PIMS: Knowledge based Image Information Mining providing new functionalities in the TerraSAR Ground Segment System

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ABSTRACT

The paper presents the architecture and new functionalities implemented for the TerraSAR-X ground segment system by the synergy of DIMS (DLR's Data and Information Management System) and KIM (Knowledge based Image Information Mining system). In the spirit of the KEO (Knowledge Centred EO) concept, this system aims at simplifying the access to, and therefore expanding the use of multi-mission EO data. This achievement comes from the use of emerging technologies for Image Information Mining (IIM), which enables also the selection of images via their content, and for simplified service publication, provision and chaining, as implemented in the ESA Service Support Environment (SSE). PIMS is interfaced with the Service Support Environment SSE on one end and with DIMS on the other. PIMS provides to SSE compliant Web Services to be easily accessed though its operational portal. These services externalize some of the functionalities provided by the PIMS system itself. In this way, PIMS is tailored to develop new services (modules) some of which could be "plugged" in the KEO architecture. Moreover, to be able to process data to get valuable information and services, PIMS will be fed by external data sources represented by either the DLR Ground Segment facility, as for instance TerraSAR-X or a third-party user machine for those end-users interested in using ingestion and processing services offered by the system. Therefore, the system provides a Machine Interface View, which will externalize the provision of services like data ingestion, data processing and catalogue access. Being a KEO component-based system, based on a SOA, the PIMS components are web services, in order to be orchestrated by the KEO workflow manager. Also PIMS takes into account the possibility to be manned by human operators; hence it provides a GUI to be used by end-users for a certain number of PIMS specific tasks.

Keywords: DIMS, Image Information Mining, KEO, KIM, SSE

INTRODUCTION

The purpose of this paper is to present the architecture and functionalities of PIMS, which provides interfaces both to ESA's Service Support Environment (SSE) [1] and to DLR's Data and Information Management System (DIMS). Using the KEO (Knowledge Centred EO) [2] concept, PIMS aims at simplifying the access to, and therefore expanding the use of, multi-mission EO data. This achievement comes from the use of emerging technologies for Image Information Mining (IIM), which enables also the selection of images via their content and for simplified service publication, provision and chaining, as implemented in the SSE.

This paper is organized in five sections: The first one presents the main goals of the system; the second one introduces the Service Oriented Architecture (SOA); the third one points out the GUIs available for the operation of the system; the fourth one explains the external interfaces to the SSE and the TerraSAR-X Ground Segment through DIMS and the last one is the conclusion.

GOALS

The PIMS system aims at providing a variety of new functionalities to support access and exploitation of EO data content:

- Extract relevant features from EO data through Image Information Mining (IIM) techniques, developed in the scope of Knowledge-based Information Mining (KIM) [3] and Knowledge Enabled Services (KES) [4], and by means of processing algorithms developed specifically for this system.
- Support end-users in finding EO products and services best suited to their needs.
- Accept EO data from Ground Segments through web service based interfaces.
- Provide SSE compliant Web Services to be accessed through the operational SSE portal.

ARCHITECTURE

PIMS, making use of the existing KEO architecture, has been designed as a Service Oriented Architecture (SOA) in order to provide a modularized structure easy to maintain, upgrade and expand. Fig. 1 shows the architectural decomposition of PIMS. It is based on the orchestration of Web Services, some of which will be accessed exclusively inside the systems environment and some will instead be exposed to the outer world by means of the SSE Portal.

