

SATELLITE REMOTE OBSERVATION DATA DISSEMINATION FOR MOBILE DEVICES USING ESA HMA STANDARDS

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Abstract

Currently, there is number of observation satellites that provide continuous observation of the Earth's planet. The variety of observing systems leads to significant difficulties in big data processing and browsing through observational datasets retrieved from various types of sensors. In this context, the main objective of the Heterogeneous Missions Accessibility (HMA) initiative is to establish harmonised access to the ESA mission data, Ground Segment services from the GMES Contributing Missions (GCM) and related interfaces. The objective of the study presented in the paper is the implementation of HMA standards focused on developing and validating an open source operational platform that allows for an access to a set of Heterogeneous Missions data and services in native thin clients. The article describes a SmartHMA software as a mobile platform for deployment of HMA standardized data and services into different types of system environments, which allows for discovery and distribution of data and services in the form acceptable by mobile devices and based on OGC and HMA specifications.

Key words: *Android; HMA; ESA; GMES; remote observation; satellite; derived; bathymetry*

Introduction

Global Earth Observation (EO) satellite systems provide valuable measurements related to our globe's environment. Providing high quality information requires several satellite missions to be placed in orbit space (DRYPCZEWSKI et al., 2015)(MOSZYŃSKI et al. 2015). For instance, new European Space Agency (ESA) Sentinel-1 mission provides high-resolution land and ocean radar images, Sentinel-2 allows for global monitoring of sea and land processes (Bezy, 2014) and Sentinel-3 is dedicated for observing meteorological and global climatic changes. In the above mentioned context, the overall aim of Copernicus (former name: Global Monitoring for Environment and Security - GMES) programme is to provide easy to use, applicable and high quality data from spaceborn observing sensors for various applications (CINQUINI et al., 2014), (GRANELL et al., 2014), (EVANGELIDIS et al. 2014).

In order to achieve this goal, it is essential to establish harmonized access to heterogeneous EO missions' data from multiple mission Ground Segments' (GS), including national missions and ESA Sentinel missions. In this context, the main objective of the ESA Heterogeneous Missions Accessibility (HMA) initiative is to establish harmonised access to the ESA mission data, Ground Segment services from the GMES Contributing Missions (GCM) and related interfaces. Currently, HMA delivers set of standards and proposes technological solutions in four areas related to dissemination of observational products, namely:

- catalogue services, that allow for discovering and retrieving metadata on collections and products available across the HMA collaborating catalogues,

- ordering service, to order products identified in a catalogue,
- programming service, to place request for new acquisitions into the HMA partner missions' ground segments,
- Online Data Access Services, to retrieve products from the online access archives offered through the HMA.

In this context, the main purpose of the study described in the paper is to present SmartHMA - developed and validated open source operational platform which implements a set of HMA standards in the form of native client Android application. The proposed solution allows for access to GS data and services from the Copernicus/GMES Contributing Missions (GCM) and the ESA missions distributed by different existing and planned services through FedEO interfaces. The main functionality of the SmartHMA application is to provide an access via FedEO interfaces to the existing EO data and those that will be available in the near future, that will be acceptable by mobile devices (mainly tablets). Also, the method for extending the basic functionality of the proposed solution, that relies on adding external source of high-level processed observational data, is also presented in the paper.

HMA SERVICES

HMA is the initiative that follows general principles of the international standards for architecting open, distributed processing systems that provide an overall conceptual framework for building distributed systems in an incremental manner (USLÄNDER et al., 2012). Following the concepts of geospatial Software Oriented Architectures (SOAs), EO ground segments are implemented as geospatial service networks specified by the constraints and rules of service platforms related to particular missions (Fig. 1). A geospatial service network hereby comprises the set of networked hardware components and geospatial service instances that interact in order to serve the objectives of various mission applications.

