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CASE STUDY

A case study: Grid services for satellite image processing

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Satellite image processing is an intricate task that requires vast computation and data processing, which cannot be handled by a single computer. Furthermore, the processing of the massive amount of data accumulated by the satellite is a huge challenge for the end user. Hence, grid computing is the essential platform to provide high computing performance at the user end. This article reviews the grid services used for satellite image processing and significant data processing.

Keywords: satellite, grid, image processing, remote sensing

1. Introduction

Satellite image processing is an intensive process involving extensive data analysis and computation. Real-time image processing in remote sensing is a quite impossible task for a single computer. Furthermore, it involves reciprocation of data and images from space to earth every second. The computational analysis of this massive amount of data requires efficient technology for remote sensing (1). Grid services are an essential platform that is anticipated to make reliable handling of data and distribution among users simultaneously. Due to the unavailability of the required computing performance, grid services have become an important platform for satellite image processing.

Grid computing is a procedure involving the use of multiple computers simultaneously to solve one or more problems that requires numerous data computing cycles. Grid technologies tend to provide efficient and desired tools and datasets for remote sensing (2). There are several grid types used in satellite image processing, like the computational grid, which is used for high-performance computational image processing, and the data or instrument grid, which is used for processing an extensive amount of data with high speed and precision. Furthermore, the service grid used for web services is required for remote sensing. MedioGrid is a type of service grid, but it is considerably used with computational grid for high performance (3, 4).

The components and structure of the computational, data or instrument, and service grids are shown in **Figures 1–3**. Those figures explicitly show the components and workflow of grids.

This article reviews grid services used for satellite image processing and other remote sensing applications like monitoring the earth and climate change and capturing images of unknown celestial bodies. The next section tends to collect previous contributions in the satellite image processing. Section 3 specifies satellite image processing using grids. Section 4 concludes the review, and the article ends with references.

2. Literature review

The grid infrastructure that is being developed by the Space Research Institute (SRI) is presented by Kussul et al. (5). In this article, the grid infrastructure that is being developed is reviewed explicitly using resources that are available. This grid focuses on quick responses from earth observation satellites to prevent disasters by taking precautions. Furthermore, they reviewed some applications

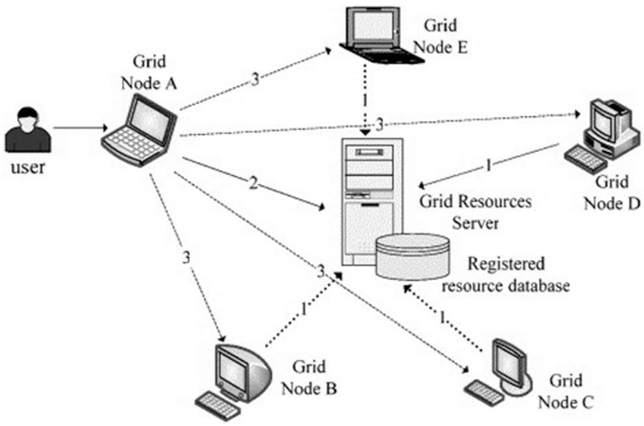

FIGURE 1 | Structure of computational grid (12).

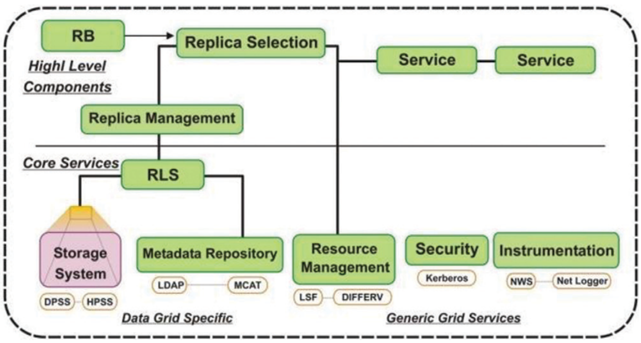

FIGURE 2 | Structure of data or instrument grid (10).

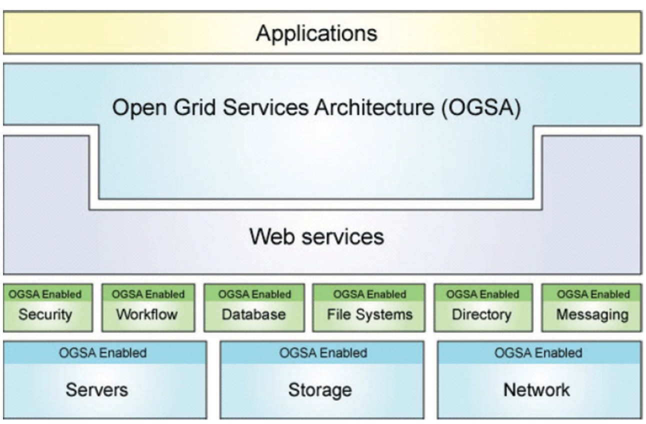

FIGURE 3 | Service grid for web services (9).

like monitoring earth's climate change, real time weather forecasting, and so on.