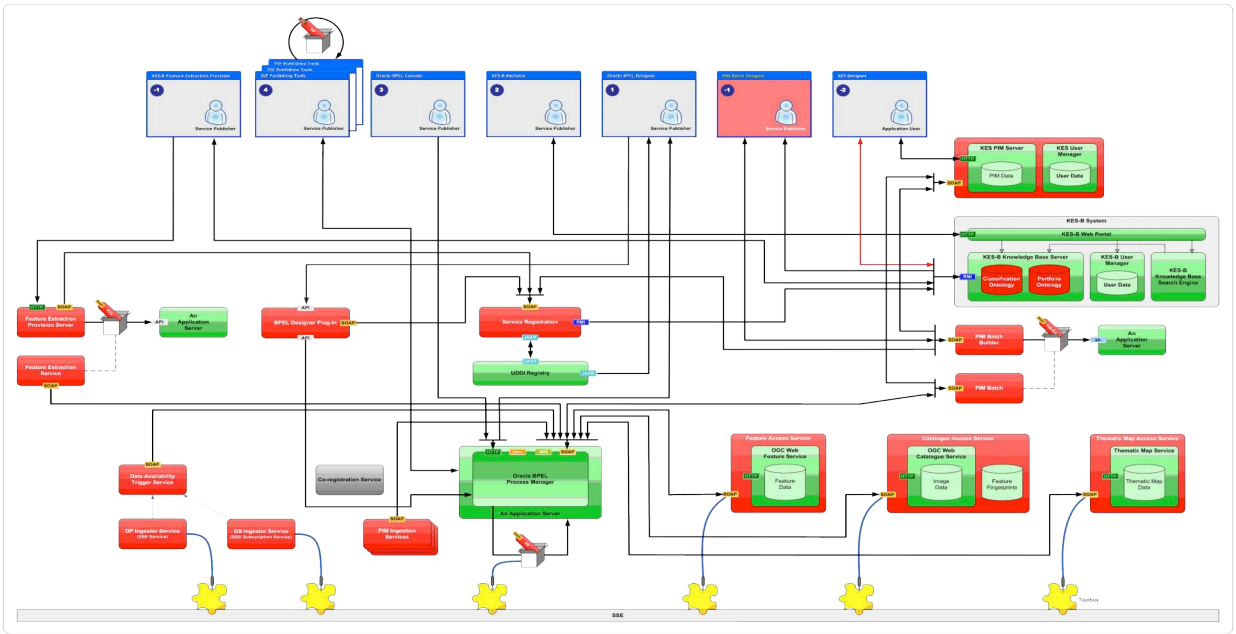

Figure 1: Architectural decomposition

Through a Web Service Interface, the system provides a number of catalogue access services to external systems (e.g. the SSE), some of which are mentioned in the following lines:

- Feature Access Service, which enables the access and retrieval of the extracted features.
- Thematic Map Access Service, which provides a combination of layers of extracted features in the form of classification maps.
- Image Catalogue Access Service, which provides browsing capabilities of the ingested product metadata.

At last we would also like to point out the Data Ingestion Service. This service is able to import data from the external world into the system by FTP exchange and process them through the activation of a certain number of Feature Extraction modules.

OPERATION

Two client applications are provided to access and manage the functionalities: KES and KAOS. KES mainly serves the purpose of feature definition and content based information retrieval catalogue browsing. However, KAOS adds more functionalities that are not only end-user, but also administrator oriented:

- Collection management, which also includes product ingestion capabilities
- User management
- System monitoring

EXTERNAL INTERFACES

The existing interface to the SSE has already been pointed out in this paper. There is another possibility of interfacing the system with EO Ground Segments. An interface to the TerraSAR-X Ground Segment has already been developed. It is based on Web Services and enables EO products to be ingested in PIMS from DLR's DIMS. DIMS is a multi-mission facility for the production, archiving, ordering and delivery of EO products, which is also used by the TerraSAR-X Ground Segment.

