



Systems Modeling Application Programming Interface (API) and Services

Version 1.0

OMG Document Number: formal/2025-09-04

Date: September 2025

Standard document URL: <https://www.omg.org/spec/SystemsModelingAPI/1.0/>

Machine Readable File(s): <https://www.omg.org/spec/SystemsModelingAPI/20250201/>

Copyright © 2019-2025, 88solutions Corporation
Copyright © 2019-2025, Airbus
Copyright © 2019-2025, Aras Corporation
Copyright © 2019-2025, Association of Universities for Research in Astronomy (AURA)
Copyright © 2019-2025, BigLever Software
Copyright © 2019-2025, Boeing
Copyright © 2022-2025, Budapest University of Technology and Economics
Copyright © 2021-2025, Commissariat à l'énergie atomique et aux énergies alternatives (CEA)
Copyright © 2019-2025, Contact Software GmbH
Copyright © 2019-2025, Dassault Systèmes (No Magic)
Copyright © 2019-2025, DSC Corporation
Copyright © 2020-2025, DEKonsult
Copyright © 2020-2025, Delligatti Associates LLC
Copyright © 2019-2025, The Charles Stark Draper Laboratory, Inc.
Copyright © 2020-2025, ESTACA
Copyright © 2023-2025, Galois, Inc.
Copyright © 2019-2025, GfSE e.V.
Copyright © 2019-2025, George Mason University
Copyright © 2019-2025, IBM
Copyright © 2019-2025, Idaho National Laboratory
Copyright © 2019-2025, INCOSE
Copyright © 2019-2025, Intercax LLC
Copyright © 2019-2025, Jet Propulsion Laboratory (California Institute of Technology)
Copyright © 2019-2025, Kenntnis LLC
Copyright © 2020-2025, Kungliga Tekniska högskolan (KTH)
Copyright © 2019-2025, LightStreet Consulting LLC
Copyright © 2019-2025, Lockheed Martin Corporation
Copyright © 2019-2025, Maplesoft
Copyright © 2021-2025, MID GmbH
Copyright © 2020-2025, MITRE
Copyright © 2019-2025, Model Alchemy Consulting
Copyright © 2019-2025, Model Driven Solutions, Inc.
Copyright © 2019-2025, Model Foundry Pty. Ltd.
Copyright © 2023-2025, Object Management Group, Inc.
Copyright © 2019-2025, On-Line Application Research Corporation (OAC)
Copyright © 2019-2025, oose eG
Copyright © 2019-2025, Østfold University College
Copyright © 2019-2025, PTC
Copyright © 2020-2025, Qualtech Systems, Inc.
Copyright © 2019-2025, SAF Consulting
Copyright © 2019-2025, Simula Research Laboratory AS
Copyright © 2019-2025, System Strategy, Inc.
Copyright © 2019-2025, Thematix Partners, LLC
Copyright © 2019-2025, Tom Sawyer
Copyright © 2023-2025, Tucson Embedded Systems, Inc.
Copyright © 2019-2025, Universidad de Cantabria
Copyright © 2019-2025, University of Alabama in Huntsville
Copyright © 2019-2025, University of Detroit Mercy
Copyright © 2019-2025, University of Kaiserslauten
Copyright © 2020-2025, Willert Software Tools GmbH (SodiusWillert)

USE OF SPECIFICATION - TERMS, CONDITIONS & NOTICES

The material in this document details an Object Management Group specification in accordance with the terms, conditions and notices set forth below. This document does not represent a commitment to implement any portion of this specification in any company's products. The information contained in this document is subject to change without notice.

LICENSES

The companies listed above have granted to the Object Management Group, Inc. (OMG) a nonexclusive, royalty-free, paid up, worldwide license to copy and distribute this document and to modify this document and distribute copies of the modified version. Each of the copyright holders listed above has agreed that no person shall be deemed to have infringed the copyright in the included material of any such copyright holder by reason of having used the specification set forth herein or having conformed any computer software to the specification.

Subject to all of the terms and conditions below, the owners of the copyright in this specification hereby grant you a fully-paid up, non-exclusive, nontransferable, perpetual, worldwide license (without the right to sublicense), to use this specification to create and distribute software and special purpose specifications that are based upon this specification, and to use, copy, and distribute this specification as provided under the Copyright Act; provided that: (1) both the copyright notice identified above and this permission notice appear on any copies of this specification; (2) the use of the specifications is for informational purposes and will not be copied or posted on any network computer or broadcast in any media and will not be otherwise resold or transferred for commercial purposes; and (3) no modifications are made to this specification. This limited permission automatically terminates without notice if you breach any of these terms or conditions. Upon termination, you will destroy immediately any copies of the specifications in your possession or control.

PATENTS

The attention of adopters is directed to the possibility that compliance with or adoption of OMG specifications may require use of an invention covered by patent rights. OMG shall not be responsible for identifying patents for which a license may be required by any OMG specification, or for conducting legal inquiries into the legal validity or scope of those patents that are brought to its attention. OMG specifications are prospective and advisory only. Prospective users are responsible for protecting themselves against liability for infringement of patents.

GENERAL USE RESTRICTIONS

Any unauthorized use of this specification may violate copyright laws, trademark laws, and communications regulations and statutes. This document contains information which is protected by copyright. All Rights Reserved. No part of this work covered by copyright herein may be reproduced or used in any form or by any means--graphic, electronic, or mechanical, including photocopying, recording, taping, or information storage and retrieval systems--without permission of the copyright owner.

DISCLAIMER OF WARRANTY

WHILE THIS PUBLICATION IS BELIEVED TO BE ACCURATE, IT IS PROVIDED "AS IS" AND MAY CONTAIN ERRORS OR MISPRINTS. THE OBJECT MANAGEMENT GROUP AND THE COMPANIES LISTED ABOVE MAKE NO WARRANTY OF ANY KIND, EXPRESS OR IMPLIED, WITH REGARD TO THIS PUBLICATION, INCLUDING BUT NOT LIMITED TO ANY WARRANTY OF TITLE OR

OWNERSHIP, IMPLIED WARRANTY OF MERCHANTABILITY OR WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE OR USE. IN NO EVENT SHALL THE OBJECT MANAGEMENT GROUP OR ANY OF THE COMPANIES LISTED ABOVE BE LIABLE FOR ERRORS CONTAINED HEREIN OR FOR DIRECT, INDIRECT, INCIDENTAL, SPECIAL, CONSEQUENTIAL, RELIANCE OR COVER DAMAGES, INCLUDING LOSS OF PROFITS, REVENUE, DATA OR USE, INCURRED BY ANY USER OR ANY THIRD PARTY IN CONNECTION WITH THE FURNISHING, PERFORMANCE, OR USE OF THIS MATERIAL, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.

The entire risk as to the quality and performance of software developed using this specification is borne by you. This disclaimer of warranty constitutes an essential part of the license granted to you to use this specification.

RESTRICTED RIGHTS LEGEND

Use, duplication or disclosure by the U.S. Government is subject to the restrictions set forth in subparagraph (c) (1) (ii) of The Rights in Technical Data and Computer Software Clause at DFARS 252.227-7013 or in subparagraph (c)(1) and (2) of the Commercial Computer Software - Restricted Rights clauses at 48 C.F.R. 52.227-19 or as specified in 48 C.F.R. 227-7202-2 of the DoD F.A.R. Supplement and its successors, or as specified in 48 C.F.R. 12.212 of the Federal Acquisition Regulations and its successors, as applicable. The specification copyright owners are as indicated above and may be contacted through the Object Management Group, 9C Medway Road, PMB 274, Milford, MA 01757, U.S.A.

TRADEMARKS

CORBA[®], CORBA logos[®], FIBO[®], Financial Industry Business Ontology[®], Financial Instrument Global Identifier[®], IIOP[®], IMM[®], Model Driven Architecture[®], MDA[®], Object Management Group[®], OMG[®], OMG Logo[®], SoaML[®], SOAML[®], SysML[®], UAF[®], Unified Modeling Language[™], UML[®], UML Cube Logo[®], VSIPL[®], and XMI[®] are registered trademarks of the Object Management Group, Inc.

For a complete list of trademarks, see: https://www.omg.org/legal/tm_list.htm. All other products or company names mentioned are used for identification purposes only, and may be trademarks of their respective owners.

COMPLIANCE

The copyright holders listed above acknowledge that the Object Management Group (acting itself or through its designees) is and shall at all times be the sole entity that may authorize developers, suppliers and sellers of computer software to use certification marks, trademarks or other special designations to indicate compliance with these materials.

Software developed under the terms of this license may claim compliance or conformance with this specification if and only if the software compliance is of a nature fully matching the applicable compliance points as stated in the specification. Software developed only partially matching the applicable compliance points may claim only that the software was based on this specification, but may not claim compliance or conformance with this specification. In the event that testing suites are implemented or approved by Object Management Group, Inc., software developed using this specification may claim compliance or conformance with the specification only if the software satisfactorily completes the testing suites.

OMG'S ISSUE REPORTING PROCEDURE

All OMG specifications are subject to continuous review and improvement. As part of this process we encourage readers to report any ambiguities, inconsistencies, or inaccuracies they may find by completing the Issue Reporting Form listed on the main web page <https://www.omg.org>, under Documents, Report a Bug/Issue.

Preface

OMG

Founded in 1989, the Object Management Group, Inc. (OMG) is an open membership, not-for-profit computer industry standards consortium that produces and maintains computer industry specifications for interoperable, portable, and reusable enterprise applications in distributed, heterogeneous environments. Membership includes Information Technology vendors, end users, government agencies, and academia.

OMG member companies write, adopt, and maintain its specifications following a mature, open process. OMG's specifications implement the Model Driven Architecture[®] (MDA[®]), maximizing ROI through a full-lifecycle approach to enterprise integration that covers multiple operating systems, programming languages, middleware and networking infrastructures, and software development environments. OMG's specifications include: UML[®] (Unified Modeling Language[™]); CORBA[®] (Common Object Request Broker Architecture); CWM[™] (Common Warehouse Metamodel); and industry-specific standards for dozens of vertical markets.

More information on the OMG is available at <https://www.omg.org/>.

OMG Specifications

As noted, OMG specifications address middleware, modeling, and vertical domain frameworks. All OMG Specifications are available from the OMG website at: <https://www.omg.org/spec>

All of OMG's formal specifications may be downloaded without charge from our website. (Products implementing OMG specifications are available from individual suppliers.) Copies of specifications, available in PostScript and PDF format, may be obtained from the Specifications Catalog cited above or by contacting the Object Management Group, Inc. at:

OMG Headquarters
9C Medway Road, PMB 274
Milford, MA 01757
USA
Tel: +1-781-444-0404
Fax: +1-781-444-0320

Email: pubs@omg.org

Certain OMG specifications are also available as ISO standards. Please consult <https://www.iso.org>

Issues

All OMG specifications are subject to continuous review and improvement. As part of this process we encourage readers to report any ambiguities, inconsistencies, or inaccuracies they may find by completing the Issue Reporting Form listed on the main web page <https://www.omg.org>, under Specifications, Report an Issue.

Table of Contents

1 Scope	1
2 Conformance	3
3 Normative References	7
4 Terms and Definitions	9
5 Symbols	11
6 Introduction	13
6.1 API and Services Architecture	13
6.2 Document Conventions	14
6.3 Document Organization	15
6.4 Acknowledgements	15
7 Platform Independent Model (PIM)	17
7.1 API Model	17
7.1.1 Record	17
7.1.2 Project Data Versioning	18
7.1.3 ExternalData and ExternalRelationship	22
7.1.4 Query	24
7.2 API Services	25
7.2.1 ProjectService	25
7.2.2 ElementNavigationService	27
7.2.3 ProjectDataVersioningService	28
7.2.4 QueryService	32
7.2.5 ExternalRelationshipService	32
7.2.6 ProjectUsageService	33
8 Platform Specific Models (PSMs)	35
8.1 REST/HTTP PSM	35
8.1.1 Overview	35
8.1.2 PIM API Model - REST/HTTP PSM Model Mapping	35
8.1.3 PIM API Services - REST/HTTP PSM Endpoints Mapping	36
8.2 OSLC 3.0 PSM	42
8.2.1 Overview	42
8.2.2 OSLC Nomenclature	43
8.2.3 PIM API Model – OSLC PSM Resource Mapping	44
8.2.4 PIM API Services – OSLC PSM Service Mapping	45
A Annex: Conformance Test Suite	55
A.1 ProjectService Conformance Test Cases	55
A.2 ElementNavigationService Conformance Test Cases	57
A.3 ProjectDataVersioningService Conformance Test Cases	61
A.4 QueryService Conformance Test Cases	72
A.5 ExternalRelationshipService Conformance Test Cases	74
A.6 ProjectUsageService Conformance Test Cases	76
A.7 Cross-Cutting Conformance Test Cases	77
B Annex: API and Services Examples and Cookbook	83
B.1 Examples	83
B.2 Cookbook	93

List of Tables

1. Operations	25
2. Operations	27
3. Operations	28
4. Operations	28
5. Operations	31
6. Operations	32
7. Operations	33
8. Operations	33
9. PIM API Model - REST/HTTP PSM Model Mapping Table	35
10. PIM to REST / HTTP PSM Mapping	36
11. PIM Concept to OSLC Resource type Mapping.....	44
12. PIM API Services - OSLC Services Mapping.....	45

List of Figures

1. API and Services Provider and Consumer.....	3
2. API and Services Architecture.....	13
3. Use of PIM and PSMs by Providers and Consumers	14
4. Types of Records	17
5. Project Data Versioning API Model.....	18
6. External Relationship API Model.....	22
7. Query API Model.....	24
8. ProjectService Operations.....	25
9. ElementNavigationService Operations.....	27
10. ProjectDataVersioningService Operations	28
11. QueryService Operations.....	32
12. ExternalRelationshipService Operations	32
13. ProjectUsageService Operations.....	33

1 Scope

The purpose of this standard is to specify the Systems Modeling Application Programming Interface (API) and Services that provide standard services to access, navigate, and operate on KerML-based models [KerML], and, in particular, SysML models [SysML]. The standard services facilitate interoperability both across SysML modeling environments and between SysML modeling environments and other engineering tools and enterprise services.

The Systems Modeling API and Services specifies the types and details of the requests that can be made and responses that can be received by software applications that are consuming the services to software applications that are providing the services.

The Systems Modeling API and Services specification includes the Platform Independent Model (PIM) - see [Clause 7](#) - and two Platform Specific Models (PSMs) - see [Clause 8](#): REST/HTTP PSM and OSLC PSM.

2 Conformance

This specification defines the Systems Modeling API and Services that provide standard services to access, navigate, and operate on KerML-based models [KerML] and, in particular, SysML models [SysML]. The specification comprises this document together with the content of the machine-readable files listed on the cover page. If there are any conflicts between this document and the machine-readable files, the machine-readable files take precedence.

A **Systems Modeling API and Services Provider** is a software application that provides the services defined in this specification.

A **Systems Modeling API and Services Consumer** is a software application that consumes the services defined in this specification and provided by the Service Provider.

Consumers send requests to Providers and receive responses with results, as illustrated in [Fig. 1](#) below.

For brevity, this specification uses the phrase **Service Provider** for **Systems Modeling API and Services Provider**, and the term **Service Consumer** for **Systems Modeling API and Services Consumer**.

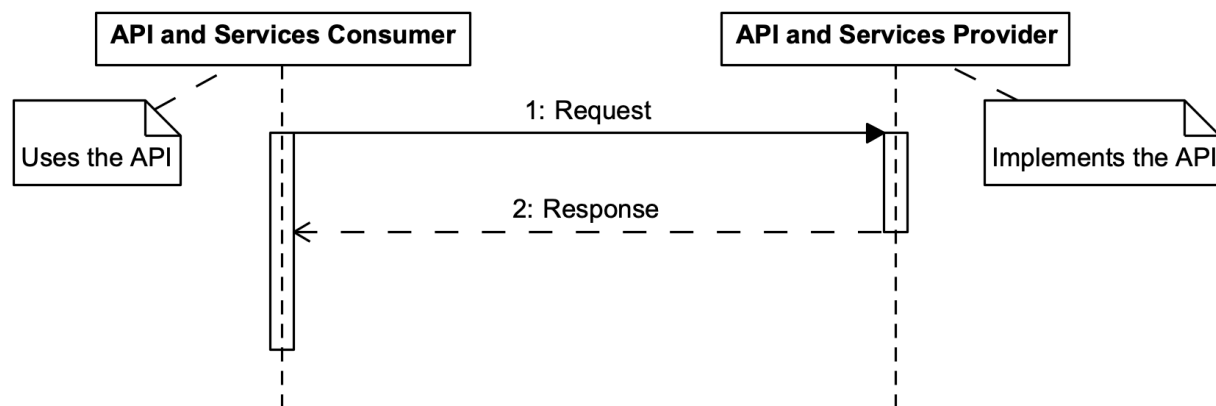


Figure 1. API and Services Provider and Consumer

A Service Provider can conform to this specification at the PSM or PIM level.

1. **PSM-level Conformance** - A Service Provider demonstrating PSM-level Conformance implements one or more of the Systems Modeling API and Services PSMs defined in this specification. For example, a Provider can implement the REST/HTTP PSM, the OSLC PSM, or both. PSM-level conformance of Service Providers ensures interoperability of Service Consumers using the PSM across the different Service Providers. See [Clause 8](#).
2. **PIM-level Conformance** - A Service Provider demonstrating PIM-level Conformance implements a PSM that is not defined in this specification but is based on Systems Modeling API and Services PIM defined in this specification. The Service Provider shall define the PSM and the mapping from PIM to PSM with the goal that the new PSM may become part of future versions of this specification. See [Clause 7](#).

A Service Provider tool must demonstrate conformance to one or more services, as described below.

1. **ProjectService Conformance** - A Service Provider must implement all the operations in the ProjectService, and demonstrate that the implementation successfully passes all the ProjectService Conformance Test Cases (see [A.1](#)) and Cross-Cutting Conformance Test Cases (see [A.7](#)).
2. **ProjectService Read Conformance** - A Service Provider must implement the following operations in the ProjectService, and demonstrate that the implementation successfully passes all the ProjectService

Conformance Test Cases (see [A.1](#)) and Cross-Cutting Conformance Test Cases (see [A.7](#)) related to these operations. The UML attribute isQuery is set to true (isQuery=true) for these operations.

1. getProjectById
2. getProjects
3. **ElementNavigationService Conformance** - A Service Provider must implement all the operations in the ElementNavigationService, and demonstrate that the implementation successfully passes all the ElementNavigationService Conformance Test Cases (see [A.2](#)) and Cross-Cutting Conformance Test Cases (see [A.7](#)). ElementNavigationService includes operations that get data and not create/modify any data. As such, the ElementNavigationService Conformance does not have a corresponding ElementNavigationService Read Conformance.
4. **ProjectDataVersioningService Conformance** - A Service Provider must implement all the operations in the ProjectDataVersioningService, and demonstrate that the implementation successfully passes all the ProjectDataVersioningService Conformance Test Cases (see [A.3](#)) and Cross-Cutting Conformance Test Cases (see [A.7](#)).
5. **ProjectDataVersioningService Read Conformance** - A Service Provider must implement the following operations in the ProjectDataVersioningService, and demonstrate that the implementation successfully passes all the ProjectDataVersioningService Conformance Test Cases (see [A.3](#)) and Cross-Cutting Conformance Test Cases (see [A.7](#)) related to these operations. The UML attribute isQuery is set to true (isQuery=true) for these operations.
 1. getCommits
 2. getHeadCommit
 3. getCommitById
 4. getCommitChange
 5. getCommitChangeById
 6. getBranches
 7. getBranchById
 8. getDefaultBranch
 9. getTags
 10. getTagById
 11. getTaggedCommit
 12. diffCommits
6. **QueryService Conformance** - A Service Provider must implement all the operations in the Query Service, and demonstrate that the implementation successfully passes all the QueryService Conformance Test Cases (see [A.4](#)) and Cross-Cutting Conformance Test Cases (see [A.7](#)).
7. **QueryService Read Conformance** - A Service Provider must implement the following operation in the QueryService, and demonstrate that the implementation successfully passes all the QueryService Conformance Test Cases (see [A.4](#)) and Cross-Cutting Conformance Test Cases (see [A.7](#)) related to this operation. The UML attribute isQuery is set to true (isQuery=true) for this operation.
 1. executeQuery
8. **ExternalRelationshipService Conformance** - A Service Provider must implement all the operations in the ExternalRelationshipService, and demonstrate that the implementation successfully passes all the ExternalRelationshipService Conformance Test Cases (see [A.5](#)) and Cross-Cutting Conformance Test Cases (see [A.7](#)). ExternalRelationshipService includes operations that get data and not create/modify any data. As such, the ExternalRelationshipService Conformance does not have a corresponding ExternalRelationshipService Read Conformance.
9. **ProjectUsageService Conformance** - A Service Provider must implement all the operations in the ProjectUsageService, and demonstrate that the implementation successfully passes all the ProjectUsageService Conformance Test Cases (see [A.6](#)) and Cross-Cutting Conformance Test Cases (see [A.7](#)).
10. **ProjectUsageService Read Conformance** - A Service Provider must implement the following operation in the ProjectUsageService, and demonstrate that the implementation successfully passes all the ProjectUsageService Conformance Test Cases (see [A.6](#)) and Cross-Cutting Conformance Test Cases (see [A.7](#)) related to this operation. The UML attribute isQuery is set to true (isQuery=true) for this operation.
 1. getProjectUsages

Derived Property Conformance

Various Element (KerML) data may have derived properties defined for them. However, not all Service Providers are required to perform the computations that evaluate these properties and obtain their values. There are two specific Derived Property Conformance levels, as described below. A Service Provider demonstrating Derived Property Conformance must demonstrate one of two conformance levels presented below. As with other Service Conformances, it is also permitted for a Service Provider to claim no Derived Property conformance.

