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NEXT- GENERATION BLADE-BASED ARCHITECTURE for GOES SENSOR PROCESSING SYSTEM (SPS)

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Abstract – NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) provides timely access to global environmental data from satellites and other sources to promote, protect, and enhance the Nation's economy, security, environment, and quality of life. Since 1975, the Geostationary Operational Environmental Satellite (GOES) has been a critical component in providing a complete global weather monitoring system. The GOES Program continues to be paramount to the success of the NESDIS mission.

The Office of Systems Development (OSD) Ground Systems Division (GSD) intends to make a number of architectural upgrades to the GOES ground system components in an effort to extend the longevity of the system, increase operational reliability, combine functional components into a single architecture, and reduce long-term maintenance and operations costs. The GOES Operations Ground Equipment (OGE) components, supporting the GOES I-M and GOES NOP series of satellites, must be maintained at least through 2020 after which the existing series of satellites are retired and GOES-R will be the primary GOES constellation. The transition of the OGE to a next-generation architecture presents many challenges due to the variety of computing platforms, hardware, operating systems, and legacy applications.

An "As Is" IT assessment of the existing architecture of the GOES OGE was conducted in 2008, and a roadmap and consolidation strategy to migrate the existing OGE components to a next-generation state-of-the-art architecture was laid out. Employing enterprise management capabilities and economies of scale, an enterprise managed system for the GOES constellation was developed under the acronym of GOES Enterprise Managed System (GEMS).

The GEMS architecture has tremendous potential for the Ground Systems Division (GSD) and the continuity of operations for the GOES OGE. It significantly reduces ground system life-cycle costs, improves future standardization between component systems, standardizes O&M of OGE components, provides reliable operations with hot backup and fault-tolerant component systems, enhances IT security, and provides enterprise management capabilities. The intent of the new architecture is to have an enterprise managed system that will host the entire GOES OGE components including the MSPS/ESPS, RPM Servers and Clients, SPS Database Servers, CAWS, and possibly the OATS.

Using a phased approach, NOAA has started to migrate the OGE components to a more centralized low-maintenance blade-based architecture. In December 2008, the RPM Server was hosted and successfully deployed as GEMS at the Wallops Command and Data Acquisition Station (WCDAS), followed by deployment at the NOAA Satellite Operations Facility (NSOF) in January 2009.

The SPS is the second OGE component to be migrated to the GEMS architecture. There are currently 10 operational SPS units at the NOAA facilities: seven at WCDAS, two at FCDAS, and one at WBU. This paper describes the migration of the SPS units to the GEMS architecture.

Index Terms – GOES, Ground System Data Processing, Blades, Sensor Processing System (SPS), GOES Enterprise Managed System (GEMS)

I. INTRODUCTION

The components that constitute the GOES Operations Ground Equipment (OGE), including the Modernized/Enhanced Sensor Processing System (MSPS/ESPS), Replacement Product Monitor (RPM) Servers and Clients, Orbit and Attitude Tracking System (OATS), SPS Database Servers, and Consolidated Analysis Workstations (CAWS), have been evolving over many years. These various components use different hardware platforms and operating systems (OS), some of which are outdated and in need of major upgrade. To keep these systems running for the foreseeable future and to be able to handle larger data requirements, NOAA has planned a gradual migration of the OGE components to an enterprise-level blade-based and scalable architecture. This not only will lower operations and maintenance (O&M) costs, but also will take advantage of emerging hardware and software technologies.

Using a phased approach, NOAA has started to migrate the OGE components to a more centralized low-maintenance blade-based architecture. In 2008, a comprehensive "As Is" IT assessment was conducted of the existing architecture of the GOES OGE, and a road map and consolidation strategy was laid out to migrate the existing OGE components to a next-generation state-of-the-art architecture employing enterprise management capabilities and economies of scale. We laid out and built the foundation for this architecture by designing and developing the GOES Enterprise Managed System (GEMS) that was successfully deployed at the Wallops Command and Data

Acquisition Station (WCDAS) in December 2008 and at the NOAA Satellite Operations Facility (NSOF) in February 2009. The GEMS architecture has tremendous potential for the Ground Systems Division (GSD) and the continuity of operations for the GOES OGE. We developed an architecture that significantly reduces ground system life-cycle costs, improves future standardization between component systems, standardizes O&M of OGE components, provides reliable operation with hot backup and fault-tolerant component systems, enhances IT security, and provides enterprise management capabilities. The intent of the new architecture is to have an enterprise managed system that will host the entire GOES OGE components. The first OGE component hosted within GEMS was the RPM Server.

