	Mobile Virtual Network Operators
NFS	Network File System
NFV	Network Function Virtualization
OS	Operating System
OPEX	Operating Expenses
PDCP	Packet Data Convergence Protocol
PHY	Physical Layer
QoS	Quality of Service
QoE	Quality of Experience
RAN	Radio Access Network
RIC	Radio Intelligent Controller
RF	Radio Frequency
RLC	Radio Link Control
RRC	Radio Resource Control
RU	Radio Unit
SDAP	Service Data Adaptation Protocol
SDN	Software Defined Network
SD-RAN	Software Defined - RAN
SLA	Service Level Agreement
SPM	Statistical Parametric Mapping
UI	User Interface
VM	Virtual Machine
VNF	Virtualized Network Function
vRAN	Virtualized RAN

1 Introduction

1.1 Purpose of the document

This deliverable outlines the design of the use cases scenarios, including their description, the scenario requirements and targets, the infrastructures and platforms that will be incorporated. The use case scenarios target various application areas such as 5G software defined networks, brain medical imaging, and computational fluid dynamics.

1.2 Scope

The MORPHEMIC platform brings a significant change in the way applications are deployed and managed, offering users incredible value. By introducing polymorphic architecture adaptation and proactive adaptation, MORPHEMIC offers a novel solution for adapting and optimizing Cloud Computing applications. MORPHEMIC extends a state-of-the-art modelling language CAMEL to allow for the flexible, provider-independent modelling of cloud applications at various abstraction levels, covering big data and network aspects, as well as any type of resource, platform, or service (including both cloud & edge resources and services). This document defines the use case (deployment, application) through these scenarios, the developed platform will be able to demonstrate their broad applicability.

The content of this document, the use cases and the scenarios are directly linked to the following MORPHEMIC features:

Table 1 - List of Features

Feature Id	Feature Name
Feature 1	Polymorphic adaptation
Feature 2	Proactive adaptation
Feature 3	Self-healing capabilities
Feature 4	Hardware accelerators support
Feature 5	Security concepts
Feature 6	Unified User Interface

Additionally, these descriptions will cover the following topics:

Table 2 - List of Activities

Activities Id	Activities Name
Activities:1	Use case applications adaptation
Activities:2	Use case applications validation
Activities:3	Scientific dissemination
Activities:4	Industry communication

1.3 Outline

Deliverable structure: In this deliverable, different scenarios are outlined explaining how MORPHEMIC will handle each individual use case within the project. This will include both detailed descriptions of the requirements and required technology.

In details:

- **Chapter 2** presents briefly the three use cases of the project and outlines the process for preparing use cases scenarios, including the definition of the primary MORPHEMIC usage scenarios used to interpret more complex use cases.
- **Chapter 3** contains templates for more detailed descriptions of use case scenarios in narrative form or sequence diagrams.
- **Chapter 4** discusses the detailed, step-by-step MORPHEMIC usage scenarios: modelling, polymorphic deployment, proactive adaptation.

- In the **chapter 5** we cover the use case scenarios in greater detail, including application domain, business needs, business performance and key performance indicators, application to be deployed, use case scenario roles, use case scenario definition.
- In **chapter 6**, an overview of target infrastructure is presented for the validation and future production based on the use case requirements
- In **chapter 7**, the requirements provided earlier in D6.1 Industrial requirements analysis are linked with the MORPHEMIC usage scenarios and use case scenarios.
- Finally, **chapter 8** conclusions are provided along with future steps.

1.4 Target audience

The deliverable is beneficial for technical audiences, including platform administrators, application developers, testers, etc., since it provides requirements and scenarios that can be utilized to build validation tests for the platform.
The other audience of this document is target users and potential customers of all the implemented use cases in their respective application domains (5G, brain imaging, and computational fluid dynamics). Note that, to reach this audience, the related part of the deliverable will be converted to guides.

2 Use case scenario preparation

2.1 Use cases owners

MORPHEMIC was defined in the context of three use cases that were introduced in D6.1. Here we extend the definition of these use cases to show how they interact with the MOPHEMIC platform.

The three use cases highlight a broad range of potential scenarios across multiple application domains. The use cases considered are:

1. **Virtualized base station for 5G cloud-RAN**, proposed by **IS-Wireless**. IS-Wireless is a leader in the development of algorithms, protocols and tools for 4G and 5G mobile networks. IS-Wireless provides licensable, NFV-compatible (*Network Function Virtualization*) software implementing standard-compliant RAN (Radio Access Network) protocols ready for evolution to 5G.
2. **E-Brain Science**, proposed by **Centre Hospitalier Universitaire Vaudois** (**CHUV**). CHUV is one of the five Swiss University hospitals. Specifically, the use case can be applied to the work of the *Laboratoire de recherche en neuroimagerie* (LREN), which consists of a cross-disciplinary team of basic and clinical neuroscientists with an interest in the role of human brain structure and function in neurological disorders and healthy aging.
3. **Computational Fluid Dynamic Simulation**, proposed by **ICON**. ICON Technology & Process Consulting Limited operates in the high-tech field of Computational Fluid Dynamics (CFD) and provides blue-chip multi-sector engineering companies, their suppliers and consultants with the ability to predict fluid flow using 3D computer simulation.

2.2 Use cases scenarios process

Analysis of requirements that were collected previously, combined with a discussion about the business needs and challenges expressed by the users involved in the use cases, led to the creation of **MORPHEMIC usage scenarios** and the use case scenarios. MORPHEMIC's usage scenarios illustrate the various ways in which the platform can be used, and help to clarify the more complex **use case scenarios**.

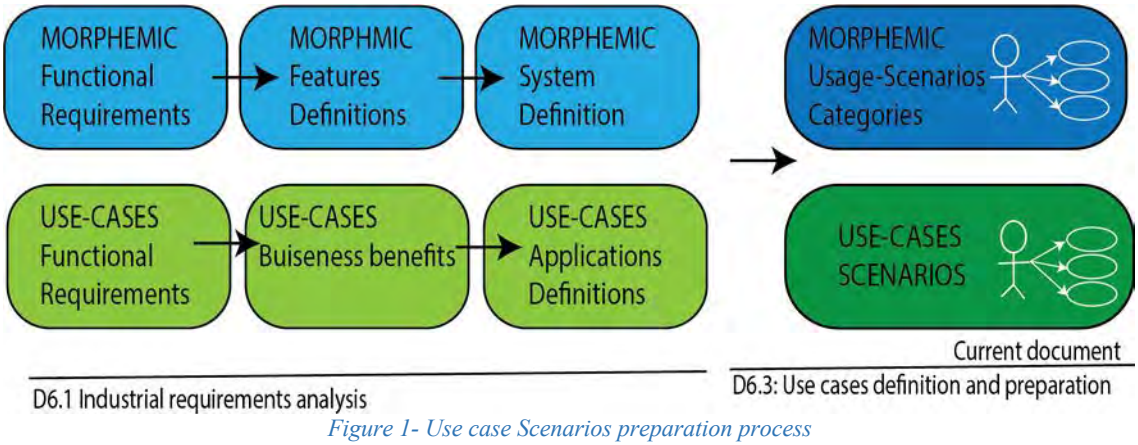


Figure 1- Use case Scenarios preparation process

MORPHEMIC's use case scenarios underscore the benefits it brings to the European industry in healthcare, 5G, and industrial engineering. Some of these benefits include:

- Through the deployment of multiple clouds, it is possible to expand and scale applications, resulting in low cloud costs by preventing vendor lock-in.
- The automatic configuration of an application enhances its reliability and maintains service levels while improving its robustness.
- Adaptive application provisioning reduces the administration workload and costs associated with managing applications, as well as increasing automation.

The table below shows the overall objectives for each use case and the expected MORPHEMIC value proposition corresponding to them.

Table 3- Use case objectives and corresponding expected MORPHEMIC value proposition

	Virtualized base station for 5G cloud-RAN	E-Brain Science	Computational Fluid Dynamics
Industry	Mobile 5G	Medicine	Industrial Engineering
Business benefits and Requirements	Support for orchestration of SD-RAN functions in the context of a mobile cloud-edge environment.	Support for the development of a clinical data analysis system that utilizes machine-learning algorithms for analysing clinical data stored across multiple clinics/hospitals.	Supports the adaptation of computational fluid dynamics calculation to the increase in data and the increase in computing requirements.
MORPHEMIC Value Proposition	Enhance vertical integration and adaptable multiple deployment strategies in order to improve quality of service.	Optimize the utilization of public and private cloud infrastructures in order to ensure strict adherence to privacy principles.	Scaling to the cloud and to the edge enables access to more resources with a lower processing latency.
MORPHEMIC Features and usage Scenarios	**Application modelling** **Polymorphic deployment** **Proactive adaptation**		
Use case scenarios	**Static scenario** to demonstrate static deployment of the RAN	**Image processing scenario** to demonstrates the deployment of complex neuroimaging workflow	**Small - low-fidelity simulations scenario** can be run on single workers with limited resource pool for compute
	Dynamic scenario to demonstrate the automatic modification of the deployment as the context changes	**(Statistical Parametric Mapping) SPM on the web**, Deployment of application for viewing brain models.	**Medium - medium-fidelity simulations scenario** can be run on high core count (16-128) shared-memory machines or on HPC clusters
		Federated machine scenario to demonstrate the running of machine learning application across multiple centres.	**Large - high-fidelity simulations scenario** to demonstrate very demanding application in terms of resources, including memory and network bandwidth and typically require an HPC cluster (128 – 2000+) with high-speed interconnect.

3 Use case scenario design

The definition of the use case scenarios describes the relationship between the users of each use case application and the MORPHEMIC platform in order for them to achieve their goal. The methodology followed here is to describe the users' actions when using the use case applications and the interactions they have with the MORPHEMIC platform before (Modelling), during (Deployment) and after deployment (Adaptation). Thus, we begin by describing the main MORPHEMIC usage scenarios. Composite use case scenarios are then derived from these primary MORPHEMIC usage scenarios.

3.1 Design of MORPHEMIC usage scenarios

MORPHEMIC usage scenarios are grouped into three main categories: modelling, deployment and adaptation. A sequence diagram, which illustrates the actions within each scenario category, is used to describe how components of the system communicate with each other (Figure 2). In the first group (Modelling Scenarios), the application is described as a collection of the components and resources required. In addition, the description includes the utilities functions and constraints that will be optimized by MORPHEMIC. By combining the CAMEL model and the cloud providers offers in the second stage (Polymorphic deployment scenarios), the applications can be deployed using the dedicated UI and tools of MORPHEMIC. Finally, the last important step (Proactive Adaptation scenarios) consists of managing and adapting the application in a proactive manner.

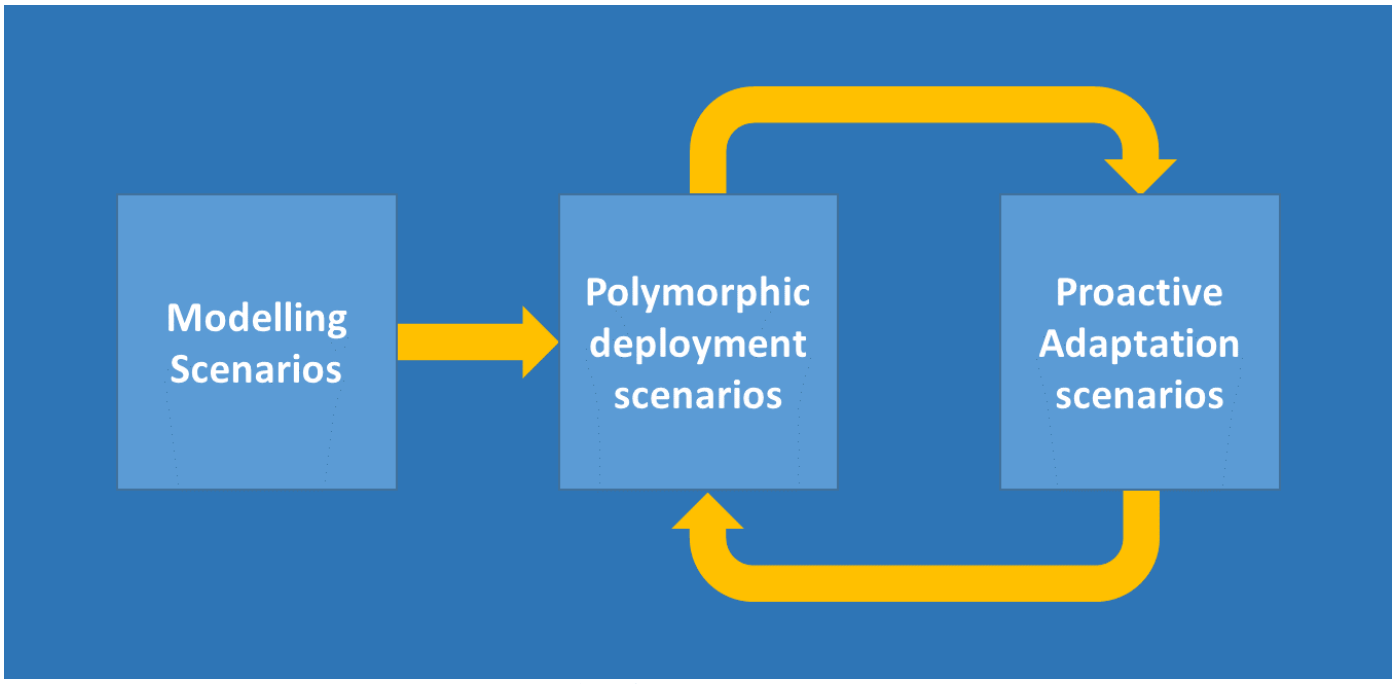


Figure 2 - Flow of MORPHEMIC usage scenarios

In order to describe user actions, we use a use case scenario template, as shown below.

- Use case scenario template, for each use case the following elements will be included:
  - **case ID:** A unique number for identifying each scenario
  - **Name:** The title of the scenario, usually indicative of the main activity.
  - **Actor:** An actor is a user who interacts with a system in order to accomplish a task. They are divided into roles such as Admin, DevOps, Developers, and End Users.
  - **Pre-conditions:** The pre-conditions are requirements which must be met before the scenario can begin.
  - **Post-conditions**: Post-conditions represent the system's state after the scenario has finished.
  - **Steps**: Steps represents the steps taken by the user as she interacts with the system.
  - **Description**: Brief summary of the scenario, including the user's objective and the benefit the user receives.

- **Use case diagram**: Graphical representation of the actions that a user performs as he/she interacts with the system.
- **Relationship**: Dependencies and relation with other scenarios.
- **Requirements**: List of use case and systems requirements.

3.2 Design of Use cases Scenarios

In each of the use cases, we begin by presenting important information about the business environment and the anticipated benefits of using the MORPHEMIC platform. The format of these descriptions is presented in the form of a narrative and a business process diagram. Both methods provide a concise description of the sequence of steps as described in the MORPHEMIC usage scenarios.

3.3 List of the Use cases scenarios and nomenclatures

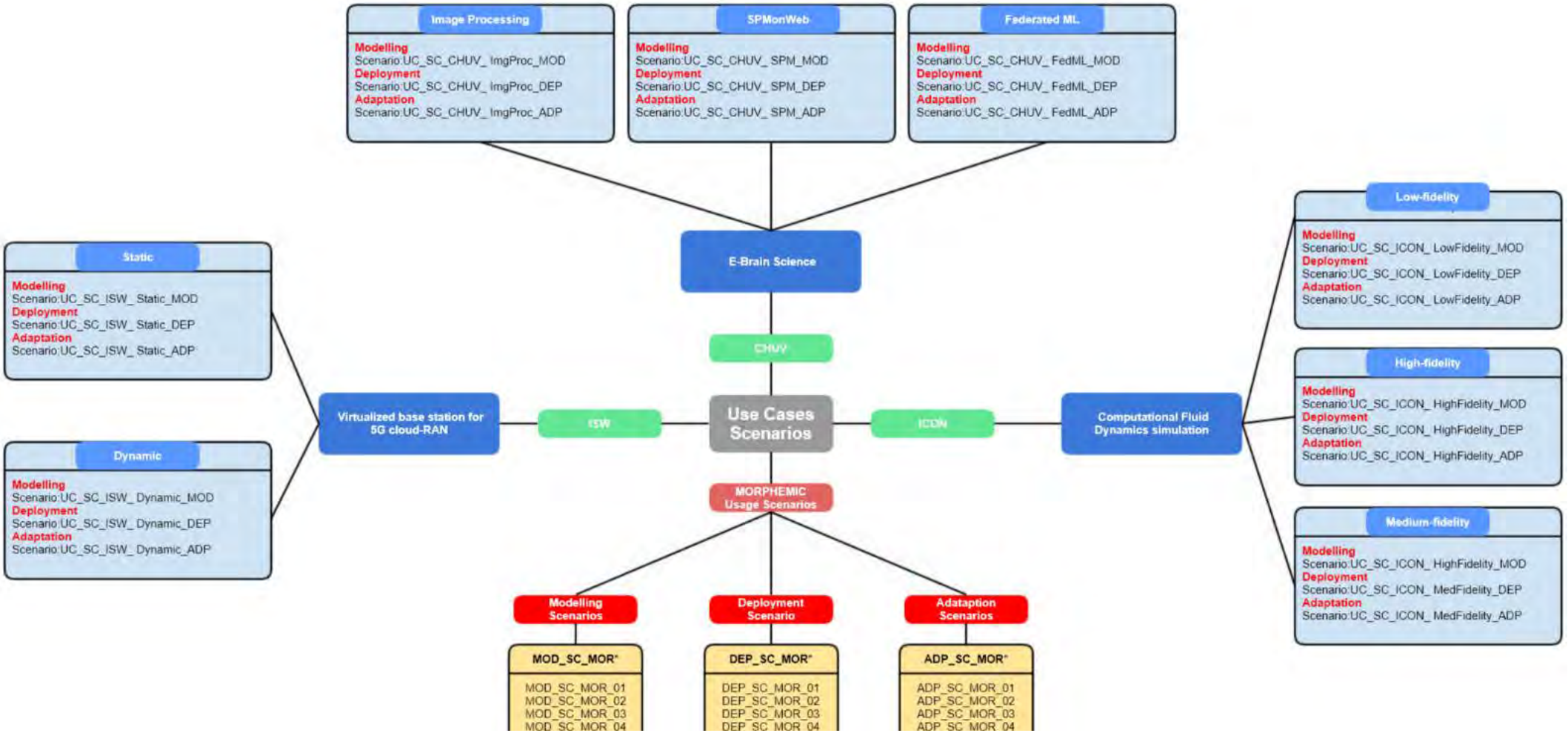


Figure 3 - List of Use Cases scenarios and nomenclatures

4 Use case scenarios definition

4.1 MORPHEMIC Usage: Modelling Scenarios

The modelling scenarios include the steps required to describe the application's components. MOPRPHEMIC utilises Melodic solutions and tools for application modelling, including Cloud Application Modelling and Execution Language (CAMEL). CAMEL enables the modelling of all aspects of multi-cloud application management. From the point of view of the user, the completion of the model includes the execution of a number of sequential steps indicated in the figure below. In the following sections, we will detail each step corresponding to specific scenarios:

- Set CAMEL model Application requirements
- Set CAMEL model Application Metrics and utility Functions
- Set CAMEL model Application constraints
- Export CAMEL model