Each of the two Derived Property Conformance levels described below has different guarantees on derived property values as inputs and derived property values as outputs of operations covered by this specification. These guarantees need to be met across all the services and operations supported by the Service Provider, such as in the case of operations that return Element data in the response, e.g. `ElementNavigationService.getElementById` or `QueryService.executeQuery`. Furthermore, the guarantees are to be met for all Elements, whether the Element was originally supplied by a Service Consumer in Service operations that write Element data (primarily `ProjectDataVersioningService.createCommit`), or however else the Service Provider obtains Project contents to store and output, such as import operations not covered by this specification.

The two Derived Property Conformance levels are the following:

1. **Derived Property Passthrough Conformance:** A Service Provider declaring this conformance level must take at face value any derived property values obtained, and store these values along with all the other non-derived property values of the Element, in order to be faithfully reproduced in any operation of any Service where the Service Provider returns the properties of this Element to the Service Consumer. In addition, if the Service Provider conforms with the `QueryService`, these stored derived property values must be usable in Query structures as `PrimitiveConstraint` properties. The Service Provider is not required to ever perform the derived property computations or verify that derived property values presented by a Service Consumer are correct. Any derived property values obtained as an input to an operation defined in this specification are accepted as-is.
2. **Derived Property Full Conformance:** A Service Provider declaring this conformance level must, for operations in any Service where Element (KerML) data is returned, guarantee that the derived properties for the Element are included in the response with their correctly computed, up-to-date value. Furthermore, if the Service Provider conforms with the `QueryService`, it also ensures that derived properties can be used in Query structures as `PrimitiveConstraint` properties, and that the query execution will consider the correctly computed and up-to-date values of such derived properties. In operations where Elements are given as input, the Service Consumer is free to omit derived properties, since their value will be computed by the Service Provider. Note that the actual time when the computation of derived feature values is to be performed, such as just in time when producing a response, or ahead of time upon the reception of the latest commit that affected the derived feature value, is an implementation detail of the Service Provider and not prescribed for Conformance. However, appropriate caution should be taken as the values of derived properties of a given Element may be affected by commits that do not directly change that Element.

3 Normative References

[GraphQL] GraphQL
<https://graphql.org/>

[Gremlin] Gremlin Graph Traversal Machine and Language
<https://tinkerpop.apache.org/gremlin.html>

[IRI] *Internationalized Resource Identifiers* (IRI)
<https://www.w3.org/International/articles/idn-and-iri/>

[KerML] *Kernel Modeling Language (KerML)*, Version 1.0
<https://www.omg.org/spec/KERML/1.0>

[MOFVD] *MOF2 Versioning and Development Lifecycle (MOFVDTM)*, Version 2.0
<https://www.omg.org/spec/MOFVD/2.0>

[OpenAPI] *OpenAPI Specification*
<https://www.openapis.org/>

[OSLC] *Open Services for Lifecycle Collaboration (OSLC)*
<http://open-services.net/>

[QVT] *MOF Query/View/Transformation (QVTTM)*, Version 1.3
<https://www.omg.org/spec/QVT/1.3>

[SEBoK] *Systems Engineering Body of Knowledge (SEBoK)*
www.sebokwiki.org

[SE Handbook] *INCOSE Systems Engineering Handbook*
<https://www.incose.org/products-and-publications/se-handbook>

[SMOF] *MOF Support for Semantic Structures (SMOFTM)*, Version 1.0
<https://www.omg.org/spec/SMOF/1.0>

[SPARQL] *SPARQL Query Language for RDF*
<https://www.w3.org/TR/rdf-sparql-query/>

[SQL] *ISO/IEC 9075:2016, Information technology — Database languages — SQL*
<https://www.iso.org/standard/63555.html>

[STEP] *ISO 10303-233:2012 (STEP)*
<https://www.iso.org/standard/55257.html>

[SysML] *OMG Systems Modeling Language (SysML[®])*, Version 2.0
<https://www.omg.org/spec/SYSML/2.0>

[UML] *Unified Modeling Language (UML)*, Version 2.5.1
<https://www.omg.org/spec/UML/2.5.1>

[UUID] *Universally Unique Identifier (UUID) URN Namespace*
<https://tools.ietf.org/html/rfc4122>

[XMI] *XML Metadata Interchange (XMI®)*, Version 2.5.1
<https://www.omg.org/spec/XMI/2.5.1>

4 Terms and Definitions

Various terms and definitions are specified throughout the body of this specification.

5 Symbols

There are no special symbols defined in this specification.

6 Introduction

6.1 API and Services Architecture

The Systems Modeling API and Services includes the following.

(1) **Platform-Independent Model (PIM)** provides a service specification independent of any platform or technology. This specification defines each of the services and their operations with inputs and outputs. The PIM serves as the logical API model.

(2) **Platform-Specific Models (PSMs)** are bindings of the PIM using a particular technology, such as REST/HTTP, SOAP, Java, and .NET. Multiple platform-specific models can exist for a given PIM. Two PSMs are provided in this specification:

- REST/HTTP PSM - a binding of the PIM as a REST/HTTP API using OpenAPI specification.
- OSLC PSM - a binding of the PIM as services based on the OSLC standard.

For each PSM, a mapping is defined. This mapping is used to generate the PSM from the PIM.

[Fig. 2](#) illustrates the PIM, PSMs, Service Providers that implement API PSMs, and Service Consumers that consume the API PSMs from multiple Providers.

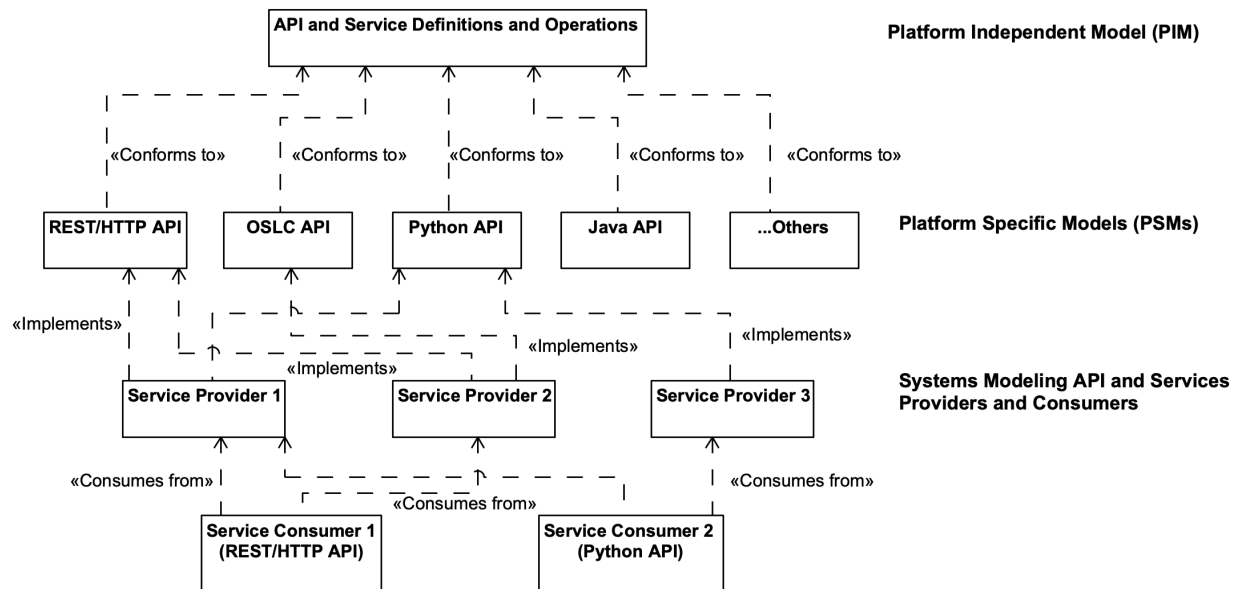


Figure 2. API and Services Architecture

Service specifications in the PIM do not prescribe or constrain the architecture of the Service Providers. For example, Service Providers with file-based, 3-tier application-based, or federated microservices-based architectures can all implement one or more PSMs derived from the same service specifications (PIM).

Service Consumers that use a specific PSM should be interoperable across multiple Service Providers that implement that PSM without requiring any modification in the consumer.

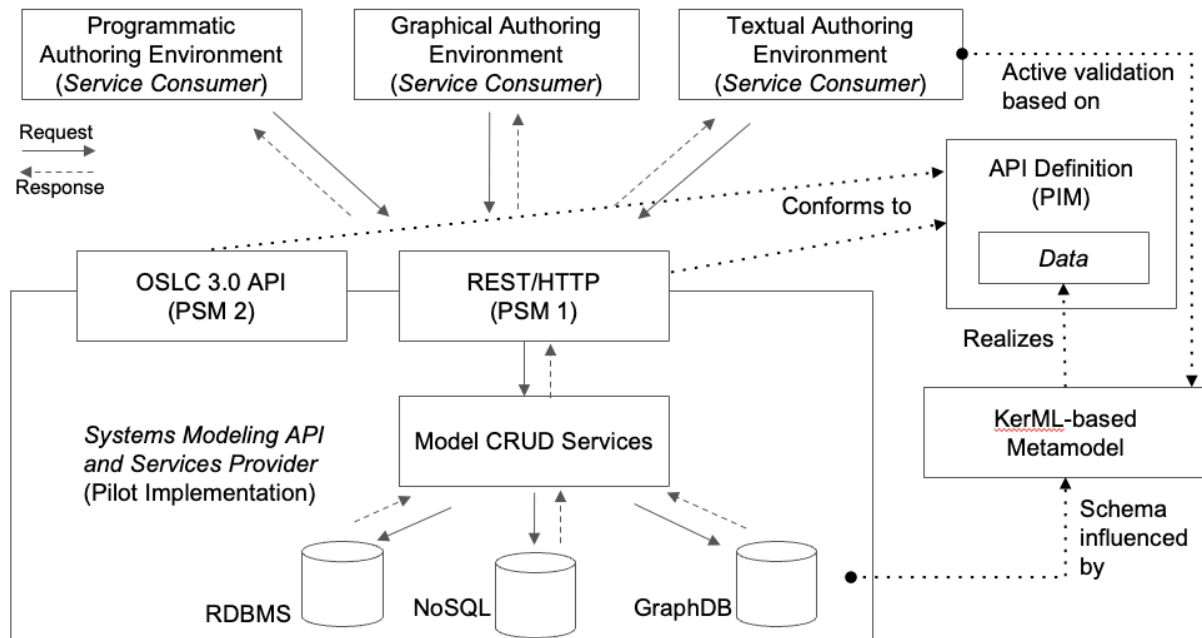


Figure 3. Use of PIM and PSMs by Providers and Consumers

[Fig. 3](#) illustrates the role of PIM and PSMs in the context of Systems Modeling API and Services providers and consumers. The Systems Modeling API and Services, version 1.0, includes two PSMs, specifically the REST/HTTP PSM and OSLC 3.0 PSM.

A System Modeling API and Services provider implements either or both the PSMs using its native technology stack, such as databases and web-service frameworks. Service consumers, such as those used for programmatic, graphical, or textual authoring, navigation, and querying data use the PSMs (e.g. REST/HTTP API), agnostic of the native technology stack of the providers.

The choice of REST/HTTP PSM is key. Most modern programming languages provide libraries for consuming REST/HTTP APIs. Enterprise applications, written in any modern programming language, can consume the standard Systems Modeling API and Services, and interoperate with multiple providers.

6.2 Document Conventions

The following stylistic conventions are applied in the presentation of the Platform Independent Model (PIM) of the Systems Modeling API and Services.

Service definitions

1. Names of classes representing services start with an uppercase letter and use the camel case notation, such as *ElementNavigationService*.
2. Names of operations representing the API calls available for each service start with a lowercase letter and are italicized, such as *getElementById*

Input and output data

1. Names of classes representing data that is the input or output of services start with an uppercase letter, such as *Project* and *Data*
2. Names of attributes representing the details of the data that is the input or output of services start with a lowercase letter and are italicized, such as *identifier*

The services and operations in the PIM are presented using class diagrams and tables with descriptions of each operation.

The input and output data for services in the PIM are presented using class diagrams followed by detailed descriptions.

6.3 Document Organization

The rest of this document is organized into two major clauses.

- [Clause 7](#) - Platform Independent Model (PIM) of the Systems Modeling API and Services
- [Clause 8](#) - Platform Specific Models (PSMs) of the Systems Modeling API and Services
 - [8.1](#) - REST/HTTP PSM
 - [8.2](#) - OSLC PSM

These clauses are followed by two annexes.

- [Annex A](#) defines the suite of conformance tests that must be used to demonstrate the conformance of Service Providers to this specification - see [Clause 2](#).
- [Annex B](#) includes the following.
 - Examples of requests and responses for the REST/HTTP API endpoints, and
 - Cookbook with a collection of recipes, as Jupyter notebooks, demonstrating patterns and examples for using the Systems Modeling API and Services

6.4 Acknowledgements

The primary authors of this specification document, the PIM, and the REST/HTTP PSM are:

- Manas Bajaj, Intercax LLC
- Ivan Gomes, Twingineer LLC

The primary authors of the OSLC PSM are:

- David Honey, IBM
- Jad El-Khoury, KTH Royal Institute of Technology
- Jim Amsden, IBM

Other contributors include:

- Tomas Vileiniskis, Dassault Systèmes

The specification was formally submitted for standardization by the following organizations:

- 88Solutions Corporation
- Dassault Systèmes
- GfSE e.V.
- IBM
- INCOSE
- Intercax LLC
- Lockheed Martin Corporation
- Model Driven Solutions, Inc.
- PTC
- Simula Research Laboratory AS

However, work on the specification was also supported by over 200 people in 80 organizations that participated in the SysML v2 Submission Team (SST). The following individuals had leadership roles in the SST:

- Manas Bajaj, Intercax LLC (API and services development lead)
- Yves Bernard, Airbus (v1 to v2 transformation co-lead)
- Bjorn Cole, Lockheed Martin Corporation (metamodel development co-lead)
- Sanford Friedenthal, SAF Consulting (SST co-lead, requirements V&V lead)
- Charles Galey, Lockheed Martin Corporation (metamodel development co-lead)
- Karen Ryan, Siemens (metamodel development co-lead)
- Ed Seidewitz, Model Driven Solutions (SST co-lead, pilot implementation lead)
- Tim Weilkens, oose (v1 to v2 transformation co-lead)

The specification was prepared using CATIA Magic/No Magic modeling tools and the OpenMBEE system for model publication (<http://www.openmbee.org>), supported by the 3DEXPERIENCE platform, with the invaluable support of the following individuals:

- Tyler Anderson, Dassault Systèmes
- Christopher Delp, Jet Propulsion Laboratory
- Jackson Galloway, Dassault Systèmes
- Ivan Gomes, Jet Propulsion Laboratory
- Robert Karban, Jet Propulsion Laboratory
- Christopher Klotz, Dassault Systèmes
- John Watson, Lightstreet consulting

The following individuals made significant contributions to the API and Services pilot implementation developed by the SST in conjunction with the development of this specification:

- Manas Bajaj, Intercax LLC
- Ivan Gomes, Twingineer LLC
- Brian Miller, Intercax LLC

7 Platform Independent Model (PIM)

7.1 API Model

7.1.1 Record

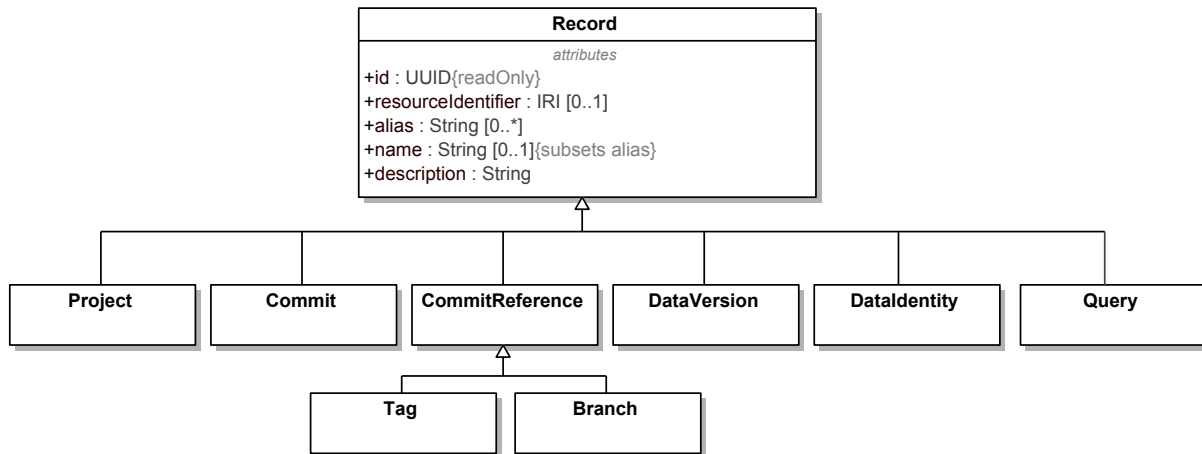


Figure 4. Types of Records

Record - A Record represents any data that is consumed (input) or produced (output) by the Systems Modeling API and Services. A Record is an abstract concept from which other concrete concepts inherit. A Record has the following attributes:

- *id* is the UUID assigned to the record
- *resourceIdentifier* is an IRI for the record
- *alias* is a collection of other identifiers for this record, especially if the record was created or represented in other software applications and systems. Note that for DataIdentity and DataVersion records, this does not conflict with *Element.aliasIds* in KerML. Instead, it enables service providers to add other aliases on any record
- *name* is an optional human-friendly identifier for a record. The value assigned to the *name* for a given record must be in the set of values assigned to *alias* for that record
- *description* is a statement that provides details about the record.

7.1.2 Project Data Versioning

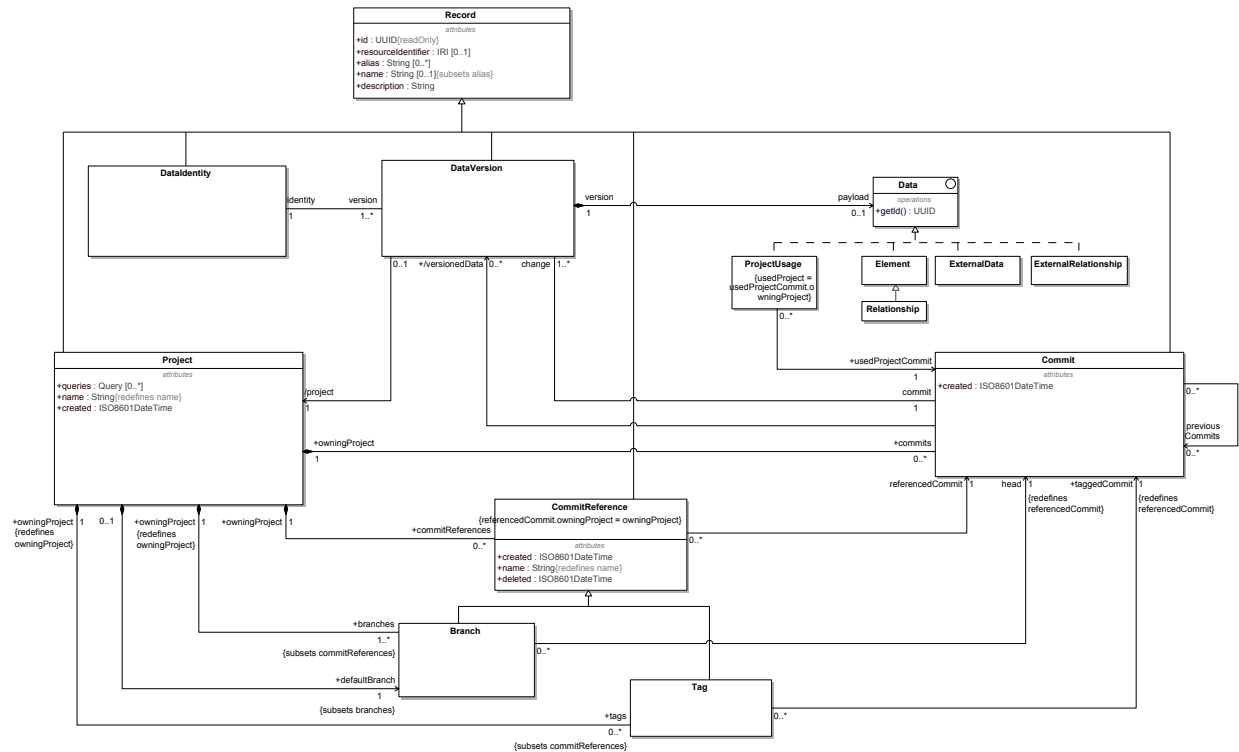


Figure 5. Project Data Versioning API Model

The class diagram above presents concepts related to Project and Data Versioning Service.