The SPS is the second OGE component to be migrated to GEMS. Its role within the OGE is to process Imager and Sounder instrument data from the GOES spacecraft and generate a GOES VARiable (GVAR) formatted data stream for real-time transmission back to the GOES spacecraft. There are currently 10 operational SPS units at the NOAA facilities: seven at WCDAS, two at FCDAS, and one at WBU. Because of the complexity and the distributed nature of the SPS, a multi-phased approach is being used for hardware and software migration of the SPS to the GEMS architecture.

Currently, the SPS consists of three servers and one workstation: the GOES Ingest Unit (GIU), the GOES Resampling Unit (GSU), the GOES Ranging Unit (GRU), and the Androgynous Machine Interface (AMI) workstation. The GIU ingests raw Imager and Sounder data from the spacecraft and performs low-level processing of the data that is sent to the GRU. For spacecraft orbiting at high-orbit inclination, the data from the GIU is sent to the GSU (before it is sent to the GRU), where it is resampled and remapped to compensate for errors induced by the higher orbit inclination that cannot be completed onboard the spacecraft. The data from the GSU is then passed on to the GRU. The GRU formats it into the GVAR data stream and uplinks it to the GOES spacecraft for rebroadcast to GVAR users. The GRU also performs ranging for the GOES satellite.

During the first phase of the SPS migration to GEMS, the AMI, GIU and GRU will be migrated to the x86 architecture. The GSU will be migrated in the second phase, which will also entail the migration of GOES I-M Telemetry and Command System / GOES NOP Telemetry and Command System (GIMTACS/GTACS) communication interfaces in the SPS. Finally, in the third phase, the AMI Thin Client upgrades will be applied.

II. SYSTEM ARCHITECTURE

A. GEMS Architecture

The GEMS is an enterprise architecture based on blade technology. It consolidates all system components into a single compact platform where electronic components, power, and cooling can be shared. This configuration allows a more unified, centralized, and efficient management and monitoring of the entire enterprise infrastructure. Various hardware elements such as hard disks, network switches, power supplies, and cooling fans have built-in redundancy that ensures uninterrupted operation and low maintenance costs. Most GEMS components are hot-pluggable, allowing their removal and installation during operation, which eliminates system downtime for parts replacement and maintenance. Advanced diagnostics can alert users of impending failure, allowing efficient and timely preventive or restorative action.

The GEMS provides enterprise data archiving and storage through its integrated Storage Area Network (SAN) implementation. In addition to SAN, a suite of enterprise-wide functions including system and network monitoring, rapid imaging and provisioning, system-wide security scanning, and two-factor authentication is provided.

B. SPS Architecture

The SPS is a highly complex system consisting of custom hardware, multiple servers, a front-end workstation, a Cisco switch, time and terminal servers, and specialized telecommunication Peripheral Component Interconnect (PCI) cards for data ingest and broadcast. The SPS consists of three servers (GIU, GSU, and GRU) performing data ingest, calibration, ranging, and GVAR output formatting functions for both the Imager and Sounder instruments. Each spacecraft has a dedicated primary and backup SPS, resulting in seven SPS racks at WCDAS and one backup unit at WBU. There are two spare SPS units at FCDAS and one development rack at NSOF. Figure 1 shows the SPS and its interactions with other OGE components.

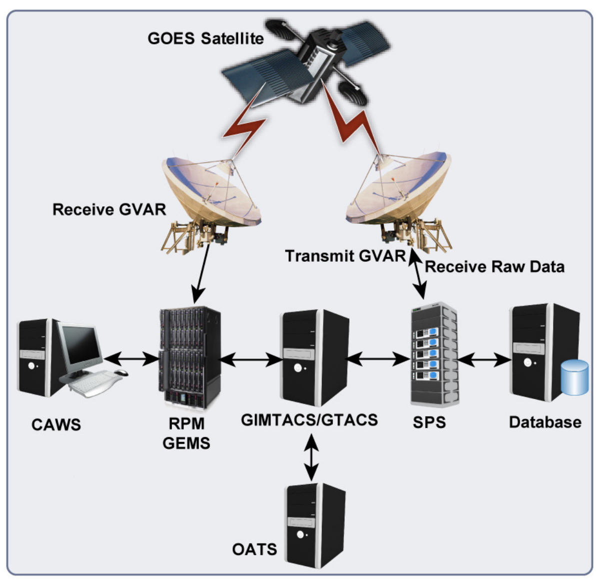

Figure 1. SPS and its interactions with other OGE components.