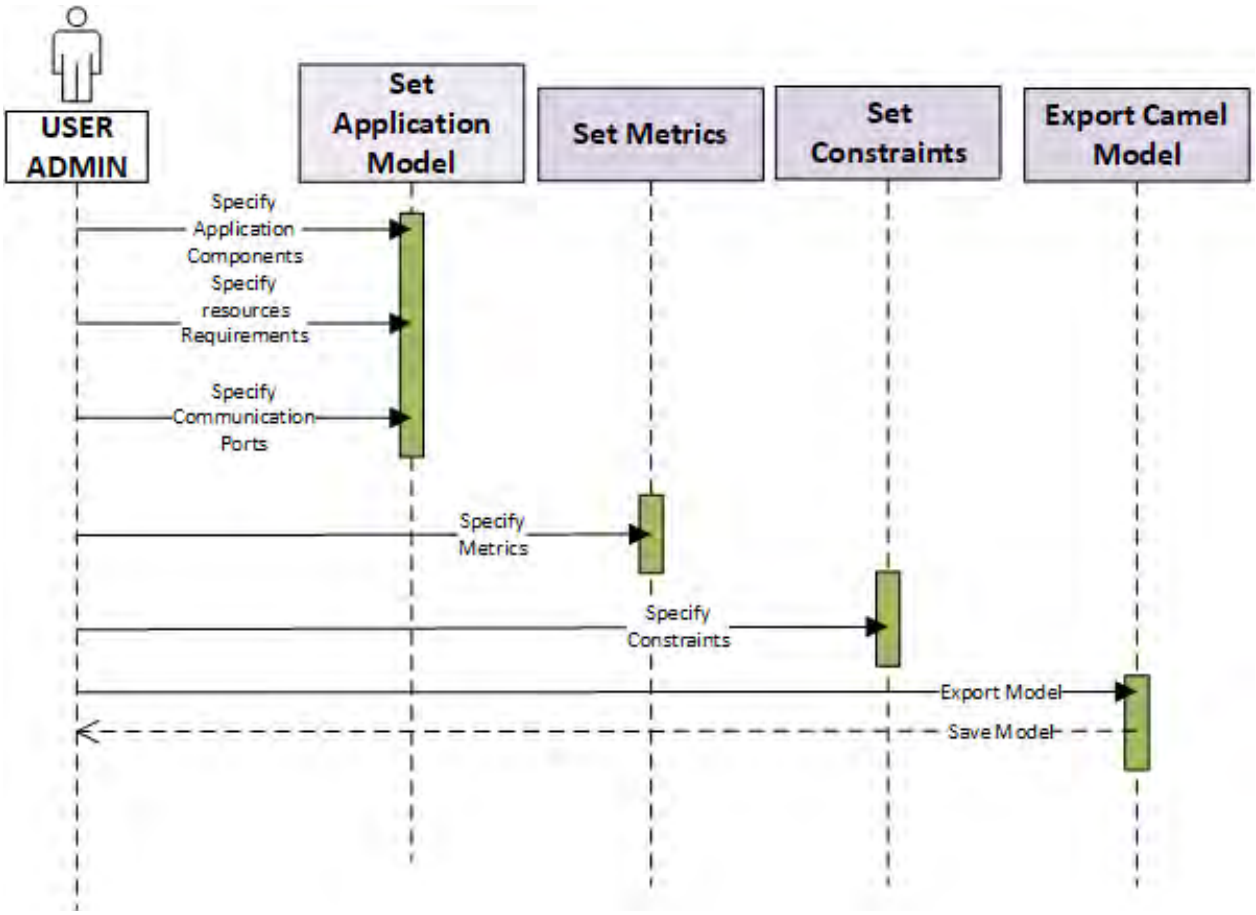


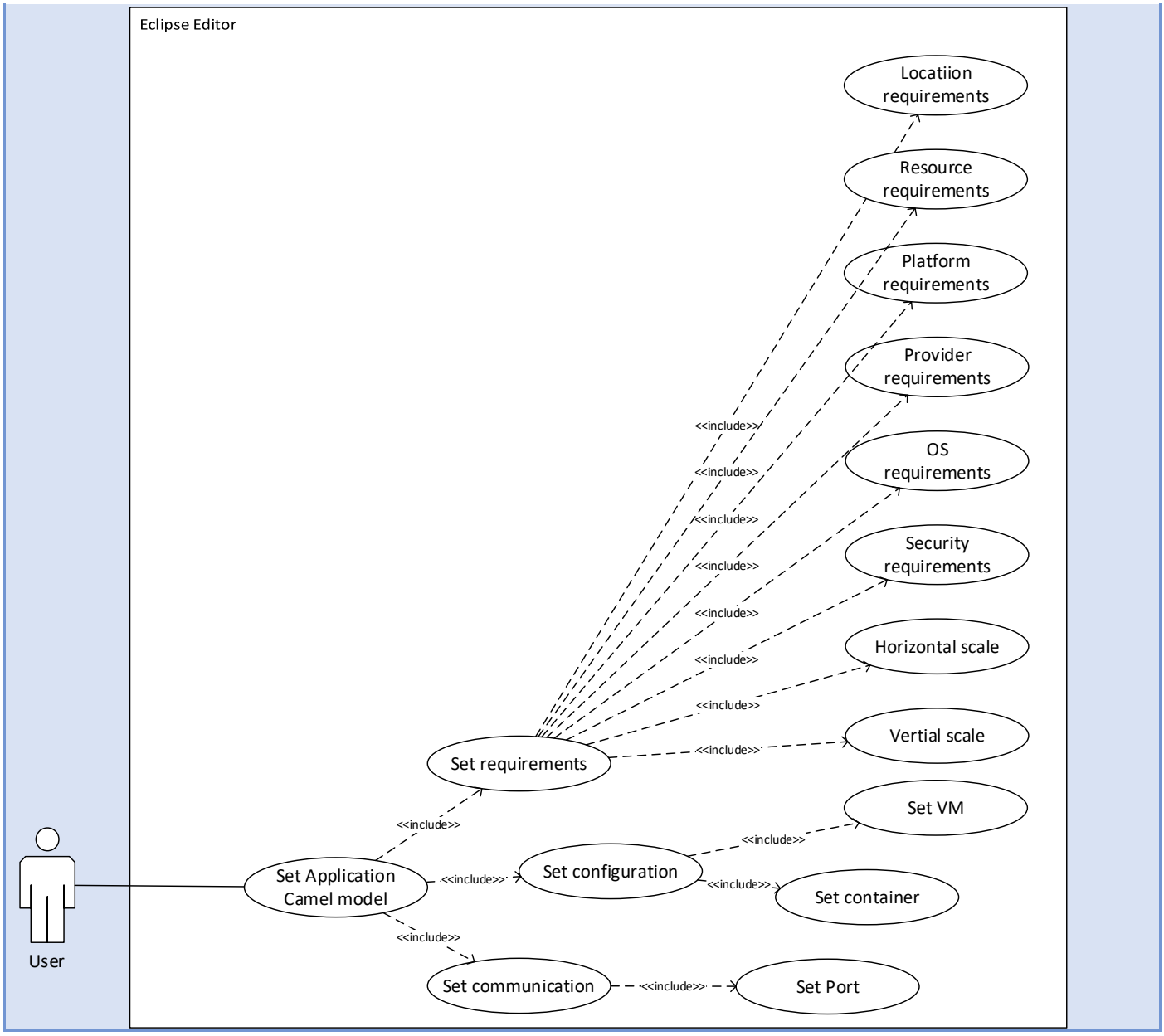
Figure 4 - Modelling Scenarios Sequence Diagram.

The diagram traces the path of steps of the MOPHEMIC usage scenarios related to polymorphic modelling

4.1.1 Scenario 1: Set CAMEL model Application requirements

Table 4 - Modellimg Scenario 1 Definition

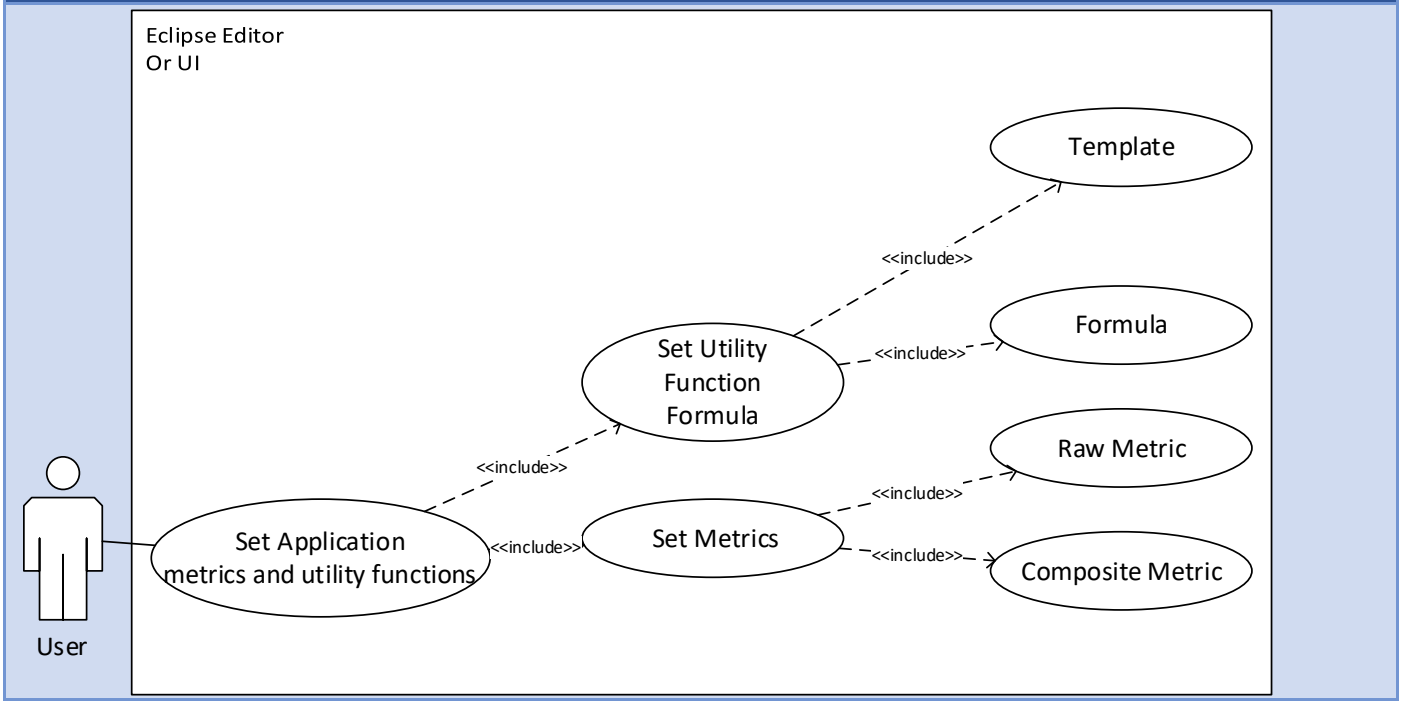
ID	Name	Short description	Relationship
MOD_SC_MOR_01	**Set CAMEL model application requirements**	The user use Eclipse or UI to define the CAMEL model with the application requirements	Included in Modelling scenario
Actors			
Admin			
Pre-condition			
CAMEL Designer			
Post-condition			
CAMEL model updated and saved			
Link to requirements (D6.1)			
Please refer to the requirements tables			
Steps			
- Set application CAMEL model o Set requirements ▪ Location requirements ▪ Resource requirements ▪ Platform requirements ▪ Provider requirements ▪ OS requirements ▪ Security requirements ▪ Horizontal scale ▪ Vertical scale o Set configuration ▪ Set VM ▪ Set container o Set communication ▪ Set port			
Use case diagram			


Eclipse Editor
Locatiion requirements
Resource requirements
Platform requirements
Provider requirements
OS requirements
Security requirements
Horizontal scale
Vertial scale
Set VM
Set container
Set Port
Set requirements
Set Application Camel model
Set configuration
Set communication
User
<<include>>

4.1.2 Scenario 2: Set CAMEL model Application Metrics and utility Functions

Table 5 - Modelling Scenario 2 Definition

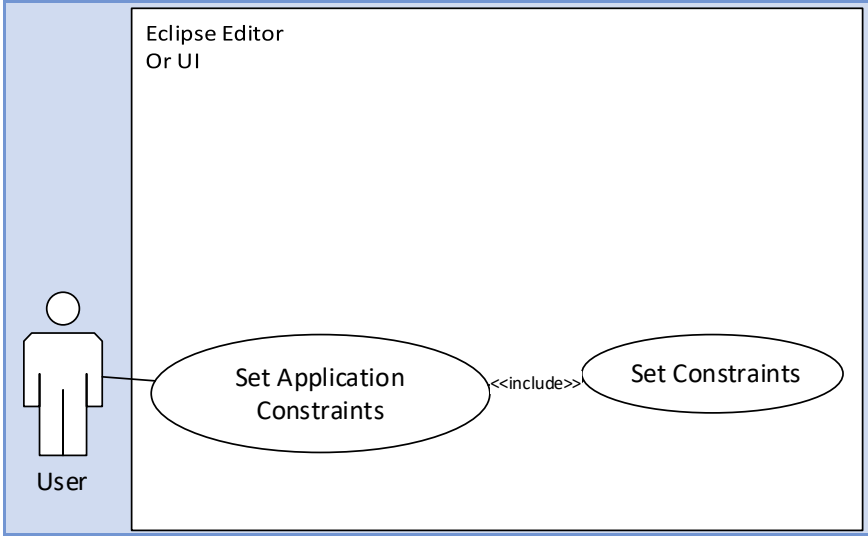
ID	Name	Short description	Relationship
MOD_SC_MOR_02	**Set CAMEL model application metrics**	The user uses Eclipse or UI to define CAMEL model with the application metrics	Included in Modelling scenario
Actors			
Admin			
Pre-condition			
- Eclipse CAMEL editor installed Or - Unified user interface installed			
Post-condition			
- CAMEL model updated and saved			
Link to requirements (D6.1)			
- Please refer to the requirements tables			
Steps			
- Set application metrics o Set utility function formula ▪ Template ▪ Formula o Set metrics ▪ Raw metric ▪ Composite metric			
Use case diagram			



4.1.3 Scenarios 3: Set CAMEL model Application constraints

Table 6 - Modelling Scenario 3 Definition

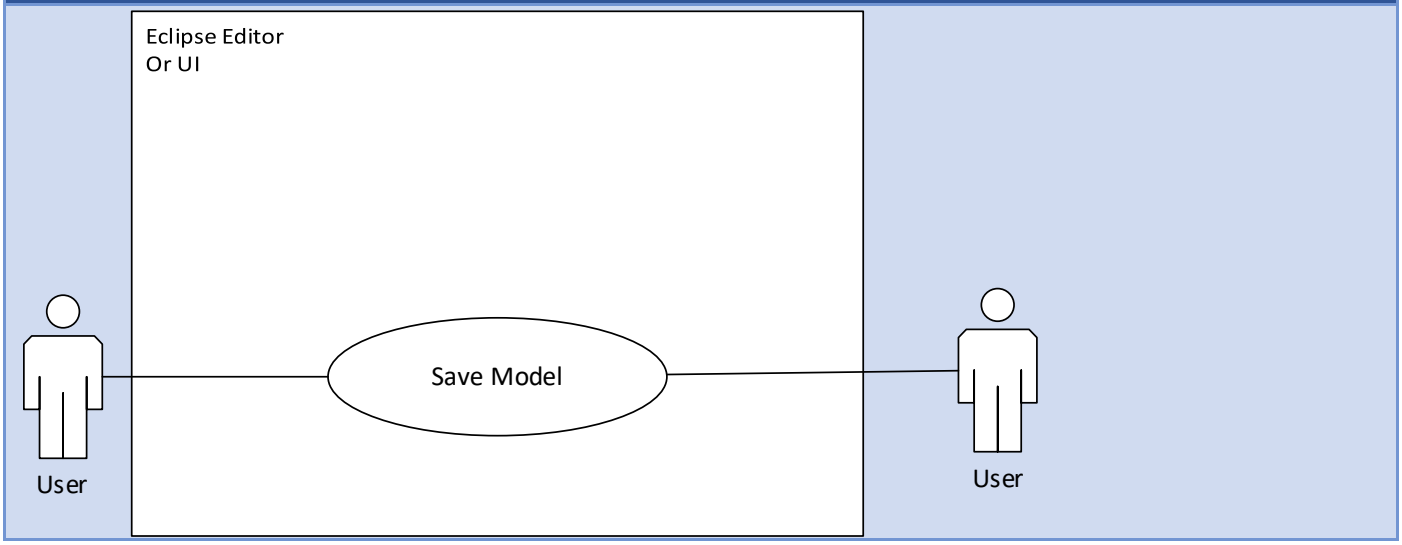
ID	Name	Short description	Relationship
MOD_SC_MOR_03	**Set CAMEL model Application constraints**	The user uses Eclipse or UI to define CAMEL model with the Application constraints	Included in Modelling scenario
Actors			
Admin			
Pre-condition			
- Eclipse CAMEL editor installed - Or - Unified user interface installed			
Post-condition			
- CAMEL model updated and saved			
Link to requirements (D6.1)			
- Please refer to the requirements tables			
Steps			
- Set application constraints o Set constraints			
Use case diagram			



4.1.4 Scenarios 4: Export CAMEL model

Table 7 - Modelling Scenario 4 Definition

ID	Name	Short description	Relationship
MOD_SC_MOR_04	**Export CAMEL Model**	The user uses Eclipse or UI to export the CAMEL model as XMI file.	Included in Modelling scenario
Actors			
- Admin			
Pre-condition			
- Eclipse CAMEL editor installed Or - Unified user interface installed			
Post-condition			
- CAMEL model updated and saved			
Link to requirements (D6.1)			
- Please refer to the requirements tables			
Steps			
- Save model			
Use case diagram			



4.2 MORPHEMIC Usage: Polymorphic deployment scenarios

This section provides a map of the steps that a user must follow to successfully deploy the application using the MORPHEMIC platform. An overview is provided in the sequential diagram, and we go into more detail about each step in the following sections for each usage scenarios:

- **Set up and login**
- **Add Application**
- **Set cloud providers setting**
- **Initial Application Deployment**

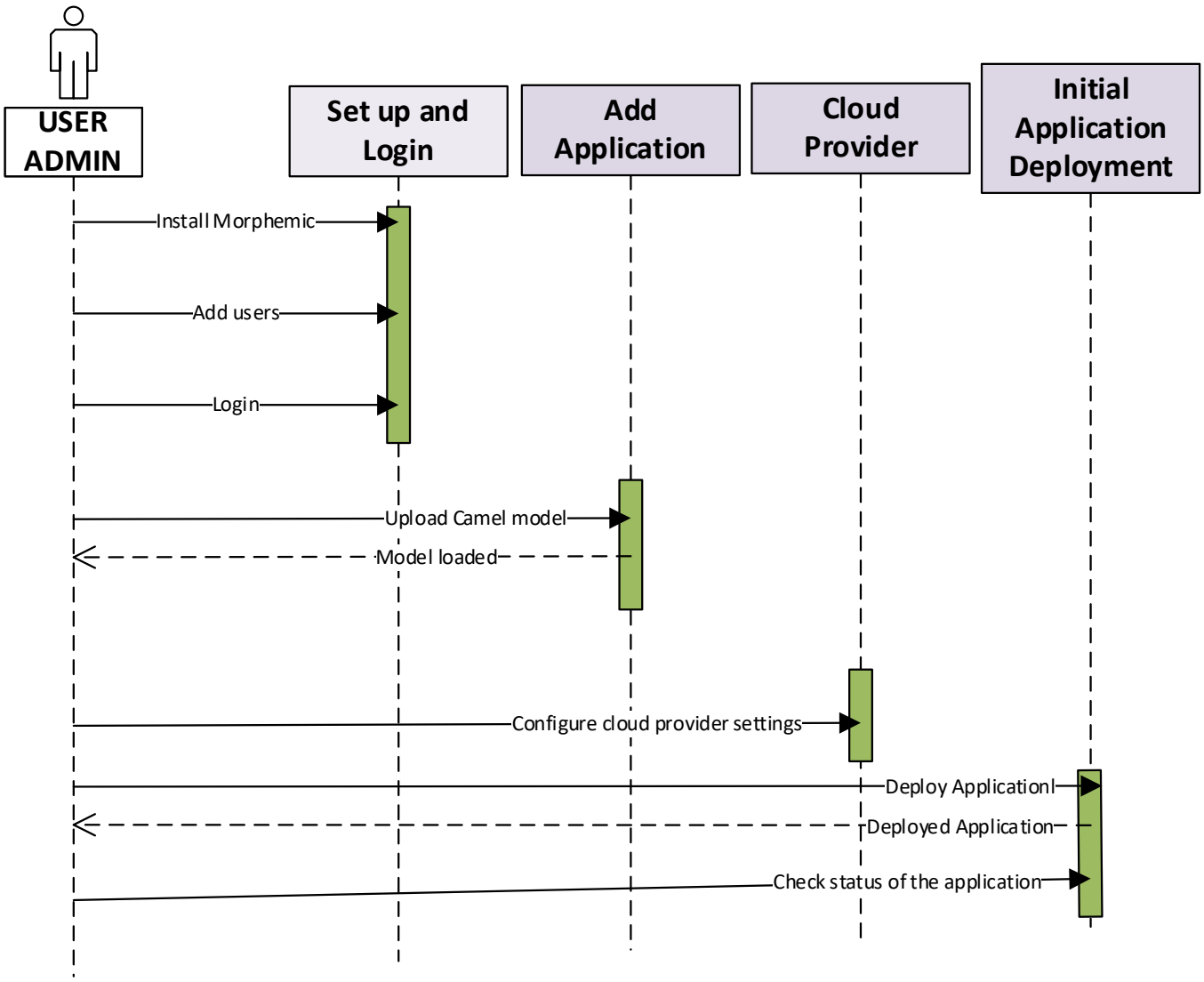
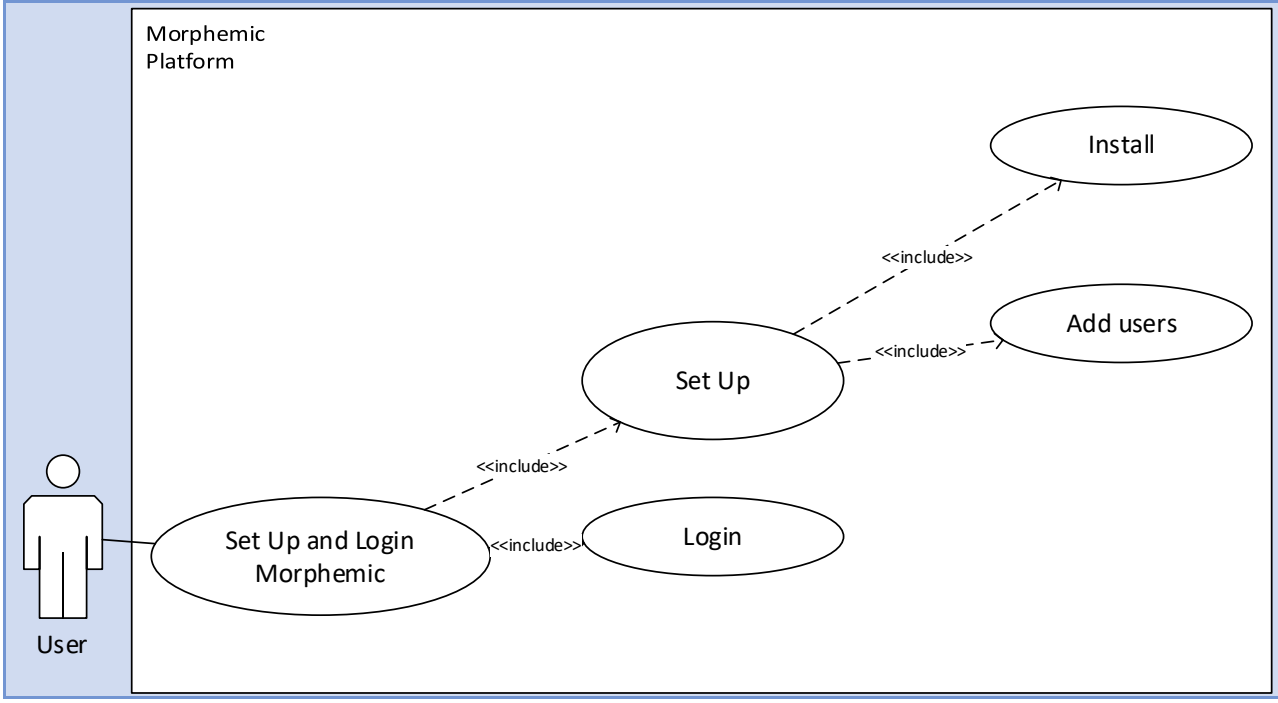