Data - Data represents any entity that can be created, updated, deleted, and queried by the Systems Modeling API and Services. In the PIM, Data is represented as an Interface that is realized by the following concepts in the scope of Systems Modeling API and Services.

- Element, root metaclass in the SysML v2 language metamodel
- External Data
- External Relationship
- Project Usage

Each realization of Data must implement the *getId()* operation that provides a valid UUID.

Data Identity - Data Identity is a subclass of Record that represents a unique, version-independent representation of Data through its lifecycle. A Data Identity is associated with 1 or more Data Version records that represent different versions of the same Data. A Data Identity record has the following additional attributes:

- *createdAt* is a derived attribute that references the Commit in a project in which the given Data was created
- *deletedAt* is a derived attribute that references the Commit in a project in which the given Data was deleted

Data Version - Data Version is a subclass of Record that represents Data at a specific version in its lifecycle. A Data Version record is associated with exactly one Data Identity record. Data Version serves as a wrapper for Data (*payload*) in the context of a Commit in a Project; associating the data identity with the state of the Data (payload) in the specific (range of) Commits, or no payload if no Data element with the given identifier is present at that

Commit. Different versions of the same Data, identified by the same UUID values returned by *Data.getId()*, are represented in the following manner:

- One (1) Data Identity record is created for all versions of the same Data, where Data Identity.*id* returns the same UUID value as *Data.getId()*
- A Data Version record is created for each version of Data (and, if needed, also for a Commit where no Data exists for the given identity), where:
 - Data Version.*payload* is set to Data if exists in the commit, null otherwise.
 - Data Version.*identity* is set to the Data Identity common to all versions of the same Data.
 - Data Version.*id* is set to a new, randomly generated UUID for the specific Data Version record.

Data Version record has the following additional attributes:

- *commit* is the project commit at which the wrapped data (*payload*) was created, modified, or deleted
- */project* is a derived attribute referencing the owning project

Project - Project is a subclass of Record that represents a container for other Records and an entry point for version management and data navigation. The Project record has the following attributes:

- *identifiedData* is a derived attribute that is the set of Data Identity records corresponding to the Data contained in the project
- *commit* is the set of all commits in the Project
- *commitReference* is the set of all commit references in the Project
- *branch* is the set of all the branches in the Project and a subset of *commitReference*
- *defaultBranch* is the default branch in the Project and a subset of *branch*
- *tag* is the set of all the tags in the Project and a subset of *commitReference*
- *usage* is the set of Project Usage records representing all other Projects being used by the given Project (*Project Usage.usedProject*)
- *queries* is the set of Query records owned by the project. Each Query record represents a saved query for the given project. See [7.1.4 Query](#) for details.
- *name* is a human-friendly identifier for a Project
- *created* is the creation timestamp for the project, in ISO8601DateTime format

A project also represents a permission target at which access and authorization controls may be applied to teams associated with a project.

ProjectUsage - ProjectUsage is a subclass of Record that represents the use of a Project in the context of another Project. ProjectUsage is represented as a realization of Data, and has the following attributes:

- *usedProject* references the Project being used
- *usedProjectCommit* references the Commit of the Project being used

Commit - Commit is a subclass of Record that represents the changes made to a Project at a specific point in time in its lifecycle, such as the creation, update, or deletion of data in a Project. A Project has 0 or more Commits. A Commit has the following additional attributes:

- *created* is the timestamp at which the Commit was created, in ISO8601DateTime format
- *owningProject* is the Project that owns the Commit
- *previousCommit* is the set of immediately preceding Commits
- *change* is the set of Data Version records representing Data that is created, updated, or deleted in the Commit
- *versionedData* is the set of cumulative Data Version records in a Project at the Commit

Clarifications and Invariants:

- `Commit.versionedData` must indicate only the Data records that actually exist at the given Commit; all listed `DataVersion` records must have their `payload` attribute set to a non-null Data record.
- `Commit.change` indicates deletions by listing `DataVersion` records with their `payload` attribute set to null. This is only valid if at least one Commit in `previousCommits` contains a `DataVersion` with the same `identity` in its `versionedData` (i.e. only existing Data records may be deleted).
- `DataVersion.identity` is unique among records listed in `Commit.versionedData` and in `Commit.change`.
- A Commit must resolve all conflicts in its parent Commits: if the Commit C has two parent Commits C_a and C_b in `C.previousCommits`, where $C_a.versionedData$ lists a `DataVersion` D_a but `C.versionedData` does not contain D_a (either the Data associated with $D_a.identity$ is different, or not present at all), then `C.change` must list a `DataVersion` with $D_a.identity$.
- Version histories must monotonically increase in time: for Commit C, the value of `C.created` must be strictly newer than the value of `D.created` for any commit D in `C.previousCommit`. An implementation should ensure that the selected timestamp resolution (which corresponds to a required number of decimals in the ISO 8601 second field) is sufficient to ensure the strict monotonicity of the timestamps for the supported number of Commits per second per branch.

The `versionedData` for a *Commit* is computed as follows:

1. Let `updatedNotDeleted` be all `DataVersions` in the change set of the *Commit*, excluding deletions.
2. Let `updatedIdentities` be all `DataIdentities` in the change set of the *Commit*, including deletions.
3. Let `retainedWithDuplicates` be the union of the `versionedData` of all the *previousCommits* of this *Commit*, excluding `DataVersions` whose identities are in the `updatedIdentities` of this commit.
4. Let `retained` be the set of `DataVersions` obtained from `retainedWithDuplicates` by choosing from each subset of duplicate `DataVersions` with the same identity a single one of them to include. See the Note below for additional clarification.
5. The `versionedData` of this *Commit* is the union of the `updatedNotDeleted` set and the `retained` set.

Note. If there are multiple *previousCommits*, `retainedWithDuplicates` may include `DataVersions` from different *previousCommits* with the same identity. If any of the *previousCommits* have `DataVersions` with the same identity but different payloads, then this *Commit* is required to have resolved this merge conflict by including merged `DataVersions` for the conflicting identities in its change set, so the conflicting `DataVersions` will not be included in `retainedWithDuplicates`. Therefore, any `DataVersions` in `retainedWithDuplicates` with the same identity must also have the same payload, and any one of them can be chosen for inclusion in the `versionedData` of this commit.

This is formalized in the following OCL:

```
let updatedNotDeleted : Set(DataVersion) = change->select(payload <> null) in
let updatedIdentities : Set(DataIdentity) = change.identity in
let retainedWithDuplicates : Bag(DataVersion) =
    previousCommits.versionedData->select(oldData |
        updatedIdentities->excludes(oldData.identity)
    ) in
let retained : Set(DataVersion) =
    retainedWithDuplicates.identity->asSet()->collect(retainedID |
        retainedWithDuplicates->any(identity == retainedID)
    )->asSet() in
versionedData = updatedNotDeleted->union(retained)
```

Commits are immutable. For a given Commit record, the value of `Commit.change` cannot be modified after a Commit has been created. If a modification is required, a new Commit record can be created with a different value of `Commit.change`.

Commits are not destructible¹. A Commit record cannot be deleted during normal end-user operation. Commits represent the history and evolution of a Project. Deleting and mutating Commit records must be disabled for the normal end-user operations to preserve Project history.

¹**Note.** A provider tool may provide administrative functions to repair the Commit graph of a Project but this is not considered a normal end-user operation.

CommitReference - CommitReference is an abstract subclass of Record that references a specific Commit (CommitReference.*referencedCommit*). Project.*commit* is the set of all the Commit records for a given Project. Project.*commitReferences* identifies specific Commit records in a Project that provide the context for navigating the Data in a Project. A CommitReference has the following additional attributes:

- *created* is the timestamp at which the CommitReference was created, in ISO8601DateTime format
- *deleted* is the timestamp at which the CommitReference was deleted, in ISO8601DateTime format
- *name* is a human-friendly identifier for a CommitReference, inherited from Record

Two special types of CommitReference are Branch and Tag, as described below.

Branch - Branch is an indirect subclass of Record (via CommitReference) that represents an independent line of development in a project. A Project can have 1 or more branches. When a Project is created, a default branch is also created. The default branch of a project can be changed, and a project can have only 1 default branch.

A Branch is a type of CommitReference. A Branch is a pointer to a commit (Branch.*head*). The commit history of a Project on a given branch can be computed by recursively navigating Commit.*previousCommit*, starting from the head commit of the branch (Branch.*head*). A Branch has the following additional attributes:

- *created* is the timestamp at which the Branch was created, in ISO8601DateTime format. This attribute is inherited from Commit Reference.
- *deleted* is the timestamp at which the Branch was deleted, in ISO8601DateTime format. This attribute is inherited from Commit Reference.
- *head* is the commit to which the branch is currently pointing. It represents the latest state of the project on the given branch
- *owningProject* is the project that owns the given branch

Branches are mutable. Since a Branch is a pointer to a Commit, it can be updated to point to a different Commit. If a new Commit is created on a Project Branch, the value of Branch.*head* refers to that new Commit.

Branches are destructible under normal end-user operation. Branches can be deleted and merged with other branches.

Tag - Tag is an indirect subclass of Record (via CommitReference) used for annotating specific commits-of-interest during Project development, such as for representing Project milestones, releases, baselines, or snapshots. A Project can have 0 or more tags. A Tag has the following additional attributes:

- *created* is the timestamp at which the Tag was created, in ISO8601DateTime format. This attribute is inherited from Commit Reference.
- *deleted* is the timestamp at which the Tag was deleted, in ISO8601DateTime format. This attribute is inherited from Commit Reference.
- *taggedCommit* is a pointer to a commit
- *owningProject* is the project that owns the given tag

Tags are immutable. Tag.*taggedCommit* cannot be modified after a Tag record has been created. If Tag.*taggedCommit* needs to be modified to refer to a different Commit record, then the existing Tag can be deleted and a new Tag can be created with the same name and description.

Tags are destructible under normal end-user operation.

The table below summarizes the Mutability and Destruction semantics for Commit, Branch, and Tag.

Type of Record	Mutable	Destructible
Commit	No	No
Branch	Yes	Yes
Tag	No	Yes

Timestamps - The following requirements and recommendations apply to timestamps:

- All attributes typed by ISO8601DateTime must be communicated over the API as either a time instant expressed directly on the UTC (Coordinated Universal Time) time scale, or on a local time scale with an explicit time shift with respect to UTC, as specified in [ISO8601-1]. The reason is to avoid any implicit dependency on timezone-specific representation of time instants.
 - Examples of valid UTC timestamps in [ISO8601-1] extended format are: 2024-12-18T16:45:34.635726Z and 2024-12-18T16:45:34.635726+00:00.
 - Examples of valid local timestamps in [ISO8601-1] extended format are: 2024-12-18T11:45:34.635726-05:00 and 2024-12-18T17:45:34.635726+01:00. These example values represent the same time instant as the previous UTC timestamp examples.
 - **Note.** Be aware that the explicit time shift for a selected timezone may change throughout a calendar year due to switching between standard and daylight saving time, typically by one hour.
- Service implementations should ensure that all timestamps for a given Project are expressed in UTC or apply a time shift for one selected timezone.
- For reasons of simplicity it is recommended that service implementations consistently apply UTC timestamps, if there is no requirement to support a local time scale.
- Computation of time intervals between two timestamps should make use of an appropriate software library that supports UTC-based arithmetic including handling of possible leap seconds.

7.1.3 ExternalData and ExternalRelationship

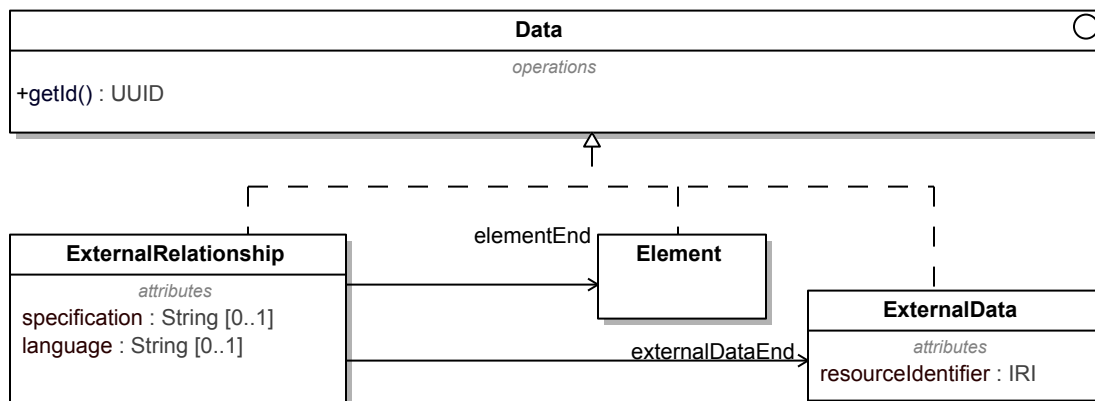


Figure 6. External Relationship API Model

The class diagram above presents concepts related to ExternalRelationship Service.

ExternalRelationship - ExternalRelationship is a realization of Data, and represents the relationship between a KerML Element [KerML] available from a service provider to ExternalData available over the web using an IRI. The ExternalData may be a KerML Element available from another service provider using an IRI. A hyperlink

between a KerML Element to a web resource is the most primitive example of an ExternalRelationship. An ExternalRelationship has the following attributes:

- *specification* is the formal representation of the semantics of the ExternalRelationship. The specification can be a collection of mathematical expressions. For example, an ExternalRelationship can be defined to map the attributes of a KerML Element to the attributes of an ExternalData. In this case, the specification would contain mathematical expressions, such as equations, representing the mapping. This is an optional attribute.
- *language* is the name of the expression language used for the specification. This is an optional attribute.

ExternalData - ExternalData is a realization of Data, and represents a resource available over the web using an IRI. ExternalData is defined only for the purpose of defining an ExternalRelationship. An ExternalData has the following additional attributes.

- *resourceIdentifier* is the IRI of the resource represented by the ExternalData

7.1.4 Query

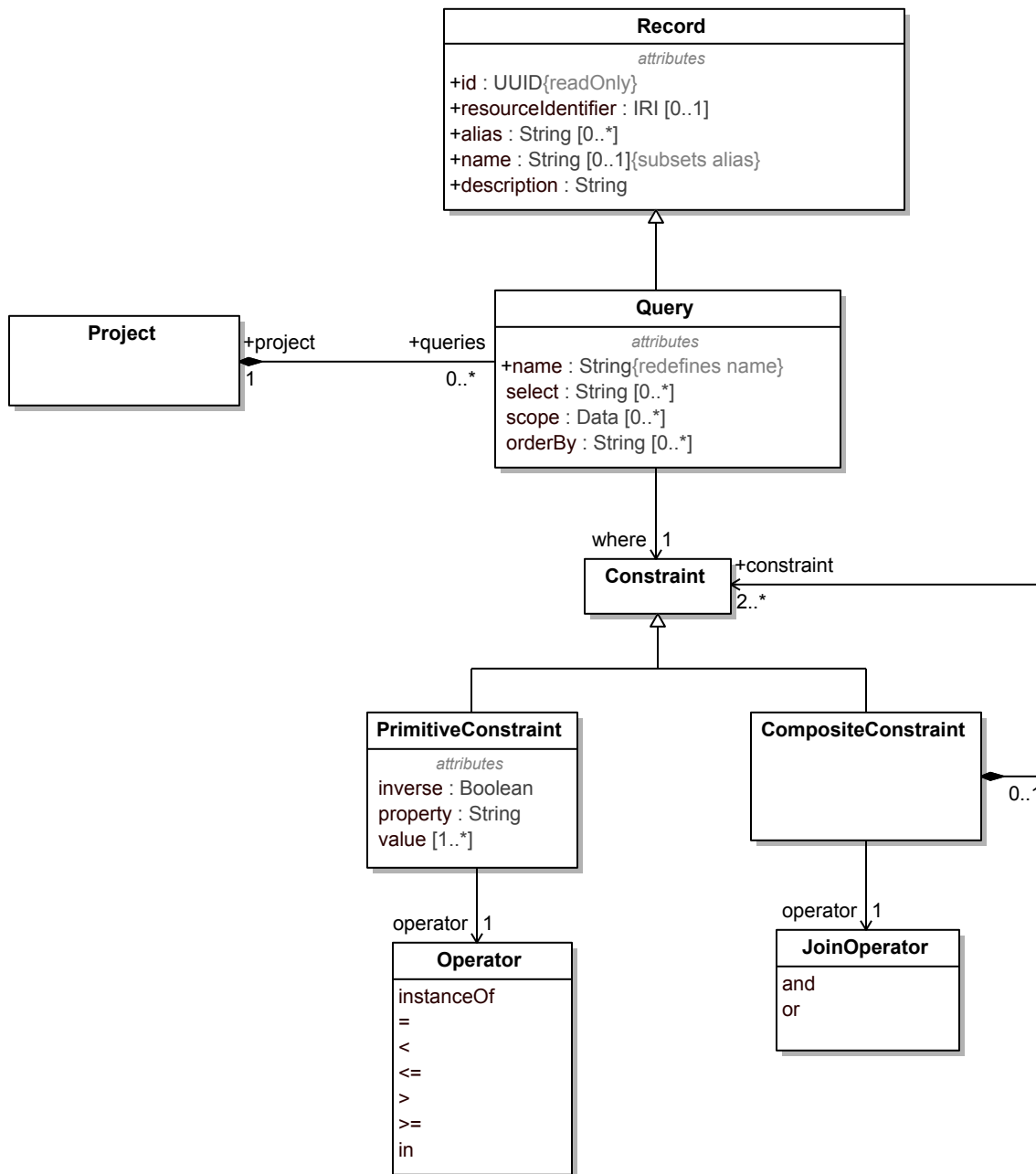


Figure 7. Query API Model

The class diagram above presents concepts related to the Query service.

Query- Query is a subclass of Record that represents a precise and language-independent request for information retrieval using the Systems Modeling API and Services. Query can be mapped to commonly used query languages, such as SQL, Gremlin, GraphQL, and SPARQL.

A Query record has the following attributes:

- *name* is a human-friendly identifier for a Query

- *select* is a list of properties of Data (or its realizations) that will be included for each Data object in the query response. If no properties are specified, then all the properties will be included for each Data object in the query response.
- *scope* is a list of Data objects that define the scope context for query execution. The default scope of a Query is the owning Project.
- *where* is a Constraint that represents the conditions that Data objects in the query response must satisfy
- *orderBy* is a list of properties of Data (or its realizations) that are used for sorting the Data objects in the query response. The order of properties in the list governs the sorting order.

Constraint - Constraint is an abstract concept that represents conditions that must be satisfied by Data objects in the query response.

PrimitiveConstraint is a concrete subtype of Constraint that represents simple conditions that can be modeled using the *property-operator-value* tuple, e.g. *mass <= 4 kg.*, or *type instanceof Generalization*. A PrimitiveConstraint has the following attributes:

- *property* is a property of Data (or its realizations) that is being constrained
- *operator* is of type Enumeration whose literals are mathematical operators, as shown in the figure above
- *value* is either a list of primitive objects, such as String, Boolean, Integer, Double, UUID, or null. An explicit type is not assigned to this property since it can be any of the specified types above.
- *inverse* is of type Boolean. If true, a logical NOT operator is applied to the PrimitiveConstraint.

CompositeConstraint is a concrete subtype of Constraint that represents complex conditions composed of two or more Constraints using logical AND or OR operator. CompositeConstraint has the following attributes:

- *constraint* is the set of Constraints being composed
- *operator* is the logical operator for composing the Constraints

7.2 API Services

7.2.1 ProjectService

ProjectService
<i>operations</i>
<pre> getProjects() : Project [0..*]{query} getProjectById(projectId : UUID) : Project [0..1]{query} createProject(name : String, description : String [0..1]) : Project updateProject(projectId : UUID, name : String [0..1], description : String [0..1], defaultBranch : Branch [0..1]) : Project deleteProject(projectId : UUID) : Project </pre>

Figure 8. ProjectService Operations

Table 1. Operations

Name	Documentation
createProject	Create a new project with the given name and description (optional).
getProjects	Get all projects.
updateProject	Update the project with the given id (projectId).

Name	Documentation
deleteProject	<p>Delete the project with the given id (projectId).</p> <p>The following pre-condition must be satisfied for a project to be deleted.</p> <ol style="list-style-type: none"> 1. Project with given projectId exists. <p>The following post-condition must be satisfied for a project to be deleted.</p> <ol style="list-style-type: none"> 1. All operations of all services where projectId (Id of the deleted project) is an input argument will return null. <p>Note that when a project is being deleted, elements owned by the project may be used in other projects via project usages. The detection of this condition and subsequent behavior is left to the API and Service providers. As a general recommendation, API and Service providers may implement different behaviors, such as, but not limited to, the following.</p> <ol style="list-style-type: none"> 1. Allow projects to be deleted irrespective of any of the elements from its latest tag (commit), default or pre-specified branches, being used in other projects, via project usages. The Service provider guarantees that future operations involving the using projects will continue to work in the absence of referenced elements owned by the deleted project. It is up to the Service Provider to find a way to implement this guarantee, such as by suppressing such nonexistent element references or reporting only unique identifiers of nonexistent element references in operation results. 2. Allow projects to be deleted only if none of the elements in a list of pre-specified commits (e.g. latest tag and main branch) are being used in the list of pre-specified commits (e.g. latest tag or main branch) of another project, via project usage. 3. Allow projects to be deleted only if none of their commits are referenced by project usages in any of the commits of any other project.
getProjectById	Get project with the given id (projectId).

