

Design and Implementation of a Universal Middleware-Based Dynamic Module for SAR Electric Signal Processing in Satellite Systems

Hae-Jun LEE

Abstract: The implementation requirement of an AI modular system is expanding with various application technology fields. This integration of external application services could be a complete extensible system that should be flexible with dynamic modular components. The role between design for operation and service integrations, which is a prerequisite for dynamic application service modules and data convergence from compatible devices, should be tied to a value chain that circulates throughout processing, including the middleware concept. A universal middleware-based dynamic module as a platform is the discovery of value between such as an external system for AI modules inactivation, which is one step further extensible than the existing convergence middleware from devices to contextual application. This study addresses the challenges of managing and solving complexity control data about electric signals in satellite systems through the application of each unit as a dynamic process based on the universal middleware. In order to apply this universal middleware-based dynamic method, we constructed a space system with SAR signal data in a device, one of the satellite payload circuits in the low orbit, and a dynamic module. Among them, time constraints can be overcome by designing and applying dynamic systems using Universal Middleware in electrical devices, electronic modules, signal processing, and service gateways based on open architecture. In addition, function is given of communication and application interfaces, interaction convenient component as a dynamic service platform that could be connected to development modules, mission rules, and operation processes. A stable and independent system is configured to apply dynamic modules for these satellite circuit development requirements. In addition, these modules are based on compatible context models between different interfaces at the application service level. We propose a novel architecture that integrates SAR signal processing with a flexible middleware platform, enabling efficient resource management and dynamic service integration. Our approach combines Capsule Networks and Self-Attention Mechanisms to model both short-term and long-term user borrowing preferences in satellite operations. Experimental results demonstrate improved performance in terms of processing speed and resource utilization compared to traditional methods. The proposed system shows potential for enhancing the flexibility and efficiency of satellite payload operations.

Keywords: context awareness; dynamic service integration; satellite power modules; space systems; universal middleware

1 INTRODUCTION

AI, which is positioning itself as an icon of innovation, is confusing the knowledge industry that can create itself. This confusion is not expected to be organized in a short period of time due to arithmetic operation smarts in numerous manufacturing lines. Only recently, the system that can interact closest to humans aims to build a value chain that circulates throughout the electronic device fields of society. Satellite payload development is conducting multiple research projects on complicated dynamic systems connecting modules for device and service convergence powered by the widespread adoption of ICT computing convergence technologies. This vision still needs a role between operations and information technology for the convergence of data and AI. Therefore, we propose an integration using the Universal Middleware, which is a step further based on existing middleware solutions. As two short-term research methods for this proposal, we built the system to confirm the configuration method that can be verified on the testbed with SAR signal data, one of the existing satellite payload circuits, through the Dynamic Module concept as a design model [1]. The design of SAR application system is launched in the orbital mission which could influence the performance and the software module implementation. Its stability and thread process should be adequately proved. In the middle of application service with imaging data are included the challenges in managing SAR electric signals [2]. There have been limitations in resource management due to differences in technology between countries and biased system infrastructure in the satellite technology development stage [3]. In recent years, technical cooperation between researchers and institutions for managing common earth resources like the natural

environment, population, and climate has been passive [4]. In particular, the exchange of development resources for digital conversion of basic non-digital technology is passive, and research on the structure of an open system for establishing an open convergence service development environment is necessary [5]. This open system based on Universal Middleware concept could be divided into four layers, that is modular device approach that allows integrators to create programmable application [6]. This whole device extended from its applicable metadata like a common IoT application service model based on context components that depend on the framework into Universal Middleware [7]. The integrated Universal Middleware platform provides an environment to overcome the inefficiency of service convergence development due to the lack of linkage between satellite systems [8]. With the technology of Universal Middleware architecture for satellite design, development, operation, and utilization, it is possible to discover challenging and creative fields by selecting areas necessary for complex and demanding satellite development and further researching new service models by increasing their scalability [9]. The ESA's SantiNel Application Platform (SNAP) and NASA's OneWeb projects are identified as structures that consider scalability as examples of application platform research models based on similar dynamic service models [10]. The dynamic module in Universal Middleware provides scalability between different heterogeneous systems on the application platform, providing an inventory that allows you to systematically configure and manage the end-to-end structure of complex satellite systems [11]. In this paper, the main body presents a sample satellite hardware device structure for sharing interfaces between analytics and a framework for utilizing existing system resources using dynamic modules on the service registry in the system