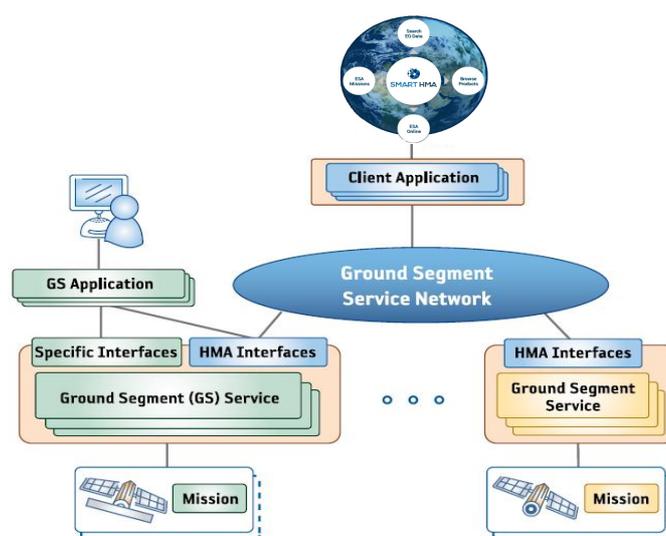


Fig. 1. SmartHMA in relation to ground segment system-of-systems approach. Source: ESA.

As a result of HMA concepts, EO applications are designed in such a way that their generic parts are developed as compatible increments to existing service capabilities. The design of an EO application should support the use cases and, on the other hand, make maximum use of those capabilities of HMA-compliant ground segment service networks that the user is allowed and enabled to access. This is achieved by HMA Service Viewpoint, which provides the functional requirements that were identified for an HMA-compliant system environment realised in terms of services.

Typical HMA-compliant system environment constitutes mainly from web-services technology. Fig. 2 depicts the conceptual level of the services and an overview of the major categories of functional requirements and their mapping to categories of HMA services. Furthermore, each service description illustrates which of the information models presented in the HMA Information Viewpoint are used.

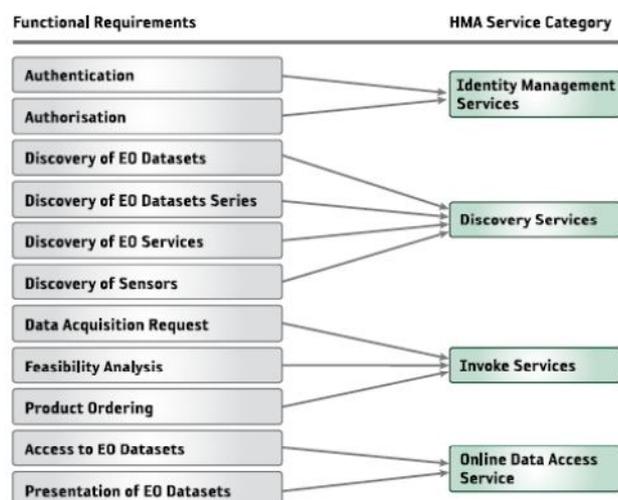


Fig. 2. Mapping of functional requirements to HMA service categories.

Though HMA is only the set of recommendations related to the technical aspects, the developed SmartHMA application is based on real outcomes coming from HMA, namely the Federated Earth Observation Missions (FedEO) initiative that was initially an OGC pilot activity aimed to refine OGC specifications relevant to Earth Observation (Coene, 2015). Currently SmartHMA supports following function of FedEO:

- OpenSearch interfaces for discovery of products (the outcome of HMA-S project)
- Updated OGC CIM EP protocol (the outcome of HMA-S project) – used for service and collection catalogues
- OpenSearch interface for Feasibility Analysis (outcome of HMA-S project).
- FedEO also provides discovery, ordering and on-line data access services for space based Earth Observation missions, as a potential contribution to GEO GEOSS.

In above mentioned context, the intention of the SmartHMA application is to provide a widely reusable mobile client libraries with slight customization which may be usable to access the deployed systems such as HMA-SE for access to digital EO content. From the operational point of view, the SmartHMA application is based on data provided by FedEO system via FedEO interfaces (API) as a HMA oriented information. SmartHMA, as an end client, implements all FedEO functionalities of data discovery, data search obtained from FedEO endpoints and distributed in standardised format.

RESULTS

The developed SmartHMA application allows a user to search EO data in a two stage approach: in the first stage the user defines parameters for searching for EO collections, and then, the second stage relies on looking for EO products within the specified collection. In the SmartHMA application, the “discovery” of EO data is defined in two ways:

- as a “Search EO Data” function, which allows users to set a query phrase in the search box;
- as a “Browse EO Data” function, which allows users to browse EO collections and their contents catalogue by catalogue.