7.2.2 ElementNavigationService

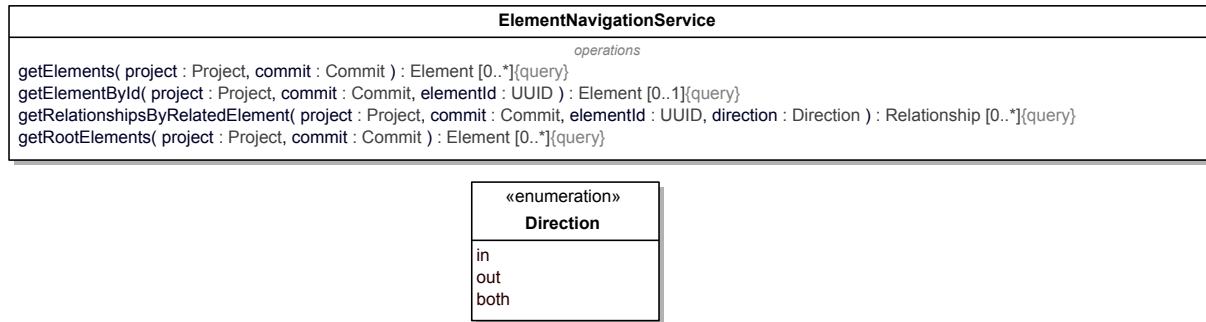


Figure 9. ElementNavigationService Operations

Element is the root metaclass in the KerML abstract syntax [KerML]. Relationship is a subtype of Element. Both Element and Relationship realize the Data interface defined in the API Model (refer to 7.1.2 - Project Data Versioning).

Table 2. Operations

Name	Documentation
<code>getRelationshipsByRelatedElement</code>	Get relationships that are incoming, outgoing, or both relative to the given related element.
<code>getElements</code>	Get all the elements in a given project at the given commit.
<code>getElementById</code>	Get element with the given id (elementId) in the given project at the given commit.
<code>getRootElements</code>	Get all the root elements in the given project at the given commit.

7.2.3 ProjectDataVersioningService

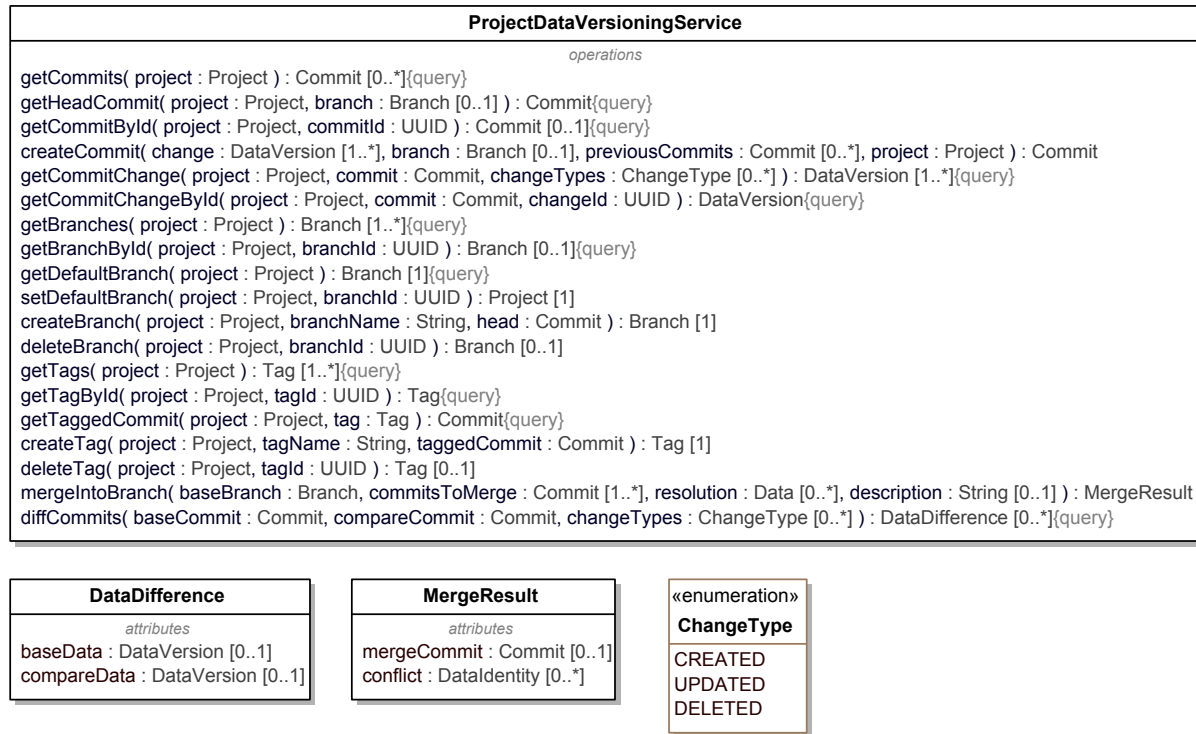


Figure 10. ProjectDataVersioningService Operations

Table 4. Operations

Name	Documentation
deleteBranch	Delete the branch with the given id (branchId) in the given project.
createTag	Create a new tag with the given name (tagName) in the given project, and set the taggedCommit of the new tag as the given commit (taggedCommit).
getTagById	Get the tag with the given id (tagId) in the given project.
getTaggedCommit	Get the tagged commit of the given tag in the given project.

Name	Documentation
diffCommits	<p>Get the difference between two commits - compareCommit and baseCommit. The set of all DataVersion records in a project at a given commit is accessible as Commit.versionedData. From a set theoretic perspective, this operation gets compareCommit.versionedData - baseCommit.versionedData and returns a DataDifference object with baseData and compareData for each difference. If any data is present in the compareCommit but absent in the baseCommit, DataDifference.compareData will include the corresponding DataVersion and DataDifference.baseData will be empty. If any data is absent in the compareCommit but present in the baseCommit, DataDifference.compareData will be empty and DataDifference.baseData will include the corresponding DataVersion. If any data is present in both but different in the compareCommit and baseCommit, DataDifference.compareData and DataDifference.baseData will include the corresponding DataVersion records.</p> <p>The operation diffCommits in ProjectDataVersioningService has an optional argument changeTypes that is a collection typed by the enumeration ChangeType with three literals (CREATED, UPDATED, DELETED).</p> <p>If the argument changeTypes is passed, then only the changes of the given type will be returned by the operation as DataDifference objects. Some examples to elaborate this behavior are included below.</p> <p>If changeTypes = [], i.e. the argument is not specified, then the DataDifference objects for all the data that was created, updated, or deleted in the compareCommit versus the baseCommit will be returned.</p> <p>If changeTypes = ['DELETED'], then the DataDifference objects for all the data that was deleted in the compareCommit versus the baseCommit will be returned. If changeTypes = ['CREATED', 'UPDATED'], then the DataDifference objects for all the data that was created or updated in the compareCommit versus the baseCommit will be returned.</p>
getCommits	Get all the commits in the given project.
getHeadCommit	Get the head commit of the given branch in the given project. If the branch is not specified, the default branch of the project is used.
setDefaultBranch	Set the branch with the given branchId as the default branch of the given project.

Name	Documentation
getCommitChangeById	Get the change with the given id (changeId) in the given commit of the given project. The changeId is the id of the DataVersion that changed in the commit.
getBranches	Get all the branches in the given project.
createBranch	Create a new branch with the given name (branchName) in the given project, and set the head of the new branch as the given commit (head).
createCommit	<p>Create a new commit with the given change (collection of DataVersion records) in the given branch of the project. If the branch is not specified, the default branch of the project is used. Commit.change should include the following for each Data object that needs to be created, updated, or deleted in the new commit. (1) Creating Data - Commit.change should include a DataVersion record with DataVersion.payload populated with the Data being created. DataVersion.identity is either left empty, in which case a new DataIdentity needs to be created by the Service and assigned to DataVersion.identity in the new commit; or provided a brand new value (one that does not already exist in any of the <i>previousCommits</i>) by the client and accepted by the Service as is. (2) Updating Data - Commit.change should include a DataVersion record with DataVersion.payload populated with the updated Data. DataVersion.identity should be populated with the DataIdentity for which a new DataVersion record will be created in the new commit. (3) Deleting Data - Commit.change should include a DataVersion record with DataVersion.payload not provided, thereby indicating deletion of DataIdentity in the new commit. DataVersion.identity should be populated with the DataIdentity that will be deleted in the new commit. When a DataIdentity is deleted in a commit, all its versions (DataVersion) are also deleted, and any references from other DataIdentity are also removed to maintain data integrity. In addition, for Element Data (KerML), deletion of an Element must also result in deletion of incoming Relationships. When Element Data (KerML) is created or updated, derived properties must be computed or verified if the API provider claims Derived Property Conformance. The deleted element - DataIdentity and its DataVersion records - will be accessible in previous commits.</p>

Name	Documentation
getCommitChange	<p>Get the change in the given commit of the given project.</p> <p>The operation getCommitChange in ProjectDataVersioningService has an optional argument changeTypes that is a collection typed by the enumeration ChangeType with three literals (CREATED, UPDATED, DELETED).</p> <p>If the argument changeTypes is passed, then only the changes of the given type will be returned by the operation as DataVersion records. Some examples to elaborate this behavior are included below.</p> <p>If changeTypes = [], i.e. the argument is not specified, then the DataVersion records for all the data that was created, updated, or deleted in the given commit will be returned.</p> <p>If changeTypes = ['DELETED'], then the DataVersion records for all the data that was deleted in the given commit will be returned.</p> <p>If changeTypes = ['CREATED', 'UPDATED'], then the DataVersion records for all the data that was created or updated in the given commit will be returned.</p>
getBranchById	Get the branch with the given id (branchId) in the given project.
deleteTag	Delete the tag with the given id (tagId) in the given project.
mergeIntoBranch	<p>Merge the given commits (commitsToMerge) in the given branch (baseBranch). The commits included in commitsToMerge may be commits referenced by a CommitReference, such as Branch.head or Tag.taggedCommit, or any other commit in the owning project (Project.commits). This operation returns a MergeResult which will include either of the following:</p> <p>(1) commit after the merge operation if successful, or</p> <p>(2) a set of DataIdentity records representing the merge conflicts if the merge operation is unsuccessful. Two optional inputs may be provided: (1) resolution as a set of Data that will resolve the merge conflicts, and (2) description of the merged commit if this operation is successful.</p>
getDefaultBranch	Get the default branch of the given project.
getCommitById	Get the commit with the given id (commitId) in the given project.
getTags	Get all the tags in the given project.

7.2.4 QueryService

QueryService
<i>operations</i>
<pre> getQueries(project : Project) : Query [0..*] getQueryById(project : Project) : Query [0..1] createQuery(name : String, project : Project, select : String [0..*], scope : Data [0..*], where : Constraint, orderBy : String [0..*]) : Query updateQuery(project : Project, updateQuery : Query) : Query deleteQuery(project : Project, queryId : UUID) : Query executeQueryById(queryId : UUID, commit : Commit [0..1]) : Data [0..*] executeQuery(query : Query, commit : Commit [0..1]) : Data [0..*]{query} </pre>

Figure 11. QueryService Operations

Table 6. Operations

Name	Documentation
getQueries	Get all the queries in the given project.
getQueryById	Get the query with the given id (queryId) in the given project.
updateQuery	Update the given query (updateQuery) in the given project.
createQuery	Create a query in the given project with the given inputs.
executeQuery	Execute the given query in the owning project (Query.project) at the given commit. If the commit is not specified, then the head commit of the default branch of the project will be used.
deleteQuery	Delete the query with the given id (queryId) in the given project.
executeQueryById	Execute the query with the given id in the owning project (Query.project) at the given commit. If the commit is not specified, then the head commit of the default branch of the project will be used.

7.2.5 ExternalRelationshipService

ExternalRelationshipService
<i>operations</i>
<pre> getExternalRelationships(project : Project, commit : Commit) : ExternalRelationship [0..*]{query} getExternalRelationshipsByElement(project : Project, commit : Commit, elementId : UUID) : ExternalRelationship [0..*]{query} getExternalRelationshipById(project : Project, commit : Commit, externalRelationshipId : UUID) : ExternalRelationship [0..1]{query} createExternalRelationship(project : Project, branch : Branch [0..1], externalRelationship : ExternalRelationship) deleteExternalRelationship(project : Project, branch : Branch [0..1], externalRelationshipId : UUID) </pre>

Figure 12. ExternalRelationshipService Operations

Table 7. Operations

Name	Documentation
getExternalRelationshipById	Get the external relationship with the given id (externalRelationshipId).
getExternalRelationships	Get all the external relationships in a given project at a given commit.
deleteExternalRelationship	Delete the external relationship with the given id (externalRelationshipId).
createExternalRelationship	Create an external relationship in a given project on a given branch.
getExternalRelationshipsByElement	Get all the external relationships in the given project at the given commit, where the id of elementEnd of the external relationship is the given elementId.

7.2.6 ProjectUsageService

ProjectUsageService
<i>operations</i>
getProjectUsages(project : Project, commit : Commit) : ProjectUsage [0..*]{query}
createProjectUsage(project : Project, branch : Branch [0..1], projectUsage : ProjectUsage) : Commit
deleteProjectUsage(project : Project, branch : Branch [0..1], projectUsageId : UUID) : Commit

Figure 13. ProjectUsageService Operations**Table 8. Operations**

Name	Documentation
getProjectUsages	Get all the project usages in the given project at the given commit.
deleteProjectUsage	Deletes the project usage with the given id (projectUsageId) from the given project at the head commit of the given branch. This operation returns a new commit where the given project usage does not exist, and sets the head of the given branch to the new commit. If a project branch is not given, then the default branch of the project will be used.
createProjectUsage	Create a new project usage in the given project at the head commit of the given branch. This operation returns a new commit that includes the new project usage, and sets the head of the given branch to the new commit. If a project branch is not given, then the default branch of the project will be used.

8 Platform Specific Models (PSMs)

8.1 REST/HTTP PSM

8.1.1 Overview

The REST/HTTP Platform-Specific Model (PSM) for the Systems Modeling API and Services is described using OpenAPI Specification (OAS) 3.1 and is included with this specification. The REST/HTTP PSM is described in the following sections.

- **PIM API Model - REST/HTTP PSM Model Mapping:** This section presents the mapping from the PIM API Model concepts to the JSON Models in the REST/HTTP PSM (OpenAPI specification).
- **PIM API Services - REST/HTTP PSM Endpoints Mapping:** This section presents the mapping from the PIM API Service definitions and operations to the API endpoints in the REST/HTTP PSM (OpenAPI specification).

8.1.2 PIM API Model - REST/HTTP PSM Model Mapping

The table below presents the mapping from the PIM API Model concepts to the JSON Models in the REST/HTTP PSM (OpenAPI specification).

Table 9. PIM API Model - REST/HTTP PSM Model Mapping Table

PIM Concept	REST/HTTP PSM Model (JSON)
Project	Project
Commit	Commit
Tag	Tag
Branch	Branch
Data	Data
DataIdentity	DataIdentity
DataVersion	DataVersion
Element	Element
Relationship	Relationship
ExternalData	ExternalData
ExternalRelationship	ExternalRelationship
ProjectUsage	ProjectUsage
Query	Query
PrimitiveConstraint	PrimitiveConstraint
CompositeConstraint	CompositeConstraint
DataDifference	DataDifference
MergeResult.mergeCommit	Commit
MergeResult.conflict	DataIdentity [0..*]

8.1.3 PIM API Services - REST/HTTP PSM Endpoints Mapping

The table below presents the mapping between the PIM Services to the REST/HTTP PSM Endpoints. This is followed by a detailed description of the pagination strategy used by the REST/HTTP PSM.

Table 10. PIM to REST / HTTP PSM Mapping

PIM Service	REST / HTTP PSM Endpoint
ProjectService	
createProject	POST /projects
getProjects	GET /projects
getProjectById	GET /projects/{projectId}
updateProject	PUT /projects/{projectId}
deleteProject	DELETE /projects/{projectId}
ElementNavigationService	
getElements	GET /projects/{projectId}/commits/{commitId}/elements
getElementById	GET /projects/{projectId}/commits/{commitId}/elements/{elementId}
getRelationshipsByRelatedElement	GET /projects/{projectId}/commits/{commitId}/elements/{relatedElementId}/relationships <ul style="list-style-type: none"> • <i>direction</i> query parameter with allowable values {in, out, both}
getRootElements	GET /projects/{projectId}/commits/{commitId}/roots
ProjectDataVersioningService	
getCommits	GET /projects/{projectId}/commits
getHeadCommit	<ul style="list-style-type: none"> • GET /projects/{projectId}/branches/{branchId} returns the branch with the given branch ID. If the branch ID is not provided, then the ID of the default branch of the project is used. Use the following steps to get the ID of the default branch. <ul style="list-style-type: none"> ◦ GET /projects/{projectId} return the project with the given project ID ◦ Project.defaultBranch provides the ID of the default branch of the project • Branch.head provides the ID of the head commit of the branch • GET /projects/{projectId}/commits/{commitId} returns the head commit with the the given commit ID
getCommitById	GET /projects/{projectId}/commits/{commitId}

PIM Service	REST / HTTP PSM Endpoint
createCommit	<p>POST /projects/{projectId}/commit</p> <ul style="list-style-type: none"> The body of the POST request is a CommitRequest. The content of CommitRequest.change for creating, updating, and deleting Data maps directly to the corresponding PIM operation (createCommit), and is described below. <ul style="list-style-type: none"> For creating new Data, CommitRequest.change should include a DataVersion where DataVersion.payload includes the Data being created and DataVersion.identity is either not specified or set to a new DataIdentity that does not already exist in any of the previousCommits. For updating existing Data, CommitRequest.change should include a DataVersion where DataVersion.payload includes the updated Data, and DataVersion.identity is the DataIdentity for which a new DataVersion will be created in the commit. For deleting existing Data, CommitRequest.change should include a DataVersion where DataVersion.payload is not specified, and DataVersion.identity is the DataIdentity that will be deleted in the commit.
getCommitChange	GET /projects/{projectId}/commits/{commitId}/changes
getCommitChangeById	GET /projects/{projectId}/commits/{commitId}/changes/{changeId}
getBranches	GET /projects/{projectId}/branches
getBranchById	GET /projects/{projectId}/branches/{branchId}
getDefaultBranch	<ul style="list-style-type: none"> GET /projects/{projectId} returns a Project with the given ID (projectId) Project.defaultBranch provides the ID of the default branch of the project
setDefaultBranch	<ul style="list-style-type: none"> PUT /projects/{projectId} The body of the PUT request is a ProjectRequest. Set the ID of the new default branch as ProjectRequest.defaultBranch in the body.
createBranch	POST /projects/{projectId}/branches
deleteBranch	DELETE /projects/{projectId}/branches/{branchId}
getTags	GET /projects/{projectId}/tags
getTagById	GET /projects/{projectId}/tags/{tagId}

PIM Service	REST / HTTP PSM Endpoint
getTaggedCommit	<ul style="list-style-type: none"> GET /projects/{projectId}/tags/{tagId} returns the tag with the given ID (tagId) Tag.taggedCommit provides the ID of the tagged commit GET /projects/{projectId}/commits/{commitId} returns the tagged commit given its ID (see the previous step)
createTag	POST /projects/{projectId}/tags
deleteTag	DELETE /projects/{projectId}/tags/{tagId}
mergeIntoBranch	POST /projects/{projectId}/branches/{targetBranchId}/merge
diffCommits	GET /projects/{projectId}/commits/{compareCommitId}/diff
QueryService	
getQueries	GET /projects/{projectId}/queries
getQueryById	GET /projects/{projectId}/queries/{queryId}
createQuery	POST /projects/{projectId}/queries
updateQuery	PUT /projects/{projectId}/queries/{queryId}
deleteQuery	DELETE /projects/{projectId}/queries/{queryId}
executeQueryById	GET /projects/{projectId}/queries/{queryId}/results
executeQuery	GET /projects/{projectId}/query-results POST /projects/{projectId}/query-results Either the GET or the POST endpoint may be used. The POST endpoint is provided for compatibility with clients that don't support GET requests with a body
ExternalRelationshipService	