component. As a result, it explains the sharing module for dynamic modularization of the structure of the Universal Middleware system using the network system method with the application client and the dynamic module of the application platform [12]. In addition, the effectiveness of dynamic modules between application modules is evaluated as a storage system model for simultaneously processing application instances and managing complex systems. Chapter 3 explains the conclusions [13, 14]. In order to dynamically configure for clustering with each kind of signal module, concurrency must be provided on the Universal Middleware as a contribution using the research platform. In this design, existing multiple distributed structures are provided in these deliverable service modules. This study applies the concept of life cycle processes using interfaces and dynamic systems between various device modules. First, a shared module for dynamic modularization was established using these, and the system structure was launched as a method to connect the application platform's dynamic module and the fundamental application client. Second, a storage system was designed to manage and organize instances of different applications concurrently. Third, the application features were extended to external systems and shared through dynamic modules to provide system resource management consequences.

2 LITERATURE REVIEW

A Universal Middleware started with the concept of integrating the systems that connect to each space on a low orbit network that integrates broadband from WAN to LAN. We refer to the integration of the service gateway based on a smart function as an open-structure serving system as a heterogeneous resource that exists between devices and application services [15]. Previous convergence research on devices and application services could not find coexistence orbital network with smart application services in several cases about the IoT field at the same cluster [16]. The different points of view on middleware service development and convergence service research using the Universal Middleware for satellite development and operation have huge resource constraints for system environment configuration [17]. It is to solve the huge system resource management issues of the multi-resource cyclic allocation mechanism. Dynamic resources lead to an increase of the utilisation rate of idle resources for jointly matching large amounts. This can be used as a reference to effectively realize optimal allocation of resources in resource-constrained environments [18]. In the process, controlling the change in the output rate according to the change in power, or checking the possibility of the change rate per hour, determines the performance of the development result according to the input and output results. IoT middleware provides real-time measurement of the root mean square values of active and reactive power over the efficiency of demand response services [19]. The electric circuitry used in satellite-mounted systems and the simulation tool at the design stage provide a dataset before configuring the actual signal. Using this, application services can be configured based on various design scenarios at the development module level [20]. As a consequence, the slew rate control

for maintaining SAR power electric signal stability and application services for elaborate variability reduction can be applied to the Universal Middleware of this study by referring to IoT for the Universal Middleware research cases. These reduction results can lead to minimizing the risk of examining the process of other related signal circuit power resources in an evaluation data control.

3 EXPERIMENTAL

The design method is based on the structure of the Universal Middleware exchange with two parts of applicable section and service interface. The first concentrated part of the hardware resource management is maintaining the stability of the SAR power electric signal. The second is the modularization part of the application services that make up the dynamic module. The major focus is to interact with the life cycle framework in the form of an objectified bundle of applications, communication services, and hardware that make up the interface with the Universal Middleware in the form of a dynamic module.

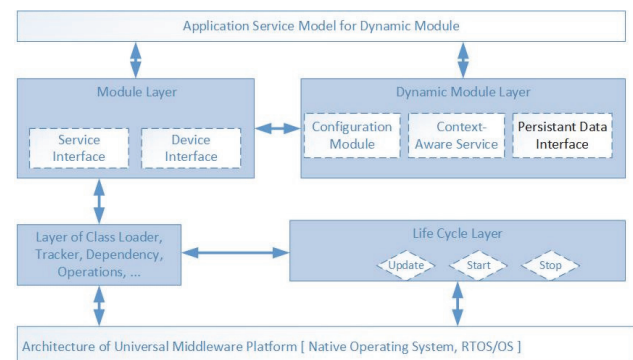


Figure 1 The benefit and dynamic module of layering for Universal Middleware Architecture

Fig. 1 describes the design of system concept that could be divided into four types of dynamic layer. The first layer is modularity. This breaks device application into manageable pieces, making it easier to maintain and evolve. The second layer is dynamic updates, i.e. updating or replacing already known modules in a running system without restarting the Java virtual machine. The third layer defines an interface module on how a bundle can import and export the other layer. It enables such a system keeping things as service oriented architecture and promotes layer of context where components communicate through well-defined interfaces. The fourth layer is an isolated class-loader with each universal module operating with its own class-loader, ensuring that module dependencies are properly separated, and unintentional interference between units is prevented.