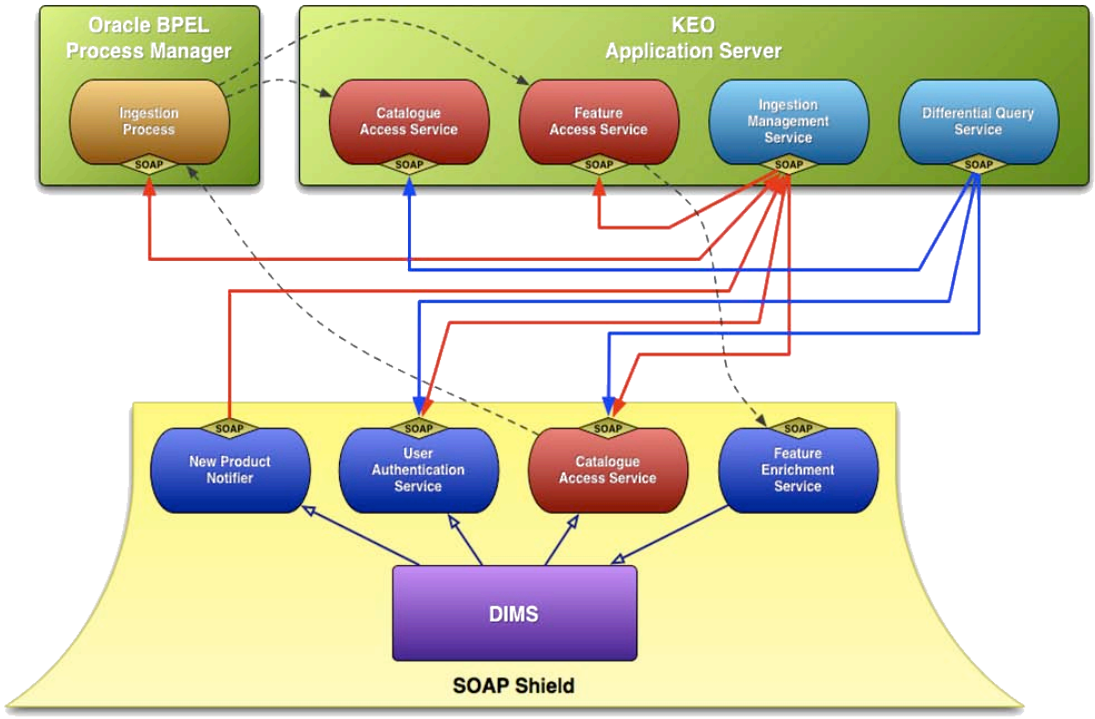

Figure 2: Interface to DIMS

Fig. 2 shows the existing interface to DIMS. Three web services (i.e. the *New Product Notifier*, the *User Authentication Service* and the DIMS *Catalogue Access Services*) adapt DIMS to (and shield it from) the outer world, allowing authenticated users to gather access to DIMS products, to add more information to them and to be notified when a new product (i.e. from TerraSAR-X) is available. To be able to interact with these web services, PIMS needs two web services: the first one (*Ingestion Management Service*) acts as an "ingestion director", adapting the BPEL ingestion process (a web service itself) to the PIMS needs and processes; the second one (*Differential Query Service*) provides the capability of discovering if a particular (DIMS) product was already ingested in PIMS or not, eventually starting automatically the ingestion if necessary.

CONCLUSION

PIMS provides a new generation of functionalities for the operation of the TerraSAR-X Ground Segment:

- Product upload:
  - Ingestion of DIMS products into PIMS.
  - Ingestion of PIMS products into DIMS.
- Ingestion management:
  - Creation of collections and connection to rolling archives.
  - Manual addition of new products to existing collections by selection of the ingestion source: an existing rolling archive, a remote FTP server or a local files(s).
- Differential query system:
  - Step 1: The DIMS and PIMS catalogues are queried in parallel in order to obtain from both the list of products matching the query parameters.
  - Step 2: Common results will be removed from both lists so that the list obtained from the DIMS catalogue will contain products not yet ingested in PIMS and the list from the PIMS catalogue will contain products no more present in DIMS.
  - Step 3: Ingestion of DIMS products and/or deletion of products that are no more in DIMS.
- Image browsing for DIMS product orders:
  - Image browsing of the PIMS image catalogue.
  - Ordering of the original DIMS product through redirection to the EOWEB page.
- Interactive probabilistic information mining:
  - Interactive detection of features.
  - Feature label definition, storage and retrieval.
  - Exploration of image collections for specific features.
  - Thematic map creations.

Moreover, new perspectives are opened for:

- Real time capturing of the TerraSAR-X data.
- Validation and evaluation of the interface to the TerraSAR-X GS.
- Extension and adaptation to spatial interferometric data (TanDEM-X).
- Extension and adaptation to hyper spectral data (EnMAP).
- Extension and adaptation to the multi-mission and multi-temporal data in the GMES frame.
- Extension and adaptation to other mission data.

- Provision of a new generation of EO services.

REFERENCES

[1] - SSE Portal, http://services.eoportal.org/

[2] - KEO Project page, http://earth.esa.int/rtd/Projects/KEO/index.html

[3] - KIM Project page, http://earth.esa.int/rtd/Projects/KIM/index.html

[4] - KES Project page, http://earth.esa.int/rtd/Projects/KES/index.html