Requirements Study of a High-Resolution Satellite Image Receiving, Processing and Archiving System

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ABSTRACT:

This paper addresses a new project being carried out at Satellite Technology Research Center. The purpose of the project is to implement a system which receives, processes and stores 1m resolution satellite image transmitted at over 300Mbps down link data rates. In order to develop such a system, a system operational concept design and a requirements study were being carried out. As a result of the operational concept design, system objectives, system context and system functions were defined. The system shall be operated according to the philosophy of maximum automation, rapid processing, reliability, integrity, cost effectiveness, and expandability.

The system is divided into twelve independent processes and its behavior is modeled by operational scenario, which are combinations of independent processes. Process information and logs generated by the system shall be stored in databases and data received and generated be automatically archived and managed in a hierarchical storage device. The system shall have redundant components in order to be ready for recovering from sudden system failures. This paper will describe in detail the system operational concept design and the system requirements derived from the operational concept design.

1. Introduction

Since the end of the Cold War, the satellite image data that had been used previously for military purposes were being applied to commercial purposes such as communication, meteorology and earth observation. As the technologies of commercial remote sensing satellite and sensor development have been progressing rapidly, high-resolution satellite images and data extracted from such images are now available. Accordingly, the roles of ground stations such as receiving, processing and distributing image data have increased in order to provide to users high-quality satellite images in a prompt and efficient manner.

In particular, Korean government launched a long-term space development plan, which includes the development and launch of seven remote sensing satellites until the year 2015. The roles of ground stations in Korea became very important too.

This paper addresses about a project being carried out at the authors' affiliation for the development of a new image receiving, processing and distribution system for 1m resolution satellite imagery transmitted at over 300Mbps down link data rates. The project is in the process of operational concept design and requirement analysis and therefore this paper will describe the progresses achieved so far.

2. System Overviews

In order to develop the system mentioned above we first defined system objectives and, then, derived system main functions on the basis of the objectives.

2.1 System Objectives

The system shall receive, process and archive 1m resolution satellite images transmitted at over 300Mbps down link data rates. When a user requests image data, the system shall generate image products and deliver in a form the user requests

2.2 System Functions

For the accomplishment of the system objectives described in the section 2.1, the system must execute the following three system functions.

The first system function is receiving satellite data transmitted at over 300Mbps down link data rates and generating catalog data and archive-images. The second is processing and generating pre-processed image data and value-added products. An authorized user can search catalog data stored in the system and order image data. The third is receiving these orders as system inputs and providing system outputs to the user in a user-requested form.

3. System Operational Concepts

In order to develop the aforementioned system, we designed system operational concepts. As a result of this, we defined system context, operational philosophy, processes and scenarios.

3.1 System Context

The system receives 'system input' (or order), which initiates system's functions, and 'control input' which is used for processing data.

A system context is relationship between the system and external entities that exchange data with the system. The system fulfills its objectives by interacting with external entities. The system context defined is described in Figure 1.

The system receives image data from the satellite via an antenna. Users will generate on-line orders and the system will provide outputs to users. The system will request the reception of satellite data to Mission Control Center (MCC) and MCC will give an approval and auxiliary data for receiving such as calibration and orbit data. Auxiliary organization provides auxiliary data for processing.

3.2 System Operational Philosophy

The system shall be operated according to seven operational principles.

• Maximum automation – The system shall be centralized

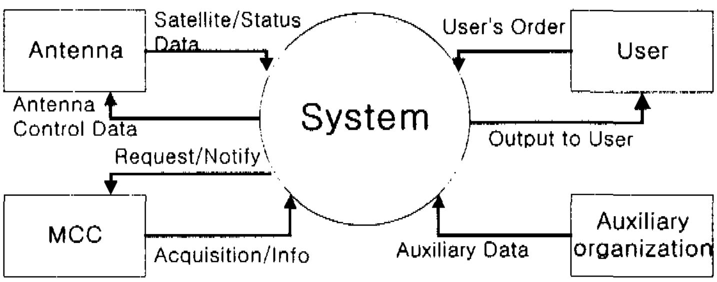

Figure 1. System Context Diagram

and operated with minimum operator's interaction. To achieve maximum automation, the system shall process automatically as many steps as possible and keep operators' actions minimum. Authorized users shall be able to easily access catalog data by using a web-browser and to search data rapidly. No extra component shall be required at the user's side for the access and search of catalog data.

• Rapid processing – The system shall process inputs speedily so that it can generate products rapidly. An image catalog database shall be managed efficiently and support multi-users' access without a significant delay. Users shall be able to rapidly access catalog data and browse images.

As soon as the system receives inputs from a user, the system shall search for the information of the similar processes previously executed and generate an execution process list on the basis of the information. The execution process list shall be stored into a queue in the system and each process in the list start immediately when the system is idle.