In other words, SAR power electric signal data should be independently evaluated for frequency and application services for the algorithms configured as dynamic modules, depending on the quantity and accuracy of the circuit's experimental results. Therefore, the design of dynamic modules can reflect the analog circuit and system application organically with Universal Middleware. Radar systems that process large amounts of data at high speeds are tested at the subsystem stage for integrated synchronous data collection. It is necessary to build a

system that supports stable multi-threads that must maintain data processing levels to obtain optimal resolution at high-altitude locations that scan by moving geosynchronous orbits by tens of kilometers in real time. While supporting signal reception characteristics, scan speed, and object detection performance in the form of separate data threads, a separate radar is configured in the system's storage. Fig. 2 explains the methodology of a diagram to develop a subsystem experimental environment system dynamic module as an electric signal process using the Universal Middleware.

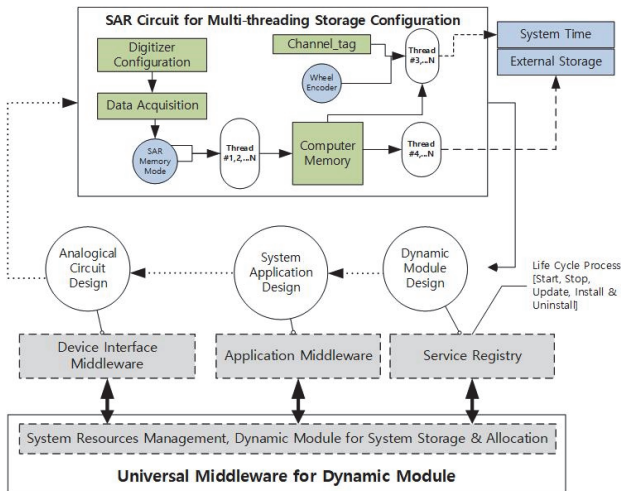


Figure 2 The diagram to develop a subsystem experimental environment using the dynamic module

It was referred to from a similar signal process case of high-speed dual-channel ultra-wideband Ground Penetration Radar (GPR) [21]. The GPR can be loaded into the system's dynamic execution storage using a different scanning method than the SAR but a similar electrical signal resource. As a result, the data in storage can be managed in the service registry, allowing the life cycle management process to control execution, deletion, and update processes by referencing other modules and requests for external services. To summarize this research, first, you can see the Satellite SAR Power Circuit Design and Analysis steps. Second, the dynamic modulation of the P-Channel Main Switching Model is applied. Third, various types of programs can be configured with application services through the Satellite Application Service and Interface.

3.1 Satellite SAR Power Circuit Design

Until recently, satellite state information monitoring technology was executed manually. The development environment is limited to the application of automation and smart solutions using ICT technology. In general, the layout can be designed using model-based system engineering (MBSE). In the MBSE model, the requirements for the verification design of the sensor layout of the electric device joint and the posture control system (AOCS) can be identified. The speed of passive model-based layout design due to a number of verification requirements is time-consuming, but it is a prerequisite for operational stability and the development process for mission execution. In addition, satellite circuit design and analysis are multiple overlapping processes. They involve

many use cases, such as a power design model operating in a space environment, a power stability model, an independent system engineering model of the body, an application device and service model of the payload, and a performance verification of the flight model [22].

Preferentially, in this study, the power design model and the application device and service model of the payload, according to the open structure mentioned in the introduction, are limited to be within the scope of the Universal Middleware environment.