Figure 5 - Proactive deployment scenarios Sequence Diagram

4.2.1 Scenarios 1: Set up and login

Table 8 - Polymorphic deployment Scenario 1 Definition

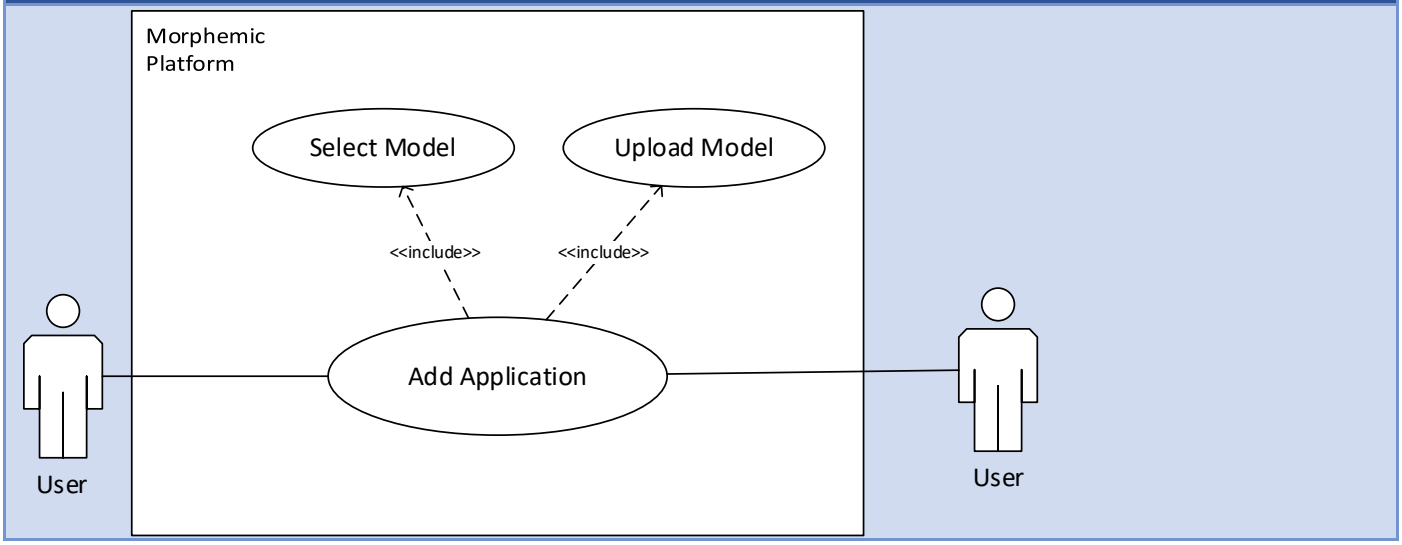
ID	Name	Short description	Relationship
DEP_SC_MOR_01	**Set Up and Login**	The user installs and login into the MORPHEMIC platform	Included in deployment scenarios
Actors			
Admin			
Pre-condition			
- Open-source code of MORPHEMIC is accessible - A machine matching the MORPHEMIC platform prerequisites			
Post-condition			
- User is logged into the platform			
Link to requirements (D6.1)			
- Please refer to the requirements tables			
Steps			
- Set up and login to MORPHEMIC o Set up ▪ Install ▪ Add users o Login			
Use case diagram			



4.2.2 Scenarios 2: Add Application

Table 9 - Polymorphic deployment Scenario 2 Definition

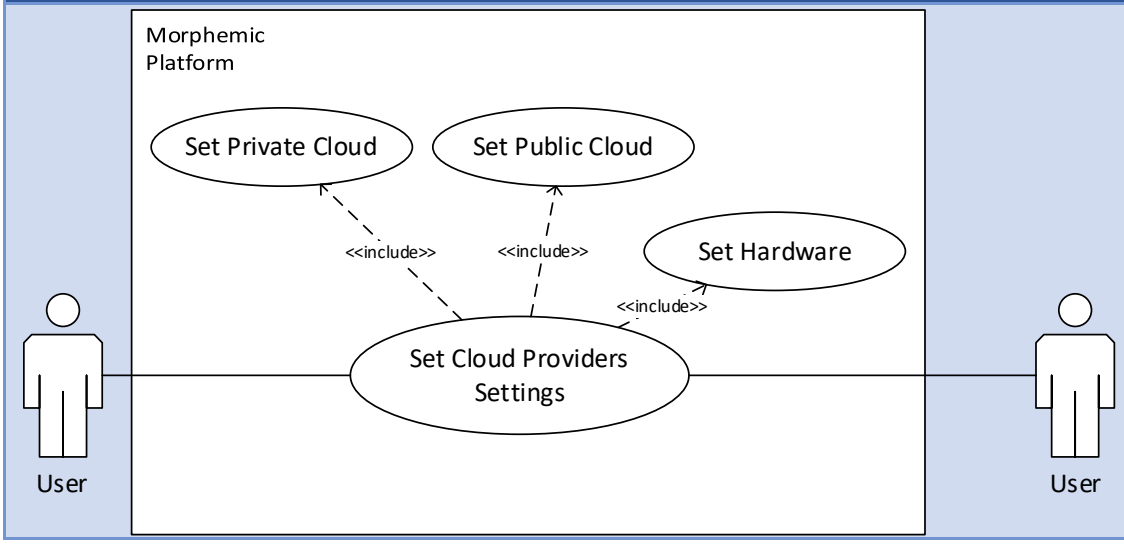
ID	Name	Short description	Relationship
DEP_SC_MOR_02	**Add application**	The user uploads the CAMEL model	Included in deployment scenarios
Actors			
Admin			
Pre-condition			
- MORPHEMIC platform is installed and running			
- Post-condition			
- Application model is loaded into the platform			
Link to requirements (D6.1)			
- Please refer to the requirements tables			
Steps			
- Add application o Select model o Upload model			
Use case diagram			



4.2.3 Scenarios 3: Set cloud providers setting

Table 10 - Polymorphic deployment Scenario 3 Definition

ID	Name	Short description	Relationship
DEP_SC_MOR_03	**Set cloud provider settings**	The user sets the cloud providers setting	Included in deployment scenarios
Actors			
- Admin			
Pre-condition			
- MORPHEMIC platform is installed and running			
Post-condition			
- Cloud providers offers			
Link to requirements (D6.1)			
- Please refer to the requirements tables			
Steps			
- Set cloud providers settings o Set private cloud o Set public cloud o Set hardware			
Use case diagram			



4.2.4 Scenarios 4: Initial Application Deployment

Table 11 - Polymorphic deployment Scenario 4 Definition

ID	Name	Short description	Relationship
DEP_SC_MOR_04	**Initial Application Deployment**	The user selects application to be deployed and cloud providers and initiate deployment	Included in deployment scenarios
Actors			
- Admin			
Pre-condition			

- MORPHEMIC platform is installed and running
- Application CAMEL model loaded
- Cloud providers offers available

Post-condition

- Application is deployed

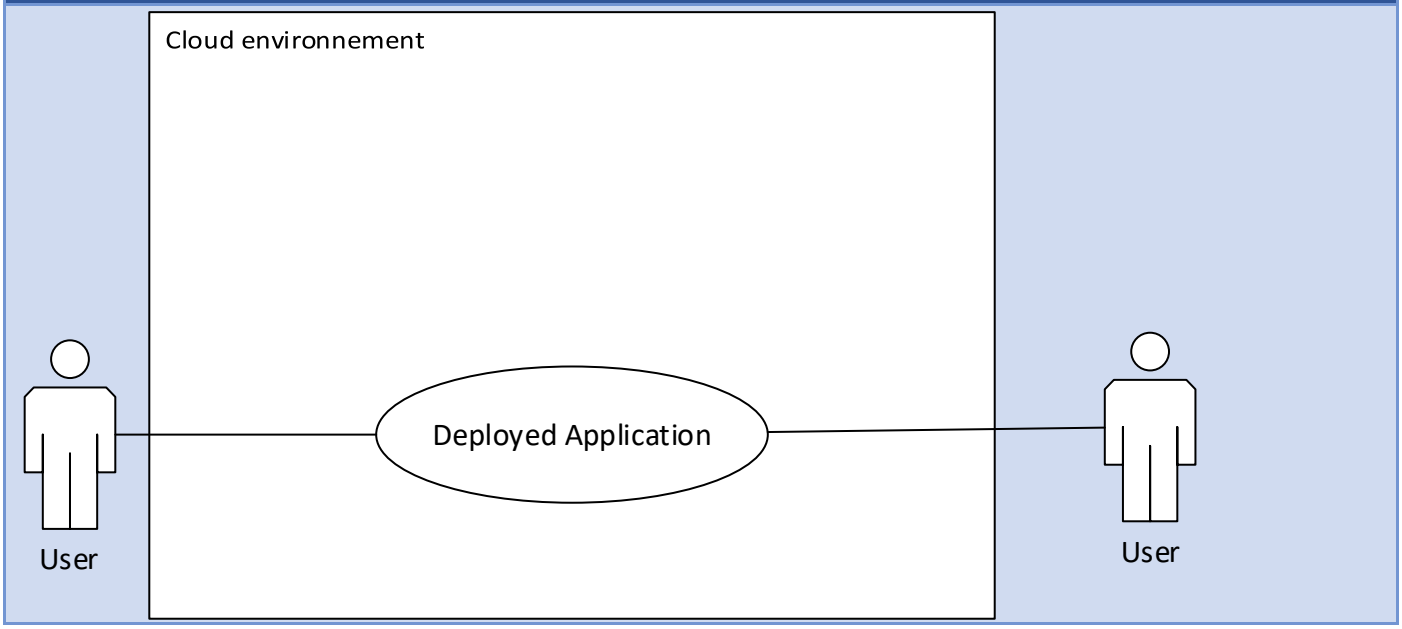
Link to requirements (D6.1)

Please refer to the requirements tables

Steps

- Initial deployment

Use case diagram



4.3 MORPHEMIC Usage: Proactive Adaptation scenarios

The polymorphic adaptation scenarios describe the sequential steps involved in the adaptation of a given application's software architecture in order to optimise its deployment plan according to the users' needs. An overview is provided in the sequential diagram, and we go into more detail about each step in the following sections for each usage scenarios:

- Application Deployment
- Metrics collection from sensors
- Application redeployment

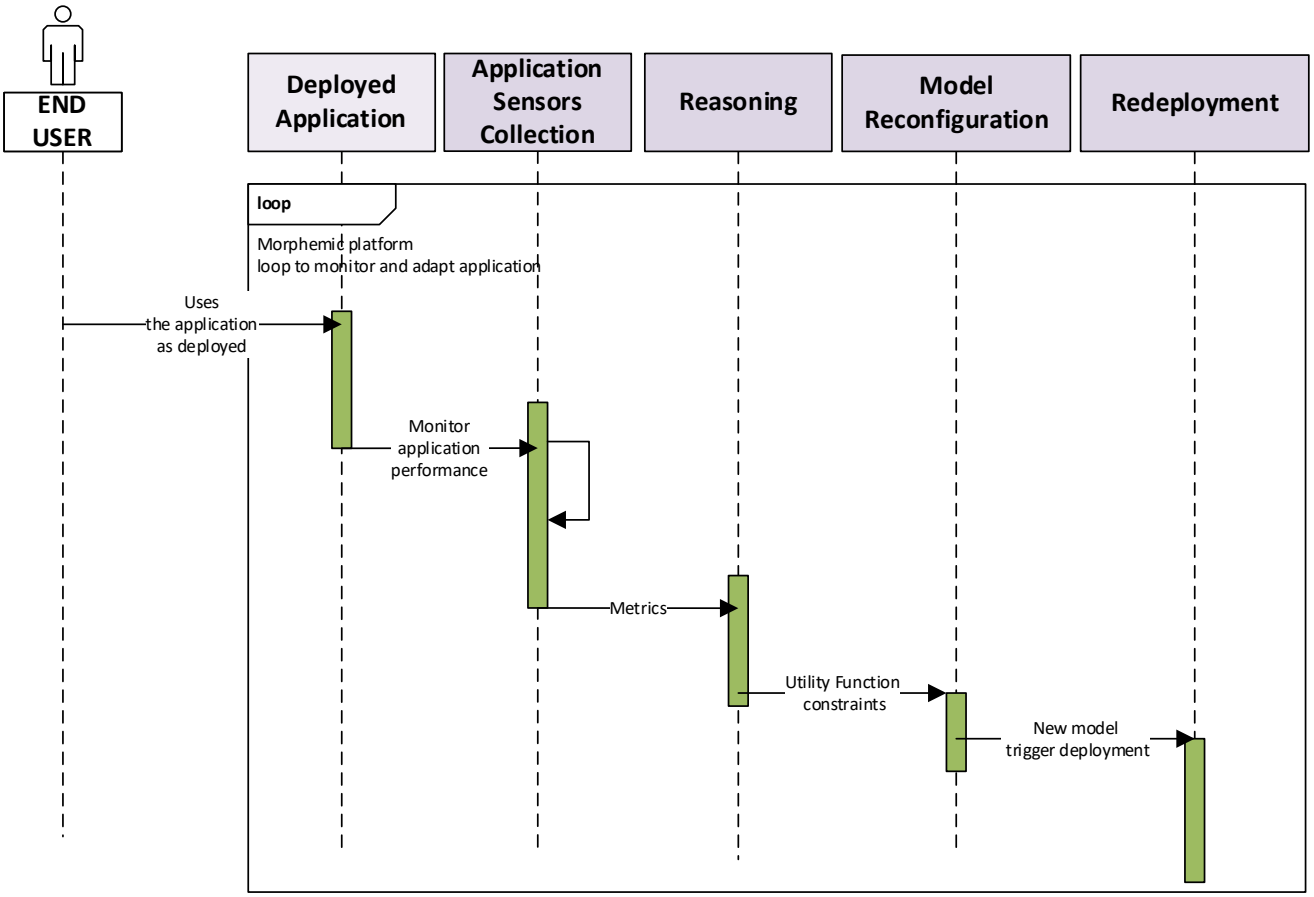


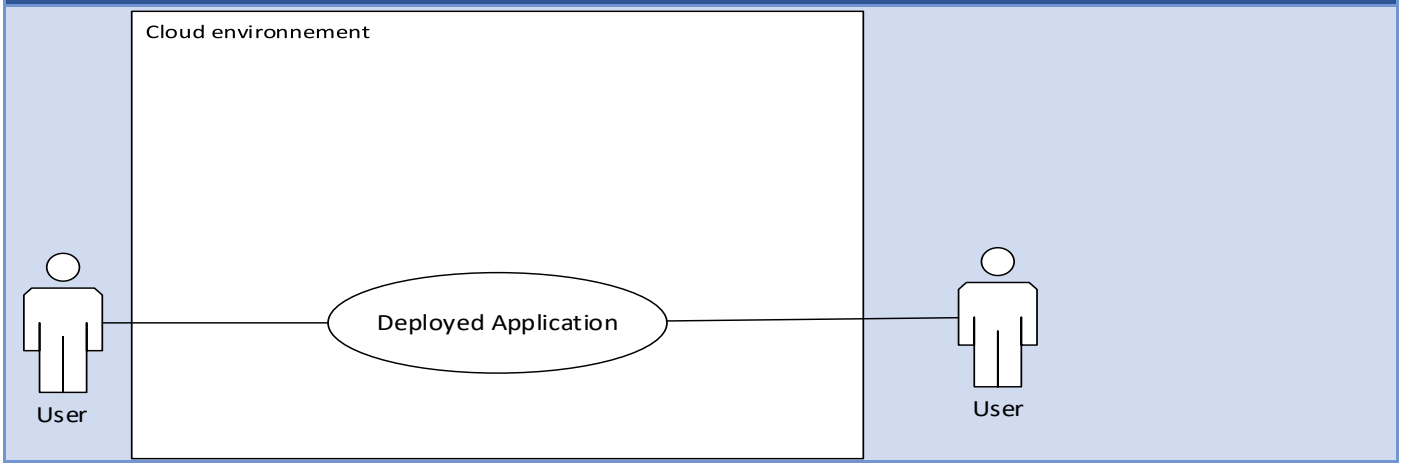
Figure 6 - Proactive Adaptation scenarios Sequence Diagram

4.3.1 Scenarios 1: Application Deployment

Table 12 - Proactive adaptation Scenario 1 Definition

ID	Name	Short description	Relationship
ADP_SC_MOR_01	**Application Deployment**	The end users use the deployed application	Included in adaptation scenarios
Actors			
- End User			
Pre-condition			
- MORPHEMIC platform is installed and running - Application CAMEL model loaded - Cloud providers offers available			
Post-condition			
- Application is deployed			
Link to requirements (D6.1)			
Please refer to the requirements tables			