III. IMPLEMENTATION

A. Software Methodology and Tools

The legacy SPS software was developed for the Big-Endian architecture used by SPARC-based servers. Although the Solaris operating system (OS) will be used to host the SPS software, migrating the SPS software to the x86 architecture will require identification and modification of existing source code that is not portable. This will ensure that data shared between the SPS and other OGE components conforms to the data format specified in the DRL504-02[6]. The same is true for the GVAR format.
To migrate the SPS software from the SPARC-based platform to the x86 architecture, we have developed a successful, effective, and efficient methodology to port legacy application software to run on x86 as shows in Figure 2. This methodology was developed from our experience of migrating the RPM Server software to the GEMS.

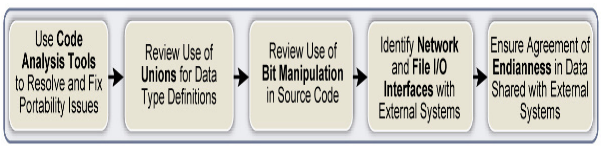

Figure 2. Methodology to port legacy application software to x86 architecture.

Our methodology uses sophisticated static analysis tools to analyze, detect, and repair portability issues in the legacy SPS code. As part of this activity, we will identify non-portable code, fix portability issues, and address SPARC versus x86 Byte-order differences. Although these tools are very useful in detecting most issues in the legacy code, a good understanding of the domain and software architecture is also required to ensure all issues with porting the software are detected and addressed. A brief description of static analysis tools that can be used for porting applications from SPARC to x86 platforms on Solaris is given below.

Sun's *lint* Source Code Checker is a freely available source code analysis tool provided by Sun to check C code for errors that may cause a compilation failure or unexpected results at runtime. It is being used to identify and fix incorrect, error-prone, or non-standard code that compilers do not necessarily detect.

Sun's *AppCert* is a freely available static analysis tool that checks for binary compatibility problems in applications running on the Solaris operating system. It is being used to check for potential binary problems in the SPS software; for e.g., the use of deprecated libraries.

IBM Rational Software Analyzer is a static code analysis tool that reviews software code and identifies software defects in the development cycle. This tool is being used to identify issues related to data structure differences between the SPARC and x86 platforms, and also to detect software errors and defects associated with non-standard code practices resulting in non-portable code or memory leaks.

IBM Rational Purify is a runtime analysis tool that provides advanced runtime and memory management error detection, including memory leaks. It is being used to ensure no memory leaks are introduced when the SPS software is ported to the x86 architecture.

Our methodology also includes steps to ensure that I/O interfaces used to exchange data between the SPS and other OGE components, such as the GIMTACS and GTACS, are identified and modified for conformance. This is especially important for the GOES ground system where SPARC-based legacy systems and next-generation x86 systems co-exist and provide mission-critical services in tandem. The use of our methodology to analyze and fix legacy code, in addition to our experience and knowledge of the SPS software, will greatly reduce the time required to port the SPS software and will significantly improve the robustness of the software on GEMS.

Table 1 shows how the aforementioned tools are being used to migrate the SPS software to the x86 architecture.

Issues Associated with the SPS Migration to x86 Architecture	Sun's Lint	Sun's AppCert	IBM's Rational Software Analyzer	IBM's Rational Purify
I/O Architecture				
Storage order differences	✓		✓	
Data Alignment Differences				
Read and write structures	✓		✓	
Padding	✓			
Coding Best Practices				
Portability	✓		✓	
Initialization issues	✓		✓	
Memory leaks				✓
Operating System & Other Differences				
Binary compatibility		✓		

Table 1. Assessment of tools to identify and fix portability issues in the SPS software.

B. SPS Software Migration Plan

The SPS software will be migrated to GEMS in three phases as shown in Figure 3. Each phase is tailored to achieve a fixed set of well-defined requirements, and is designed to progress in increasing complexity until the SPS is fully supported within the GEMS architecture.

In Phase 1, the AMI, GIU and GRU will be migrated to the x86 architecture. In Phase 2, the GSU and the GIMTACS/GTACS communication interfaces will be migrated to the x86 architecture. In Phase 3, Thin Client Upgrades will be applied to the AMI, with potential server consolidation upgrades to the GIU, GRU and GSU.