• Reliability – The system shall not fail to achieve system objectives by operators' trivial mistakes. Critical sub-systems such a real-time data reception subsystem must be designed with a redundant backup in order to minimize the damage caused by sudden operation failures and to be ready for recovering from those failures.

Several software components to be implemented in the system have user interfaces. Such software shall be started automatically in usual cases, and also manually using user interfaces when automatic execution chains fail.

• Integrity – Operations and management of system is integrated in the most efficient manner. The system shall have a component, named "order manager", which supervises all other subsystems and components. The "order manager" shall handle the backup of database s in the system periodically. The system shall have an integrated user interface. Results of changing states of subsystems or components will be displayed in the interface and the operators easily know the whole system's status.

The data that system received, generated and archived in a hierarchical storage device and managed automatically by the system.

• Cost Effectiveness – The system shall be operated economically so that it can save time, efforts and resources.

• Expandability – The system shall be upgraded for processing other satellite data with little change of system components. "Frame-sync module" in the receiving subsystem shall be implemented not as hardware but as software. When the system is upgraded to receive other satellite data, a dedicated hardware shall not be needed. Only by changing configuration files, the system shall handle other satellite data.

• Security – Only authorized users shall have access to catalog data and only operators operate system components. Due to the importance of the information extracted from 1m resolution image data, some security and data access policies shall be imposed.

3.3 Operational Processes

In order to describe the way the system operates, we divided system's works into processes according to the system functions and operational philosophy. A process is an independent work that can be done without other processes' results. The system is divided into 12 processes and each process split up into sub-processes and subsub-processes hierarchically. A process can be described with a process diagram. The process diagram described in Figure 2 is for "catalog search and input order" process. This process diagram describes an internal flow of the process. When a user searches for catalog data or retrieves status of a previously request order(User request A), the "catalog DB search" and

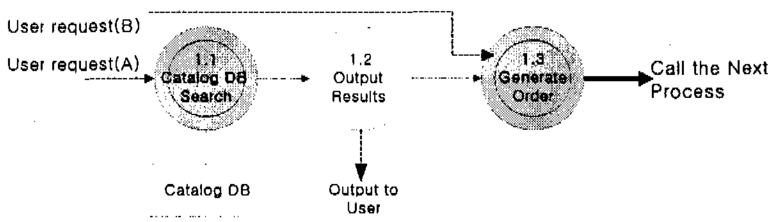

Figure 2. An Example of Process Diagram

"output results" sub-processes will be activated. When a user inputs a request for image products (User request B), the "generate order" sub-process will be activated. In this case, the "generate order" sub-process will call the next process in execution chains.

3.4 Operational Scenarios and Dynamic Modeling

A Scenario is a combination of processes. This is initiated by a system input from a user. We defined six operational scenarios. The system shall be operated according to these scenarios. An example of an operational scenario is described in Figure 3.

When a user requests pre-processed image product, the "search catalog and input order" process will be activated. Then the system analyzes the user's input ("Analyze User's Order" process) and on the basis of this process the system starts a pre-processing image data ("Generate pre-processed Product" process). A product generated by pre-processing will be transferred to user in on-line or off-line ("Output to user" process).

Dynamic modeling can show dynamic behaviors of the system such as cooperation of processes. As already described, we can see dynamic behaviors of the system via operation scenarios.

4. System Requirements

System Requirements are identifiable capabilities expressed as measurable performance or functions that the system must possess to meet the mission objectives [1]. System requirements describe the behavior of the system as seen from the outside (e.g., by the user). System requirements serve at least as a partial communications vehicle to the more technically inclined users, or to a purchasing organization, as well as to analysts and designers who are concerned with the development of system [2].

On the basis of operational concepts, We defined system requirements that the system must satisfy. We grouped overall system requirements into functional, performance, environment, maintenance and test requirements.

4.1 Functional Requirements

A functional requirement is a function that the system must carry out. The functional requirements describe system actions, inputs to these actions and outputs from these actions. We defined thirteen functional requirements, out of which we describe seven here.

- The system shall provide a tool to plan image acquisition and to help satellite-programming requests to MCC according to a predefined protocol.
- The system shall receive and archive satellite data transmitted at over 300Mbps.
- The system shall generate catalog data from satellite data received, store the catalog data in a database and process the satellite data to generate products.

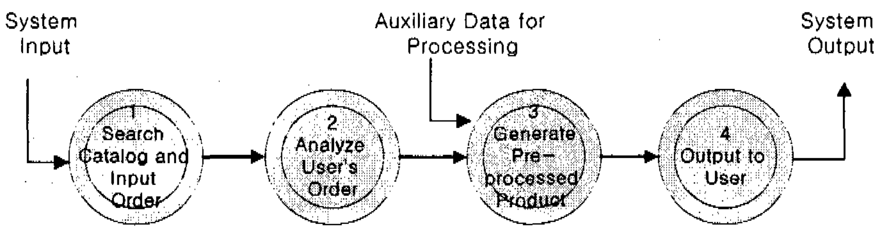

Figure 3. An Example of Operational Scenario

- The system shall generate value-added products using auxiliary data.
- The system shall store and maintain satellite data, image products and auxiliary data used.
- The system shall provide a tool to authorized users to search for catalog data and to generate on-line image request orders. The system shall provide results for users in online or offline.
- The system shall read data from input media and write data to output media in a form user requested.