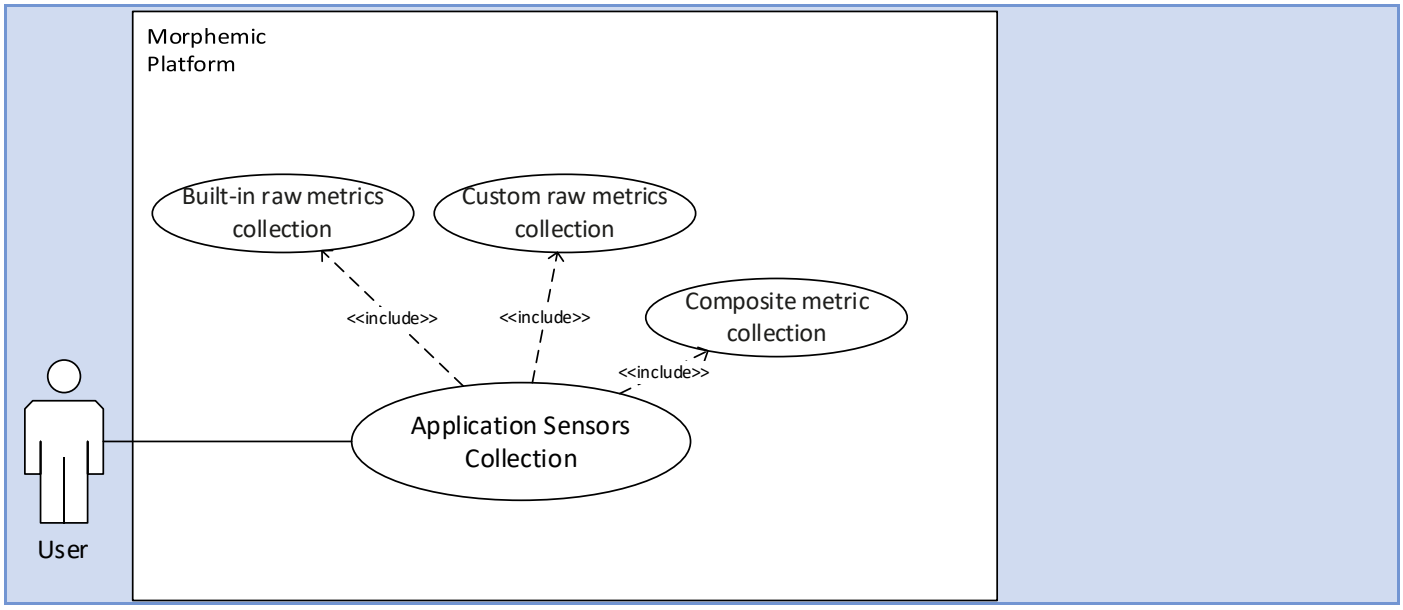
Steps
Deployed application
Use case diagram



4.3.2 Scenarios 2: Metrics collection from sensors

Table 13 - Proactive adaptation Scenario 2 Definition

ID	Name	Short description	Relationship
ADP_SC_MOR_02	**Metrics sensors collection**	The application is monitored via the metric collected from the application sensors	Included in adaptation scenarios
Actors			
- End User			
Pre-condition			
- MORPHEMIC platform is installed and running - Application is deployed and running			
Post-condition			
- Application is monitored			
Link to requirements (D6.1)			
- Please refer to the requirements tables			
Steps			
- Application sensors o Built-in raw metrics collection o Custom raw metrics collection o Composite metric collection			
Use case diagram			



4.3.3 Scenarios 3: Reasoning

Table 14 - Proactive adaptation Scenario 3 Definition

ID	Name	Short description	Relationship
ADP_SC_MOR_11	**Reasoning**	The reasoning is concerned with the steps by which MOPHEMIC will determine what deployment model is optimal for the current application according to the utility functions and constraints.	Included in adaptation scenarios
Actors			
- End User			
Pre-condition			
- MORPHEMIC platform is installed and running - Application is deployed - Metrics are collected - Utility functions are computed			
Post-condition			
- Optimized deployment model			
Link to requirements (D6.1)			
- Please refer to the requirements tables			

4.3.4 Scenarios 4: reconfiguration

Table 15 - Proactive adaptation Scenario 4 Definition

ID	Name	Short description	Relationship

ADP_SC_MOR_04	**Reconfiguration**	A new deployment model is generated based on the utility function and the constraints, and the application will be re-deployed accordingly.	Included in adaptation scenarios
Actors			
- End User			
Pre-condition			
- MORPHEMIC platform is installed and running - Application is deployed - Metrics are collected - Utility functions are computed			
Post-condition			
- Optimized deployment model			
Link to requirements (D6.1)			
- Please refer to the requirements tables			

4.3.5 Scenarios 5: Application redeployment

Table 16 - Proactive adaptation Scenario 5 Definition

ID	Name	Short description	Relationship
ADP_SC_MOR_05	Redeployment	Application is redeployed according to the newly optimized deployment model.	Included in adaptation scenarios
Actors			
- End User			
Pre-condition			
- MORPHEMIC platform is installed and running - Application is deployed - Metrics are collected - Utility functions are computed			
Post-condition			
- Optimized deployment model			
Link to requirements (D6.1)			
- Please refer to the requirements tables			

5 Use case Scenarios

5.1 Use case Scenarios: Virtualized base station for 5G cloud-RAN

5.1.1 Applications Domain

IS-Wireless develops and delivers 5G networking solutions. The solution includes standard-compliant software and hardware required to build 5G as well as 4G telco networks by mobile network operators (MNO), mobile virtual network operators (MVNO), private institutions, municipalities and many more.

IS-Wireless specializes in software solutions for the Radio Access Network (RAN), which is the most costly, cross-disciplinary and challenging part of a telecom network. 1000x higher capacity can only be provided with a much denser RAN network, where spectrum is reused aggressively by numerous low-power low-cost Radio Heads. There exist various challenges to achieve these goals such as interference, assured and increased QoS, which needs to be provided at lower network CAPEX and OPEX. This makes RAN the critical part of 5G.

The telecom industry currently undergoes the shift from proprietary solutions, where custom made hardware is tightly connected to the software running on top, to virtualized approach in which software is able to run on the COTS (Commercial Of-The-Shelve) equipment. Such solution is named interchangeably as SD-RAN, vRAN or Cloud RAN. The virtualization, however, must go hand-in-hand with substantial changes in the way the software is built. In order harvest the full potential of the cloud computing paradigm the software should be divided into a microservices to improve flexibility and facilitate agile software development. On the other hand, proper virtualization technique to tackle different operational and business needs must be also taken into consideration.

5.1.2 Business needs

The main challenge facing the telecom industry is to ensure the quality of the telecom services won't degrade by operating on COTS equipment. The stringent requirements regarding the latency and throughput between components, as well as reliability must be seamlessly mapped on the common-purpose computing infrastructure. Employing specialized acceleration hardware, awareness of the hardware platform (such as Intel’s Enhanced Platform Awareness), and dynamic (proactive) resource allocation seems to be necessary. Another question is how to allocate enough resources so to handle the significant variation in the amount of user and user data so it does not become a bottleneck in the end-to-end communication. Static computing resources coming with the proprietary hardware are now being replaced with the flexible resource pools, proper (dynamic) allocation of the resources to the actual demand of the RAN communication services is key to ensure the profitability.

5.1.3 Business Performance and Key Performance Indicators

Table 17 - IS-Wireless expected business benefits from the MORPHEMIC platform

Business performance per role		
MORPHEMIC platform administrator	**Use cases Scenarios Involved: UC_SC_ISW_Static_MOD, UC_SC_ISW_Static_DEP UC_SC_ISW_Dynamic_MOD, UC_SC_ISW_Dynamic_DEP**	
In charge of administering the platform	Telcom integrators and operators providing 5G connectivity to the end user (mobile subscribers, IoT devices).	
Business Performance	Speed	Immediate execution of CAMEL script on the underlying cloud platforms
	Cost	Possible cost reduction due to the bug-free design and open-source origin
	Reliability	Reliable functioning of the MORPHEMIC platform and its components, ensuring the complete and error free task execution
	Flexibility	Flexibility in adding cloud providers, images and CAMEL descriptors increases the agility related to the maintenance
	Quality	Precision in executing workloads according to CAMEL guidance improves the quality of work with the MORPHEMIC platform
Resource provider	**Use cases Scenarios Involved UC_SC_ISW_Static_DEP UC_SC_ISW_Dynamic_DEP**	
Responsible for providing the computational resources?	Public cloud providers: (AWS, Azure, Google Cloud, etc.), client's local data centres (private clouds), IS-Wireless data centre.	
Business Performance	Speed	It is faster for 5G deployments to find suitable resources meeting corresponding requirements (e.g., location oriented) in the context of resource allocation in cross-cloud environments
	Cost	Cost-efficient use of computing resources across cross-cloud environments
	Reliability	Gathering all available offers matching CAMEL based criteria from the multiple cloud providers brings a bigger pool of resources to choose from when deploying a particular instance; in result, precision of choosing right resources (e.g., resource type) as well as the availability of resources for the deployments are improved contributing to higher reliability.
	Flexibility	Easy way to accommodate new resource pools
	Quality	Efficient use of allocated resources and decommission if not needed
Application provider	**Use cases Scenarios Involved: UC_SC_ISW_Static_MOD, UC_SC_ISW_Static_DEP UC_SC_ISW_Dynamic_MOD, UC_SC_ISW_Dynamic_DEP**	
Responsible for providing the application to be deployed?	IS-Wireless	
Business Performance	Speed	Fast adaptation due to the proactive adaptation feature
	Cost	Reduced cost due to the utility based choosing of the most optimal offer based on the trade-off between the cost and the performance
	Reliability	Possibility to switch or scale resources in case of constraint violation, even before the violation actually occurs
	Flexibility	Polymorphic adaptation enables a flexible choice of deployment technology

	Quality	Constraint and utility definition enables a highly customizable and targeted reaction with regard to the changing operational environment enabling the self-optimization of the deployed instance of the application so as to preserve the quality level delivered
Application end-user	**Use cases Scenarios Involved: UC_SC_ISW_Static_DEP UC_SC_ISW_Dynamic_DEP, UC_SC_ISW_Dynamic_ADP**	
Final user of the application	Telcom integrators and operators providing 5G connectivity to the end user (mobile subscribers, IoT devices).	
	Speed	Getting 5G connectivity deployment in a timely manner
	Cost	5G services are deployed in multi-cloud environment ensuring cost optimization
	Reliability	Constraint violation tracking and proactive adaptation feature ensure fast reaction to the problem, even before its actual occurrence
	Flexibility	Different use scenarios are covered by the enhanced adaptivity offered through the MORPHEMIC platform
	Quality	Due to securing enough resources for the SD-RAN system to support QoS related to 5G connectivity of the user and at the same time long up-time of the 5G services, quality of experience (QoE) is improved

Table 18 - IS-Wireless KPI metrics and targets from the MORPHEMIC platform

KPI **metrics and targets**	
Network deployment cost (CAPEX)	
Target	Decrease by up to 30% (e.g., ca. 10mln EUR for a network of 600 cells based on the references included in the project GA).
Network redesign time	
Target	Savings up to 2 site visits per site per year.
Network deployment automation strategies	
Target	3-4 operator-oriented strategies available (e.g., “performance / security tradeoff”, “low radio network capacity but high security”).

5.1.4 Applications to be deployed

The deployment scenario is focused on static deployment of the RAN. In other terms, according to the required infrastructural capabilities, MORPHEMIC will determine the best polymorphic application deployment configuration on edge and cloud. In this scenario, depicted in below, all the RAN elements (DU, CU-UP, CU-CP, RIC) are deployed in the local Edge server with enough allocated resources to support basic operations for one user. The core networking element of the 5G network (5GC), which together with RAN will allow end-to-end communication, will reside on the cloud and be either pre-deployed or deployed by MORPHEMIC in the multi-cloud deployment.

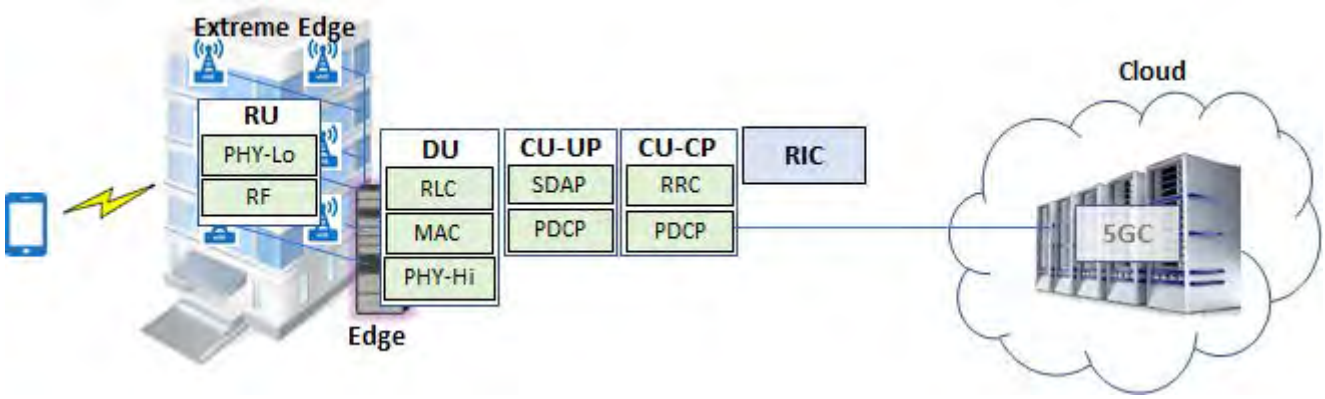


Figure 7 - Cloud RAN: example of deployment

Components can be virtualized at the edge and in the cloud. A component's location may depend on the availability of resources and the RAN resource demand (e.g., number of users).

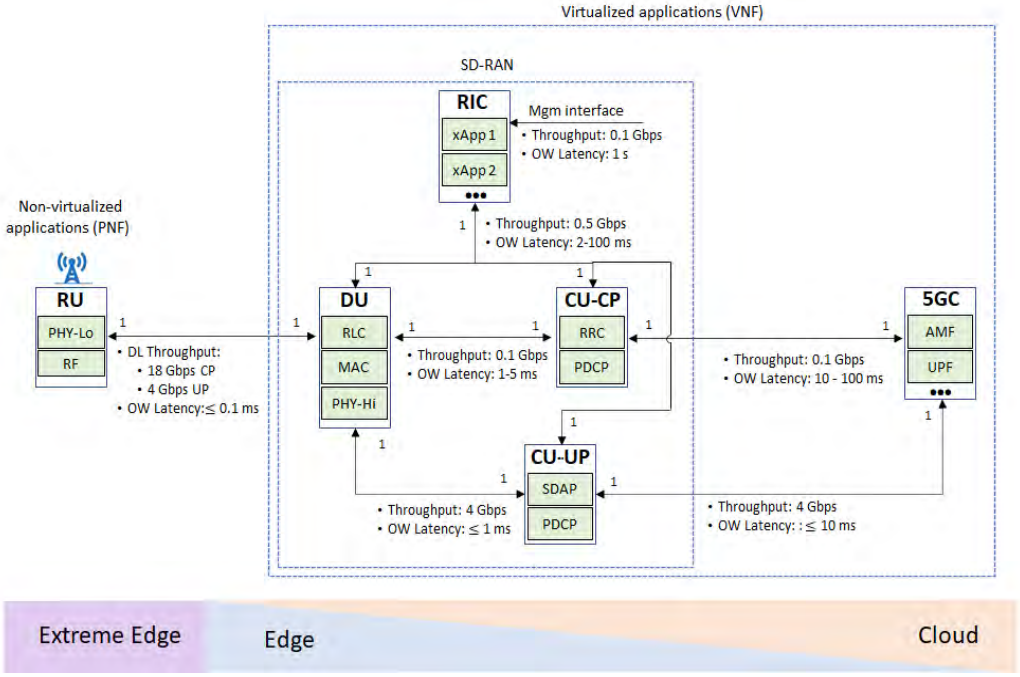


Figure 8 - Scenario of 5G cloud-RAN use case

5.1.5 Use case scenario roles

Table 19- IS-Wireless use case scenario roles

Validation Group	Role in MORPHEMIC	Role description
Administrators	System administrator (MORPHEMIC administrator)	Installs and maintains the MORPHEMIC platform.
DevOps	Application model designer (CAMEL DevOps)	The person is able to define the application deployment requirements, application configuration and topology to include it in the CAMEL model.
DevOps	Metric model designer (CAMEL DevOps)	The person is able to define needed metrics required for the constraint and utility function. It is also able to extract needed metrics from the application and provide it to MORPHEMIC platform in the form of timeseries.

DevOps	Constraint model designer (CAMEL DevOps)	The person is able to design the constraint and utility function required for the target deployment scenario of the application.
DevOps	Test engineer	Deploys an application with a CAMEL model and verifies whether the deployment is operational.
Business Managers	Application evaluator	Verifies whether the 5G services deployed with help of MORPHEMIC satisfy his/her business and operational requirements.

5.1.6 Use case scenario definition

A virtualized RAN allows users to allocate computing resources across three distinct network entities. Furthermore, it may allow traffic rates to be reduced and latency requirements to be met at the same time. MORPHEMIC platform will thus act as an intelligent orchestrator for providing Polymorphic and Proactive Adaptation as well as access to hardware acceleration while at the same time being able to dynamically adapt deployment configurations.

The mechanism provided by MORPHEMIC can be grouped, depending on whether it is deployment or run-time phase. For the deployment phase the static optimization of the deployment on heterogeneous environments and forms (**Polymorphic Adaptation**), the performance level control (**Hardware Accelerator Support**) and a usable UI (**Uniform User Interface**) are considered an added value. For the run-time phase more dynamic benefits, i.e., **Proactive Adaptation**, to predict metric value behaviour, and **Self-Healing Capability**, to maintain the stability of the platform itself**,** will be important to support the application in the quickly changing context.

Two scenarios have been proposed:

1. the *static scenario* is focused on static deployment of the RAN; in other terms, according to the required infrastructural capabilities, MORPHEMIC will determine the best polymorphic application deployment configuration on edge and cloud.
2. the *dynamic scenario* is focused on the automatic modification of the deployment as the context changes. This scenario is the most complete one, since, along with the *polymorphic* features, it also exploits the feature of dynamic deployment modification and potentially *Proactive Adaptation*.

Table 20 - ISW static use case scenarios

Use case Scenario ID	Name	Morphemic Scenarios included	Users
UC_SC_ISW_ Static_MOD	ISW_Static scenario CAMEL Model	• MOD_SC_MOR_01 (Set CAMEL model application requirements) • MOD_SC_MOR_02 (Set CAMEL model application metrics) • MOD_SC_MOR_03 (Set CAMEL model application constraints) • MOD_SC_MOR_04 (Export CAMEL model)	Administrators DevOps
UC_SC_ISW_ Static_DEP	ISW_Static scenario Deployment	• DEP_SC_MOR_01 (Set up and login) • DEP_SC_MOR_02 (Add application) • DEP_SC_MOR_03 Set cloud provider settings) • DEP_SC_MOR_04 (Initial application deployment)	Administrators DevOps

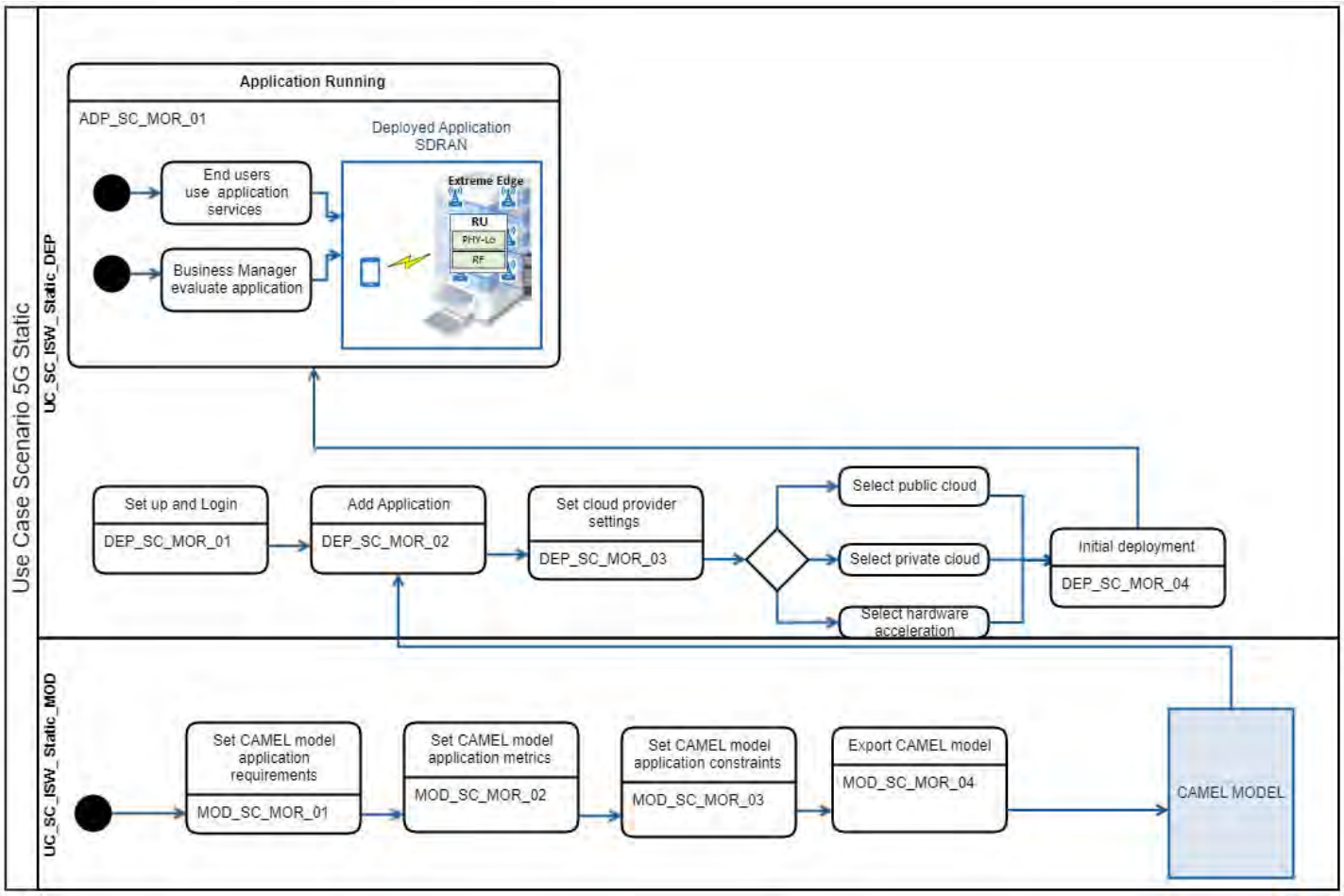


Figure 9 - ISW static use case scenarios process diagram

Table 21 - ISW dynamic use case scenarios

Use case Scenario ID	Name	Scenarios included	Users
UC_SC_ISW_Dynamic _MOD	ISW_ Dynamic scenario CAMEL Model	• MOD_SC_MOR_01 (Set CAMEL model application requirements) • MOD_SC_MOR_02 (Set CAMEL model application metrics) • MOD_SC_MOR_03 (Set CAMEL model application constraints) • MOD_SC_MOR_04 (Export CAMEL model)	Administrators DevOps
UC_SC_ISW_Dynamic _DEP	ISW_ Dynamic scenario Deployment	• DEP_SC_MOR_01 (Set up and login) • DEP_SC_MOR_02 (Add application) • DEP_SC_MOR_03 (Set cloud provider settings) • DEP_SC_MOR_04 (Initial application deployment)	Administrators DevOps