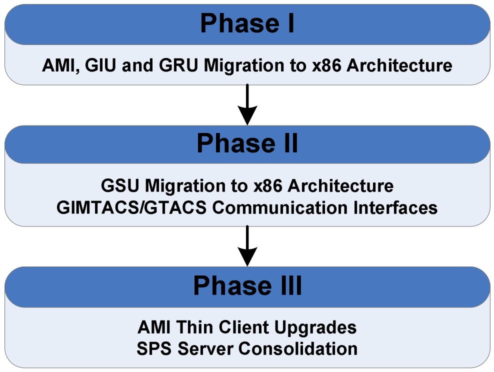

Figure 3. Three phases of SPS migration to GEMS

C. SPS Migration Quality Control

To complement the plan of migrating the SPS software in phases, a quality-gate approach is being used to verify the quality of the software at each stage of the development process. This approach forces a continuous focus on quality, ensuring that the migrated software complies with requirements before the next stage of the SPS migration. It also ensures that software defects are detected and fixed early on, ensuring a high quality of migrated modules as they are ported to the new x86 platform. Figure 4 shows the SPS migration QC as a parallel effort, ensuring that all software changes are thoroughly verified and validated prior to proceeding to the next stage.

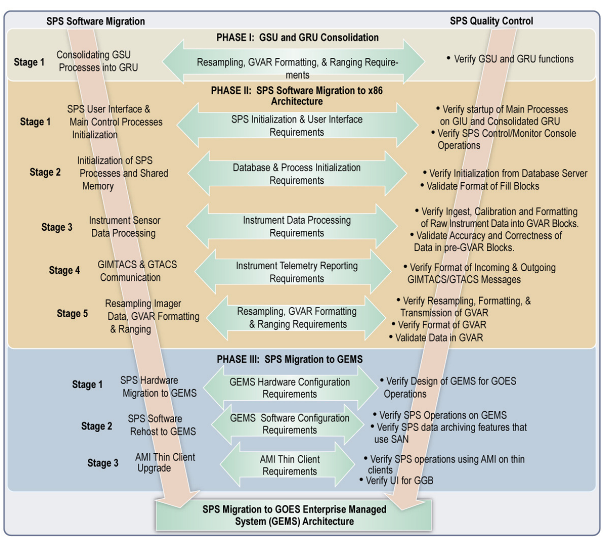

Figure 4. Quality Control at each Phase of the SPS Migration.

QC will also require the development of new tools to compare the results of the migrated SPS with the operational systems. This will include new tools to sample GVAR at various points in the GVAR pipeline, to verify and validate the accuracy and correctness of the GVAR content.

D. SPS Hardware Architecture for GEMS

SPS will be migrated to the GEMS architecture using a similar design that was developed and used for the RPM-GEMS units at WCDAS and NSOF. In this design, all SPS components will reside in a single rack, configured to house all blades and networking modules in a blade chassis at the bottom of the GEMS rack. The rest of the rack will house all other hardware components, such as the GOES Gear Box[9], Time Servers and IO-LAN Servers[9]. Each SPS will require two blade servers plus two Expansion blades for the EDT[15] cards associated with the GIU and the GRU. Figure 5 illustrates the consolidation of a single SPS into GEMS. The GEMS hardware configuration for SPS includes many redundant components to ensure continuity of operations in case of hardware failure of a component within GEMS.

Currently, seven SPS units are operational at WCDAS. Migrating the SPS to GEMS will consolidate all of the existing seven SPS units and one additional SPS into only three separate racks. This will greatly reduce the space requirement from eight racks to three racks while providing the same SPS functionality with significantly enhanced reliability, maintainability, and scalability. This configuration not only adds an eighth SPS, but also provides enough space on the racks for the optional installation of three database servers, one in each rack. Figure 6 illustrates the proposed hardware layout of the three racks at WCDAS.