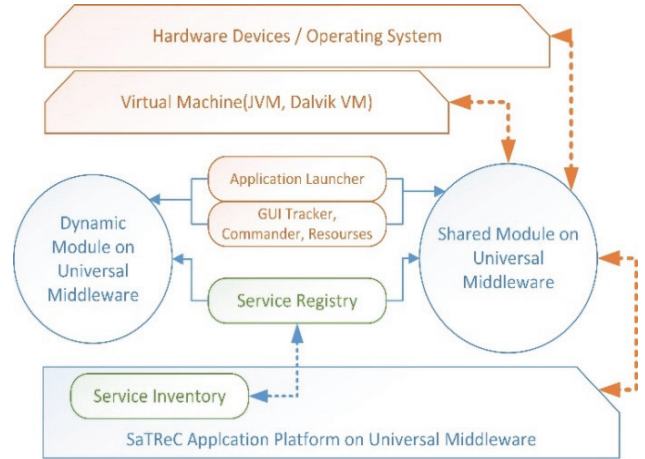


Figure 3 Construction of a universal middleware-based satellite power module evaluation service platform

In order to build the conceptual design of the dynamic module on a real system, as shown in Fig. 3, apply it in three layers as follows: The first is to build the service inventory located in the kernel. The second is to assign the role of the service registry. The third is to build a shared module to interact with the dynamic module. The role of service inventory is to recompile a public engine that supports the least amount of kernel, such as Linux, an operating system, and optimize it to conform to the Universal Middleware structure. Systemically, between storage allocation during kernel execution and data and application services, technology is applied to objectify resources needed to operate higher satellite systems. For this type of technology, you can use open engines that correspond to representative protocols and basic services supported by ontology, distributed objects, and remote systems. In the middleware Fig. 3, its service inventory is presented that constructs the basic framework of the Satellite Technology Research Center (SaTReC) Application Platform. This real time process could allocate the engineering model as an atmosphere and presents and evaluates resources related to the main switching model as a P-Channel [23, 24]. Thousands of modules are also intricately intertwined in each model that is integrated into this system. Among these types, the layer that can be introduced in the process from the design stage to the final prototype model is the introduction of the concept of the application platform. The types of modules in the integrated system are the distributed system, workflow and provision, deep learning, analysis, and engineering models. The application of the application platform concept is one of these types that can be introduced from the design stage to the final prototype model. This concept can be divided into three parts below.

- Dynamic module areas that organize movement between areas in contextual units.
- Modularization of Application service areas, including services and interfaces.
- System resources and performance management areas.

In order to implement modular objects, properties that can control the tracking system can be set, and a computational framework that can recognize the state of interworking with other modules is needed. The concept that plays this role is service registration, and it has properties that can be searched, modified, deleted, and updated in the context and connection direction of moving objects. It was built by applying systematic resource management engineering service technology for real-time data processing that must be built closely with system resources. The modularization principle is to classify the SAR electrical signal result data and extract it as meta-information. It saves time and money by packaging the input and output information included in the application service into meta information and providing customized services for system users. The application service modularization process provides a standardized model that can be executed according to performance, even on heterogeneous resources, by considering verification on external systems. It supports the system to guarantee the function of the satellite, which plays a key role in the lifespan of the satellite system and directly affects it. It is responsible for the development and standardization of the universal system, which serves as the integration of the software considering interoperability architecture. In the situation where the control module and the power consumption ratio change irregularly according to the mission trajectory, the state monitoring information was checked to form a reduction effect using resource sharing, which refers to the interaction with the ground station. It is possible to provide dynamic module services that can be expanded to various fields such as step-by-step testing, data acquisition and operation of the launch process, and remote management to improve satellite performance.