PIM Service	REST / HTTP PSM Endpoint
getExternalRelationships	<ul style="list-style-type: none"> • POST /projects/{projectId}/queries with QueryRequest JSON model <ul style="list-style-type: none"> ◦ Query.where is set to a PrimitiveConstraint ◦ PrimitiveConstraint.property = @type ◦ PrimitiveConstraint.value = 'ExternalRelationship' ◦ PrimitiveConstraint.operator = '=' • Execute the query with the following request <ul style="list-style-type: none"> ◦ GET /projects/{projectId}/queries/{queryId}/results?commitId={commitId}, where {projectId} and {commitId} are the ids of the given Project and Commit
getExternalRelationshipsByElement	<ul style="list-style-type: none"> • POST /projects/{projectId}/queries with QueryRequest JSON model <ul style="list-style-type: none"> ◦ Query.where is set to a CompositeConstraint ◦ CompositeConstraint.constraints includes the following 2 instances of PrimitiveConstraint with the and operator <ul style="list-style-type: none"> ▪ PrimitiveConstraint 1 <ul style="list-style-type: none"> ▪ PrimitiveConstraint.property = @type ▪ PrimitiveConstraint.value = 'ExternalRelationship' ▪ PrimitiveConstraint.operator = '=' ▪ PrimitiveConstraint 2 <ul style="list-style-type: none"> ▪ PrimitiveConstraint.property = elementEnd ▪ PrimitiveConstraint.value = {elementId} ▪ PrimitiveConstraint.operator = '=' • Execute the query with the following request <ul style="list-style-type: none"> ◦ GET /projects/{projectId}/queries/{queryId}/results?commitId={commitId}, where {projectId} and {commitId} are the ids of the given Project and Commit

PIM Service	REST / HTTP PSM Endpoint
getExternalRelationshipsById	<ul style="list-style-type: none"> POST /projects/{projectId}/queries with Query JSON model <ul style="list-style-type: none"> Query.<i>where</i> is set to a CompositeConstraint CompositeConstraint.<i>constraints</i> includes the following 2 instances of PrimitiveConstraint with the <i>and</i> operator <ul style="list-style-type: none"> PrimitiveConstraint 1 <ul style="list-style-type: none"> PrimitiveConstraint.<i>property</i> = @type PrimitiveConstraint.<i>value</i> = 'ExternalRelationship' PrimitiveConstraint.<i>operator</i> = '=' PrimitiveConstraint 2 <ul style="list-style-type: none"> PrimitiveConstraint.<i>property</i> = @id PrimitiveConstraint.<i>value</i> = {externalRelationshipId} PrimitiveConstraint.<i>operator</i> = '=' Execute the query with the following request <ul style="list-style-type: none"> GET /projects/{projectId}/queries/{queryId}/results?commitId={commitId}, where {projectId} and {commitId} are the ids of the given Project and Commit
createExternalRelationship	<ul style="list-style-type: none"> POST /projects/{projectId}/commits?branchId={branchId} with CommitRequest JSON model, such that: <ul style="list-style-type: none"> CommitRequest.<i>change</i> = DataVersion object with specifics below DataVersion.<i>payload</i> = ExternalRelationship object
deleteExternalRelationship	<ul style="list-style-type: none"> POST /projects/{projectId}/commits?branchId={branchId} with CommitRequest JSON model, such that: <ul style="list-style-type: none"> CommitRequest.<i>change</i> = DataVersion object with specifics below DataVersion.<i>payload</i> = null DataVersion.<i>identity</i> = DataIdentity object with the specifics below <ul style="list-style-type: none"> DataIdentity.<i>id</i> = {externalRelationshipId}
Project Usage Service	

PIM Service	REST / HTTP PSM Endpoint
getProjectUsages	<ul style="list-style-type: none"> POST /projects/{projectId}/queries with QueryRequest JSON model <ul style="list-style-type: none"> Query.<i>where</i> is set to a PrimitiveConstraint PrimitiveConstraint.<i>property</i> = @type PrimitiveConstraint.<i>value</i> = 'ProjectUsage' PrimitiveConstraint.<i>operator</i> = '=' Execute the query with the following request <ul style="list-style-type: none"> GET /projects/{projectId}/queries/{queryId}/results?commitId={commitId}, where {projectId} and {commitId} are the ids of the given Project and Commit
createProjectUsage	<ul style="list-style-type: none"> POST /projects/{projectId}/commits?branchId={branchId} with CommitRequest JSON model, such that: <ul style="list-style-type: none"> CommitRequest.<i>change</i> = DataVersion with the following inputs <ul style="list-style-type: none"> DataVersion.<i>payload</i> = ProjectUsage with the following inputs <ul style="list-style-type: none"> ProjectUsage.<i>usedProjectCommit</i> = {commitId} of the Project and Commit being used.
deleteProjectUsage	<ul style="list-style-type: none"> POST /projects/{projectId}/commits?branchId={branchId} with CommitRequest JSON model, such that: <ul style="list-style-type: none"> CommitRequest.<i>change</i> = DataVersion with the following inputs <ul style="list-style-type: none"> DataVersion.<i>identity</i> = DataIdentity with the following inputs <ul style="list-style-type: none"> DataIdentity.<i>id</i> = {projectUsageId} DataVersion.<i>payload</i> = null

Pagination

The REST/HTTP PSM uses a Cursor-based pagination strategy for the responses received from the GET requests. The following 3 query parameters can be specified in any GET request that returns a collection of records.

1. *page[size]* specifies the maximum number of records that will be returned per page in the response
2. *page[before]* specifies the URL of the page succeeding the page being requested
3. *and page[after]* specifies the URL of a page preceding the page being requested

If neither *page[before]* nor *page[after]* is specified, the first page is returned with the same number of records as specified in the *page[size]* query parameter. If the *page[size]* parameter is not specified, then a default page size is used, which can be set by the API provider.

The *Link* header in the response includes links (URLs) to the previous page and the next page, if any, for the given page in the response. The specification of these links is conformant to the [IETF Web Linking standard](#). As an example, the value of the *Link* response header is shown below. The *rel* value associated with each page link specifies the type of relationship the linked page has with the page returned in the response. Page link specified with

rel value as *next* is the link for the next (or succeeding) page to the page returned in the response, and the page link specified with *rel* value as *prev* is the link for the previous (or preceding) page to the page returned in the response.

```
<http://sysml2-api-host:9000/projects?
  page[after]=MTYxODg2MTQ5NjYzMnwyMDEwOWY0MC00ODI1LTQxNmEtODZmNi03NTA4YWM0MmEwMjE&
  page[size]=3>; rel="next",
<http://sysml2-api-host:9000/projects?
  page[before]=MTYxODg2MTQ5NjYzMnwxMDg2MDFjMS1iNzk1LTRkMGEtYTFiYy1lZjEyYmMwNTU5ZjI&
  page[size]=3>; rel="prev"
```

Example

An example demonstrating the Cursor-based paginated responses received from GET requests to the */projects* endpoint is presented here. The term "User" in the example scenario presented below refers to an API user that could be a human user or a software program.

Step 1 - User makes a GET request to the */projects* endpoint with *page[size]* query parameter set to 3. If successful, this request will return the first page with a maximum of 3 project records. The URL for this GET request is shown below.

```
http://sysml2-api-host:9000/projects?page[size]=3
```

Step 2 - If there are more than 3 projects in the provider repository, the *Link* header in the response will provide the URL for the next page with *rel* value equal to *next*. The User gathers the link to the next page.

```
<http://sysml2-api-host:9000/projects?
  page[after]=MTYxODg2MjE2NTMxNXwwOGY0MzNkYi1iNmQ0LTQxYjgtOTAyMC1lODIwZWJjNDE3YmU&
  page[size]=3>; rel="next"
```

Step 3 - User makes a GET request to the URL for the next page gathered from Step 2. The *Link* header in the response will provide the URL for the next page with *rel* value equal to *next*. Additionally, the *Link* header will include the URL for the previous page with *rel* value equal to *prev*.

```
<http://sysml2-dev.intercax.com:9000/projects?
  page[after]=MTYxODg2MjY4OTYxNHwyMDEwOWY0MC00ODI1LTQxNmEtODZmNi03NTA4YWM0MmEwMjE&
  page[size]=3>; rel="next",
<http://sysml2-dev.intercax.com:9000/projects?
  page[before]=MTYxODg2MjY4OTYxNHwxMDg2MDFjMS1iNzk1LTRkMGEtYTFiYy1lZjEyYmMwNTU5ZjI&
  page[size]=3>; rel="prev"
```

Step 4 - User continues Step 3 until the *Link* header in the response does not include the URL for the next page (*rel* value as *next*).

8.2 OSLC 3.0 PSM

8.2.1 Overview

The OSLC Platform-Specific Model (PSM) for the Systems Modeling API and Services is described using OpenAPI Specification (OAS) 2.0 and is included with this specification.

Note that the URLs listed in the OpenAPI Specification are provided as examples only. With OSLC, all URLs are implementation-specific. A OSLC client typically relies on the OSLC discovery mechanism (<https://docs.oasis-open-projects.org/oslcp/core/v3.0/ps01/discovery.html>), to determine what services are provided by an OSLC server, as well as the necessary information (such as a service URL) to be able to consume any such service. At the least, an OSLC client requires a discovery URL to bootstrap this discovery for any particular server. The various approaches for bootstrapping and discovery are further detailed in the OSLC standard.

- [8.2.2](#) presents a brief introduction to OSLC and its nomenclature.

- [8.2.3](#) presents the mapping of PIM concepts to OSLC resource types
- [8.2.4](#) presents the mapping of PIM services and operations to OSLC services

An OSLC implementation may typically need to realize a broader set of services than those defined by the PIM for full integration with other OSLC-compliant systems. Services such as Delegated UI for Selection and Creation, resource UI Preview, authentication, and support for arbitrary queries (beyond those defined in the PIM).

8.2.2 OSLC Nomenclature

What is OSLC?

Open Services for Lifecycle Collaboration (OSLC) is an open community creating specifications for integrating tools. OSLC specifications allow conforming independent software and product lifecycle tools to integrate their data and workflows in support of end-to-end lifecycle processes. OSLC is based on the W3C Linked Data and the use of RDF to represent artifacts using common vocabularies, and HTTP to discover, create, read, update, and delete such artifacts. For a more comprehensive introduction, see the [OSLC Primer](#) and the OSLC specifications at <https://open-services.net/specifications/>.

OSLC servers may support any or all of the following:

1. *Creation factories* for creating a resource of some RDF type associated with the factory. For example, a client might create a new change request by an HTTP POST including the RDF representation of the change request to be created to the URI of a change request creation factory.
2. REST services to read, update, and/or delete resources at the resource's URI.
3. *Query capabilities* that allow OSLC clients to query for resources of an RDF type associated with the query capability. For example, a client might query for change requests by an HTTP GET or POST to the query base URI of a query capability for change requests. See [OSLC Query Version 3.0](#) for further details.
4. *Creation dialog* that allows some other application to embed it in an iFrame of an application dialog that allows a user to fill in information and create a resource of some type associated with the creation dialog.
5. *Selection dialog* that allows an application to display it to select a resource of some type associated with the dialog in order to create and persist a link to that resource in the application.
6. *Resource preview*, such as a pop-up display, that is shown as a rich hover when a user hovers over a link to a resource managed by the OSLC server.

OSLC Discovery

OSLC clients and other servers discover the OSLC capabilities offered by a server through OSLC discovery. This allows clients to discover the URIs of creation factories, query capabilities, creation dialogs, and selection dialogs without the need for hard coding or constructing URIs for them. Discovery starts with a known URI for an OSLC *Service Provider Catalog*. That service provider catalog may reference zero, one, or many *service providers*. Servers that support the concept of project as a container of resources, often for access control, often define a service provider for each such container. A service provider may declare one or many services, each of which may define the creation factories, query capabilities, creation dialogs, and selection dialogs supported by that service. For more details, see [OSLC Core Version 3.0. Part 2: Discovery](#).

A creation factory for a specific RDF type is discovered by:

1. Start with a known OSLC service provider catalog URI, perform HTTP GET.
2. Get the URIs of service providers from the response.
3. For each service provider, perform HTTP GET.
4. From the response, look for services described in the response data, that declare a creation factory for the RDF type.
5. Get the URI of the creation factory.

A query capability for a specific RDF type is discovered by:

1. Start with a known OSLC service provider catalog URI, perform HTTP GET.
2. Get the URIs of service providers from the response.
3. For each service provider, perform HTTP GET.
4. From the response, look for services described in the response data, that declare a query capability for the RDF type.
5. Get the query base URI of the query capability.

OSLC Resource Shapes

Resource shapes specify a standard way (using RDF) of describing resources of specific RDF types and their properties. For more details, see [OSLC Core Version 3.0. Part 6: Resource Shape](#). Resource shapes may be discovered in a number of ways:

1. The definition of a creation factory may reference a resource shape that describes the properties that might be included in the RDF content POSTed to that creation factory.
2. The definition of a query capability may reference a resource shape that describes the properties of the query results and references a shape that describes the properties that might be queried as a condition, or selected to be included in the results.
3. A resource may reference an instance shape that describes the properties of that resource.

Linked Data Platform Containers

Linked Data Platform Containers (LDPC) are a way of representing containers as an RDF resource. OSLC specifications specify LPDCs as a container representation. See [W3C Linked Data Platform 1.0](#) for further information.

OSLC Service Providers

A "global" service provider will contain one or more services that cross all systems modeling projects. A service provider will be declared for each systems modeling project that provides capabilities specific to that project.

RDF Media Types

OSLC recommends that servers support RDF/XML (application/rdf+xml), Turtle (text/turtle, application/x-turtle), and JSON-LD (application/ld+json).

8.2.3 PIM API Model – OSLC PSM Resource Mapping

The mapping from the PIM API Model to the OSLC PSM resource types includes the following.

1. Mapping from the KerML and SysML abstract syntax (Element and subtypes) to OSLC resource shapes and vocabulary. The package containing the resulting OSLC resource shapes and vocabulary is included with this specification - see *OSLC Systems Modeling Resource Shapes and Vocabulary.zip*.
2. Mapping from the API Model concepts to resource types in other OSLC specifications, such as OSLC Configuration Management specification and OSLC Query specification. This mapping is shown in the table below. References to the OSLC specifications mentioned in the table below are as follows.
 1. OSLC Configuration Management refers to OSLC Configuration Management Version 1.0 available at <https://oslc-op.github.io/oslc-specs/specs/config/oslc-config-mgt.html>.
 2. OSLC Query refers to OSLC Query Version 3.0 available at <https://docs.oasis-open-projects.org/oslc-op/query/v3.0/os/oslc-query.html>

Table 11. PIM Concept to OSLC Resource type Mapping

PIM Concept	OSLC Resource Type (OSLC Specification)	dcterms:identifier
Project	Component (oslc_config:Component) (OSLC Configuration Management)	PIM project id
Branch	Stream (oslc_config:Stream) (OSLC Configuration Management)	PIM branch id
Tag	Baseline (oslc_config:Baseline) (OSLC Configuration Management)	PIM tag id
Commit	Not supported by OSLC Configuration Management.	PIM commit id
DataIdentity	Concept resource (OSLC Configuration Management)	PIM Data Identity id
DataVersion	Version resource (oslc_config:VersionResource) (OSLC Configuration Management)	PIM Data Version id
Query	OSLC Query (OSLC Query)	
PrimitiveConstraint	oslc.where in OSLC Query (OSLC Query)	
CompositeConstraint	oslc.where in OSLC Query (OSLC Query)	
ProjectUsage	Not Available. PIM Project concept is mapped to OSLC Component but OSLC does not define Component Usage.	
DataDifference	Not Available	
MergeResult	Not Available	
ExternalData	Not Available	
ExternalRelationship	Not Available	

8.2.4 PIM API Services – OSLC PSM Service Mapping

The table below presents the mapping between the PIM Services to the OSLC 3.0 PSM.

Table 12. PIM API Services - OSLC Services Mapping

PIM Services	OSLC PSM
ProjectService	

PIM Services	OSLC PSM
getProjectById	<p>In OSLC, a Project is identified by its URL. So simply perform a GET on the Project URL.</p> <p>To search for a project with a given dcterms:identifier (or any other property that is deemed to return a single query result):</p> <ol style="list-style-type: none"> 1. Discover a query capability for components (oslc_config:Component). See <i>OSLC Discovery</i> section. 2. Perform a GET on the query base, specifying a query for the dcterms:identifier in a <i>oslc.where</i> query parameter, and specifying which properties, if any, of the component should be returned in the query result using an <i>oslc.select</i> query parameter. <p>Example: Query for components with identifier 123, returning all properties.</p> <pre>GET queryBaseUri? oslc.where=dcterms%3Aidentifier%3D%22123%22& oslc.select=*</pre>
createProject	<ol style="list-style-type: none"> 1. Discover a creation factory for components (oslc_config:Component). See <i>OSLC Discovery</i> section. 2. POST the RDF content describing the component (with a Content-Type header set to an RDF media type supported by the server) to the creation factory. The RDF content should be compliant with the resource shape specified for the creation factory, and that resource shape must be compatible with the resource shape for Component as described in the OSLC specification (see https://docs.oasis-open-projects.org/oslc-op/config/v1.0/ps01/config-resources.html#ComponentShape). <p>Example:</p> <pre>POST creationFactoryUri</pre>
getProjects	<ol style="list-style-type: none"> 1. Discover a query capability for components (oslc_config:Component). See <i>OSLC Discovery</i> section. 2. Perform a GET on the query base, specifying which properties, if any, of the component should be returned in the query result using an <i>oslc.select</i> query parameter. <p>Example: Query for components returning their name (dcterms:title) and id (dcterms:identifier)</p> <pre>GET queryBaseUri? oslc.select=dcterms%3Atitle%2Cdcterms%3Aidentifier</pre>
updateProject	<p>Execute an HTTP PUT with the revised content of the component. The RDF content should be compliant with the instance resource shape of the Component, and this should be compatible with the resource shape for Component as described in the OSLC specification (see https://docs.oasis-open-projects.org/oslc-op/config/v1.0/ps01/config-resources.html#ComponentShape)</p>

PIM Services	OSLC PSM
deleteProject	Not supported directly. Deletion operation is not supported for Components in the OSLC Configuration Management specification. See https://oslc-op.github.io/oslc-specs/specs/config/config-resources.html#componentoperations . However, providers may implement deletion operation for Components.
ElementNavigation Service	
getElements	<ol style="list-style-type: none"> 1. Discover a query capability for elements (an API-specific RDF type) for the specified project. See <i>OSLC Discovery</i> section. 2. Perform a GET on the query base, specifying which properties, if any, of the commit should be returned in the query result using an <i>oslc.select</i> query parameter. <p>Example: Query for elements returning name (dcterms:title) and identifier (dcterms:identifier).</p> <pre>GET queryBaseUri? oslc.select=dcterms%3Atitle%2Cdcterms%3Aidentifier</pre>
getElementById	<p>In OSLC, an Element is identified by its URL. So simply perform a GET on the Element URL.</p> <p>To search for an Element with a given dcterms:identifier (or any other property that is deemed to return a single query result):</p> <ol style="list-style-type: none"> 1. Discover a query capability for elements (an API-specific RDF type) for the specified project. See <i>OSLC Discovery</i> section. 2. Perform a GET on the query base, specifying a query for the dcterms:identifier in a <i>oslc.where</i> query parameter, and specifying which properties, if any, of the commit should be returned in the query result using an <i>oslc.select</i> query parameter. <p>Example: Query for elements with identifier 123, returning all properties.</p> <pre>GET queryBaseUri? oslc.where=dcterms%3Aidentifier%3D%22123%22& oslc.select=*</pre>

PIM Services	OSLC PSM
getRelationshipsByRelatedElement	<ol style="list-style-type: none"> 1. Discover the query capability for Elements for the particular project (and its specific commit). See <i>OSLC Discovery</i> section. 2. Perform a GET on the query base, setting the <i>oslc.where</i> query parameter to: <ol style="list-style-type: none"> 1. <i>sysml:out</i> = URI of the subject element to get all the outgoing Relationships from that element 2. <i>sysml:in</i> = URI of the subject element to get all the incoming Relationships to the element <p>Example 1: Query for Relationships outgoing from an element <http://sysml2.server.com/elements/123>:</p> <pre>GET queryBaseUri? oslc.where=sysml:out=<http://sysml2.server.com/elements/123> and rdf:type=<http://omg.org/ns/sysml/v2/metamodel%23Relationship> &oslc.prefix=sysml=<http://omg.org/ns/sysml/v2/metamodel%23></pre> <p>Example 2: Query for Relationships incoming to an element <http://sysml2.server.com/elements/123>:</p> <pre>GET queryBaseUri? oslc.where=sysml:in=<http://sysml2.server.com/elements/123> and rdf:type=<http://omg.org/ns/sysml/v2/metamodel%23Relationship> &oslc.prefix=sysml=<http://omg.org/ns/sysml/v2/metamodel%23></pre> <p>For Direction equal to <i>both</i>: perform and merge the separate queries on <i>in</i> and <i>out</i> values.</p>
getRootElements	<p>Not Available.</p> <p>OSLC Query does not currently support the ability to search for resources, where certain properties (owner in this case) are not set.</p>
ProjectDataVersioning Service	
getBranchById	<ol style="list-style-type: none"> 1. Discover a query capability for streams (<i>oslc_config:Stream</i>) for the specified project. See <i>OSLC Discovery</i> section. 2. Perform a GET on the query base, specifying a query for the <i>dcterms:identifier</i> in a <i>oslc.where</i> query parameter, and specifying which properties, if any, of the component should be returned in the query result using an <i>oslc.select</i> query parameter. <p>Example: Query for streams with identifier 123, returning all properties.</p> <pre>GET queryBaseUri? oslc.where=dcterms%3Aidentifier%3D%22123%22& oslc.select=*</pre>