UC_SC_ISW_Dynamic_03	ISW_ Dynamic scenario Adaptation	• ADP_SC_MOR_01 (Application running) • ADP_SC_MOR_02 (Application Sensors collection) • ADP_SC_MOR_03 (Reasoning) • ADP_SC_MOR_04 (Reconfiguration) • ADP_SC_MOR_05 (Redeployment)	Administrators DevOps

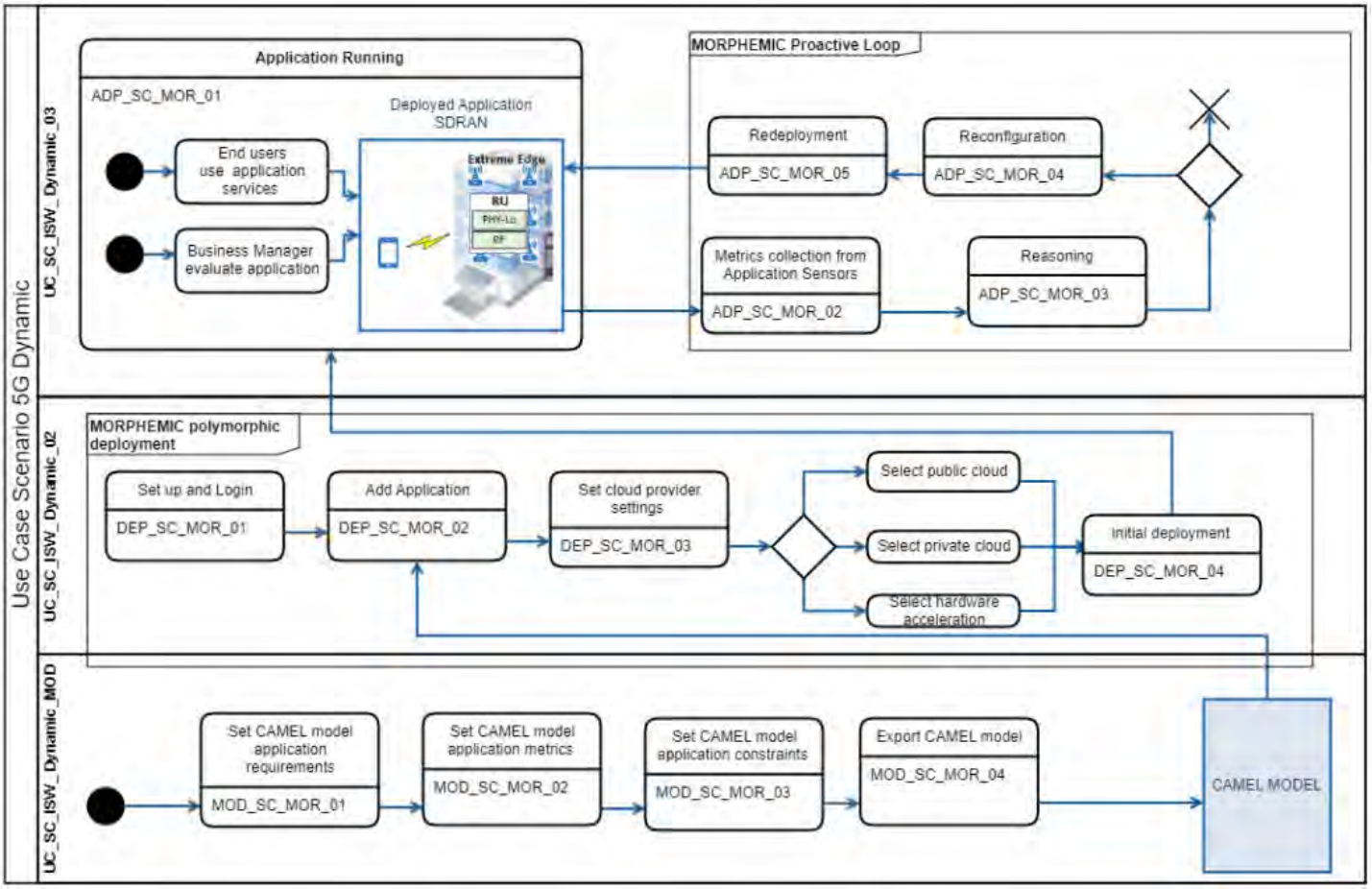


Figure 10 - ISW dynamic use case scenarios process diagram

5.2 Use case Scenarios: E-Brain Science

5.2.1 Applications Domain

Within brain medical science, neuroscientists and clinicians acquire high-resolution images of the brain with MRI scanners under different protocols or sequences to assess brain tissues' properties. For example, the two most common MRI sequences are T1-weighted and T2-weighted scans provide information about the brain's structural anatomy and function. Using Diffusion-weighted imaging (DWI) and Diffusion Tensor imaging (DTI), the orientation and direction of white matter fiber tracts can be visualized and quantified. Neuroscientists use computational anatomy software in conjunction with structural MRI to determine the morphometric properties of brain structures. The computed anatomical features produced by the different software solutions provide quantitative data regarding structure and function in the brain, including the size, shape and volumes of gray matter structures. Neuroimaging data analysis tools are then used for the detection of diseases such as Alzheimer's, Parkinson's, stroke or epilepsy. For studies of healthy populations, neuroimaging statistical packages are also used to investigate the correlation between brain structure and certain physiological, cognitive and psychological characteristics, including motor skills, mood, and cognition. The tools

developed by CHUV are intended for this dual-use: clinically to aid in diagnosing neurological diseases and for research to further enhance our understanding of brain structure and function.

5.2.2 Business needs

Computation of brain characteristics demands handling large and complex data sets; and it also requires a series of algorithmic steps in separate software packages while keeping the input and output compatible and available at each step. Although tools are available, they are themselves complex and not easy to handle by clinicians. Due to this complexity, advanced neuroimaging tools are sometimes not used, resulting in missed opportunities. In other cases, simple workflows are implemented in each clinical centre with the customized tools. Therefore, this may lead to results based upon obsolete tools and outcomes that are not comparable between locations.
Due to the massive growth in imaging data volume, the diversity of protocols, and the progressively greater number of subjects being scanned, it is increasingly evident that one of the major challenges of running computations will be to do so in a timely manner and at a low computational cost and with the highest accuracy.

5.2.3 Business Performance and Key Performance Indicators

Table 22 - CHUV expected business benefits from the MORPHEMIC platform

Business performance Per roles		
MORPHEMIC platform administrator	**Use cases Scenarios Involved: UC_SC_CHUV_ImageProc_MOD, UC_SC_CHUV_ImageProc_DEP UC_SC_CHUV_SPM_MOD, UC_SC_CHUV_SPM_DEP UC_SC_CHUV_FedML_MOD, UC_SC_CHUV_FedML_DEP**	
In charge of administering the platform	Lab managers	
Business Performance	Speed	Immediate execution of CAMEL script on the underlying cloud platforms.
	Cost	Administrators are able to lower operating costs associated with system upgrades, new hardware and software upgrades and maintenance.
	Reliability	The system is monitored automatically scale without the need of intervention.
	Flexibility	Flexible addition of processing steps in the brain neuroimaging workflow if the end user is requesting it.
	Quality	High replicability of the infrastructure provided to the users (developer or end-users).
Resource provider	**Use cases Scenarios Involved UC_SC_CHUV_ImageProc_DEP UC_SC_CHUV_SPM_DEP UC_SC_CHUV_FedML_DEP**	
Responsible for providing the computational resources?	Public cloud providers: (AWS, Azure, Google Cloud, etc.), client's local data centres (private clouds), Research institution, hospitals, pharmaceutical labs.	
Business Performance	Speed	The polymorphic adaptation of the system will enable the system to respond more quickly to shifts in demand when users start new batch processing operations.
	Cost	Polymorphic deployment allows researchers to have the ability to scale costs in accordance with their needs within a community cloud

		where resources can be shared between labs, hospitals. Thanks to these capabilities, more scientists can simultaneously utilize the system.
	Reliability	Admins may choose to deploy the application in the community cloud or on private cloud. However, the admin can prepare the deployment plan irrespective of the final destination.
	Flexibility	Resources can be adapted to the complexity of the workflows.
	Quality	Efficient use of allocated resources and decommission if not needed.
Application provider	**Use cases Scenarios Involved:** **UC_SC_CHUV_ImageProc_MOD, UC_SC_CHUV_ImageProc_DEP** **UC_SC_CHUV_SPM_MOD, UC_SC_CHUV_SPM_DEP** **UC_SC_CHUV_FedML_MOD, UC_SC_CHUV_FedML_DEP**	
Responsible for providing the application to be deployed?	CHUV Research labs, clinical centres, pharma	
Business Performance	Speed	The developer can offer frequent enhancements or bug corrections to the end users due to the decreased deployment time.
	Cost	With morphemic deployment and adaptation, it is easier to re-deploy the application after an upgrade, saving both time and money.
	Reliability	The uniform deployment makes it possible to deploy the same application to future users, which is critical for Reliability, reproducibility and record-keeping.
	Flexibility	Developers can easily add processes to brain neuroimaging workflows if their end users request it; MORPHEMIC will be responsible for ensuring the best execution plan and resource allocation.
	Quality	Efficient use of allocated resources and decommission if not needed.
Application end-user	**Use cases Scenarios Involved:** **UC_SC_CHUV_ImageProc_ADP** **UC_SC_CHUV_SPM_ADP** **UC_SC_CHUV_FedML_ADP**	
Final user of the application	Clinical researchers and neuroscientists	
	Speed	As workflows are executed faster, more data can be analysed in a shorter amount of time, enabling researchers to engage in more scientific research.
	Cost	Using community cloud resources to optimize lab workflow can improve productivity therefore minimize costs when using large scale imaging processing tasks.
	Reliability	Process is reliable, repeatable. Every user has access to the same services and runs the same application, but with their own personal data.
	Flexibility	Easy configuration from simple to complex workflow and configuration of the machine learning algorithms.
	Quality	The quality of clinical trials depends on reproducible workflows and an extensive set of data. Workflows based on MORPHEMIC can provide automation to the processing of data, and can provide a higher level of quality than manual execution.

Table 23 - CHUV KPIs metrics and targets from the MORPHEMIC platform

KPI metrics and targets	
Users	
Target	Scalability for a number of clinical researchers using the workflow 100.
Data	
Target	Scalability for the amount of data and patients' records 10 000 records.
Deployment automation strategies	
Target	5 pre-processing and data analyses workflow integrated: image conversion, image normalization, brain maps creation, brain atlas creation, neuromorphometrics computation.

5.2.4 Applications to be deployed

The main functionalities that E-Brain Science use case will provide are:

- **image pre-processing pipeline**, which consists in providing standardized workflow for pre-processing neuroimaging data. The users will be able to select and configure neuroimaging workflows from data conversion, in order to segment the images and extract the brain features

- **SPM on web** provides a web tool for sharing and visualization of image analysis conducted with SPM (Statistical Parametric Mapping), the most popular open-source package for neuroimaging analysis.

- **federated machine learning** consists in providing an innovative system that wide users (clinicians, neuroscientists, epidemiologists) can access and use to analyse clinical and research data without moving them from the hospital or private cloud servers where they reside and without infringing on patient privacy.

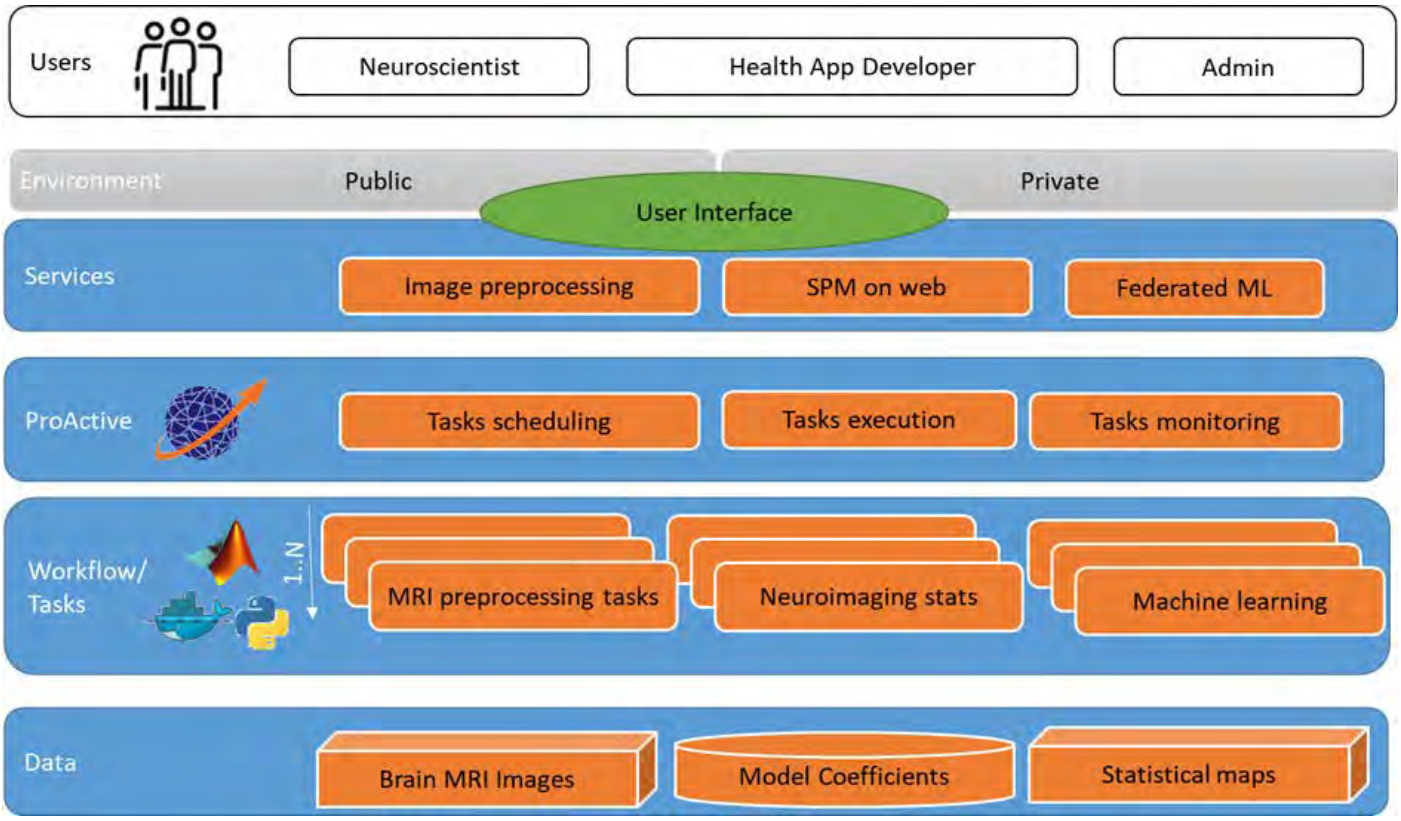


Figure 11 - CHUV architecture

5.2.5 Use case scenario roles

Table 24 - CHUV validation roles for the MORPHEMIC platform

Validation Group	Role in MORPHEMIC	Role description
Administrators	Administrator (Lab manager)	Responsible that the resources (compute and data storage) are available. Add and manage users (developer and end users).
DevOps	Application developer (Clinical researchers, neuroscientists)	Model designers and developers configure and modify the workflows, add tasks, remove tasks, and implement new methods (new neuroimaging application of machine learning methods).
Application end-user	Application end-user (Clinical researchers, neuroscientists. Clinicians, pharma, students)	Upload his/her data, Configure and run workflow download the results.

5.2.6 Use case scenario Definitions

Our research set out to develop neuroimaging methods that exploit current technologies, including dockerization, in order to compute brain characteristics, organize large complex datasets efficiently and logically, and maintain input and output in synchrony.
E-Brain Science's architecture is conceived to advance the fundamental and digital knowledge on healthy brain aging and neurocognitive disorders. Specifically, the provided functionalities will be:

1. establish a framework for **federating clinical data** within and across **data sources** (*hospitals*, *clinics* and *cohorts*)
2. develop **benchmarking technology** that respects **anonymity** requirements
3. evaluate **AI based diagnostic**

4. derive **biological signatures** of **brain diseases**.

More in general, the use case concerns the analysis of a big amount of data coming from different data sources. As well as any healthcare data, these data are often *sensitive data* with stringent requirements in terms of security and anonymization. MORPHEMIC will not manage these aspects, but it could be possible to deploy an application covering these requirements. MORPHEMIC contributes to the delivery of the results and data as expected by deploying resources, managing workloads, monitoring task status, and assessing capacity needs to support the provision of resources as required. MORPHEMIC contributes to the improvement of data reliability by running multiple jobs concurrently and by accounting for the relationship between the processing steps. MORPHEMIC allows the application of a huge number of neuroimaging tools on a large number of samples rapidly, easily and precisely.