The Romanian collaborative project MedioGrid aims to provide large and extensive grid services for satellite image processing. The summary of this project is provided by Dana Petcu et al. (6). This article presents a brief review of MedioGrid for remote sensing with real-world applications. The data are collected and compared with previous results in order to improve precision.

Remote-sensed image processing using grids for earth observation training study and observation is presented by Daniala Zaharie et al. (7) in order to fulfill the need of training in earth observation on grid platforms. The project provides grid training platforms for earth observation and the technologies used for training. The basic grid services, their applications, and the results of image processing are provided by the GiSHEO platform. The structure of the GiSHEO platform is shown in **Figure 4**.

Sowmya D.R. et al. (8) have presented a comprehensive survey of satellite image processing techniques for image classification. This article aims to present a comprehensive survey of advanced technologies used in satellite image processing. The image processing is classified into four different categories, namely, pre-processing, enhancing, transformation, and image classification. Pre-processing of images includes correction of several kinds of distortions present in the image. Image enhancement consists of visual data interpretation. Transformation is used to identify image data and features, and classification is characterized by the grouping of pixels.

For environment and natural resource monitoring, there is a platform called 'Greenland Web-Based Platform', which uses grids for remote sensing. The development of applications and comprehensive analysis are presented by Filiz Bektas Balcik et al. (9). High-performance computation methods are required to perform earth monitoring; hence, grid infrastructure is an essential platform to provide these capabilities. This article aims to develop new applications in remote sensing with an open Greenland web-based platform using computational grids.

Andrei Eckstein et al. (10) have presented different case studies and scenarios of satellite image processing using grids that consist of remote processing of images, remote parallel processing of images, and processing of images using grids. By analyzing these scenarios, a prototype is developed, designed, and tested for classification of satellite images.

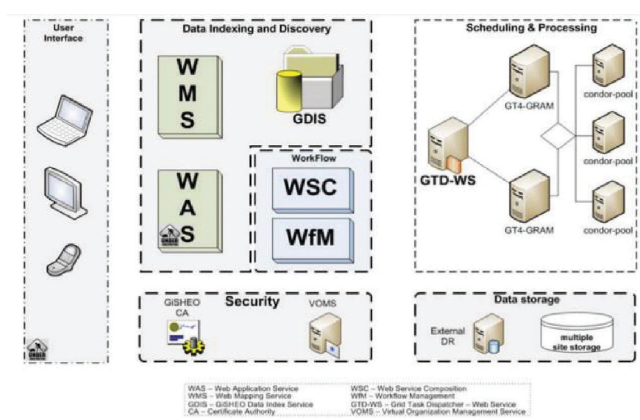

FIGURE 4 | Structure of GiSHEO platform (3).

3. Satellite image processing using grids

We have considered two methods for satellite image processing that are commonly used for satellite image processing. We are going to look into these two methods briefly before diving into another significant method that is used for satellite image processing using grid services.

3.1. Remote satellite image processing

A massive amount of data is available for various research and academic uses. Extraction of particular information from specific images using certain procedures is something a user intends to do. A user has been granted access to a workstation and a grid certificate issued by the virtual organization. The user should have technical knowledge of the operations that needs to be performed as well as lower or upper intermediate knowledge of programming. The CPU's time increases for extraction of features simultaneously as the number of images increases. Instantaneously, the user would get an idea about the available resources and computation techniques that are not able to acquire the satellite images (10).

The available technology must acquire the following components to support this scenario. The codes provided by the clients and some essential facilities to operate grids are at the one end, where the user is; satellite data and grid services for indexing are at the second node, which is the repository nodes; software for satellite image and data processing is at the retrieval, storage, and computation nodes.

A grid prototype for the GIMP tool was developed using Globus Toolkit 4 to respond to this method for image processing.

3.2. Remote parallel image processing

The protocols and essential requirements are the same as those mentioned earlier in the previous method. Furthermore, neither of the nodes has the required capability to perform the operation in the required time.

The infrastructure used in this method is considerably modified using the available tools. The head node, which is used for computation, is on the one side that manages the grid services. The constellation of head nodes is explicitly visible on the virtual organization's index. Additionally, the assumption that is made is that the processing of image replicas is available on every head node, which makes it available for computation.

A new grid prototype was built in order to respond to this method. The user has access to remote images and the authority to give commands to be performed in GIMP. The GNU program language that is used for image manipulation is GIMP (11). The image is divided into several number of parts tends to produce sub-images. Using the constellation of head nodes, the user selects the required cluster where the operation is intended to be performed.

3.3. Satellite image processing using grids

The user intends to apply special methods for processing images to extract required information from the images that are being selected. A significant number of images are being analyzed simultaneously, and if the CPU is taking more than anticipated time to extract the required data from the selected images, the user will apparently have the idea that the local tools available for processing satellite images are not sufficient.

To support this method, the available technology must acquire the components as follows: some essential facilities and codes provided by the clients to operate grid services at the node, which is operated by the user; the infrastructure of grid must have middleware grid to execute the codes at remote computation nodes. The structure mentioned here is for the grids used for computation.