After starting the application, the initial screen with four buttons is displayed (Fig. 3). The buttons on the main screen permit to move across different successive screens, each one providing different functionalities:

- 1) the “Search EO Data” screen provides tools for searching EO collections and products;
- 2) the “Browse EO Data” screen offers the functionality of browsing EO data and displaying the content of each available catalogue;
- 3) the “ESA Missions” screen provides general information about ESA and the Third Party EO missions and start point to search particular EO data;
- 4) the “ESA Online” screen shows the latest news regarding ESA EO.

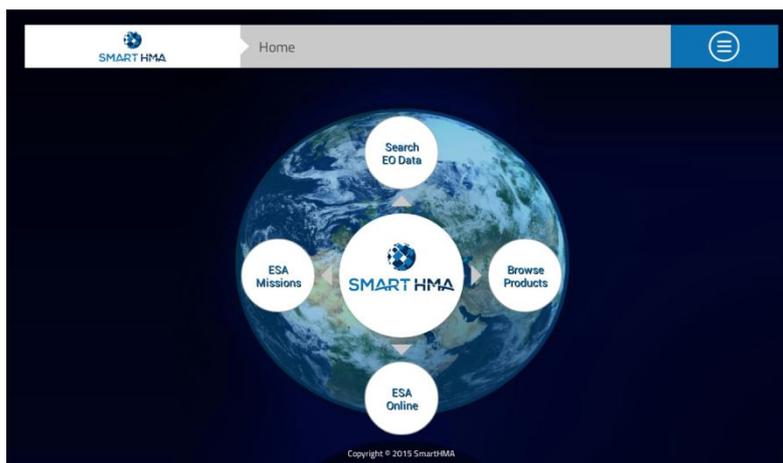


Fig. 3. The main screen of the SmartHMA application.

The "Search EO Data" screen permits the user to perform searches of EO data through available collections. A number of basic parameters can be configured, such as the catalogue to be used to perform the search, as well as the search area to restrict the search to a specified geographic area and the time period to restrict the search to a specified time interval. Once the parameters are configured, the main search screen with a search box permits the user to provide a search term. Advanced search parameters are also provided in an extended screen, which include configurable parameters such as the address of FedEO instance which will provide the responses, collections title, organisation name and the unique name of the platform defined in metadata. Searching process can take up to several seconds and as a result it returns a list of collections representing dataset series. When a collection is chosen from the list, additional information about it can be displayed, including its metadata. At this point it is also possible to redefine basic search parameters, such as the time and area of search. The user also has the option to perform search for EO products within the selected collection. When the searching process is successfully completed, a product search screen appears which includes a list with results. When an item is selected from the list, an additional screen with product details is displayed, featuring options which allow for downloading raw data of the product and saving them to cloud services, as well as viewing the product's image and metadata, displaying the georeferenced image on a map and sharing information about the selected EO product in social media. Fig.4. illustrates the process of requesting data via the "Search EO Data" screen and browsing through the obtained results.

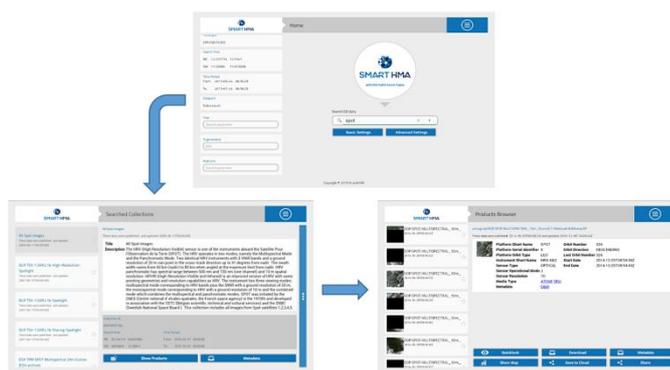


Fig. 4. The workflow of the "Search EO Data" module.