Table 25 - CHUV image preprocessing use case scenarios

Use case Scenario ID	Name	MORPHEMIC usage Scenarios included	Users
UC_SC_CHUV_ ImageProc_MOD	CHUV_ ImageProc scenario CAMEL Model	• MOD_SC_MOR_01 (Set CAMEL model application requirements) • MOD_SC_MOR_02 (Set CAMEL model application metrics) • MOD_SC_MOR_03 (Set CAMEL model application constraints) • MOD_SC_MOR_04 Export CAMEL model)	Administrators DevOps
UC_SC_CHUV_ ImageProc_DEP	CHUV_ ImageProc scenario Deployment	• DEP_SC_MOR_01 (Set up and login) • DEP_SC_MOR_02 (Add application) • DEP_SC_MOR_03 (Set cloud provider settings) • DEP_SC_MOR_04 (Initial application deployment)	Administrators DevOps
UC_SC_CHUV_ ImageProc_ADP	CHUV_ ImageProc scenario Adaptation	• Scenarios 9 (Application running) • ADP_SC_MOR_02 (Application Sensors collection) • ADP_SC_MOR_03 (Reasoning) • ADP_SC_MOR_04 (Reconfiguration) • ADP_SC_MOR_05 (Redeployment)	Application end-user

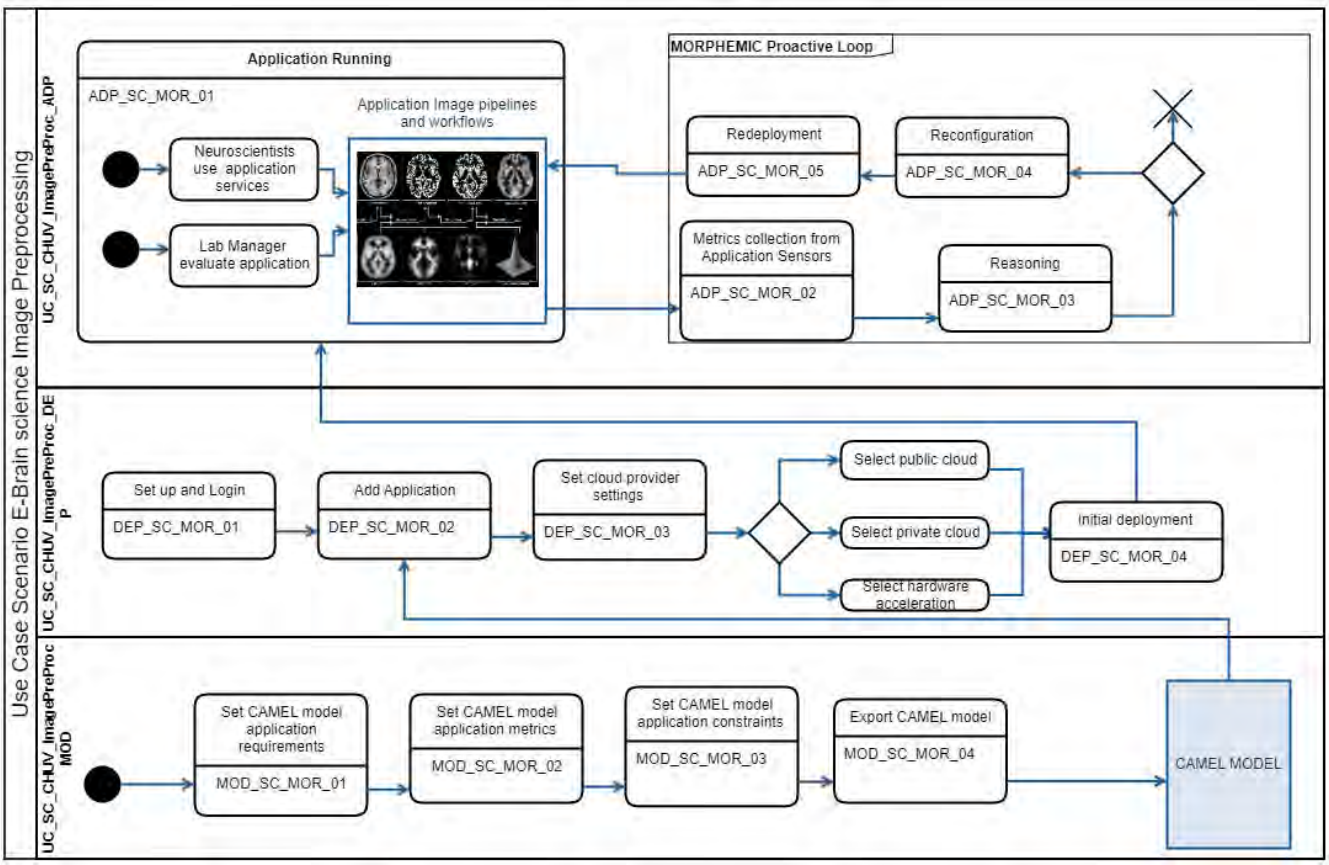


Figure 12 - CHUV image preprocessing use case scenarios process diagram

Table 26 - CHUV SPM on web use case scenarios

Use case Scenario ID	Name	M MORPHEMIC usage Scenarios included	Users
UC_SC_CHUV_ SPM_MOD	CHUV_SPM scenario CAMEL Model	• MOD_SC_MOR_01 (Set CAMEL model application requirements) • MOD_SC_MOR_02 (Set CAMEL model application metrics) • MOD_SC_MOR_03 (Set CAMEL model application constraints) • MOD_SC_MOR_04 (Export CAMEL model)	Administrators DevOps
UC_SC_CHUV_SPM _DEP	CHUV_SPM scenario Deployment	• DEP_SC_MOR_01 (Set up and login) • DEP_SC_MOR_02 (Add application) • DEP_SC_MOR_03 (Set cloud provider settings) • DEP_SC_MOR_04 (Initial application deployment)	Administrators DevOps
UC_SC_CHUV_SPM _ADP	CHUV_SPM scenario Adaptation	• ADP_SC_MOR_01 (Application running) • ADP_SC_MOR_02 (Application Sensors collection) • ADP_SC_MOR_03 (Reasoning)	Application end-user

		• ADP_SC_MOR_04 (Reconfiguration) • ADP_SC_MOR_05 (Redeployment)	
UC_SC_CHUV_SPM_04	CHUV_SPM Self-healing		

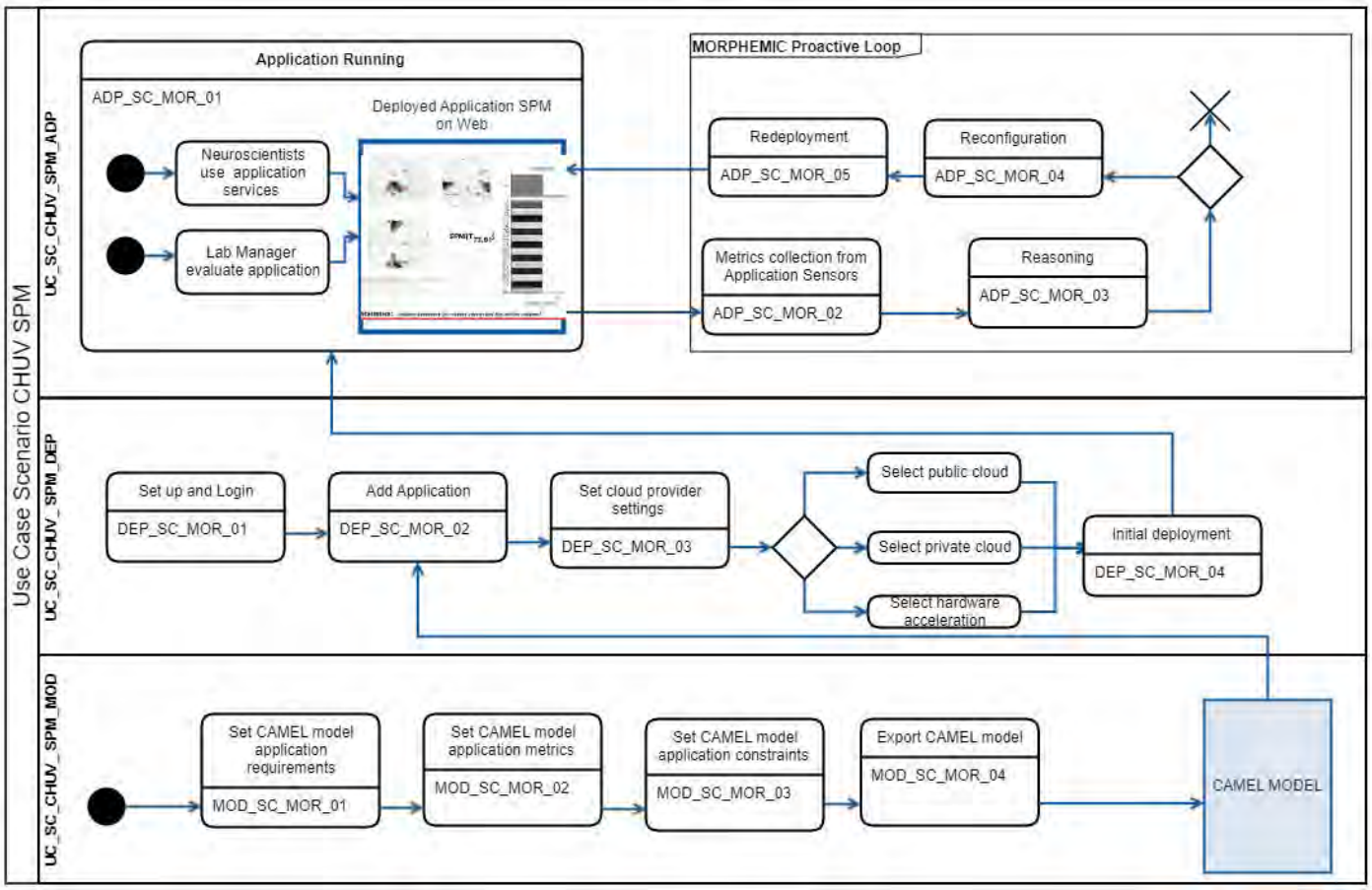


Figure 13 - CHUV SPM on web use case scenarios process diagram

Table 27 - CHUV federated machine learning use case scenarios

Use case Scenario ID	Name	MORPHEMIC usage Scenarios included	Users
UC_SC_CHUV_FedML_MOD	CHUV_FedML scenario CAMEL Model	• MOD_SC_MOR_01 (Set CAMEL model application requirements) • MOD_SC_MOR_02 (Set CAMEL model application metrics) • MOD_SC_MOR_03 (Set CAMEL model application constraints) • MOD_SC_MOR_04 (Export CAMEL model)	Administrators DevOps
UC_SC_CHUV_FedML_DEP	CHUV_FedML scenario Deployment	• DEP_SC_MOR_01 (Set up and login) • DEP_SC_MOR_02 (Add application) • DEP_SC_MOR_03 (Set cloud provider settings)	Administrators DevOps

		• DEP_SC_MOR_04 (Initial application deployment)	
UC_SC_CHUV_ FedML_ADP	CHUV_FedML scenario Adaptation	• ADP_SC_MOR_01 (Application running) • ADP_SC_MOR_02 (Application Sensors collection) • ADP_SC_MOR_03 (Reasoning) • ADP_SC_MOR_04 (Reconfiguration) • ADP_SC_MOR_05 (Redeployment)	Application end-user

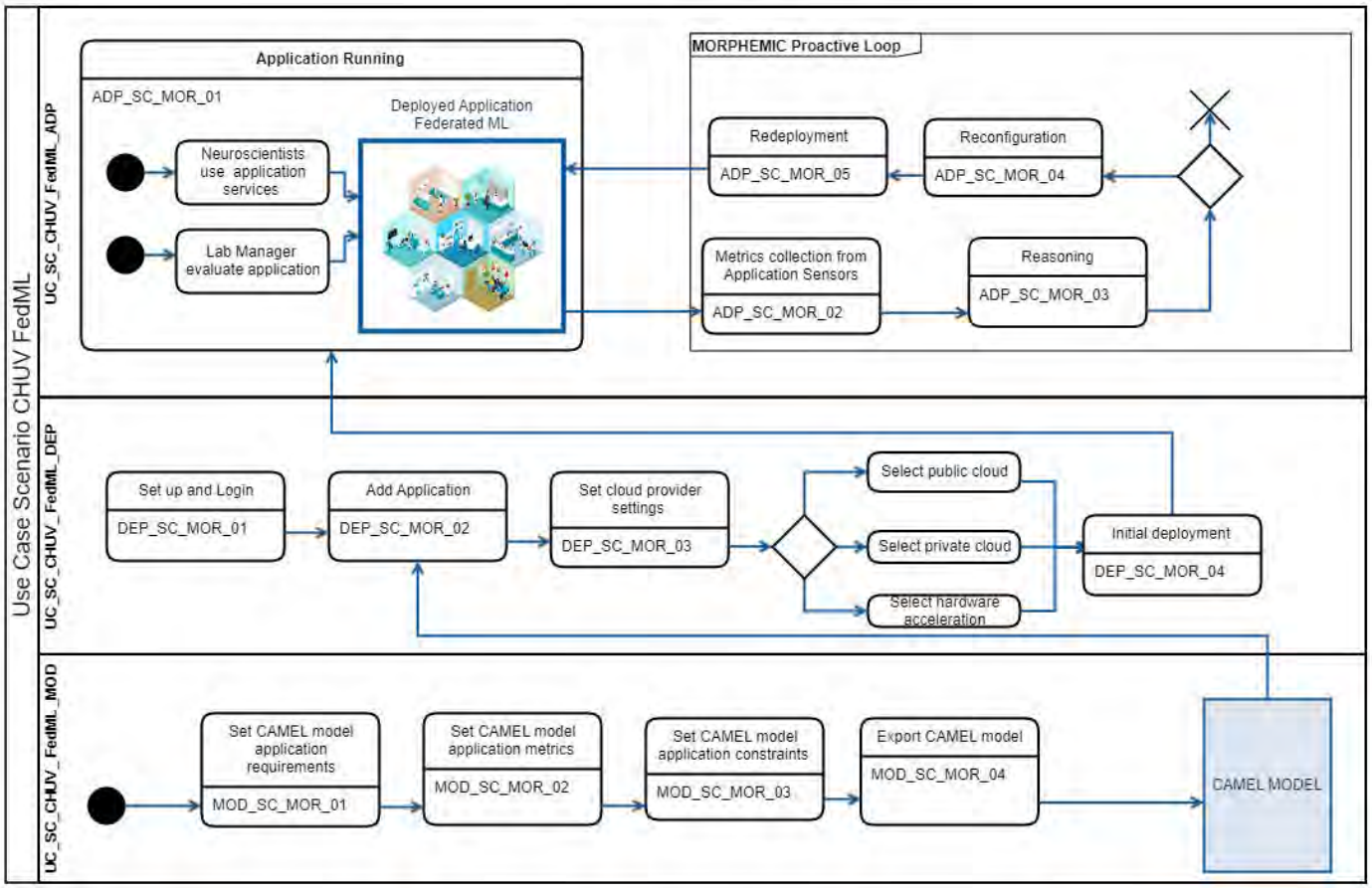


Figure 14 - CHUV federated machine learning scenarios process diagram

5.3 Use case Scenarios: Computational Fluid Dynamics simulation

5.3.1 Applications Domain

ICON's Computational Fluid Dynamics (CFD) tools are used to compute flow quantities in a wide range of industrial applications, like aerodynamics in the automotive and aerospace industry, free surface flows, species transport, multi component flows as well as thermal simulations.

5.3.2 Business needs

There are multiple challenges for deploying a CFD application on the cloud. There are significant changes in the runtime of a simulation which can be few minutes on a small number of cores up to multiple days on a large number of cores. The three sub cases of the use case capture these demands. Another challenge is the usage of different hardware architectures like on the CPUs there are differences by using Intel, AMD or ARM. The next challenge in difference to permanent running web applications is the request of compute power on demand.

5.3.3 Business Performance and Key Performance Indicators

Table 28 - ICON expected business benefits from the MORPHEMIC platform

Business performance Per roles		
MORPHEMIC platform administrator	**Use cases Scenarios Involved: UC_SC_ICON_LowFidelity_MOD, UC_SC_ICON_LowFidelity_DEP, UC_SC_ICON_MediumFidelity_MOD, UC_SC_ICON_MediumFidelity _DEP, UC_SC_ICON_HighFidelity_MOD, UC_SC_ICON_HighFidelity_DEP**	
In charge of administering the platform	ICON	
Business Performance	Speed	Quick installation, short turnaround time to be online with your application.
	Cost	Efficient due to reduced administration times.
	Reliability	Platform has high availability.
	Flexibility	Flexible to choose different cloud providers and resources.
	Quality	Minimise administration overhead through standardised, repeatable and automated processes.
Resource provider	**Use cases Scenarios Involved UC_SC_ICON_LowFidelity_DEP UC_SC_ICON_MediumFidelity_DEP UC_SC_ICON_HighFidelity_DEP**	
Responsible for providing the computational resources?	ICON, ICON's iconCFD Platform clients, HPC centres	
Business Performance	Speed	Fast deployment in multicloud environments, hardware is used efficiently.
	Cost	Cost savings by optimal choice of cloud hardware on different cloud providers.
	Reliability	Virtual machines are started on demand, in time.
	Flexibility	New instances are added automatically.
	Quality	Resources (VMs) are handled dynamically.
Application provider	**Use cases Scenarios Involved: UC_SC_ICON_LowFidelity_MOD, UC_SC_ICON_LowFidelity_DEP, UC_SC_ICON_MediumFidelity_MOD, UC_SC_ICON_MediumFidelity _DEP, UC_SC_ICON_HighFidelity_MOD, UC_SC_ICON_HighFidelity_DEP**	
Responsible for providing the application to be deployed?	ICON	
Business Performance	Speed	Rapid deployment of iconCFD Platform application. The computing resources (VMs) are optimized on the fly dynamically based on the current load and projected simulation loads.
	Cost	iconCFD Platform is assisted in obtaining the resources proactively to minimize cost and optimize the cost-to-simulation-time ratio based on end-user constraints. Enables access to reduced operational/maintenance and hosting costs and hence

		potential for greater profit generation per simulation sold by ICON.
	Reliability	Increased reliability of iconCFD Platform application offered to ICON customers (through ability to adapt resources more dynamically to achieve results in quantifiable timeframes for customers). High availability of resources due to ability to switch provider if one service is down.
	Flexibility	Flexible simulation requests are solved on demand meeting this challenge of dynamically diverse simulation requirements. For example, an engineer might have to run Digital Engineering Experiments with 1000s of short simulations which only take a few computer cores and then a smaller number of simulations taking days on 1000s of computer cores.
	Quality	Quality benefits include a more repeatable, predictable and consistent solution to be provided in every deployment, to a defined timescale and measurable quality. Further benefits include high availability and stable processes and better dynamic exploitation of multiple cloud environments in public and private modes.
Application end-user	**Use cases Scenarios Involved:** **UC_SC_ICON_LowFidelity_ADP,** **UC_SC_ICON_MediumFidelity_ADP,** **UC_SC_ICON_HighFidelity_ADP**	
Final user of the application	ICON's iconCFD Platform clients	
	Speed	Product engineering in quantifiable timeframes. Speed is increased from having options of simulation workers on demand via iconCFD Platform.
	Cost	Cheaper digital engineering by optimal utilization of the most cost-effective cloud infrastructures via iconCFD Platform.
	Reliability	Increased reliability of iconCFD Platform application through ability to adapt resources more dynamically to achieve results in quantifiable timeframes.
	Flexibility	Increased flexibility from having access to multiple cloud environments via iconCFD Platform.
	Quality	Quality benefits include a more repeatable, predictable and consistent solution to be provided in every deployment, to a defined timescale and measurable quality. Stable simulation processes, delivering better quality results in quantifiable time.

Table 29 - ICON KPIs metrics and targets from the MORPHEMIC platform

Reduction of platform.iconcfd.com maintenance cost.	
Target	Reduction of platform.iconcfd.com maintenance cost by 30%.
Reduction of cost, or increase in number of simulations	
Target	Reduction of cost, or increase in number of simulations at equal cost of 20%.
Seamless throughput scalability to higher number of simultaneous end-users.	

Target	Seamless throughput scalability to higher number of simultaneous end-users.

5.3.4 Use cases scenario roles

Table 30 - ICON validation roles for the MORPHEMIC platform

Validation Group	Role in MORPHEMIC	Role description
DevOps	Application developer (MORPHEMIC developer)	CAMEL
Administrators	System Administrator (MORPHEMIC administrator)	Install, setup Morphemic platform
DevOps	Application tester (MORPHEMIC tester)	Test deployments
Business Managers	Application evaluator (ICON CTO)	Evaluates application and platform

5.3.5 Applications to be deployed

The application will contain a run-manager (scheduler) which will use a "FIFO" approach with three queues, one for each scenario. The iconCFD Platform frontend is responsible for the case creation and its submission via the scheduler/run-manager. The software for the workers will be packaged in a Docker or singularity container: Figure 19 shows a schematic view of the use case scenario.

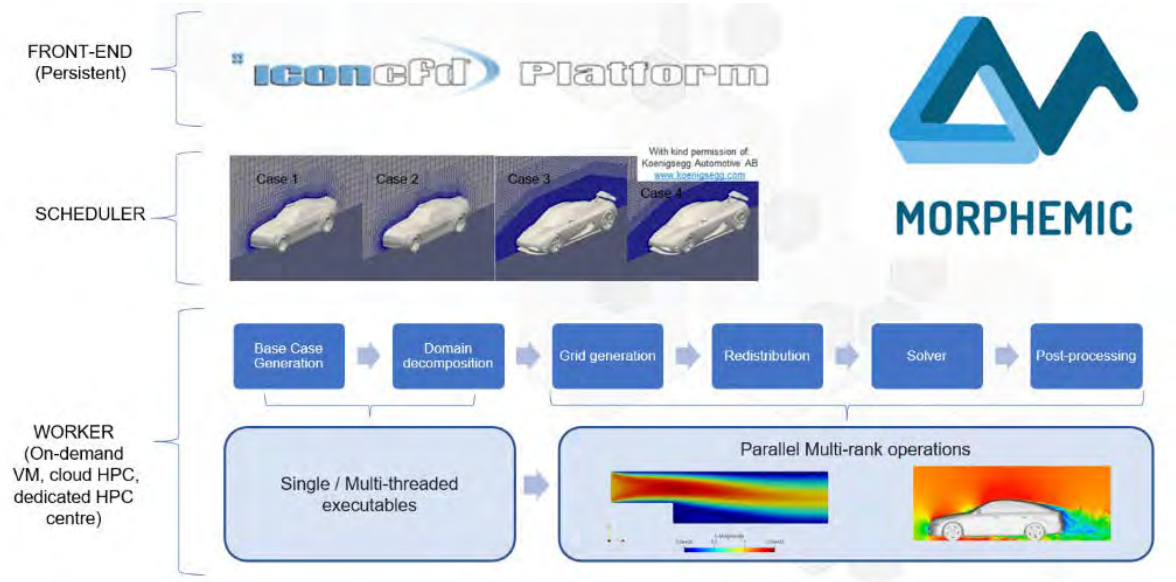


Figure 15 - ICON Architecture

5.3.6 Use case scenario Definitions

ICON aims to ensure that the users of their web-based framework, iconCFD Platform, get their results within a timeframe agreed in their SLA (for example 24 hours) and at a minimum cost. On this sense,
MORPHEMIC should be able to pro-actively adapt the number and type of workers to make sure that each job will be completed within the specified time, for each scenario. The simulations can be run on x86-64 (AMD, INTEL), or 64-bit Arm architectures of varying number of cores, or on clusters of these. The best data storage strategy needs to be evaluated, if it can be for instance local NFS storage, AWS S3 type data lake storage, **MORPHEMIC will mount and manage storage and/or hybrid storage with local cache in VMs. This depends on the data volume, the access frequency of the different types of simulations.**
Specifically, MORPHEMIC will support the deployment of three CFD scenarios different in terms of requested resources.