3.2 Dynamic Module for P-Channel Main Switching Model

The SAR satellite power system consists of a combination of high output, a pulsed power supply, and fast response speed. Based on the SAR power supply structure, between the modules connected to the SAR satellite power supply, it is connected by a discharge regulator (BDR) between the hardware bus and the SAR load bus that acts as a supply grid connection controller. The battery pack can be used efficiently by testing the solar supply bus array with the data generated from the SAR load bus. Since the power consumption for the combination must be minimized for practical operation, this study aims to confirm the accuracy of the scheme data that can satisfy the given situation. The key function of the Power Distribution Module (PDM), the SAR module of the satellite payload, is to maintain the stability of the current. It is designed by dividing it into high current switching, current sensing monitoring, current amplification, and external switching signal processing parts [25, 26]. Normal distribution and standard deviation can be found in an accurate dataset of characteristic common point coordinates affecting the accuracy of image space obtained

from satellites. We calculated the coordinate difference at the points selected from the OpenStreetMap (OSM) data and PDM data of the two image pairs SAR. In other words, the resolution can be expected based on the simulation data of OSM and PDM Circuit.

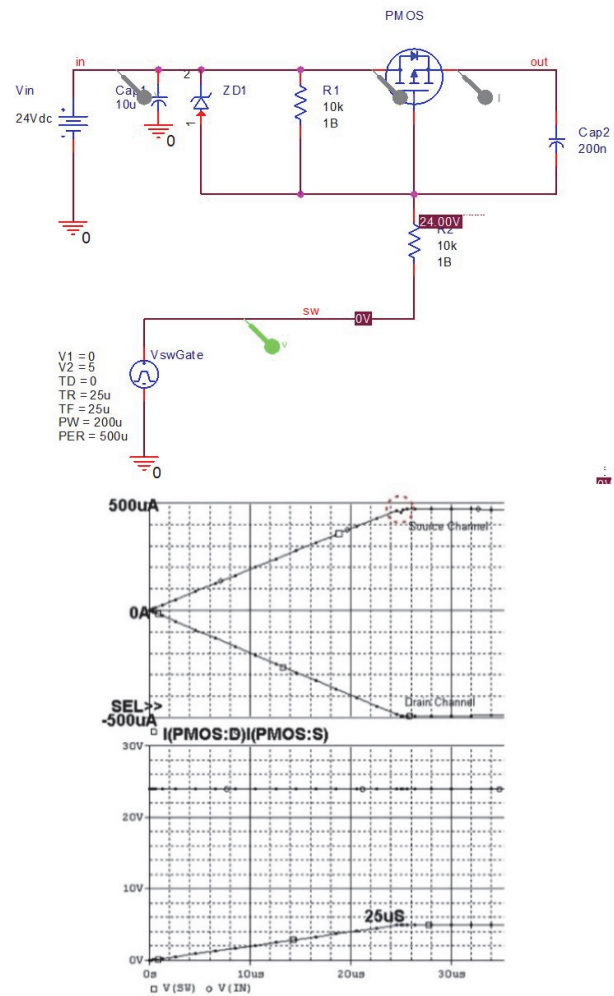


Figure 4 P-Channel main switching model & SPICE simulation

Techniques for precisely calculating different measurements are available model in SAR power simulation data module. For SPICE simulation tool provide measurement data resource about switching modules in Fig. 4, utilize the identical circuit diagram as the electric signal. As a key power distribution function supplied from the satellite, the design and simulation results of the P-Channel main switching circuit, a high current switching method from source to drain data, were presented. In addition, the results of the electronic circuit simulation show that about 800 nano-seconds, the source-drain delay and 20 uA's, the short channel is an efficient method. Inclusion occurred at 25 us, the switching on time. The expected output data can be derived through the simulator when the left circuit design is developed. After delaying some time, a light version of the circuit is redesigned on a prototyping board with systems to isolate the problem. We can get a chance to try adding pull-down resistors to the drain pins of the MOSFETs from middleware once again. The waveforms you are showing are classic capacitive discharge curves caused by high-impedance loads in part. It is crucial about your circuit, and then you could select parts of the International Rectifier (IR) series by reading the datasheet comparison. The process of