The "Browse EO Data" screen permits to use the browse functionality of the application to discover EO data by choosing a specific collection and then searching products in this collection with predefined search parameters. The browsing process is performed through a two-step approach, similar to the one used in the "Search EO Data" screen: first a collection of EO products is browsed and selected, and then the application looks for specific products within the selected collection. In latest version of application a "Search EO Data" is preferred method for FedEO instance data discovery. Some of the available collections can be seen in Fig. 5.

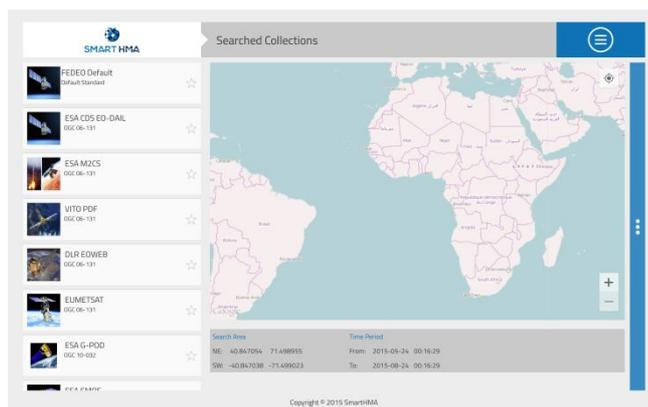


Fig. 5. The “Browse Products” screen, featuring some of the available collections and a map representing the indicated search area.

The “ESA Missions” screen is the last form of EO data discovery, which is based on the ESA EO Mission website content, linked with the FedEO search engine. It offers the functionality of displaying the list of available groups of ESA EO missions along with introduction information about each mission (Fig. 7.). Collections search summary screen provides the same type of information as described in the “Search EO Data” and “Browse Products” modules.



Fig. 6. An example of expanding one of available collections provided by the “ESA Missions” module.

The “ESA Online” screen offers an additional functionality of providing the latest information in the form of RSS/Atom news, obtained directly from the ESA website and displayed in the form of a scrollable list along with a preview of the selected article (Fig. 8.). Full version of each article can be displayed in a web browser by clicking on the button located below the article's preview.

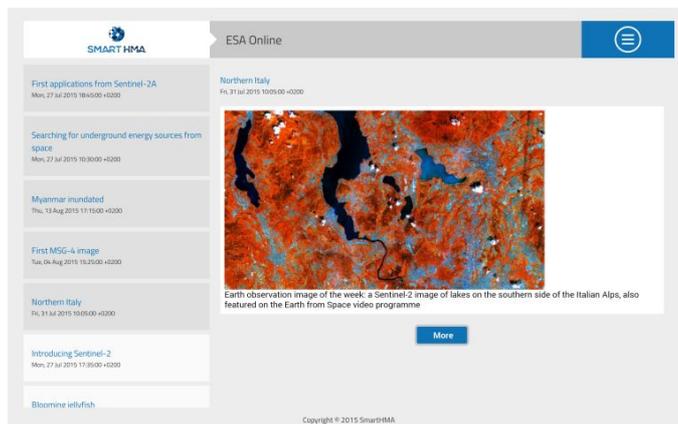


Fig. 7. The “ESA Online” screen

Auxiliary observational products in SmartHMA

In this section, the process of extending the basic functionality of proposed SmartHMA application with additional auxiliary party observational dataset is presented. The proposed mechanism was tested with the use of the satellite derived bathymetry (SDB) retrieved from Sentinel-2 observations. SDB was chosen because it is one of the most challenging and promising areas related to using observational data as it enables to derive shallow water depths in near-shore areas from remote passive satellite observations from Copernicus systems.

The basic physical principle of SDB is based on light attenuation phenomena while passing the water column. Methods of SDB utilize the set of known a priori depth points in order to calibrate and fit the

empirical model to remotely estimated depths. In order to obtain possibly precise model of estimation wavelengths with least attenuation coefficient (blue and green) are used. General quality of the SDB models depends on various factors including environmental factors (water clarity, amount of sediments, bottom type etc.), technical (spectral, radiometrical and spatial resolution of the sensor) and conceptual (utilized approach). Generally, in good conditions, SDB models are capable of obtaining bathymetry for points over 30 m. depth, however in many more difficult areas (like Baltic Sea), depths of over 10 m. can be estimated (STUMPF, 2003).