- **Large - high-fidelity simulations** are very demanding in terms of resources, including memory and network bandwidth and typically require an HPC cluster (128 – 2000+) with high-speed interconnect.
- **Medium - medium-fidelity simulations** can be run on high core count (16-128) shared-memory machines or on HPC clusters.
- **Small - low-fidelity simulations** can be run on single workers with few compute cores (<16).

Table 31 - ICON low fidelity use case scenarios

Use case Scenario ID	Name	MORPHEMIC usage Scenarios included	Users
UC_SC_ICON_ LowFidelity_MOD	ICON_ LowFidelity scenario CAMEL Model	• MOD_SC_MOR_01 (Set CAMEL model application requirements) • MOD_SC_MOR_02 (Set CAMEL model application metrics) • MOD_SC_MOR_03 Set CAMEL model application constraints) • MOD_SC_MOR_04 (Export CAMEL model)	Administrators DevOps
UC_SC_ICON_ LowFidelity_DEP	ICON_ LowFidelity scenario Deployment	• DEP_SC_MOR_01 (Set up and login) • DEP_SC_MOR_02 (Add application) • DEP_SC_MOR_03 (Set cloud provider settings) • DEP_SC_MOR_04 (Initial application deployment)	Administrators DevOps
UC_SC_ICON_ LowFidelity_ADP	ICON_ LowFidelity scenario Adaptation	• ADP_SC_MOR_01 (Application running) • ADP_SC_MOR_02 (Application Sensors collection) • ADP_SC_MOR_03 (Reasoning) • ADP_SC_MOR_04 (Reconfiguration) • ADP_SC_MOR_05 (Redeployment)	Application end-user

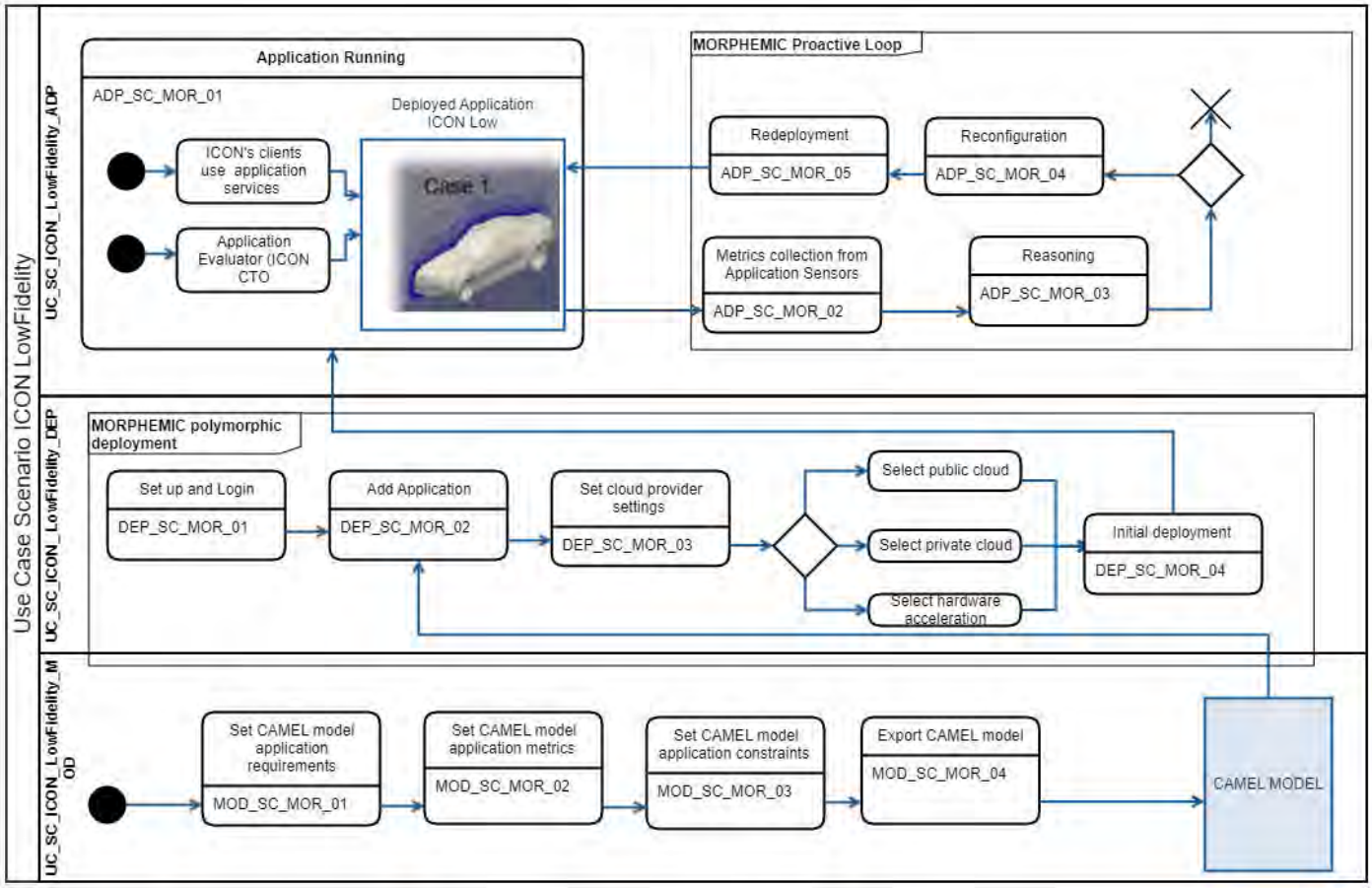


Figure 16- ICON LowFidelity scenario process diagram

Table 32 - ICON medium fidelity use case scenarios

Use case Scenario ID	Name	Morphemic Scenarios included	Users
UC_SC_ICON_ MediumFidelity_MOD	ICON_ MediumFidelity scenario CAMEL Model	• MOD_SC_MOR_01 (Set CAMEL model application requirements) • MOD_SC_MOR_02 (Set CAMEL model application metrics) • MOD_SC_MOR_03 (Set CAMEL model application constraints) • MOD_SC_MOR_04 (Export CAMEL model)	Administrators DevOps
UC_SC_ICON_ MediumFidelity _DEP	ICON_ MediumFidelity scenario Deployment	• DEP_SC_MOR_01 (Set up and login) • DEP_SC_MOR_02 (Add application) • DEP_SC_MOR_03 (Set cloud provider settings) • DEP_SC_MOR_04 (Initial application deployment)	Administrators DevOps
UC_SC_ICON_ MediumFidelity _ADP	ICON_ MediumFidelity scenario Adaptation	• ADP_SC_MOR_01 (Application running) • ADP_SC_MOR_02 (Application Sensors collection)	Application end-user

		• ADP_SC_MOR_03 (Reasoning) • ADP_SC_MOR_04 (Reconfiguration) • ADP_SC_MOR_05 (Redeployment)	

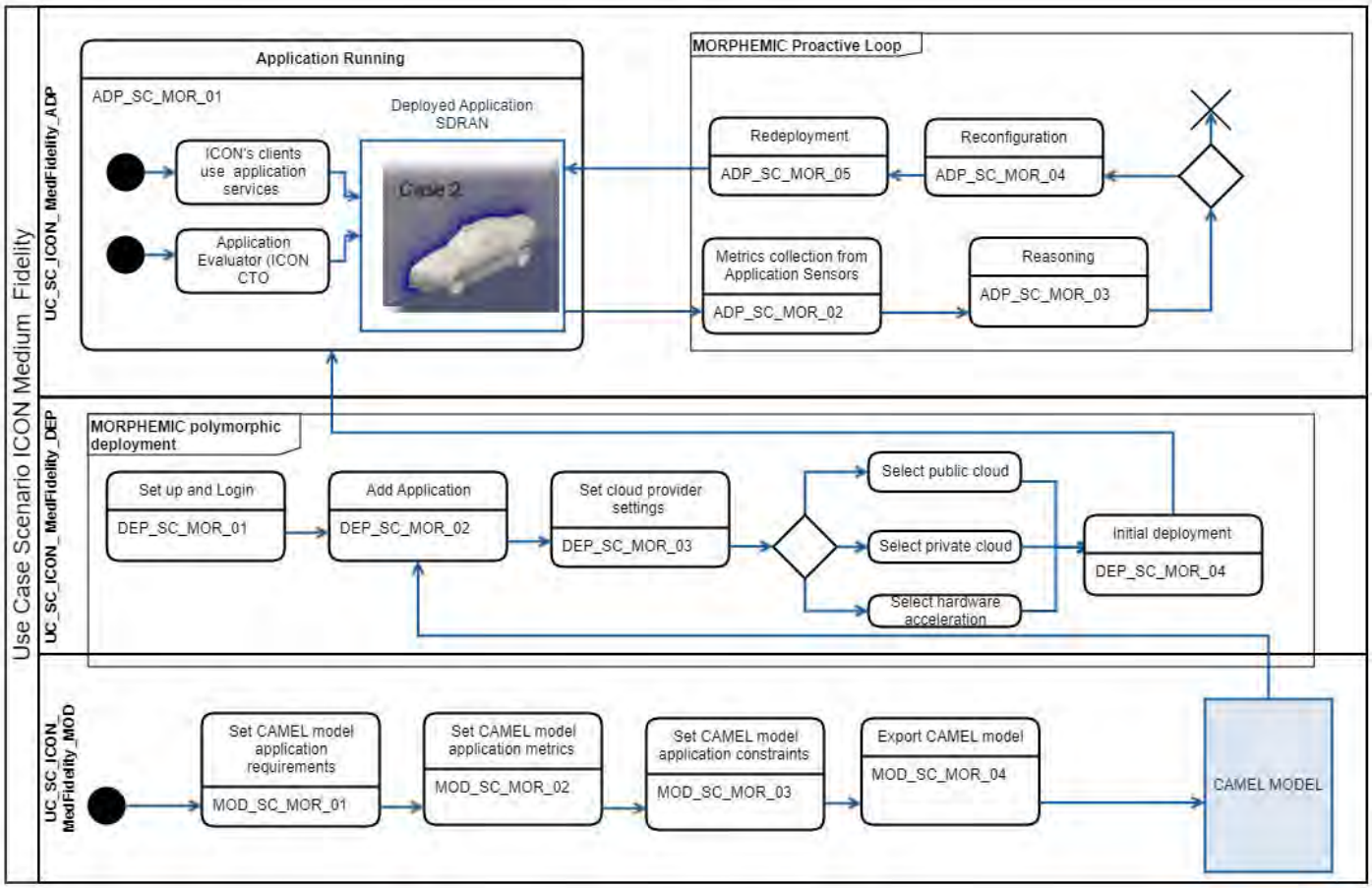


Figure 17- ICON Medium fidelity use case scenarios process diagram

Table 33 - ICON high fidelity use case scenarios

Use case Scenario ID	Name	Morphemic Scenarios included	Users
UC_SC_ICON_ HighFidelity_MOD	ICON_ HighFidelity scenario CAMEL Model	• MOD_SC_MOR_01 (Set CAMEL model application requirements) • MOD_SC_MOR_02 (Set CAMEL model application metrics) • MOD_SC_MOR_03 (Set CAMEL model application constraints) • MOD_SC_MOR_04 (Export CAMEL model)	Administrators DevOps
UC_SC_ICON_ HighFidelity_DEP	ICON_ HighFidelity	• DEP_SC_MOR_01 (Set up and login)	Administrators DevOps

	scenario Deployment	• DEP_SC_MOR_02 (Add application) • DEP_SC_MOR_03 (Set cloud provider settings) • DEP_SC_MOR_04 (Initial application deployment)	
UC_SC_ICON_ MediumFidelity _ADP	ICON_ HighFidelity scenario Adaptation	• ADP_SC_MOR_01 (Application running) • ADP_SC_MOR_02 (Application Sensors collection) • ADP_SC_MOR_03 (Reasoning) • ADP_SC_MOR_04 (Reconfiguration) • ADP_SC_MOR_05 (Redeployment)	Application end-user

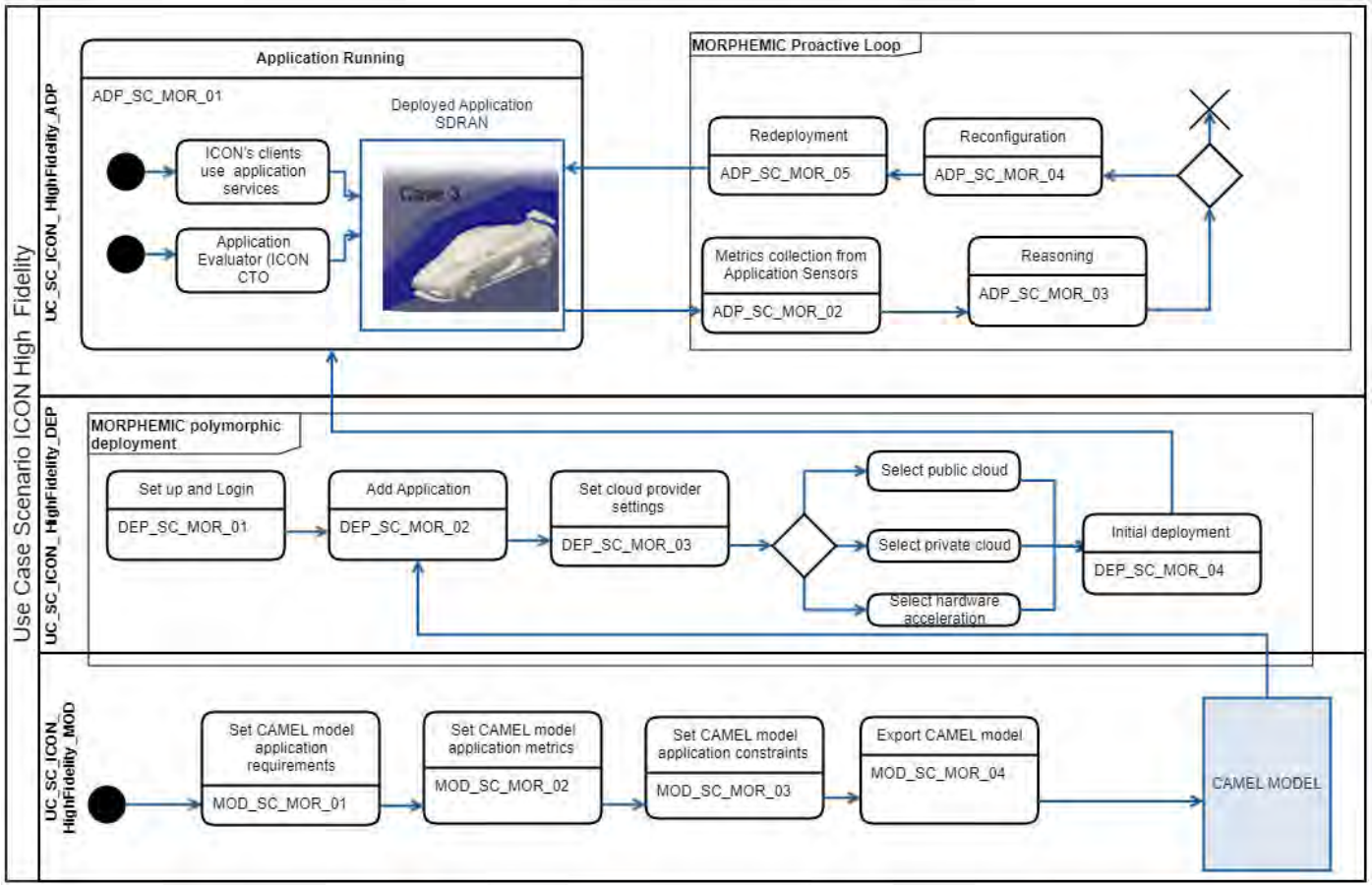


Figure 18 - ICON high fidelity use case scenarios process diagram

6 Target infrastructure

The target infrastructure is based on requirements of use cases discussed in details in D6.1 Industrial requirements analysis. Unlike traditional deployment models, MORPHEMIC features the ability to dynamically change application form (container, serverless, VMs...) and provisioning environment (cloud, fog, edge...) based on current and predicted applications behaviour, thus maximizing benefits for the application. Listed below are the use cases scenarios assigned to the MORPHEMIC supported target infrastructure.

Table 34 - Use cases scenarios assigned to MORPHEMIC supported target infrastructure

Target Infrastructure	Use case Scenarios: Virtualized base station for 5G cloud-RAN	Use case Scenarios: E-Brain Science	Use case Scenarios: Computational Fluid Dynamics simulation
Public Cloud		**SPMonWeb Scenarios** **Image Pre-processing Scenarios**	
Private Cloud		**Image Pre-processing Scenarios**	**High-fidelity Scenarios** **Med-fidelity Scenarios** **Low-fidelity Scenarios**
Hybrid Cloud	**Static Scenarios**	**Federated ML Scenarios**	**High-fidelity Scenarios**

	Dynamic Scenarios		**Med-fidelity Scenarios** **Low-fidelity Scenarios**
Edge	**Static Scenarios** **Dynamic Scenarios**		
Bare Metal	**Static Scenarios** **Dynamic Scenarios**		
Hardware Accelerators	**Static Scenarios** **Dynamic Scenarios**	**Image Pre-processing Scenarios**	
Containers	**Static Scenarios** **Dynamic Scenarios**	**Image Pre-processing Scenarios** **Federated ML Scenarios**	**High-fidelity Scenarios** **Med-fidelity Scenarios** **Low-fidelity Scenarios**
Virtual Machines	**Static Scenarios** **Dynamic Scenarios**	**Image Pre-processing Scenarios** **SPMonWeb Scenarios** **Federated ML Scenarios**	**High-fidelity Scenarios** **Med-fidelity Scenarios** **Low-fidelity Scenarios**
Serverless		**SPMonWeb Scenarios**	
HPC			**Med-fidelity Scenarios** **Low-fidelity Scenarios**