reflecting the system design to improve the performance of the SAR system requires multidisciplinary research infrastructure in fields like astronomy and physics. We explore how to reflect these spatial and temporal limitations in real hardware system parameters and environmental conditions. The optimal frequency band setting, which depends on the weather conditions and scan range, which are the parameters that directly affect the system, affects the fixed antenna aperture dimensions. Therefore, regardless of the minimum radar Pulse repetition frequency (PRF) frequency setting, the collection of system resource data will help reduce the search time [27]. To enhance the performance of different types of remote sensing applications in the SAR system, the image acquisition process is supported through the calibration and remote sensing designation of the ground target. For corner reflector calibration, SDR technology and existing corner reflector advantages are applied as a hybrid by utilizing software flexibility. Therefore, software-defined reflector (SDR) prototypes for verifying performance from a satellite SAR system perspective using middleware can be modularized in the form of meta information. The source of the high performance of SAR, a small satellite image collection device, is to show the optimized performance of the power module, which is a PDM. This method optimizes the design of P-Channel modules to increase the performance and accuracy of SAR radar [28]. Due to the advancement of module performance, the performance of power parts, the improvement of power distribution performance, the management of resource variability, and increased demand. Tab. 1 shows the gain and efficiencies of the proposed SAR array antenna. Design of some X-band antennas with inverted, certain-shaped arms for application modules.

Table 1 E_b/N_0 gain of PL compared to CL1

Gain / dB	$f_{dn} = 0.05$	$f_{dn} = 0.01$	$f_{dn} = 0.005$
BER = 10^{-5}	1.5	1.4	1.1
BER = 10^{-6}	1.8	1.6	1.5

Experiments that affect SAR image resolution take a few months, depending on the model stage. In this regard, it is necessary to examine the relationship between the elements of the parameter table for dynamically collecting modules that can confirm the effect of BER on the PL contrast gain. The PL performance of the system refers to the Bit Error Rate (BER) in Tab. 1. This assumes antennas with no gain are being used. For example, it can run in an application service with a dynamic module. Fig. 3 explains that PL equals gain (dB) in Tab. 1. It is necessary to support an application services data that can analyze complex variables according to application platform. As shown in Fig. 3, to provide the interface layout consists of user data storage with user information, interface storage with information on various interface layouts, and a mapping system storage with information on the relationship between interfaces linked to each user.

3.3 Modularization of Satellite Application Service and Interface

Three kinds of the context object component characteristics were modularised in the application's inventory function based on Universal Middleware. It

utilizes XML, which is commonly used for metadata processing, including web-based visualization, data management, system-linked information, and collaboration information sharing between modules. The main areas of use are data nodes distributed as data and web services, data visualization nodes, nodes for data retrieval, models, viewers, and quality of data sets, which are composed of metadata management systems to provide big data for collaboration and distributed processing. This allows hardware devices and module instances to be shared through XML-based rules for inventory classification while supporting dynamic services through registration between heterogeneous shared modules [29]. Next, the application launcher, application tracker, commander, and resource were bundled and supported to share resources between standard modules and heterogeneous dynamic services. In this process, Universal Middleware can be standardized in a form desired by suppliers, managers, and users, designed and provided in a bundle form, and provided a linked service that builds scenarios through storytelling according to the dynamic situation of each life cycle. The semantic web is intended to improve data accessibility, interpretability, and interoperability by using externally connected data from satellite schemes. It is necessary to share data and information between limited systems and to maintain mission constraints. It is also possible to reliably manage the scope of the principles and frameworks needed to connect and query data on its own system. In this way, when a dataset is connected to a semantic web, an external system uses a separate ontology to provide logical information to the data to help develop a deep learning data format. Using the life cycle process, deep learning systems can be accessed using query languages. By providing complex hardware design processes, performance tests, simulations in different environments at different stages of development, integration of interfaces and functions, and scalability through modularization, dynamic modules on Universal Middleware are distributed as APIs to eliminate redundant use of development resources and support the life cycle of recycling system resources [30]. The design method for connecting the internal and external systems using the dynamic module process is the effective sharing and management of internal resources. In addition, for external systems, it supports a service protocol that is advantageous for interface access and provides internal resource sharing and management information from the requester's terminal. In this way, the dynamic module process allows the internal system to support the private protocol and the external system to apply the interaction module policy to the public protocol.