The codes must be rewritten by the user in order to perform various tasks which are split to speed up the computation for satellite image processing. The transfer of intact images must be avoided because satellite images carry enormous sizes (12). Hence, the splitting of images and tasks is preferable. The required number of tasks and images should be elected on the basis of theoretical performance to obtain the anticipated response in time.

In the next point, we are going to present a case study of satellite image processing, which was part of the MedioGrid infrastructure.

3.4. Case study

The case study consists of the classification and implementation of a basic algorithm to classify forestation and deforestation. The process of classification involves the translation of satellite images from pixel values to produce meaningful images. A decision tree is the stack, which consists of binary rules that are used to define particular terms that are assigned to each pixel. The input here is in the red and infrared bands. The classes of land that are being detected here, are open surface, forests, water sources, and rain clouds. Each specified class has a different color, as depicted in **Figure 5**.

It is assumed that the user possesses a code in sequential form that applies to the classification of decision trees on images that are being taken by satellite cameras. The

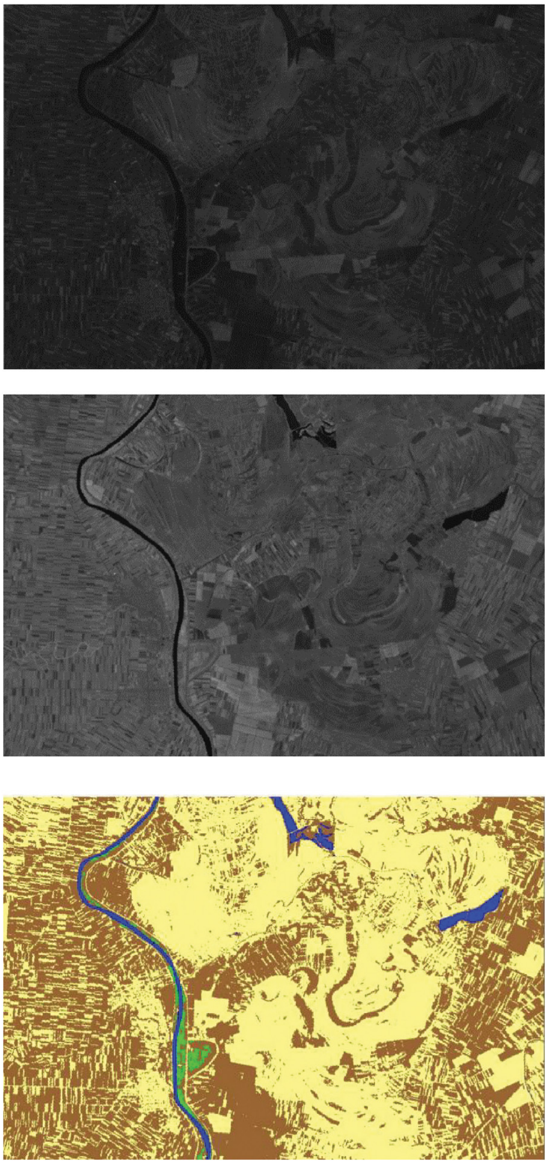

FIGURE 5 | Decision tree implementation applied to bands 3 (first) and bands 4 that yields a color image with a specified meaning (1).

sequence code must have the following components for the computation:

1. A splitter with the ability to acquire two bands in order to split them into several numbers of small images.
2. A classifier that acquires a couple of images from the bands that produces small images.
3. Essentially, a composer accumulates sub-images with defined colors (1).

The primary sequence code that applies to small images is called the classifier.

Meanwhile, the composer and splitter are situated at the user end, where the small images and classifiers are gathered for grid computation.

The case study was intended to detect the appropriate number of sub-images using appropriate dimensions of images. With the small satellite images, which have a band size of approximately 64 megabytes, it is possible to obtain an appropriate response time by performing a few operations with the help of grid services in place of a single computer. Meanwhile, for images with large sizes carrying band size around 450 megabytes, it is difficult to process on a single computer memory. A significant number of operations must be considered to write the composer and splitter.

TABLE 1 | Response time (s) for small image classification.

Split type	Nodes no.	Response time	Image file size in bytes
1×1	1	5.66	5324604
2×2	4	2.23	1331018
3×3	9	1.63	591947
4×3	12	1.49	443758

Table 1 explicitly depicts the response time reduction by utilizing grid computation technology for small image classification. The bands of smaller dimensions have a very less response time. Similar procedures and operations can be used to build codes to perform more intricate satellite image processing.

4. Conclusion

Remote sensing and information and data processing are intricate tasks, which require powerful and efficient tools. The proposed prototype of grid technology is efficient in providing desired tools for satellite image processing on grid platforms. The code used for grid computing is the property of user that splits into a number of operations that are performed on grid platform. This is a very brief overview of the framework of MedioGrid infrastructure, which shows compatibility of the grids for high-speed satellite image processing.

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