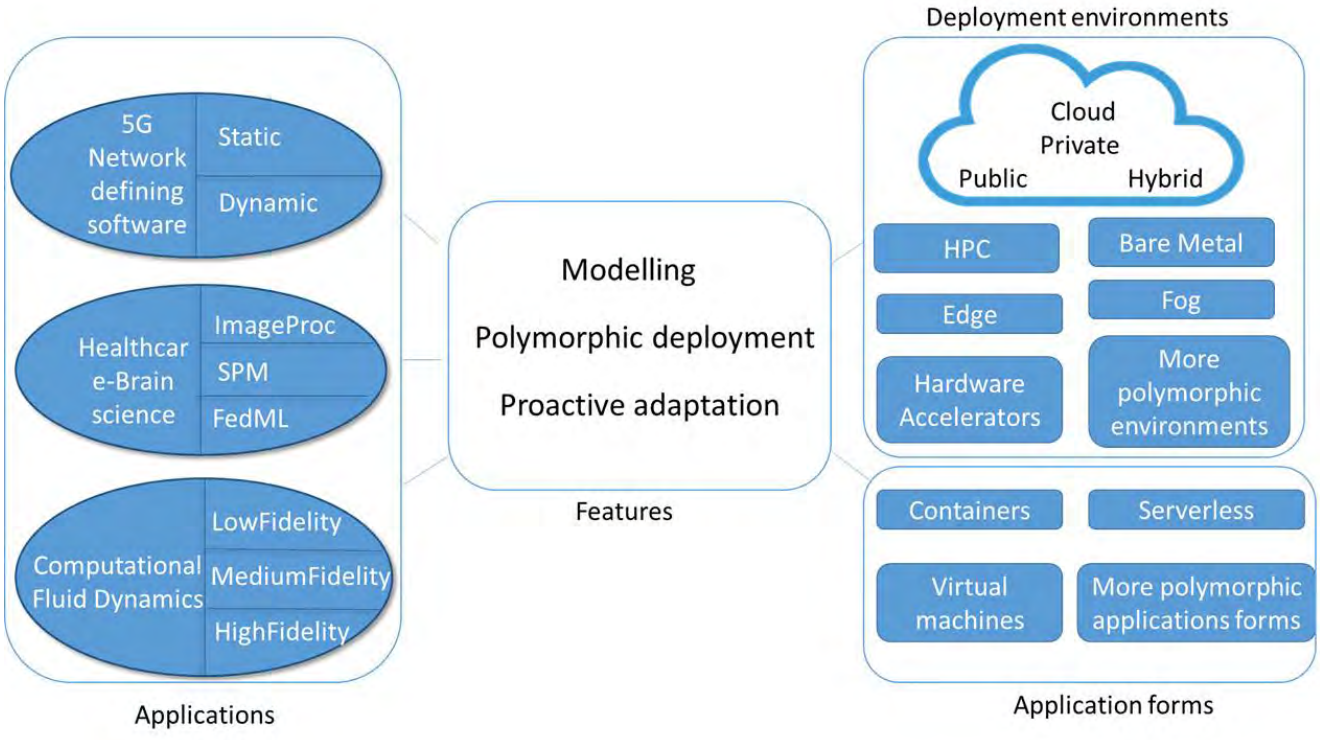


Figure 19 - Target Infrastructure

Each use case scenario, as well as MORPHEMIC releases, updates and functionalities, will be tested and validated using MORPHEMIC testbed. A detailed description of the software, set up tools and installation procedure, initial use case testing performed is provided in D5.6 Testbed installation and configuration. The figure below presents the architecture of the testbed: the interactions happening within the MORPHEMIC testbed between the users, the lead node, the partner's MORPHEMIC instances and the deployment nodes

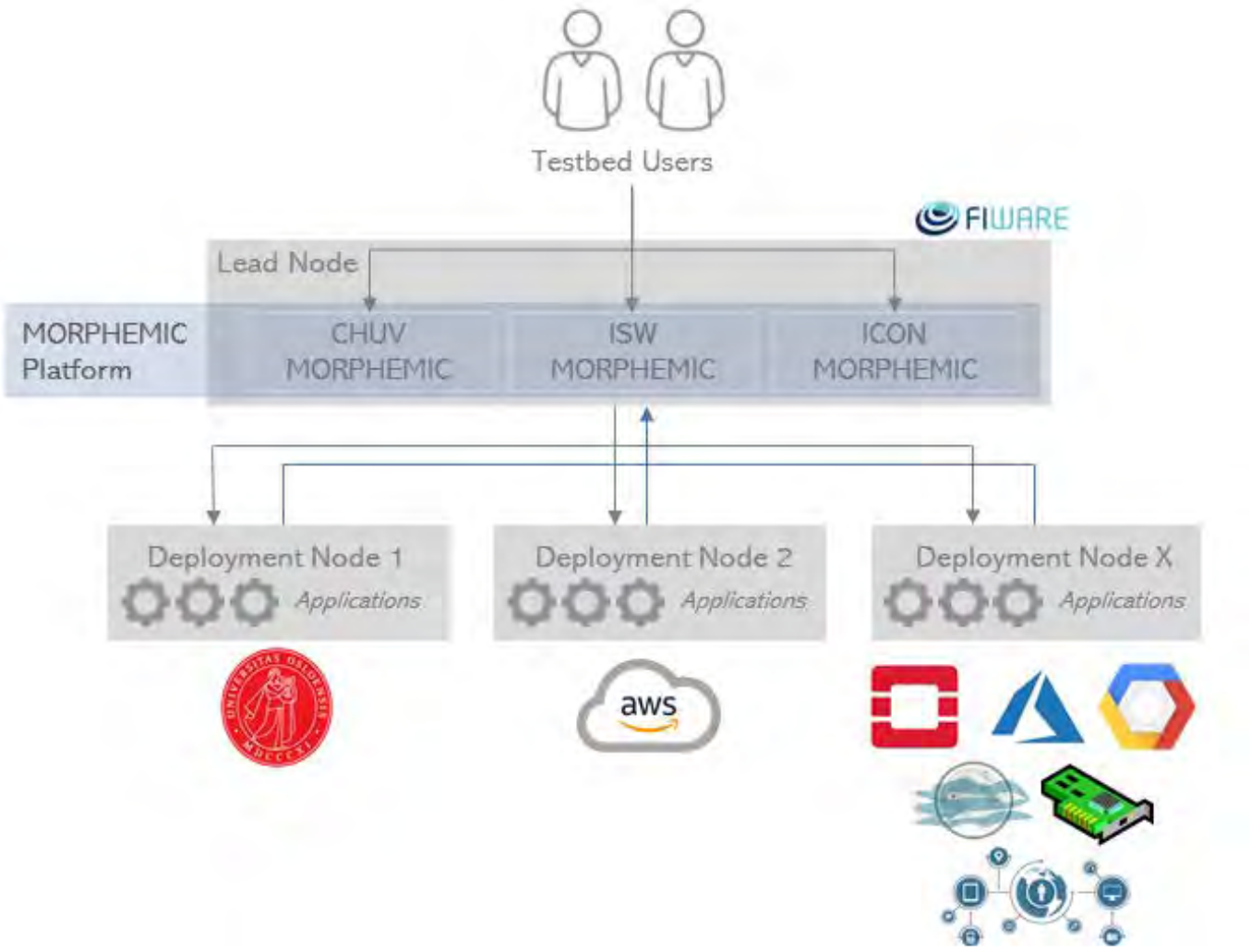


Figure 20 - Architecture of the testbed infrastructure

7 Requirements

7.1 Requirement for the MORPHEMIC Usage scenarios

Table 35 - Requirements for the MORPHEMIC Usage scenarios

Requirement ID	Name	MORPHEMIC usage scenario
MOR-SE.1	Polymorphic Environments: Cloud	MOD_SC_MOR_01 MOD_SC_MOR_02 MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01 DEP_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04
MOR-SE.2	Polymorphic Environments: Hybrid Clouds	MOD_SC_MOR_01 MOD_SC_MOR_02 MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01 DEP_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04
MOR-SE.3	Polymorphic Environments: Multi-Cloud	MOD_SC_MOR_01 MOD_SC_MOR_02 MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01 DEP_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04
MOR-SE.4	Polymorphic Environments: Fog	MOD_SC_MOR_01 MOD_SC_MOR_02 MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01 DEP_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04
MOR-SE.5	Polymorphic Environments: Edge	MOD_SC_MOR_01 MOD_SC_MOR_02 MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01 DEP_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04
MOR-SE.6	Polymorphic Environments: bare metal	MOD_SC_MOR_01 MOD_SC_MOR_02

		MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01 DEP_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04
MOR-SE.7	Polymorphic Environments: HPC	MOD_SC_MOR_01 MOD_SC_MOR_02 MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01DE P_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04
MOR-SE.8	Polymorphic Environments: hardware accelerators	MOD_SC_MOR_01 MOD_SC_MOR_02 MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01 DEP_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04
MOR-SE.9	Polymorphic Environments: FPGA	MOD_SC_MOR_01 MOD_SC_MOR_02 MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01DE P_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04
MOR-SE.10	More polymorphic environments	MOD_SC_MOR_01 MOD_SC_MOR_02 MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01 DEP_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04
MOR-SA.1	Polymorphic application forms: VM	MOD_SC_MOR_01 MOD_SC_MOR_02 MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01 DEP_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04
MOR-SA.2	Polymorphic application forms: containers	MOD_SC_MOR_01 MOD_SC_MOR_02

		MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01 DEP_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04
MOR-SA.3	Polymorphic application forms: serverless	MOD_SC_MOR_01 MOD_SC_MOR_02 MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01 DEP_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04
MOR-SA.4	More polymorphic application forms	MOD_SC_MOR_01 MOD_SC_MOR_02 MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01 DEP_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04
MOR-CON.1	Pre-configure multiple deployment configurations	MOD_SC_MOR_01 MOD_SC_MOR_02 MOD_SC_MOR_03 MOD_SC_MOR_04
MOR-SH.1	Real time infrastructure performance monitoring	ADP_SC_MOR_01 ADP_SC_MOR_02 ADP_SC_MOR_03 ADP_SC_MOR_04 ADP_SC_MOR_05
MOR-SH.2	Real time applications performance monitoring	ADP_SC_MOR_01 ADP_SC_MOR_02 ADP_SC_MOR_03 ADP_SC_MOR_04 ADP_SC_MOR_05
MOR-SH.3	Self-Healing mechanism	ADP_SC_MOR_01 ADP_SC_MOR_02 ADP_SC_MOR_03 ADP_SC_MOR_04 ADP_SC_MOR_05
MOR-AD.1	Proactive Adaptation	ADP_SC_MOR_01 ADP_SC_MOR_02 ADP_SC_MOR_03 ADP_SC_MOR_04 ADP_SC_MOR_05
MOR-AD.2	Prediction capabilities on applications	ADP_SC_MOR_01 ADP_SC_MOR_02 ADP_SC_MOR_03 ADP_SC_MOR_04 ADP_SC_MOR_05

MOR-AD.3	Prediction capabilities on infrastructures	ADP_SC_MOR_01 ADP_SC_MOR_02 ADP_SC_MOR_03 ADP_SC_MOR_04 ADP_SC_MOR_05
MOR-MD.1	Application crawling	ADP_SC_MOR_01 ADP_SC_MOR_02 ADP_SC_MOR_03 ADP_SC_MOR_04 ADP_SC_MOR_05
MOR-MD.2	Application profiling	ADP_SC_MOR_01 ADP_SC_MOR_02 ADP_SC_MOR_03 ADP_SC_MOR_04 ADP_SC_MOR_05
MOR-OP.1	Optimization of Resources	MOD_SC_MOR_01 MOD_SC_MOR_02 MOD_SC_MOR_03 MOD_SC_MOR_04 DEP_SC_MOR_01 DEP_SC_MOR_02 DEP_SC_MOR_03 DEP_SC_MOR_04

7.2 Requirement for the MORPHEMIC Use case scenarios

Table 36 - Requirements for the MORPHEMIC Use case scenarios

ID	Name	Use case Scenario
UC-C-SE.1	Support for non-virtualized components	UC_SC_ISW_Static_MOD UC_SC_ISW_Dynamic_MOD UC_SC_CHUV_ImageProc_MOD UC_SC_CHUV_SPM_MOD UC_SC_CHUV_FedML_MOD
UC-C-SE.2	Multi-site deployment	UC_SC_ISW_Static_MOD UC_SC_ISW_Dynamic_MOD UC_SC_ISW_Static_DEP UC_SC_ISW_Dynamic_DEP UC_SC_CHUV_ImageProc_MOD UC_SC_CHUV_SPM_MOD UC_SC_CHUV_FedML_MOD UC_SC_CHUV_ImageProc_DEP UC_SC_CHUV_SPM_DEP UC_SC_CHUV_FedML_DEP
UC-C-SE.3	Support for GPU	UC_SC_CHUV_ImageProc_MOD UC_SC_CHUV_SPM_MOD UC_SC_CHUV_FedML_MOD

		UC_SC_CHUV_ImageProc_DEP UC_SC_CHUV_SPM_DEP UC_SC_CHUV_FedML_DEP UC_SC_ICON_LowFidelity_MOD UC_SC_ICON_MediumFidelity_MOD UC_SC_ICON_HighFidelity_MOD UC_SC_ICON_LowFidelity_DEP UC_SC_ICON_MediumFidelity_DEP UC_SC_ICON_HighFidelity_DEP
UC-C-UF.1	Targeted deployment: network capability	UC_SC_ISW_ Dynamic_MODUC_SC_ ISW_ Dynamic_ADP UC_SC_CHUV_ImageProc_MOD UC_SC_CHUV_SPM_MOD UC_SC_CHUV_FedML_MOD UC_SC_CHUV_ImageProc_ADP UC_SC_CHUV_SPM_ADP UC_SC_CHUV_FedML_ADP
UC-C-UF.2	Targeted deployment: price	UC_SC_ISW_ Dynamic_ADP UC_SC_ICON_LowFidelity_ADP UC_SC_ICON_MediumFidelity_ADP UC_SC_ICON_HighFidelity_ADP
UC-C-UF.3	Targeted deployment: packaging	UC_SC_ISW_ Static_MOD UC_SC_ISW_ Dynamic_MOD UC_SC_CHUV_ImageProc_MOD UC_SC_CHUV_SPM_MOD UC_SC_CHUV_FedML_MOD UC_SC_ICON_LowFidelity_MOD UC_SC_ICON_MediumFidelity_MOD UC_SC_ICON_HighFidelity_MOD
UC-C-UF.4	Geographical awareness	UC_SC_ISW_ Static_MOD UC_SC_ISW_ Dynamic_MOD UC_SC_CHUV_ImageProc_MOD UC_SC_CHUV_SPM_MOD UC_SC_CHUV_FedML_MOD
UC-C-UF.5	Targeted deployment: computing power	UC_SC_ISW_ Static_MOD UC_SC_ISW_ Dynamic_MOD UC_SC_ICON_LowFidelity_MOD UC_SC_ICON_MediumFidelity_MOD UC_SC_ICON_HighFidelity_MOD
UC-C-SEC.1	Support for traffic isolation	UC_SC_ISW_ Static_MOD UC_SC_ISW_ Dynamic_MOD

		UC_SC_CHUV_ImageProc_MOD UC_SC_CHUV_SPM_MOD UC_SC_CHUV_FedML_MOD
UC-C-SEC.2	Support for secure communications	UC_SC_ISW_ Static_MOD UC_SC_ISW_ Dynamic_MOD UC_SC_CHUV_ImageProc_MOD UC_SC_CHUV_SPM_MOD UC_SC_CHUV_FedML_MOD
UC-C-SEC.3	Support for security related applications	UC_SC_ISW_ Static_DEP UC_SC_ISW_ Dynamic_DEP UC_SC_CHUV_ImageProc_DEP UC_SC_CHUV_SPM_DEP UC_SC_CHUV_FedML_DEP
UC-1-SE.1	Platform awareness: DPDK	UC_SC_ISW_ Static_DEP UC_SC_ISW_ Dynamic_DEP
UC-1-SE.2	Platform awareness: CPU pinning	UC_SC_ISW_ Static_DEP UC_SC_ISW_ Dynamic_DEP
UC-1-SE.3	Support for redundancy	UC_SC_ISW_ Static_DEP UC_SC_ISW_ Dynamic_DEP
UC-1-SE.4	Support for Fault Management	UC_SC_ISW_ Static_DEP UC_SC_ISW_ Dynamic_DEP
UC-1-SE.5	Support for Configuration Management	UC_SC_ISW_ Static_DEP UC_SC_ISW_ Dynamic _DEP
UC-1-SE.6	Support for Accounting Management	UC_SC_ISW_ Static_DEP UC_SC_ISW_ Dynamic _DEP
UC-1-SE.7	Support for Performance Management	UC_SC_ISW_ Static_DEP UC_SC_ISW_ Dynamic _DEP
UC-1-SE.8	Support for Security Management	UC_SC_ISW_ Static_DEP UC_SC_ISW_ Dynamic _DEP
UC-1-UF.1	Support for low latency in terms of deployment time	UC_SC_ISW_ Static_MOD UC_SC_ISW_ Dynamic _MOD UC_SC_ISW_ Static_DEP UC_SC_ISW_ Dynamic _DEP
UC-1-UF.2	Targeted deployment: latency between the deployed components	UC_SC_ISW_ Static_MOD UC_SC_ISW_ Dynamic _MOD UC_SC_ISW_ Static_DEP UC_SC_ISW_ Dynamic _DEP
UC-1-AD.1	Dynamic deployment configuration	UC_SC_ISW_ Dynamic _ADP
UC-1-AD.2	Live migration	UC_SC_ISW_ Dynamic _ADP
UC-2-SE.1	Support for ProActive	UC_SC_CHUV_ImageProc_MOD UC_SC_CHUV_SPM_MOD UC_SC_CHUV_FedML_MOD UC_SC_CHUV_ImageProc_DEP UC_SC_CHUV_SPM_DEP UC_SC_CHUV_FedML_DEP
UC-2-SE.2	Support for private execution environment	UC_SC_CHUV_ImageProc_MOD UC_SC_CHUV_SPM_MOD

		UC_SC_CHUV_FedML_MOD UC_SC_CHUV_ImageProc _DEP UC_SC_CHUV_SPM_DEP UC_SC_CHUV_FedML_DEP
UC-2-SE.3	Support for Master orchestrator	UC_SC_CHUV_ImageProc_MOD UC_SC_CHUV_SPM_MOD UC_SC_CHUV_FedML_MOD UC_SC_CHUV_ImageProc_DEP UC_SC_CHUV_SPM_DEP UC_SC_CHUV_FedML_DEP
UC-3-SE.1	Connection to HPC centres	UC_SC_ICON_LowFidelity_MOD UC_SC_ICON_MediumFidelity_MOD UC_SC_ICON_HighFidelity_MOD UC_SC_ICON_LowFidelity_DEP UC_SC_ICON_MediumFidelity_DEP UC_SC_ICON_HighFidelity_DEP
UC-3-SE.2	Management of workers	UC_SC_ICON_LowFidelity_MOD UC_SC_ICON_MediumFidelity_MOD UC_SC_ICON_HighFidelity_MOD UC_SC_ICON_LowFidelity_DEP UC_SC_ICON_MediumFidelity_DEP UC_SC_ICON_HighFidelity_DEP
UC-3-SA.1	Targeted deployment: containers	UC_SC_ICON_LowFidelity_MOD UC_SC_ICON_MediumFidelity_MOD UC_SC_ICON_HighFidelity_MOD UC_SC_ICON_LowFidelity_DEP UC_SC_ICON_MediumFidelity_DEP UC_SC_ICON_HighFidelity_DEP
UC-3-AD.1	Adaptation of the number of workers	UC_SC_ICON_LowFidelity_ADP UC_SC_ICON_MediumFidelity_ADP UC_SC_ICON_HighFidelity_ADP
UC-3-UF.1	Targeted deployment: memory	UC_SC_ICON_LowFidelity_MOD UC_SC_ICON_MediumFidelity_MOD UC_SC_ICON_HighFidelity_MOD UC_SC_ICON_LowFidelity_DEP UC_SC_ICON_MediumFidelity_DEP UC_SC_ICON_HighFidelity_DEP
UC-3-UF.2	Targeted deployment: deployment time	UC_SC_ICON_LowFidelity_MOD UC_SC_ICON_MediumFidelity_MOD UC_SC_ICON_HighFidelity_MOD UC_SC_ICON_LowFidelity_DEP UC_SC_ICON_MediumFidelity_DEP UC_SC_ICON_HighFidelity_DEP
UC-3-SH.1	Track worker velocity	UC_SC_ICON_LowFidelity_DEP UC_SC_ICON_MediumFidelity_DEP UC_SC_ICON_HighFidelity_DEP

Conclusion

MORPHEMIC will deliver a number of benefits to various different domains and use cases. These have been described in detail in this deliverable, along with a description of the respective use cases. With the various use case scenarios, the benefits are mostly explained from the perspective of the users and less from the technical standpoint.

A description of the use cases can be found in this document along with a description of the benefits that MORPHEMIC platform will provide. Through the various use case scenarios, the benefits are illustrated. The use case scenarios will serve as a basis for testing and validating the MORPHEMIC platform.

Use cases and use case scenarios are very important in developing software applications. For MOPRPHEMIC, it serves as an important methodology for demonstrating the intended functionality. By using this procedure, we ensure that MOPRPHEMIC 's components are tailored to the needs of the three represented company. In addition, use case scenarios can be used to assess the usability of the platform as a whole. These aspects related to the validation, verification of a use cases will be the topic of the future deliverables of MORPHEMIC projects namely "use cases validation",

- D6.2 Validation framework design"
- D6.4 Use Cases prototypes
- D6.5 Validation outcomes

In this deliverable, we provide an overview of how we prepared use case scenarios, including models and sequence diagrams in UML. We used the MORPHEMIC usage case scenarios to ensure we took a user-centric approach.

The use case definition includes the steps that are followed when different types of users interact with the MOPHEMIC functionality in order to accomplish their business objectives. We used the MORPHEMIC usage case scenarios to ensure we took a user-centric approach. Aside from that, we also highlighted the environment around the business application, its domain, and how each business actor would benefit according to his or her role.
Overall the information included here will form the the basis of the guideline that will be provided to each use case community.

Ultimately, the information that we present here will form the basis for the guides that will be provided to each community that builds on the use cases we describe here.