Software Architecture of an Information System for Aviation Broker Center

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Abstract

This article describes an information system concept designed to provide large amounts of geospatial data to the public. It addresses specific software design challenges, including wide computational power and storage scalability and unclear definition of stakeholders. It defines functional, security and performance requirements and provides a conceptual system design proposal.

Keywords software architecture, geographical data, LIDAR

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1. Introduction

Geospatial information is making a transition from paper onto the screen. There are numerous public sources of geospatial data available for commercial and noncommercial purposes. The demand for precise, high quality geospatial data is growing along with improving technologies and declining digital storage costs. Government institutions and high-end commercial clients expect better calibrated maps, higher resolutions, 3D digital terrain models, object identification and other geospatial services. The Aviation Broker Center (later "Broker Center") concept evolved to satisfy this growing market demand in the Slovak Republic. This innovative concept requires a complex and custom-designed information system, the analysis and design of which are discussed in this article.

2. Broker Center Goals

The Broker Center will provide to its clients geospatial data of the Slovak Republic from two main sources – 3D LIDAR and 2D terrain photographs. Customers will be able to choose either raw source data or deduced data, such as digital terrain models, road networks, utility networks, buildings, dams, etc.

The Broker Center will be implemented as a distributed information system, with public access via the internet [1].

Because of extreme storage demands, long-term tasks and specific security requirements, it is necessary to design a novel system, the architecture of which is described below.

3. Analysis of Requirements and System Design

At the point of concept analysis and design, the key Broker Center customer was not yet defined and there were no specific requirements to precisely anchor the system analysis. Therefore, part of the analysis was based on estimations, especially in terms of possible use cases and storage and processing requirements. Processing of LIDAR and OF data was proposed in several ways, and these proposals have not been definitely confirmed. Given this uncertainty, requirements for the new information system were defined relatively generally. That itself implied a highly modular, open and extendable system design.

The resulting information system is scalable in several aspects, including costs, hardware, richness of functionality, storage capacity, processing power, as well as variability of supported end products.

To achieve the Broker Center goals, minimal functional requirements were defined. The proposed information system is designed to enable, with comparable effort, the implementation of either a functional prototype or a real-life running system. Extending the prototype, which would process only a fraction of real-life data and provide a limited number of products, to a running system filling real-life demands, will be possible without significant increase in effort and costs.

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4. Information System Requirements

Defining requirements of an information system when there is no precise knowledge of its future use is extremely difficult. The guiding information system requirements must be balanced between the need for precision and clarity and the need for openness and flexibility. Moreover, the system design must be implementable within given cost plans while not being too general or too narrow; and the information system itself must be usable by customers from the general public.

4.1. Functional Requirements

The information system shall:

1. Store and backup stored LIDAR data and photographs of terrain.
2. Provide means to preprocess (manually or automatically) LIDAR data and photographs required for product processing – calibration, filtration, rectification, quality estimation, stitching, cropping, etc. Resulting data are orthophoto and points cloud.
3. Store, backup, and search orthophoto and points cloud.
4. Provide a public interface to present and sell products to public customers.
5. Provide means to process (manually or automatically) orthophoto and points cloud to prepare products.
6. Deliver products to their final customers.
7. Enable payment for products via the internet.
8. Present public information via the internet.
9. Provide means to perform analytical and research tasks on stored geospatial data for authorized users, independent from products and data.

4.2. Security Requirements

The information system shall:

1. Prevent downloading, manipulation or processing of the stored geospatial data by unauthorized persons or systems.
2. Process secure payments via the internet.
3. Provide means for identification of customers.
4. Prevent loss of expensive data (LIDAR data, OF, points cloud).

4.3. Performance Requirements

As it was not possible to precisely estimate performance requirements, expert estimates were used.

1. Amount of geospatial data may achieve petabytes. Therefore, the storage capacity may not fall under 100 terabytes; the storage must be scalable and distributed.
2. Data processing must be parallel, distributed and scalable.
3. Manual data processing requires prolonged duration of time. It must be finished correctly even in case the system undergoes a restart.

5. Architecture

Architectural design of this information system was especially challenging due to the open definition of the Broker Center. In an ordinary situation, boundaries and capabilities of an information system are provided by limits and requirements of its customer. In case of the Broker Center, the majority of parameters were open, yet also connected. The natural boundaries and limits of the requirements forced the authors of the information system design to define several independent subsystems with the highest isolation and clear responsibilities. The resulting design is independent from underlying technology or from one particular supplier. It is possible to develop the subsystems independently from one another, by different parties. In each subsystem, security requirements will be addressed using methods that are appropriate for the chosen technology.