The developed module that presents SDB data is a part of the SmartHMA client application and acts as an extension to the existing *Browse EO Data* component, which now grants users access to the Satellite Derived Bathymetry collection stored on a separate server which is independent from the FedEO catalogues. Fig. 8 depicts the architecture of the developed module in relation to the SDB server. The communication between the module and the server is handled by a dedicated Web Map Service provided by GeoServer. When the collection (*Products catalogue* in Fig. 8) is selected, a *getCapabilities* query is sent to the WMS service. The obtained response is then used to fill the collection with a list of products containing basic information about all available layers on the server. Detailed information about each product, including data such as raster images, can be obtained on demand from layer data provided by the server in an asynchronous way.

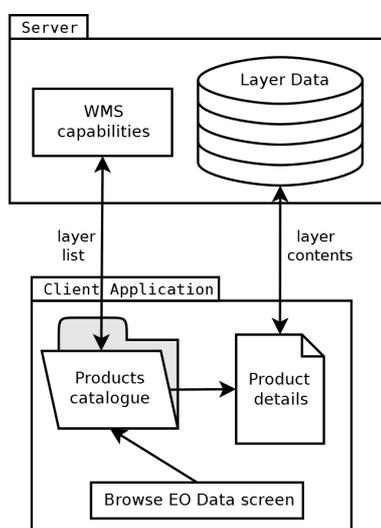


Fig. 8. Communication between the developed module and the data server

Results of module implementation enable for interactive browsing and visualization of SDB bathymetry retrieved from Sentinel-2 observations. Access to new contents is provided within the *Browse EO Data* activity by selecting the proper catalogue. The SDB products can be viewed in the same way as the FedEO collections. Fig. 9 illustrates the process of browsing through the available layers and viewing downloaded results. In this case the SDB is presented as colour-coded depth map overlaid on the Google base map. The light blue colour represents shallow water depth and dark blue represents deeper regions. At the first step of this procedure the user selects the SDB collection from the list of all catalogues accessible from the *Browse EO Data* activity. The application then downloads basic information about this collection and presents the user with a button which allows to display its products. Once clicked, the current application screen is replaced with a list of available layers obtained from the server, where a thumbnail for each product is downloaded asynchronously. After picking a layer, the user is then presented with a number of different choices, including the option to obtain a small image representing the layer's contents and display it on a map, as well as the possibility of downloading large raster data.

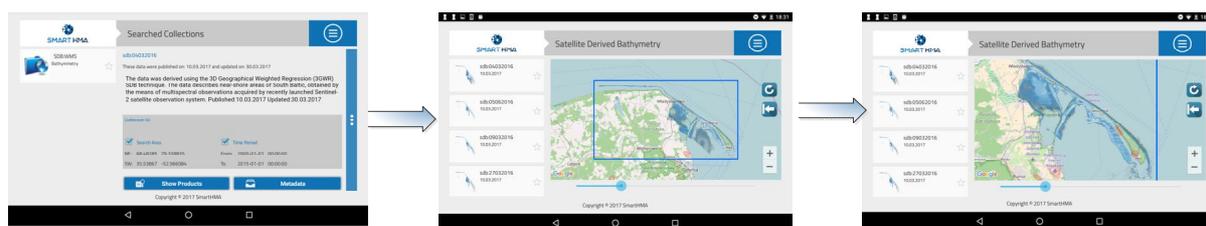


Fig. 9. The workflow of the Satellite Derived Bathymetry components.

Conclusions

In the paper, the solution for providing harmonised access to the ESA mission data, Ground Segment services from the Copernicus/GMES Contributing Missions (GCM) and related interfaces (HMA) was presented. The results of the study were exemplified by the project, design and implementation of dedicated mobile application that enables browsing and searching through resources available via HMA interfaces. The developed project is compliant with international standards for architecting open, distributed processing systems, especially those specified and utilized by ESA. The proposed solution is a native Android application, designed for an easy and cost effective data and services integration among heterogeneous infrastructures offered by HMA. SmarthHMA is an open source project and its codes are publicly available in the *GitHub* (SmarthHMA GitHub, 2017) and the *sourceforge* (SmarthHMA SourceForge, 2017) repository under GPL license.

Acknowledgment

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