PIM Services	OSLC PSM
getTagById	<ol style="list-style-type: none"> 1. Discover a query capability for baselines (oslc_config:Baseline) for the specified project. See <i>OSLC Discovery</i> section. 2. Perform a GET on the query base, specifying a query for the dterms:identifier in a <i>oslc.where</i> query parameter, and specifying which properties, if any, of the component should be returned in the query result using an <i>oslc.select</i> query parameter. <p>Example: Query for baselines with identifier 123, returning all properties.</p> <pre>GET queryBaseUri? oslc.where=dterms%3Aidentifier%3D%22123%22& oslc.select=*</pre>
getCommits	Not available. The OSLC Configuration Management specification does not define any notion of a commit. Versions of specific resources may be fetched.
getBranches	<ol style="list-style-type: none"> 1. Discover a query capability for streams (oslc_config:Stream) for the specified project. See <i>OSLC Discovery</i> section. 2. Perform a GET on the query base, specifying which properties, if any, of the stream should be returned in the query result using an <i>oslc.select</i> query parameter. <p>Example: Query for branches returning their name (dterms:title) and id (dterms:identifier)</p> <pre>GET queryBaseUri? oslc.select=dterms%3Atitle%2Cdterms%3Aidentifier</pre>

PIM Services	OSLC PSM
createCommit	<p>Not available. The OSLC Configuration Management specification does not define any notion of a commit. New versions may be created in the context of a stream or change set. However, the OSLC Configuration Management specification does not define any means to commit a change set or deliver the changes in a stream or change set to another stream.</p> <p>For creating new versions of a resource in the context of a stream or a change set, see below.</p> <ol style="list-style-type: none"> 1. Execute a PUT on version resource concept URI with configuration context parameter/header set to the URI of a stream (branch). Body contains the updated RDF representation of the element version. <p>Note that this only supports a new commit along a branch with the previous latest commit being its previous commit. If a client wants to commit from an earlier version, they must first create a stream (branch) from that earlier baseline (commit) and then use a PUT with that new stream.</p> <p>The OSLC Configuration Management specification does not currently define any mechanisms for creating new versions of multiple versioned resources in a single REST operation.</p> <p>Example 1:</p> <pre>PUT conceptResourceUri? oslc_config.context=urlEncodedStreamUri</pre> <p>Example 2:</p> <pre>Headers: Configuration-Context=streamUri PUT conceptResourceUri</pre>
getCommitById	<ol style="list-style-type: none"> 1. Discover a query capability for commits (a API-specific RDF type) for the specified project. See <i>OSLC Discovery</i> section. 2. Perform a GET on the query base, specifying a query for the dcterms:identifier in a <i>oslc.where</i> query parameter, and specifying which properties, if any, of the commit should be returned in the query result using an <i>oslc.select</i> query parameter. <p>Example: Query for commits with identifier 123, returning all properties.</p> <pre>GET queryBaseUri? oslc.where=dcterms%3Aidentifier%3D%22123%22& oslc.select=*</pre>
getCommitChange	<p>Not available. The OSLC Configuration Management specification does not define any notion of a commit. New versions may be created in the context of a stream or change set. However, the OSLC Configuration Management specification does not define any means to commit a change set or deliver the changes in a stream or change set to another stream.</p>
getCommitChangeById	<p>Not available. The OSLC Configuration Management specification does not define any notion of a commit. New versions may be created in the context of a stream or change set. However, the OSLC Configuration Management specification does not define any means to commit a change set or deliver the changes in a stream or change set to another stream.</p>

PIM Services	OSLC PSM
deleteBranch	Execute an HTTP DELETE on the URI of the stream. Note that servers may reject the delete request if the stream is used or referenced by other configurations. A server may also support archiving (soft delete) a stream using a HTTP PUT with content that includes a oslc:archived "true"^^xsd:boolean property.
getDefaultBranch	Not available. The OSLC Configuration Management specification does not define any notion of a default stream.
deleteTag	Execute an HTTP DELETE on the URI of the baseline. Note that a server might reject a request to delete a baseline if it is used or referenced by other configurations. A server may also support archiving (soft delete) a baseline using a HTTP PUT with content that includes a oslc:archived "true"^^xsd:boolean property.
setDefaultBranch	Not available. The OSLC Configuration Management specification does not define any notion of a default stream.
getHeadCommit	Not available. The OSLC Configuration Management specification does not define any notion of a commit. New versions may be created in the context of a stream or change set. However, OSLC Configuration Management does not define any means to commit a change set or deliver the changes in a stream or change set to another stream.
getTaggedCommit	Not available. The OSLC Configuration Management specification does not define any notion of a commit. New versions may be created in the context of a stream or change set. However, OSLC Configuration Management does not define any means to commit a change set or deliver the changes in a stream or change set to another stream. A baseline can provide a set of versioned resources but it is not a commit.
getTags	<ol style="list-style-type: none"> 1. Discover a query capability for baselines (oslc_config:Baseline) for the specified project. See OSLC Discovery section. 2. Perform a GET on the query base, specifying which properties, if any, of the baseline should be returned in the query result using an oslc.select query parameter. <p>Example: Query for tags returning their name (dcterms:title) and id (dcterms:identifier)</p> <pre>GET queryBaseUri? oslc.select=dcterms%3Atitle%2Cdcterms%3Aidentifier</pre>
createTag	<ol style="list-style-type: none"> 1. Get the baselines LDPC URI from the RDF of a stream. 2. POST the RDF representation of the baseline to the LDPC URI (with a Content-Type header set to an RDF media type supported by the server). The RDF content should be compatible with the resource shape for Baseline as described in the specification (see https://docs.oasis-open-projects.org/oslc-op/config/v1.0/ps01/config-resources.html#BaselineShape) <p>Example: Create a baseline from a stream</p> <pre>POST baselinesLdpcUri</pre>

PIM Services	OSLC PSM
createBranch	<p>A server might support either or both of the following:</p> <p>A) Use a creation factory:</p> <ol style="list-style-type: none"> 1. Discover a creation factory for streams (<code>oslc_config:Stream</code>) for the specified project. See <i>OSLC Discovery</i> section. 2. POST the RDF content describing the stream (with a Content-Type header set to an RDF media type supported by the server) to the creation factory. The RDF content should be compliant with the resource shape specified for the creation factory, and that resource shape must be compatible with the resource shape for Stream as described in the specification (see https://docs.oasis-open-projects.org/oslc-op/config/v1.0/ps01/config-resources.html#StreamShape) <p>Example:</p> <pre>POST <i>creationFactoryUri</i></pre> <p>or</p> <p>B) Use the streams LDPC of a component</p> <ol style="list-style-type: none"> 1. Get the URI of the streams LDPC from the RDF of a component. 2. POST the RDF content describing the stream (with a Content-Type header set to an RDF media type supported by the server) to the LDPC. The RDF content should be compatible with the resource shape for Stream as described in the specification (see https://docs.oasis-open-projects.org/oslc-op/config/v1.0/ps01/config-resources.html#StreamShape) <p>Example:</p> <pre>POST <i>streamsLdpcUri</i></pre>
mergeIntoBranch	Not Available
diffCommits	Not Available
QueryService	
getQueryById	Not Available OSLC does not provide any RDF representation or persistence mechanisms of OSLC queries.
getQueries	Not Available OSLC does not provide any RDF representation or persistence mechanisms of OSLC queries.
executeQueryById	Not Available OSLC does not provide any RDF representation or persistence mechanisms of OSLC queries.
createQuery	Not Available OSLC does not provide any RDF representation or persistence mechanisms of OSLC queries.

PIM Services	OSLC PSM
updateQuery	Not Available OSLC does not provide any RDF representation or persistence mechanisms of OSLC queries.
deleteQuery	Not Available OSLC does not provide any RDF representation or persistence mechanisms of OSLC queries.
executeQuery	<ol style="list-style-type: none"> 1. Discover a query capability for the specified project. See <i>OSLC Discovery</i> section. 2. Perform a GET on the query base, specifying the following. See OSLC Query Capability in OSLC Nomenclature <ol style="list-style-type: none"> 1. The <i>oslc.where</i> query parameter to filter for the desired elements 2. The <i>oslc.select</i> query parameter, to define the element properties that should be returned in the query result.
ExternalRelationship Service	OSLC does/can not differentiate between properties/relationships/elements that are external or otherwise. The services below are just specific examples of the getElement and getElementById service operation mappings above.
getExternalRelationshipsById	See getElementById under ElementNavigationService
getExternalRelationshipsByElementEnd	See getRelationshipsByRelatedElement under ElementNavigationService
getExternalRelationships	See getElements under Element Navigation Service
createExternalRelationship	Not available.
deleteExternalRelationship	Not available.
ProjectUsageService	
createProjectUsage	Not available. The OSLC Configuration Management specification does not define any notion of component usage.
deleteProjectUsage	Not available. The OSLC Configuration Management specification does not define any notion of component usage.
getProjectUsages	Not available. The OSLC Configuration Management specification does not define any notion of component usage.

A Annex: Conformance Test Suite

(Normative)

A.1 ProjectService Conformance Test Cases

Operation create_project

PIM-PS-001

Description	Create Project - success
Input	<ol style="list-style-type: none">1. <code>_description : String[0..1]</code>2. <code>_name : String[1]</code>
Scenario	
Precondition (OCL)	<code>let _record : Record = Record.allInstances()</code>
Steps	Execute operation <code>create_project(name = _name, description = _description) : Project[1]</code>
Result	<ol style="list-style-type: none">1. Result, defined as <code>project : Project[1]</code>, is a created Project2. The <code>id</code> attribute value of the created Project is randomly generated and universally unique, including (but not limited to) not being used as the <code>id</code> attribute value for any previously existing Record3. A Branch is created and specified as the <code>defaultBranch</code> attribute value for the created Project4. The <code>id</code> attribute value of the created Branch (<code>defaultBranch</code>) is randomly generated and universally unique, including (but not limited to) not being used as the <code>id</code> attribute value for any previously existing Record.5. The <code>name</code> attribute value of the created Branch (<code>defaultBranch</code>) is specified as <code>'main'</code>6. The <code>description</code> attribute value is specified as inputted7. The <code>name</code> attribute value is specified as inputted
Postcondition (OCL)	<pre>let project : Project = create_project(_name, _description) project->size() = 1 Project.allInstances()->includes(project) _record.id->excludes(project.id) project.defaultBranch->notEmpty() _record.id->excludes(project.defaultBranch.id) project.defaultBranch.name = 'main' project.description = _description project.name = _name</pre>

Operation get_projects

PIM-PS-002

Description	Get Projects - success
Input	None
Scenario	
Precondition (OCL)	
Steps	Execute operation <code>get_projects()</code> : <code>Project[0..*]</code>
Result	Result, defined as <code>project</code> : <code>Project[0..*]</code> , is all of the existing Projects
Postcondition (OCL)	<code>let project : Project = get_projects()</code> <code>project = Project.allInstances()</code>

Operation get_project_by_id

PIM-PS-003

Description	Get Project by ID - exists
Input	1. <code>_projectId</code> : <code>UUID[1]</code>
Scenario	A Project with an <code>id</code> attribute value equal to <code>_projectId</code> exists
Precondition (OCL)	<code>let _project : Project = Project.allInstances()->select(id = _projectId)</code> <code>_project->size() = 1</code>
Steps	Execute operation <code>get_project_by_id(projectId = _projectId)</code> : <code>Project[0..1]</code>
Result	Result, defined as <code>project</code> : <code>Project[1]</code> , is the Project with an <code>id</code> attribute value equal to <code>_projectId</code>
Postcondition (OCL)	<code>let project : Project = get_project_by_id(_projectId)</code> <code>project = _project</code>

PIM-PS-004

Description	Get Project by ID - does not exist

Input	1. <code>_projectId : UUID[1]</code>
Scenario	A Project with an <code>id</code> attribute value equal to <code>_projectId</code> does not exist
Precondition (OCL)	<code>Project.allInstances()->select(projectId = _projectId)->isEmpty()</code>
Steps	Execute operation <code>get_project_by_id(projectId = _projectId) : Project[0..1]</code>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>project : Project[0]</code>, does not include any Projects 2. Result communicates that a Project with the provided ID does not exist
Postcondition (OCL)	<code>let project : Project = get_project_by_id(_projectId)</code> <code>project->isEmpty()</code>

A.2 ElementNavigationService Conformance Test Cases

Operation `get_elements`

PIM-EN-001

Description	Get Elements - success
Input	<ol style="list-style-type: none"> 1. <code>_project : Project[1]</code> 2. <code>_commit : Commit[1]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. The inputted Commit exists 3. The inputted Commit belongs to the inputted Project
Precondition (OCL)	<code>Project.allInstances()->includes(_project)</code> <code>Commit.allInstance()->includes(_commit)</code> <code>_commit.owningProject = _project</code>
Steps	Execute operation <code>get_elements(project = _project, commit = _commit) : Element[0..*]</code>
Result	Result, defined as <code>element : Element[0..*]</code> , is all Elements at the inputted Commit
Postcondition (OCL)	<code>let element : Element = get_elements(_project, _commit)</code> <code>element = _commit.version.data->select(oclIsKindOf(Element))</code>

Operation get_element_by_id

PIM-EN-002

Description	Get Element by ID - success
Input	<ol style="list-style-type: none">1. <code>_project</code> : Project[1]2. <code>_commit</code> : Commit[1]3. <code>_elementId</code> : UUID[1]
Scenario	<ol style="list-style-type: none">1. The inputted Project exists2. The inputted Commit exists3. The inputted Commit belongs to the inputted Project4. An Element with an <code>id</code> attribute value equal to <code>_elementId</code> exists at the inputted Commit
Precondition (OCL)	<pre>Project.allInstances()->includes(_project) Commit.allInstance()->includes(_commit) _commit.owningProject = _project let _element : Element = _commit.version->select(identity.id = _elementId and data.oclIsKindOf(Element)).data _element.size() = 1</pre>
Steps	Execute operation <code>get_element_by_id(project = _project, commit = _commit, elementId = _elementId)</code> : Element[0..1]
Result	Result, defined as <code>element</code> : Element[1], is the Element with an <code>id</code> attribute value equal to <code>_elementId</code> at the inputted Commit
Postcondition (OCL)	<pre>let element : Element = get_element_by_id(_project, _commit, _elementId) element = _element</pre>

PIM-EN-003

Description	Get Element by ID - does not exist at Commit

Input	<ol style="list-style-type: none"> 1. <code>_project</code> : <code>Project[1]</code> 2. <code>_commit</code> : <code>Commit[1]</code> 3. <code>_elementId</code> : <code>UUID[1]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. The inputted Commit exists 3. The inputted Commit belongs to the inputted Project 4. An Element with an <code>id</code> attribute value equal to <code>_elementId</code> does not exist at the inputted Commit
Precondition (OCL)	<pre> Project.allInstances()->includes(_project) Commit.allInstance()->includes(_commit) _commit.owningProject = _project _commit.version->select(identity.id = _elementId and data.ocIsKindOf(Element)).data->isEmpty() </pre>
Steps	Execute operation <code>get_element_by_id(project = _project, commit = _commit, elementId = _elementId) : Element[0..1]</code>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>element</code> : <code>Element[0]</code>, does not include any Elements 2. Result communicates that an Element with the provided ID at the inputted Commit does not exist
Postcondition (OCL)	<pre> let element : Element = get_element_by_id(_project, _commit, _id) element->isEmpty() </pre>

Operation `get_relationships_by_source`

PIM-EN-004

Description	Get Relationships by source (Element) - success

Input	<ol style="list-style-type: none"> 1. <code>_project</code> : Project[1] 2. <code>_commit</code> : Commit[1] 3. <code>_elementId</code> : UUID[1]
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. The inputted Commit exists 3. The inputted Commit belongs to the inputted Project 4. An Element with an <code>id</code> attribute value equal to <code>_elementId</code> exists at the inputted Commit
Precondition (OCL)	<pre> Project.allInstances()->includes(_project) Commit.allInstance()->includes(_commit) _commit.owningProject = _project let _element : Element = _commit.version->select(identity.id = _id and data.ocIsKindOf(Element)).data _element.size() = 1 </pre>
Steps	Execute operation <code>get_relationships_by_source(project = _project, commit = _commit, elementId = _elementId) : Relationship[0..*]</code>
Result	Result, defined as <code>relationship : Relationship[0..*]</code> , is all the Relationships whose source attribute value includes the Element with <code>id</code> attribute value equal to <code>_elementId</code>
Postcondition (OCL)	<pre> let relationship : Relationship = get_relationship_by_source(_project, _commit, _elementId) relationship = _commit.version->select(data.ocIsKindOf(Relationship) and data.source->includes(_element)) </pre>

Operation `get_relationships_by_target`

PIM-EN-005

Description	Get Relationships by target (Element) - success

Input	<ol style="list-style-type: none"> 1. <code>_project</code> : Project[1] 2. <code>_commit</code> : Commit[1] 3. <code>_elementId</code> : UUID[1]
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. The inputted Commit exists 3. The inputted Commit belongs to the inputted Project 4. An Element with an <code>id</code> attribute value equal to <code>_elementId</code> exists at the inputted Commit
Precondition (OCL)	<pre> Project.allInstances()->includes(_project) Commit.allInstance()->includes(_commit) _commit.owningProject = _project let _element : Element = _commit.version->select(identity.id = _id and data.oclIsKindOf(Element)).data _element.size() = 1 </pre>
Steps	Execute operation <code>get_relationships_by_target(project = _project, commit = _commit, elementId = _elementId) : Relationship[0..*]</code>
Result	Result, defined as <code>relationship : Relationship[0..*]</code> , is all the Relationships whose target attribute value includes the Element with <code>id</code> attribute value equal to <code>_elementId</code>
Postcondition (OCL)	<pre> let relationship : Relationship = get_relationship_by_target(_project, _commit, _elementId) relationship = _commit.version->select(data.oclIsKindOf(Relationship) and data.target->includes(_element)) </pre>

A.3 ProjectDataVersioningService Conformance Test Cases

Operation `create_branch`

PIM-PCB-001

Description	Create Branch - success

Input	<ol style="list-style-type: none"> 1. <code>_project</code> : <code>Project[1]</code> 2. <code>_head</code> : <code>Commit[1]</code> 3. <code>_name</code> : <code>String[1]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. The inputted Commit (<code>_head</code>) exists 3. The inputted Commit (<code>_head</code>) belongs to the inputted Project
Precondition (OCL)	<pre> Project.allInstances()->includes(_project) Commit.allInstance()->includes(_head) _head.owningProject = _project let _record : Record = Record.allInstances() </pre>
Steps	<p>Execute operation <code>create_branch(project = _project, head = _head, name = _name)</code> : <code>Branch[1]</code></p>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>branch</code> : <code>Branch[1]</code>, is a created Branch in the inputted Project 2. The <code>id</code> attribute value of the created Branch is randomly generated and universally unique, including (but not limited to) not being used as the <code>id</code> attribute value for any previously existing Record. 3. The <code>owningProject</code> attribute value of the created Branch is specified as inputted, i.e. equal to <code>_project</code> 4. The <code>head</code> attribute value of the created Branch is specified as inputted 5. The <code>name</code> attribute value of the created Branch is specified as inputted
Postcondition (OCL)	<pre> let branch : Branch = create_branch(_project, _head, _name) branch->size() = 1 Branch.allInstances()->includes(branch) _project.branch->includes(branch) _record.id->excludes(branch.id) branch.owningProject = _project branch.head = _head branch.name = _name </pre>

Operation `get_branches`

PIM-PCB-002

Description	Get Branches - success
Input	<ol style="list-style-type: none"> 1. <code>_project</code> : <code>Project[1]</code>
Scenario	The inputted Project exists

Precondition (OCL)	<code>Project.allInstances()->includes(_project)</code>
Steps	Execute operation <code>get_branches(project = _project) : Branch[0..*]</code>
Result	Result, defined as <code>branch : Branch[0..*]</code> , is all Branches in the inputted Project
Postcondition (OCL)	<code>let branch : Branch = get_branches(_project)</code> <code>branch = _project.branch</code>

Operation `get_branch_by_id`

PIM-PCB-003

Description	Get Branch by ID - success
Input	<ol style="list-style-type: none"> 1. <code>_project : Project[1]</code> 2. <code>_branchId : UUID[1]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. A Branch with an <code>id</code> attribute value equal to <code>_branchId</code> exists in the inputted Project
Precondition (OCL)	<code>Project.allInstances()->includes(_project)</code> <code>let _branch : Branch = _project.branch->select(id = _branchId)</code> <code>_branch.size() = 1</code>
Steps	Execute operation <code>get_branch_by_id(project = _project, branchId = _branchId) : Branch[0..1]</code>
Result	Result, defined as <code>branch : Branch[1]</code> , is the Branch with an <code>id</code> attribute value equal to <code>_branchId</code> in the inputted Project
Postcondition (OCL)	<code>let branch : Branch = get_branch_by_id(_project, _branchId)</code> <code>branch = _branch</code>

PIM-PCB-004

Description	Get Branch by ID - does not exist in Project

Input	<ol style="list-style-type: none"> 1. <code>_project : Project[1]</code> 2. <code>_branchId : UUID[1]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. A Branch with an <code>id</code> attribute value equal to <code>_branchId</code> does not exist in the inputted Project
Precondition (OCL)	<pre>Project.allInstances()->includes(_project) _project.branch->select(id = _branchId)->isEmpty()</pre>
Steps	Execute operation <code>get_branch_by_id(project = _project, branchId = _branchId) : Branch[0..1]</code>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>branch : Branch[0]</code>, does not include any Branches 2. Result communicates that a Branch with the provided ID in the inputted Project does not exist
Postcondition (OCL)	<pre>let branch : Branch = get_branch_by_id(_project, _branchId) branch->isEmpty()</pre>