5.1. Functional Units

Based on the discussed requirements the authors identified the following functional units (Figure 1 – Basic functional units with a communication protocol proposal.):

1. Web Shop – a public internet site to present public information (news, marketing, etc.) to the general public; and to sell products to customers. A customer wishing to purchase a product registers an order and pays electronically via the site.
2. Data Storage – a storage point designed to store and backup LIDAR data, orthophoto and points cloud. The Data Storage interacts with human users and allows them to manage data (add, delete, etc.). It also serves as an interface for other subsystems to access LIDAR data, orthophoto and points cloud. It allows data search. It enables attachment of additional attributes to imported data. Data compression has to be considered [2].
3. Virtualization System – a system that provides processing power in the form of a virtual machine.
4. Control Center – a system center designed to control and check the performance of all customer order processing steps. It provides an interface for the Web Shop to add product orders. It interacts with all subsystems and human operators.

There were more units defined in detail; however, they are beyond the scope of this article.

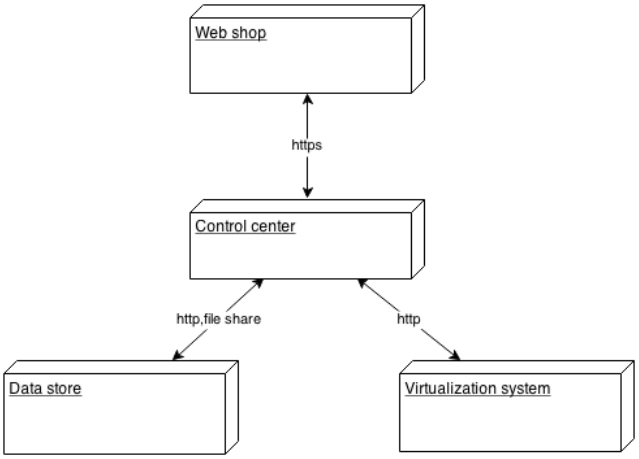

Figure 1. Basic functional units.

5.2. Actors, Use cases and Processes

Two groups of human actors involved in the operations of the Broker Centre information system were identified: internal human actors and external human actors.

External human actors access the information system of the Broker Center via the internet, through the public internet site of the Web Shop. The purpose of the information system is to fulfil their needs for information and purchase of products.

1. The General Public. The information system is designed to provide them with information about the Broker Center, its products and services.
2. Broker Center Customers. Prospective customers register in the information system through the public internet site, view its content and use the site by placing orders, paying for and retrieving their purchased products.

Internal human actors provide manual functionality for the Broker Center. Communication between internal human actors and the Broker Center runs in a variety of ways, including e-mail and the Center internal web site.

1. Data importer imports new raw and preprocessed data into the data store.
2. Data manager administers the stored data. The information system allows data manager to list and delete data, as well as manage additional data attributes.
3. Data operator manually processes the stored data. The information system allows data operator to download and process source data and store product data.
4. Delivery manager checks products before delivering them to the customer and performs the process of delivery. The information system provides delivery manager with the data pertaining to all Broker Center products.
5. System administrator manages the information system as a whole and obtains information about the state of the system at any given moment. System administrator uses management tools to control and configure the information system.
6. User administrator manages human users of the information system in their roles of internal human actors.

5.3. Use Cases

There were use cases and processes defined in detail; however, they are beyond the scope of this article.

6. Open Issues

To date, analytical and design phases of creating the Broker Center information system were undertaken. These two phases will be followed by implementation, during which new questions and challenges will arise. At present, there are several known problems requiring resolution, in order for the information system to be completed.

- Precise definition of products, which implies steps to implement the specific data processes.
- Detailed specification of interfaces between the various subsystems.

The key question to answer remains, specifically what kind of data should be stored and processed? It is necessary to define the correct way to store, index and search each kind of data.

7. Conclusion

This article describes the key issues of the analytical and design phases of the Broker Centre information system creation, including its challenges and conclusions. Requirements for an information system for the Broker center were defined. The information system based on these requirements will be able to deliver large amounts of geospatial data to customers. It will store and process LIDAR data and photographs of the Slovak Republic terrain. Its processing power and storage capacity will be scalable according to market demands. The information system will be open to future changes. It is possible to use the same system for scientific research independent of commercial usage.

8. References

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