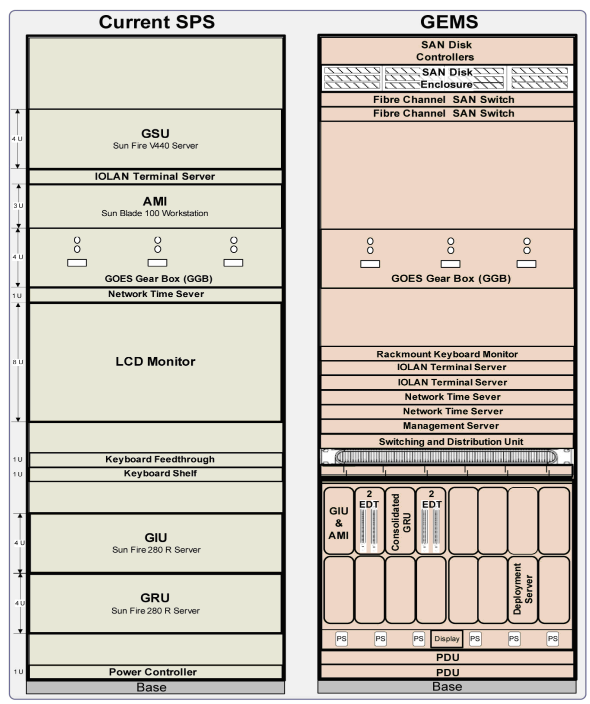

Figure 5. SPS consolidation into GEMS. The GEMS hardware and rack layout offers considerably more space for later expansion and the capability to host multiple SPSs within a single rack of equipment.

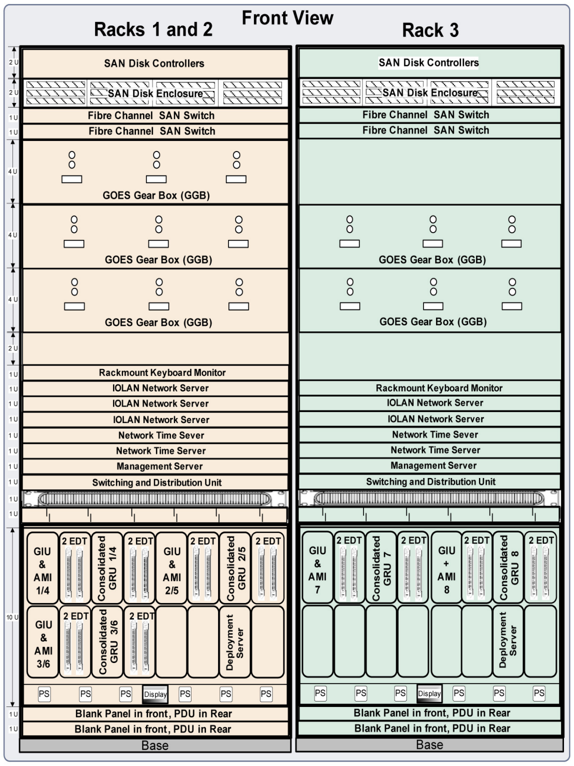

Figure 6. Hardware layout for three SPS GEMS racks at WCDAS

E. Thin Client Upgrade for AMI

The existing AMI is a workstation that resides on each SPS rack, providing a user interface for operators to view and control SPS operations on the GIU, GSU, and GRU. In the SPS racks at WCDAS, the AMI terminal and workstation are physically located within the SPS rack. For each operational SPS, the AMI terminal displaying the SPS Control Console has to be visible at all times to the operators, because monitoring the SPS is a 24/7/365 operation.

Since multiple SPS system will be hosted on a single GEMS rack in the new architecture, it would not be practical or desirable to have multiple monitors within the same rack. Instead thin clients will be used to provide user and operator access to the AMI functionalities on GEMS, as illustrated in Figure 7.

A thin client for the AMI will have only a video monitor, a mouse, a keyboard, speakers, and a network interface to connect to the AMI. All processing of data for the AMI is done on the blade server hosting the AMI application software, then relayed to the thin clients over the network. User interactions, such as mouse clicks and keystrokes on the thin clients, are also relayed back to the blade server over the network.

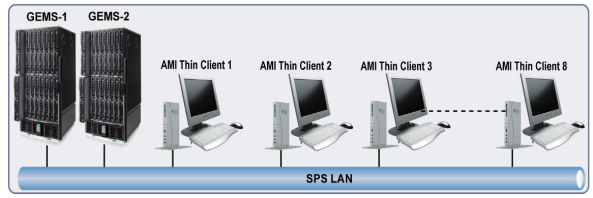

Figure 7. Use of thin clients to access AMI on GEMS at WCDAS.

The use of thin clients provides numerous advantages to the operating environment for SPS, including:

- Easy to upgrade hardware in the future,
- Reduced administration,
- Reduced energy consumption, and
- Lower hardware costs.

IV. CONCLUSION AND FUTURE WORK

Using a phased approach, NOAA has started to migrate the OGE components to a more centralized low-maintenance blade-based architecture. In this paper, we have described a software and hardware design and development approach for the migration of the second OGE component, SPS to the GEMS architecture. SPS units based on the GEMS architecture are to be deployed at WCDAS, FCDAS, WBU and NSOF.

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