Operation delete_branch

PIM-PCB-005

Description	Delete Branch - success
Input	<ol style="list-style-type: none"> 1. <code>_project : Project[1]</code> 2. <code>_branchId : UUID[1]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. A Branch with an <code>id</code> attribute value equal to <code>_branchId</code> exists in the inputted Project
Precondition (OCL)	<pre>Project.allInstances()->includes(_project) let _branch : Branch = _project.branch->select(id = _branchId) _branch.size() = 1</pre>
Steps	Execute operation <code>delete_branch(project = _project, branchId = _branchId) : Branch[0..1]</code>

Result	<ol style="list-style-type: none"> 1. Result, defined as <code>branch : Branch[1]</code>, is the Branch with an <code>id</code> attribute value equal to <code>_branchId</code> in the inputted Project 2. Branch with an <code>id</code> attribute value equal to <code>_branchId</code> does not exist
Postcondition (OCL)	<pre> let branch : Branch = delete_branch(_project, _branchId) _project.branch->excludes(branch) Branch.allInstances()->excludes(branch) _project.branch->select(id = _branchId)->isEmpty() Branch.allInstances()->select(id = _branchId)->isEmpty() </pre>

PIM-PCB-006

Description	Delete Branch - does not exist in Project
Input	<ol style="list-style-type: none"> 1. <code>_project : Project[1]</code> 2. <code>_branchId : UUID[1]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. A Branch with an <code>id</code> attribute value equal to <code>_branchId</code> does not exist in the inputted Project
Precondition (OCL)	<pre> Project.allInstances()->includes(_project) _project.branch->select(id = _branchId)->isEmpty() </pre>
Steps	Execute operation <code>delete_branch(project = _project, branchId = _branchId) : Branch[0..1]</code>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>branch : Branch[0]</code>, does not include any Branches 2. Result communicates that a Branch with the provided ID in the inputted Project does not exist
Postcondition (OCL)	<pre> let branch : Branch = delete_branch(_project, _branchId) branch->isEmpty() </pre>

Operation get_default_branch

PIM-PCB-007

Description	Get default Branch - success

Input	1. <code>_project : Project[1]</code>
Scenario	The inputted Project exists
Precondition (OCL)	<code>Project.allInstances()->includes(_project)</code>
Steps	Execute operation <code>get_default_branch(project = _project) : Branch[1]</code>
Result	1. Result, defined as <code>branch : Branch[1]</code> , is the <code>defaultBranch</code> attribute value of the inputted Project
Postcondition (OCL)	<code>let branch = get_default_branch(_project)</code> <code>branch = _project.defaultBranch</code>

Operation `set_default_branch`

PIM-PCB-008

Description	Set default Branch - success
Input	1. <code>_project : Project[1]</code> 2. <code>_branchId : UUID[1]</code>
Scenario	1. The inputted Project exists 2. A Branch with an <code>id</code> attribute value equal to <code>_branchId</code> exists in the inputted Project
Precondition (OCL)	<code>Project.allInstances()->includes(_project)</code> <code>let _branch : Branch = _project.branch->select(id = _branchId)</code> <code>_branch.size() = 1</code>
Steps	Execute operation <code>set_default_branch(project = _project, branchId = _branchId) : Project[1]</code>
Result	1. Result, defined as <code>project : Project[1]</code> , is the inputted Project 2. The <code>defaultBranch</code> attribute value of the inputted Project is specified as the Branch with an <code>id</code> attribute value equal to <code>_branchId</code>
Postcondition (OCL)	<code>let project : Project = set_default_branch(_project, _branchId)</code> <code>project.defaultBranch = _branch</code>

PIM-PCB-009

Description	Set default Branch - does not exist in Project
Input	<ol style="list-style-type: none">1. <code>_project</code> : Project[1]2. <code>_branchId</code> : UUID[1]
Scenario	<ol style="list-style-type: none">1. The inputted Project exists2. A Branch with an <code>id</code> attribute value equal to <code>_branchId</code> does not exist in the inputted Project
Precondition (OCL)	<pre>Project.allInstances()->includes(_project) _project.branch->select(id = _branchId)->isEmpty() let _defaultBranch : Branch = _project.defaultBranch</pre>
Steps	Execute operation <code>set_default_branch(project = _project, branchId = _branchId)</code> : Project[1]
Result	<ol style="list-style-type: none">1. Result, defined as <code>project</code> : Project[1], is the inputted Project2. The <code>defaultBranch</code> attribute value of the inputted Project is unchanged3. Result communicates that a Branch with the provided ID in the inputted Project does not exist
Postcondition (OCL)	<pre>let project : Project = set_default_branch(_project, _branchId) project.defaultBranch = _defaultBranch</pre>

Operation `create_commit`

PIM-PCB-010

Description	Create Commit - success

Input	<ol style="list-style-type: none"> 1. <code>_project</code> : <code>Project[1]</code> 2. <code>_change</code> : <code>DataVersion[1..*]</code> 3. <code>_branch</code> : <code>Branch[0..1]</code> 4. <code>_previousCommit</code> : <code>Commit[0..*]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. The inputted Branch, optional and if provided, exists in the inputted Project 3. The inputted Commits (<code>_previousCommit</code>), optional and if provided, exists in the inputted Commit
Precondition (OCL)	<pre> Project.allInstances()->includes(_project) _branch->isEmpty() or _project.branch->includes(_branch) _previousCommit->isEmpty() or _previousCommit->forAll(owningProject = _project) let _record : Record = Record.allInstances() let _head : Commit = _branch.head </pre>
Steps	<p>Execute operation <code>create_commit(project = _project, change = _change, branch = _branch, previousCommit = _previousCommit)</code> : <code>Commit[1]</code></p>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>commit</code> : <code>Commit[1]</code>, is a created Commit 2. The <code>id</code> attribute value of the created Commit is randomly generated and universally unique, including (but not limited to) not being used as the <code>id</code> attribute value for any previously existing Record. 3. The <code>owningProject</code> attribute value of the created Commit is specified as inputted (<code>_project</code>) 4. The <code>change</code> attribute value of the created Commit is specified as inputted 5. The <code>previousCommit</code> attribute value of the created Commit is specified as the union of the head attribute value of the inputted Branch, if provided, and the inputted Commits (<code>_previousCommit</code>) 6. The <code>version</code> attribute value of the created Commit includes the new changes 7. The <code>head</code> attribute value of the inputted Branch, if provided, is updated to the created Commit
Postcondition (OCL)	<pre> let commit : Commit = create_commit(_project, _change, _branch, _previousCommit) commit->size() = 1 _record.id->excludes(commit.id) commit.owningProject = _project commit.change = _change commit.previousCommit = _head->union(_previousCommit) commit.version->includes(_change) _branch->isEmpty() or _branch.head = commit </pre>

Operation get_commit_by_id

PIM-PCB-011

Description	Get commit by ID - success
Input	<ol style="list-style-type: none">1. <code>_project</code> : Project[1]2. <code>_commitId</code> : UUID[1]
Scenario	<ol style="list-style-type: none">1. The inputted Project exists2. A Commit with an <code>id</code> attribute value equal to <code>_commitId</code> exists in the inputted Project
Precondition (OCL)	<pre>Project.allInstances()->includes(_project) let _commit : Commit = _project.commit->select(id = _commitId) _commit.size() = 1</pre>
Steps	Execute operation <code>get_commit_by_id(project = _project, commitId = _commitId)</code> : Commit[0..1]
Result	Result, defined as <code>commit</code> : Commit[1], is the Commit with an <code>id</code> attribute value equal to <code>_commitId</code> in the inputted Project
Postcondition (OCL)	<pre>let commit : Commit = get_commit_by_id(_project, _commitId) commit = _commit</pre>

PIM-PCB-012

Description	Get commit by ID - does not exist in Project
Input	<ol style="list-style-type: none">1. <code>_project</code> : Project[1]2. <code>_commitId</code> : UUID[1]
Scenario	<ol style="list-style-type: none">1. The inputted Project exists2. A Commit with an <code>id</code> attribute value equal to <code>_commitId</code> does not exist in the inputted Project
Precondition (OCL)	<pre>Project.allInstances()->includes(_project) _project.commit->select(id = _commitId)->isEmpty()</pre>
Steps	Execute operation <code>get_commit_by_id(project = _project, commitId = _commitId)</code> : Commit[0..1]
Result	Result, defined as <code>commit</code> : Commit[0], does not include any Commits

Postcondition (OCL)	<pre>let commit : Commit = get_commit_by_id(_project, _commitId) commit->isEmpty()</pre>

Operation get_head

PIM-PCB-013

Description	Get head Commit of Branch - success
Input	<ol style="list-style-type: none"> 1. _project : Project[1] 2. _branch : Branch[1]
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. The inputted Branch exists 3. The inputted Branch belongs to the inputted Project
Precondition (OCL)	<pre>Project.allInstances()->includes(_project) Branch.allInstance()->includes(_branch) _branch.owningProject = _project</pre>
Steps	Execute operation get_head(project = _project, branch = _branch) : Commit[0..1]
Result	Result, defined as head : Commit[0..1], is the Commit that is the head attribute value of the inputted Branch
Postcondition (OCL)	<pre>let head : Commit = get_head(_project, _branch) Bag{0, 1}->includes(head->size()) head = _project.head</pre>

PIM-PCB-014

Description	Get head Commit of Branch - Branch does not exist

Input	<ol style="list-style-type: none"> 1. <code>_project : Project[1]</code> 2. <code>_branch : Branch[1]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. The inputted Branch does not exist
Precondition (OCL)	<code>Project.allInstances()->includes(_project)</code> <code>Branch.allInstance()->excludes(_branch)</code>
Steps	Execute operation <code>get_head(project = _project, branch = _branch) : Commit[0..1]</code>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>head : Commit[0]</code>, does not include any Commits 2. Result communicates that the inputted Branch does not exist
Postcondition (OCL)	<code>let head : Commit = get_head(_project, _branch)</code> <code>head->isEmpty()</code>

PIM-PCB-015

Description	Get head Commit of Branch - Branch not in Project
Input	<ol style="list-style-type: none"> 1. <code>_project : Project[1]</code> 2. <code>_branch : Branch[1]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. The inputted Branch exists 3. The inputted Branch does not belong to the inputted Project
Precondition (OCL)	<code>Project.allInstances()->includes(_project)</code> <code>Branch.allInstance()->includes(_branch)</code> <code>_branch.owningProject <> _project</code>
Steps	Execute operation <code>get_head(project = _project, branch = _branch) : Commit[0..1]</code>

Result	<ol style="list-style-type: none"> 1. Result, defined as <code>head : Commit[0]</code>, does not include any Commits 2. Result communicates that the provided input is invalid
Postcondition (OCL)	<pre>let head : Commit = get_head(_project, _branch) head->isEmpty()</pre>

A.4 QueryService Conformance Test Cases

Operation `create_query`

PIM-QS-001

Description	Create Query - success
Input	<ol style="list-style-type: none"> 1. <code>_project : Project[1]</code> 2. <code>_select : String[0..*]</code> 3. <code>_scope : DataIdentity[0..*]</code> 4. <code>_where : Constraint[0..1]</code> 5. <code>_orderBy : String[0..*]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists
Precondition (OCL)	<pre>Project.allInstances()->includes(_project) let _record : Record = Record.allInstances()</pre>
Steps	Execute operation <code>create_query(project = _project, select = _select, scope = _scope, where = _where, orderBy = _orderBy) : Query[1]</code>

Result	<ol style="list-style-type: none"> 1. Result, defined as <code>query : Query[1]</code>, is a created Query in the inputted Project 2. The <code>id</code> attribute value of the created Query is randomly generated and universally unique, including (but not limited to) not being used as the <code>id</code> attribute value for any previously existing Record. 3. The <code>owningProject</code> attribute value of the created Query is specified as inputted, i.e. equal to <code>_project</code> 4. The <code>select</code> attribute value of the created Query is specified as inputted 5. The <code>scope</code> attribute value of the created Query is specified as inputted 6. The <code>where</code> attribute value of the created Query is specified as inputted 7. The <code>orderBy</code> attribute value of the created Query is specified as inputted
Postcondition (OCL)	<pre> let query : Query = create_query(_project, _select, _scope, _where, _orderBy) query->size() = 1 Query.allInstances()->includes(query) _project.query->includes(query) _record.id->excludes(query.id) query.owningProject = _project query.select = _select query.scope = _scope query.where = _where query.orderBy = orderBy </pre>

PIM-QS-002

Description	Execute Query - success
Input	<ol style="list-style-type: none"> 1. <code>_query : Query[1]</code> 2. <code>_commit : Commit[1]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Query exists 2. The inputted Commit exists 3. The inputted Query and Commit both belong to the same Project
Precondition (OCL)	<pre> Query.allInstances()->includes(_query) Commit.allInstances()->includes(_commit) _query.owningProject = _commit.owningProject </pre>
Steps	<p>Execute operation <code>execute_query(query = _query, commit = _commit) :</code> <code>Data[0..*]</code></p>

Result	<ol style="list-style-type: none"> 1. Result, defined as <code>data : Data[0..*]</code>, is all of the Datas at the inputted Commit that satisfy the conditions of the inputted Query 2. If inputted Query has a non-empty <code>scope</code> attribute value, result only includes Data within the Query's scope
Postcondition (OCL)	<pre>let data : Data = execute_query(_query, _commit) _commit.versionedData->includesAll(data) _query.scope->isEmpty() or _query.scope->includesAll(data)</pre>

A.5 ExternalRelationshipService Conformance Test Cases

Operation `get_external_relationships`

PIM-ER-001

Description	Get ExternalRelationships - success
Input	<ol style="list-style-type: none"> 1. <code>_project : Project[1]</code> 2. <code>_commit : Commit[1]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. The inputted Commit exists 3. The inputted Commit belongs to the inputted Project
Precondition (OCL)	<pre>Project.allInstances()->includes(_project) Commit.allInstance()->includes(_commit) _commit.owningProject = _project</pre>
Steps	Execute operation <code>get_external_relationships(project = _project, commit = _commit) : ExternalRelationship[0..*]</code>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>externalRelationship : ExternalRelationship[0..*]</code>, is all of the existing ExternalRelationships at the inputted Commit
Postcondition (OCL)	<pre>let externalRelationship : ExternalRelationship = get_external_relationships(_project, _commit) externalRelationship = _commit.version.data->select(oclIsKindOf(ExternalRelationship))</pre>

Operation get_external_relationship_by_id

PIM-ER-002

Description	Get ExternalRelationships by ID - success
Input	<ol style="list-style-type: none"> 1. <code>_project</code> : Project[1] 2. <code>_commit</code> : Commit[1] 3. <code>_externalRelationshipId</code> : UUID[1]
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. The inputted Commit exists 3. The inputted Commit belongs to the inputted Project 4. An ExternalRelationship with an id attribute value equal to <code>_externalRelationshipId</code> exists at the inputted Commit
Precondition (OCL)	<pre> Project.allInstances()->includes(_project) Commit.allInstance()->includes(_commit) _commit.owningProject = _project let _externalRelationship : ExternalRelationship = _commit.version->select(identity.id = _externalRelationshipId and data.oclIsTypeOf(ExternalRelationship)).data _externalRelationship.size() = 1 </pre>
Steps	<p>Execute operation <code>get_external_relationship_by_id(project = _project, commit = _commit, externalRelationshipId = _externalRelationshipId)</code> :</p> <p>ExternalRelationship[0..1]</p>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>externalRelationship</code> : ExternalRelationship[1], is the Element with an id attribute value equal to <code>_externalRelationshipId</code> at the inputted Commit
Postcondition (OCL)	<pre> let externalRelationship : ExternalRelationship = get_external_relationship_by_id(_project, _commit, _externalRelationshipId) externalRelationship = _externalRelationship </pre>

PIM-ER-003

Description	Get ExternalRelationships by ID - does not exist at Commit

Input	<ol style="list-style-type: none"> 1. <code>_project</code> : <code>Project[1]</code> 2. <code>_commit</code> : <code>Commit[1]</code> 3. <code>_externalRelationshipId</code> : <code>UUID[1]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. The inputted Commit exists 3. The inputted Commit belongs to the inputted Project 4. An <code>ExternalRelationship</code> with an <code>id</code> attribute value equal to <code>_externalRelationshipId</code> does not exist at the inputted Commit
Precondition (OCL)	<pre>Project.allInstances()->includes(_project) Commit.allInstance()->includes(_commit) _commit.owningProject = _project _commit.version->select(identity.id = _externalRelationshipId and data.oclIsTypeOf(ExternalRelationship)).data->isEmpty()</pre>
Steps	<p>Execute operation <code>get_external_relationship_by_id(project = _project, commit = _commit, externalRelationshipId = _externalRelationshipId)</code> :</p> <p><code>ExternalRelationship[0..1]</code></p>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>externalRelationship</code> : <code>ExternalRelationship[0]</code>, does not include any <code>ExternalRelationships</code> 2. Result communicates that an <code>ExternalRelationship</code> with the provided ID at the inputted Commit does not exist
Postcondition (OCL)	<pre>let externalRelationship : ExternalRelationship = get_external_relationship_by_id(_project, _commit, _externalRelationshipId) externalRelationship->isEmpty()</pre>

A.6 ProjectUsageService Conformance Test Cases

Operation `get_project_usages`

PIM-PU-001

Description	Get ProjectUsages - success

Input	<ol style="list-style-type: none"> 1. <code>_project : Project[1]</code> 2. <code>_commit : Commit[1]</code>
Scenario	<ol style="list-style-type: none"> 1. The inputted Project exists 2. The inputted Commit exists 3. The inputted Commit belongs to the inputted Project
Precondition (OCL)	<pre>Project.allInstances()->includes(_project) Commit.allInstance()->includes(_commit) _commit.owningProject = _project</pre>
Steps	Execute operation <code>get_project_usages(project = _project, commit = _commit) : ProjectUsage[0..*]</code>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>projectUsage : ProjectUsage[0..*]</code>, is all of the existing ProjectUsages at the inputted Commit
Postcondition (OCL)	<pre>let projectUsage : ProjectUsage = get_project_usages(_project, _commit) projectUsage = _commit.version.data->select(oclIsKindOf(ProjectUsage))</pre>

A.7 Cross-Cutting Conformance Test Cases

Operations with Invalid Input

PIM-CC-001

Description	Execute operation - missing Project input
Input	<ol style="list-style-type: none"> 1. <code>_project : Project[0]</code>
Scenario	
Precondition (OCL)	

Steps	<p>Execute any of the following operations, defined as <code>x(project : Project[1], ...)</code>:</p> <ul style="list-style-type: none"> • <code>get_elements(project = _project, ...)</code> • <code>get_element_by_id(project = _project, ...)</code> • <code>get_relationships_by_source(project = _project, ...)</code> • <code>get_relationships_by_target(project = _project, ...)</code> • <code>create_branch(project = _project, ...)</code> • <code>get_branches(project = _project)</code> • <code>get_branch_by_id(project = _project, ...)</code> • <code>delete_branch(project = _project, ...)</code> • <code>get_default_branch(project = _project)</code> • <code>set_default_branch(project = _project, ...)</code> • <code>create_commit(project = _project, ...)</code> • <code>get_commit_by_id(project = _project, ...)</code> • <code>get_head(project = _project, ...)</code> • <code>create_query(project = _project, ...)</code>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>result : OclAny[0]</code>, does not include any <code>OclAny</code> 2. Result communicates that <code>project</code> is a required input
Postcondition (OCL)	<pre>let result : OclAny = x(_project, ...) result->isEmpty()</pre>

PIM-CC-002

Description	Execute operation - missing Commit input
Input	<ol style="list-style-type: none"> 1. <code>_commit : Commit[0]</code>
Scenario	
Precondition (OCL)	
Steps	<p>Execute any of the following operations, defined as <code>x(commit : Commit[1], ...)</code>:</p> <ul style="list-style-type: none"> • <code>get_elements(..., commit = _commit)</code> • <code>get_element_by_id(..., commit = _commit, ...)</code> • <code>get_relationships_by_source(..., commit = _commit, ...)</code> • <code>get_relationships_by_target(..., commit = _commit, ...)</code> • <code>create_branch(..., head = _commit, ...)</code>

Result	<ol style="list-style-type: none"> 1. Result, defined as <code>result : OclAny[0]</code>, does not include any <code>OclAny</code> 2. Result communicates that <code>commit</code> is a required input
Postcondition (OCL)	<pre>let result : OclAny = x(_commit, ...) result->isEmpty()</pre>