4.2 Performance Requirements

When the system executes its functions, there are least bounds that the system must be satisfied such as processing speed, reliability, accuracy and compatibility.

We define these bounds as performance requirements. We describe here five such requirements.

- The system shall generate pre-processed data from a single pass of satellite data within 5 hours and value-added products within 24 hours.
- The system shall receive satellite data for, at least, twelve minutes continuously.
- The system shall achieve its objectives even if some parts of the system fail.
- The system shall perform the backup of data stored periodically.
- An output of the system shall be able to be used in other commercial packages.

4.3 Environment Requirements

When the system is operated, the system needs a hardware platform, an operating system, peripheral devices such as tapes or disks drive for input/output, printers and so on. We are in the defining process of such environment requirements.

4.4 Maintenance Requirements

For the fulfillment of system objectives, the management and maintenance of the system is important. For this, the system shall generate and store process information and logs in a database. The process information and logs shall be used to recover from or analyze system failures. The process information and logs shall also be used for generating operation statistics.

The system shall archive and manage images and related data in a hierarchical storage device. According to some data management policies, the data in the storage device shall automatically be archived in on-line, near-line and off-line storage media.

4.5 Test Requirements

In order to develop and verify the system, the system shall be tested and examined by a predefined test procedure. Test requirements will define conditions and procedures of such tests which are under design.

4.6 Subsystem Design.

We divided the system into three subsystems of "receiving and archiving subsystem", "search and products generate subsystem" and "value added product generate subsystem". The "receiving and archiving subsystem" receives and archives satellite image data transmitted 300Mbps in real-time. The "search and products generate subsystem" provides a tool to search for catalog data to users and generates pre-processed products. The "search and processing subsystem" also manages the whole system. The "value added product generate subsystem" generates value-added products like precision-corrected images, ortho-corrected images, digital elevation models, building information and road information. For the successful execution of these three subsystems, we need operator's interactions so we define "operator's interaction subsystem". An architecture of the system is described in Figure 4.

4.7 Components Design.

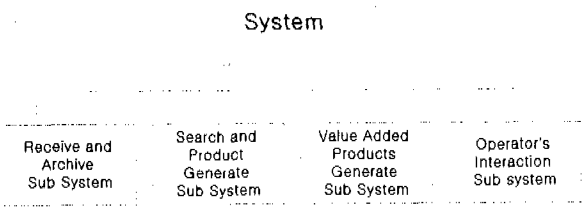

Figure 4. Architecture of System

A subsystem is divided into several components. A component works as an independent software. Some components have own user interfaces for independent execution. An architecture of the "search and products generate subsystem" is described in Figure 5.

The "search and products generate subsystem" consists of several components. The "DBMS" manages the database in system. The "network manager" sends and receives message with a receiving and archiving subsystem. The "order manager" analyzes user's order and makes a plan of execution. The "media generate S/W" reads data from input media and writes to output media. The "catalog search and system input S/W" is a tool to search for catalog data and request image products. The "catalog and product generate S/W" generates catalog data and pre-processed products. The "archive and management S/W" archives satellite data to a storage device and manages data. The "receiving plan S/W" provides a tool to plan image acquisition and to help satellite-programming request to MCC.

5.Conclusion.

Since this work is on going, we concentrated on the description of operation concepts and system requirements of the new system. When some concrete system designs are available, these will be appeared in the literature later on.

Since a number of remote sensing satellite programs are being carried out and more will start in near future, the roles of ground station shall be emphasized. The operation concepts and system requirements stated here, we hope, can help when designing such stations.

Acknowledgements

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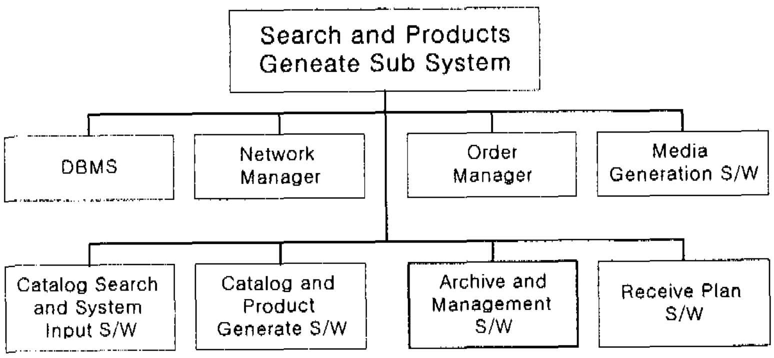

Figure 5. Architecture of Search and Products Generate Sub System