PIM-CC-003

Description	Execute operation - Project input does not exist
Input	<ol style="list-style-type: none"> 1. <code>_project : Project[1]</code>
Scenario	The inputted Project does not exist
Precondition (OCL)	<code>Project.allInstances()->excludes(_project)</code>
Steps	<p>Execute any of the following operations, defined as <code>x(project : Project[1], ...)</code>:</p> <ul style="list-style-type: none"> • <code>get_elements(project = _project, ...)</code> • <code>get_element_by_id(project = _project, ...)</code> • <code>get_relationships_by_source(project = _project, ...)</code> • <code>get_relationships_by_target(project = _project, ...)</code> • <code>create_branch(project = _project, ...)</code> • <code>get_branches(project = _project)</code> • <code>get_branch_by_id(project = _project, ...)</code> • <code>delete_branch(project = _project, ...)</code> • <code>get_default_branch(project = _project)</code> • <code>set_default_branch(project = _project, ...)</code> • <code>create_commit(project = _project, ...)</code> • <code>get_commit_by_id(project = _project, ...)</code> • <code>get_head(project = _project, ...)</code> • <code>create_query(project = _project, ...)</code>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>result : OclAny[0]</code>, does not include any <code>OclAny</code> 2. Result communicates that the inputted Project does not exist
Postcondition (OCL)	<pre>let result : OclAny = x(_project, ...) result->isEmpty()</pre>

PIM-CC-004

Description	Execute operation - Commit input does not exist
Input	1. <code>_commit : Commit[1]</code>
Scenario	The inputted Commit does not exist
Precondition (OCL)	<code>Commit.allInstances()->excludes(_commit)</code>
Steps	Execute any of the following operations, defined as <code>x(commit : Commit[1], ...)</code> : <ul style="list-style-type: none">• <code>get_elements(..., commit = _commit)</code>• <code>get_element_by_id(..., commit = _commit, ...)</code>• <code>get_relationships_by_source(..., commit = _commit, ...)</code>• <code>get_relationships_by_target(..., commit = _commit, ...)</code>• <code>create_branch(..., head = _commit, ...)</code>
Result	1. Result, defined as <code>result : OclAny[0]</code> , does not include any <code>OclAny</code> 2. Result communicates that the inputted Commit does not exist
Postcondition (OCL)	<code>let result : OclAny = x(_commit, ...)</code> <code>result->isEmpty()</code>

PIM-CC-005

Description	Execute operation - Commit input is not owned by Project input
Input	1. <code>_project : Project[1]</code> 2. <code>_commit : Commit[1]</code>
Scenario	1. The inputted Project exists 2. The inputted Commit does not exist 3. The inputted Commit does not belong to the inputted Project
Precondition (OCL)	<code>Project.allInstances()->includes(_project)</code> <code>Commit.allInstances()->includes(_commit)</code> <code>_commit.owningProject <> _project</code>

Steps	<p>Execute any of the following operations, defined as <code>x(project : Project[1], commit : Commit[1], ...)</code>:</p> <ul style="list-style-type: none"> • <code>get_elements(project = _project, commit = _commit)</code> • <code>get_element_by_id(project = _project, commit = _commit, ...)</code> • <code>get_relationships_by_source(project = _project, commit = _commit, ...)</code> • <code>get_relationships_by_target(project = _project, commit = _commit, ...)</code> • <code>create_branch(project = _project, head = _commit, ...)</code>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>result : OclAny[0]</code>, does not include any <code>OclAny</code> 2. Result communicates that the provided input is invalid
Postcondition (OCL)	<pre>let result : OclAny = x(_project, _commit, ...) result->isEmpty()</pre>

PIM-CC-006

Description	Execute operation - missing name input
Input	<ol style="list-style-type: none"> 1. <code>_name : String[0]</code>
Scenario	
Precondition (OCL)	
Steps	<p>Execute any of the following operations, defined as <code>x(name : String[1], ...) : OclAny</code>:</p> <ul style="list-style-type: none"> • <code>create_project(name = _name, ...)</code> • <code>create_branch(..., name = _name, ...)</code>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>result : OclAny[0]</code>, does not include any <code>OclAny</code> 2. Result communicates that <code>name</code> is a required input
Postcondition (OCL)	<pre>let result : OclAny = x(_name, ...) result->isEmpty()</pre>

PIM-CC-007

Description	Execute operation - missing UUID input

Input	1. <code>_id : UUID[0]</code>
Scenario	
Precondition (OCL)	
Steps	<p>Execute any of the following operations, defined as <code>x(id : UUID[1], ...) : OclAny</code>:</p> <ul style="list-style-type: none"> • <code>get_project_by_id(projectId = _id)</code> • <code>get_element_by_id(..., elementId = _id)</code> • <code>get_relationships_by_source(..., elementId = _id)</code> • <code>get_relationships_by_target(..., elementId = _id)</code> • <code>get_branch_by_id(..., branchId = _id)</code> • <code>delete_branch(..., branchId = _id)</code> • <code>set_default_branch(..., branchId = _id)</code> • <code>get_commit_by_id(..., commitId = _id)</code>
Result	<ol style="list-style-type: none"> 1. Result, defined as <code>result : OclAny[0]</code>, does not include any <code>OclAny</code> 2. Result communicates that the input for which <code>_id</code> is used is a required input
Postcondition (OCL)	<pre>let result : OclAny = x(_id, ...) result->isEmpty()</pre>

B Annex: API and Services Examples and Cookbook

(Informative)

B.1 Examples

In this section, examples of REST/HTTP PSM (API) requests and responses are presented. The examples are organized per the tags in the OpenAPI specification that group individual endpoints, such as Project, Branch, Commit, and Element. The tags defined in the OpenAPI specification of the REST/HTTP PSM are generally organized by PIM Services. For each request, the curl notation and the resulting response with JSON data are presented.

The term *Protocol://FQDN* in the request URLs indicates the protocol (e.g. http/https) and the Fully Qualified Domain Name (FQDN) of the System Modeling API and Services Provider, e.g. <https://sysml2-test.omg.org>.

Project

GET /projects

Gets all the projects.

Request:

```
curl -X GET "Protocol://FQDN/projects" -H "accept: application/json"
```

Response:

```
[
  {
    "@id": "09257c67-2dce-4177-a95a-f2ede95b3ef3",
    "@type": "Project",
    "defaultBranch": {
      "@id": "71904fd1-2d86-4bb3-a626-ca94097f746c"
    },
    "description": null,
    "name": "1c-Parts Tree Redefinition Mon Oct 18 21:43:35 CDT 2021"
  },
  {
    "@id": "0d885964-c176-4006-9809-4c74621da0f0",
    "@type": "Project",
    "defaultBranch": {
      "@id": "0a021fc1-b70c-4256-9342-41ed383d3933"
    },
    "description": null,
    "name": "Hello SysML v2"
  },
  {
    "@id": "11507ece-f27b-4b01-bc7e-1fe8cb4b665c",
    "@type": "Project",
    "defaultBranch": {
      "@id": "3e01a5f9-95bc-40de-8332-3d0d2c111d55"
    },
    "description": null,
    "name": "8-Requirements Wed Oct 20 14:24:05 CDT 2021"
  }
]
```

GET /projects/{projectId}

Gets the project with id {projectId}.

Request:

```
curl -X GET "protocol://FQDN/projects/0d885964-c176-4006-9809-4c74621da0f0" -H
"accept: application/json"
```

Response:

```
{
  "@id": "0d885964-c176-4006-9809-4c74621da0f0",
  "@type": "Project",
  "defaultBranch": {
    "@id": "0a021fc1-b70c-4256-9342-41ed383d3933"
  },
  "description": null,
  "name": "Hello SysML v2"
}
```

POST /projects

Creates a new project using the project data specified in the body of the request.

Request:

```
curl -X POST "Protocol://FQDN/projects" -H "accept: application/json" -H "Content-
Type: application/json" -d "{ \"@type\": \"Project\", \"description\": \"Getting
started with SysML v2 REST/HTTP API\", \"name\": \"SysML v2 API Start\"}"
```

Response (body):

```
{
  "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288",
  "@type": "Project",
  "defaultBranch": {
    "@id": "e9e33b09-ad9b-45ea-a85b-107dc862c1ff"
  },
  "description": "Getting started with SysML v2 REST/HTTP API",
  "name": "SysML v2 API Start"
}
```

Branch

GET /projects/{projectId}/branches

Gets all the branches in the project with id {projectId}.

Request:

```
curl -X GET "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/branches"
-H "accept: application/json"
```

Response (body):

```
[
  {
    "@id": "e9e33b09-ad9b-45ea-a85b-107dc862c1ff",
```

```

    "@type": "Branch",
    "head": {
      "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
    },
    "name": "main",
    "owningProject": {
      "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
    },
    "referencedCommit": {
      "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
    },
    "timestamp": "2021-11-06T15:45:34.967737-04:00"
  },
  {
    "@id": "feefb263-f330-49da-b679-1d65602bf611",
    "@type": "Branch",
    "head": {
      "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
    },
    "name": null,
    "owningProject": {
      "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
    },
    "referencedCommit": {
      "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
    },
    "timestamp": "2021-11-06T15:55:57.332349-04:00"
  }
]

```

GET /projects/{projectId}/branches/{branchId}

Gets the branch with id {branchId} in the project with id {projectId}.

Request:

```
curl -X GET "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/branches/e9e33b09-ad9b-45ea-a85b-107dc862c1ff" -H "accept: application/json"
```

Response (body):

```

{
  "@id": "e9e33b09-ad9b-45ea-a85b-107dc862c1ff",
  "@type": "Branch",
  "head": {
    "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
  },
  "name": "main",
  "owningProject": {
    "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
  },
  "referencedCommit": {
    "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
  },
  "timestamp": "2021-11-06T15:45:34.967737-04:00"
}

```

POST /projects/{projectId}/branches

Creates a new branch in the project with id {projectId} using the branch data specified in the body of the request.

Request:

```
curl -X POST "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/branches"
-H "accept: application/json" -H "Content-Type: application/json" -d "{ \"@type\":
\"Branch\", \"head\": { \"@id\": \"068440fd-9294-4acf-bc61-00b9156c9dde\" },
\"name\": \"SysML v2 API Explore Branch\", \"owningProject\": { \"@id\":
\"6b5e80d1-7291-4eef-880c-c462ca5a3288\" } }"
```

Response (body):

```
{
  "@id": "feefb263-f330-49da-b679-1d65602bf611",
  "@type": "Branch",
  "head": {
    "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
  },
  "name": null,
  "owningProject": {
    "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
  },
  "referencedCommit": {
    "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
  },
  "timestamp": "2021-11-06T15:55:57.332349-04:00"
}
```

Tag

GET /projects/{projectId}/tags

Gets all the tags in the project with id {projectId}.

Request:

```
curl -X GET "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/tags" -H
"accept: application/json"
```

Response:

```
[
  {
    "@id": "d4657183-c4c1-45e9-90ac-dc984fc7c488",
    "@type": "Tag",
    "name": "Release 1",
    "owningProject": {
      "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
    },
    "referencedCommit": {
      "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
    },
    "taggedCommit": {
      "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
    },
    "timestamp": "2021-11-06T16:18:42.992149-04:00"
  }
]
```

POST /projects/{projectId}/tags

Creates a new tag in the project with id {projectId} using the tag data specified in the body of the request.

Request:

```
curl -X POST "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/tags" -H
"accept: application/json" -H "Content-Type: application/json" -d "{ \"name\":
\\\"Release 1\\\", \\\"taggedCommit\\\": { \\\"@id\\\": \\\"068440fd-9294-4acf-
bc61-00b9156c9dde\\\" } }"
```

Response (body):

```
{
  "@id": "d4657183-c4c1-45e9-90ac-dc984fc7c488",
  "@type": "Tag",
  "name": "Release 1",
  "owningProject": {
    "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
  },
  "referencedCommit": {
    "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
  },
  "taggedCommit": {
    "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
  },
  "timestamp": "2021-11-06T16:18:42.992149-04:00"
}
```

GET /projects/{projectId}/tags/{tagId}

Gets the tag with id {tagId} in the project with id {projectId}.

Request:

```
curl -X GET "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/tags/
d4657183-c4c1-45e9-90ac-dc984fc7c488" -H "accept: application/json"
```

Response (body):

```
{
  "@id": "d4657183-c4c1-45e9-90ac-dc984fc7c488",
  "@type": "Tag",
  "name": "Release 1",
  "owningProject": {
    "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
  },
  "referencedCommit": {
    "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
  },
  "taggedCommit": {
    "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
  },
  "timestamp": "2021-11-06T16:18:42.992149-04:00"
}
```

Commit**GET /projects/{projectId}/commits**

Gets all the commits in a project with id {projectId}.

Request:

```
curl -X GET "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/commits"
-H "accept: application/json"
```

Response:

```
[
  {
    "@id": "068440fd-9294-4acf-bc61-00b9156c9dde",
    "@type": "Commit",
    "owningProject": {
      "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
    },
    "previousCommit": null,
    "timestamp": "2021-11-06T15:54:11.867499-04:00"
  },
  {
    "@id": "cd4e9929-a51f-4f68-b87e-42b63083d9e6",
    "@type": "Commit",
    "owningProject": {
      "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
    },
    "previousCommit": {
      "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
    },
    "timestamp": "2021-11-06T16:39:46.579269-04:00"
  }
]
```

GET /projects/{projectId}/commits/{commitId}

Gets the commit with id {commitId} in the project with id {projectId}.

Request:

```
curl -X GET "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/commits/
cd4e9929-a51f-4f68-b87e-42b63083d9e6" -H "accept: application/json"
```

Response (body):

```
{
  "@id": "cd4e9929-a51f-4f68-b87e-42b63083d9e6",
  "@type": "Commit",
  "change": [
    {
      "@id": "635e54a6-f091-4925-b784-96c5243ca99d",
      "identity": {
        "@id": "7787bf4a-48fb-4176-a495-d23b38c2f3ec",
        "@type": "DataIdentity"
      },
      "payload": null
    }
  ],
  "owningProject": {
    "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
  },
  "previousCommit": {
    "@id": "068440fd-9294-4acf-bc61-00b9156c9dde"
  },
  "timestamp": "2021-11-06T16:39:46.579269-04:00"
}
```

POST /projects/{projectId}/commits

Creates a new commit in the given project with id {projectId} using the commit data specified in the body of the request. If the branch is not specified ({branchId} query parameter is absent), the default branch of the project will reference the new commit.

Request:

```
curl -X POST "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/commits"
-H "accept: application/json" -H "Content-Type: application/json" -d "{ \"@type\":
\\\"Commit\\\", \\\"change\\\": [ { \\\"@type\\\": \\\"DataVersion\\\", \\\"payload\\\":
{ \\\"@type\\\": \\\"PartDefinition\\\", \\\"name\\\": \\\"Vehicle_B\\\" },
\\\"identity\\\": { \\\"@type\\\": \\\"DataIdentity\\\" } } ],
\\\"containingProject\\\": { \\\"id\\\": \\\"6b5e80d1-7291-4eef-880c-c462ca5a3288\\\"
}, \\\"previousCommit\\\": { \\\"id\\\":
\\\"d3b258d4-c2e3-4385-b044-e32f535ae673\\\" } } }
```

Response:

```
{
  "@id": "42122503-70f1-42e9-ac6d-9b1ea2790138",
  "@type": "Commit",
  "owningProject": {
    "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
  },
  "previousCommit": {
    "@id": "d3b258d4-c2e3-4385-b044-e32f535ae673"
  },
  "timestamp": "2021-11-06T17:01:11.031488-04:00"
}
```

Element

GET /projects/{projectId}/commits/{commitId}/elements

Gets all the elements at the commit with id {commitId} in the project with id {projectId}.

Request:

```
curl -X GET "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/commits/
42122503-70f1-42e9-ac6d-9b1ea2790138/elements" -H "accept: application/json"
```

Response:

```
[
  {
    "@type": "PartDefinition",
    "@id": "4ace3d89-fd5d-4a03-a303-376eea6fbf29",
    "identifier": "4ace3d89-fd5d-4a03-a303-376eea6fbf29",
    "name": "Vehicle_B",
    ...
  },
  {
    "@type": "PartDefinition",
    "@id": "72f90039-064b-4e91-a21d-7c58813aa4c1",
    "identifier": "72f90039-064b-4e91-a21d-7c58813aa4c1",
    "name": "Vehicle_A",
    ...
  }
]
```

GET /projects/{projectId}/commits/{commitId}/elements/{elementId}

Gets the element with id {elementId} at the commit with id {commitId} in the project with id {projectId}.

Request:

```
curl -X GET "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/commits/42122503-70f1-42e9-ac6d-9b1ea2790138/elements/72f90039-064b-4e91-a21d-7c58813aa4c1"
-H "accept: application/json"
```

Response:

```
{
  "@type": "PartDefinition",
  "@id": "72f90039-064b-4e91-a21d-7c58813aa4c1",
  "name": "Vehicle_A",
  ...
}
```

Query

GET /projects/{projectId}/queries

Gets all the queries defined in the project with id {projectId}.

Request:

```
curl -X GET "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/queries"
-H "accept: application/json"
```

Response (body):

```
[
  {
    "@id": "1e368830-eee5-404a-be93-490a2b84d28f",
    "@type": "Query",
    "owningProject": {
      "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
    },
    "scope": [],
    "select": [
      "owner",
      "@type",
      "name",
      "@id"
    ],
    "where": {
      "@type": "PrimitiveConstraint",
      "inverse": false,
      "operator": "=",
      "property": "@type",
      "value": "PartDefinition"
    }
  },
  {
    "@id": "2cfc2123-90c3-48a9-a165-b50d21ab067d",
    "@type": "Query",
    "owningProject": {
      "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
    },
  },
]
```



```

"scope": [],
"select": [
  "owner",
  "@type",
  "name",
  "@id"
],
"where": {
  "@type": "PrimitiveConstraint",
  "inverse": false,
  "operator": "=",
  "property": "@type",
  "value": "PartDefinition"
}
},
{
  "@id": "930167d5-0d5e-4f2e-8544-8f66f200e56a",
  "@type": "Query",
  "owningProject": {
    "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
  },
  "scope": [],
  "select": [
    "owner",
    "@type",
    "name",
    "@id"
  ],
  "where": {
    "@type": "PrimitiveConstraint",
    "inverse": false,
    "operator": "=",
    "property": "name",
    "value": "Vehicle_A"
  }
},
{
  "@id": "ab894e8b-d6be-4af0-b029-b52058f20b93",
  "@type": "Query",
  "owningProject": {
    "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
  },
  "scope": [],
  "select": [
    "owner",
    "@type",
    "name",
    "@id"
  ],
  "where": {
    "@type": "PrimitiveConstraint",
    "inverse": false,
    "operator": "=",
    "property": "name",
    "value": "Vehicle_A"
  }
}
]

```

POST /projects/{projectId}/queries

Creates a new query in project with id {projectId} using the query data specified in the body of the request.

Request:

```
curl -X POST "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/queries"
-H "accept: application/json" -H "Content-Type: application/json" -d "{ \"@type\":
\"Query\", \"select\": [ \"name\", \"id\", \"@type\", \"owner\" ], \"where\":
{ \"@type\": \"PrimitiveConstraint\", \"inverse\": false, \"operator\":
\"=\", \"property\": \"@type\", \"value\": \"PartDefinition\" }}"
```

Response (body):

```
{
  "@id": "2cfc2123-90c3-48a9-a165-b50d21ab067d",
  "@type": "Query",
  "owningProject": {
    "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
  },
  "scope": [],
  "select": [
    "owner",
    "@type",
    "name",
    "id"
  ],
  "where": {
    "@type": "PrimitiveConstraint",
    "inverse": false,
    "operator": "=",
    "property": "@type",
    "value": "PartDefinition"
  }
}
```

GET /projects/{projectId}/queries/{queryId}

Gets the query with id {queryId} in project with id {projectId}.

Request:

```
curl -X GET "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/queries/
2cfc2123-90c3-48a9-a165-b50d21ab067d" -H "accept: application/json"
```

Response (body):

```
{
  "@id": "2cfc2123-90c3-48a9-a165-b50d21ab067d",
  "@type": "Query",
  "owningProject": {
    "@id": "6b5e80d1-7291-4eef-880c-c462ca5a3288"
  },
  "scope": [],
  "select": [
    "owner",
    "@type",
    "name",
    "id"
  ],
  "where": {
    "@type": "PrimitiveConstraint",
    "inverse": false,
    "operator": "=",
    "property": "@type",

```

```

    "value": "PartDefinition"
  }
}

```

GET /projects/{projectId}/queries/{queryId}/results

Executes the query with id {queryId} in project with id {projectId}. If the commit is not specified ({commitId} query parameter is absent), the query is executed at the head commit in the default branch of the project.

Request:

```

curl -X GET "Protocol://FQDN/projects/6b5e80d1-7291-4eef-880c-c462ca5a3288/queries/2cfc2123-90c3-48a9-a165-b50d21ab067d/results?commitId=42122503-70f1-42e9-ac6d-9b1ea2790138" -H "accept: application/json"

```

Response (body):

```

[
  {
    "@type": "PartDefinition",
    "@id": "4ace3d89-fd5d-4a03-a303-376eea6fbf29",
    "name": "Vehicle_B",
    "owner": null
  },
  {
    "@type": "PartDefinition",
    "@id": "72f90039-064b-4e91-a21d-7c58813aa4c1",
    "name": "Vehicle_A",
    "owner": null
  }
]

```

B.2 Cookbook

The Systems Modeling API Cookbook is a collection of recipes demonstrating patterns and examples for using the Systems Modeling API and Services. Each recipe is a Jupyter (IPython) notebook (see <https://jupyter.org>) with a series of API calls using the REST/HTTP PSM of the API.

The Systems Modeling API Cookbook is available as a zip file containing the Jupyter (IPython) notebooks with this specification.