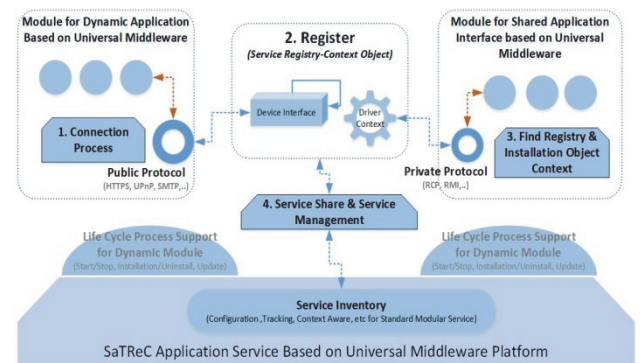


Figure 5 Dynamic module process between public and private protocol

Fig. 5 shows the configuration of a dynamic module that integrates hardware devices and application services in the satellite.

In the Dynamic Module, the function of Universal Middleware interacts between the Service Registry and the inventory classified in addition to it. As for the principle of interaction, it is possible to apply a dynamic service that gives each link between Connection, Register, Find and Install and Share and Management.

4 RESULT AND VERIFICATION

4.1 Result of Performance using Universal Middleware

The dynamic module is a sharing module with a user object-type structure that provides dynamic services. Interaction flows using Dynamic Service can analyze and model the state of personalized service flows through the interaction of modules using parameters as a medium. This is part of understanding the service context inside the SAR payload of a parameter medium. Dynamic service analysis techniques can store situational service interactions at a level that does not burden system performance. First, it can be linked to the service management information system and the human-computer interface field when converting to a personalized service by analyzing the parameter service interaction state. After that, the personalization model of the service interaction flow provides an interaction analysis technique using spatial coordinates. Universal Middleware, responsible for the interaction between the basic application client and the application platform, serves as a network system medium between services [31]. Fig. 5 and Tab. 2 are the results of determining and evaluating the configuration of a storage system that simultaneously processes and manages application instances of the devices, as mentioned earlier.

Table 2 The results of determining and evaluating of the storage system

Elapsed time	CPU	Memory	Swap
granularity/1sec	1*10 ⁹	1*10 ⁹	
00:01 (System Idle)	17.775	60.309	7.59E+09
00:14 (Run A.P.)	35.541	60.576	7.83E+09
00:15 (Run Application)	51.729	60.608	7.83E+09
00:30 (Run Application)	73.838	61.954	7.89E+09
00:44 (Run Idle)	31.642	61.4	7.87E+09
00:55 (Exit Application)	48.475	60.379	7.61E+09

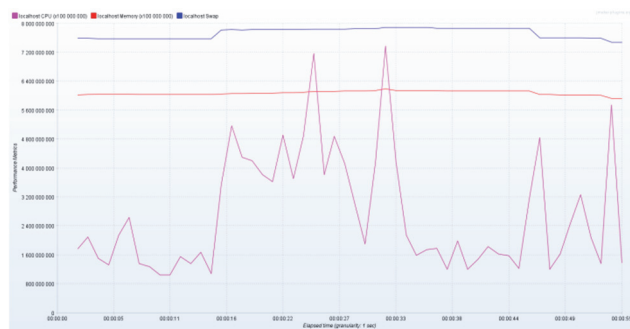


Figure 6 Results measured by JMeter

In comparison of the elapsed time to Tab. 1, measurement item of the system idle resource is more efficient. There is keeping around 1.645 on the same system for application execution that exhausted from

60.309 to 61.954. As shown in Fig. 6, descriptions of the application load context object and results measured by the application drive log and the Apache JMeter (ACME) are attached.

Looking at the measurement results, it can be seen that the performance of the red memory is constant compared to the deviation of the purple CPU performance on the local host. It parses system resource for multi-modal data and other kernel resources and sends application requests to retrieve them. Its primary purpose is to conduct load testing like this dynamic module for functional activation and evaluate performance. The application load measurement data stored in the CSV file was checked. As an evaluation performance in the user ramp-up environment, execution time distribution in Table 1 has a gap in application service execution time. In addition, there are gaps in system execution and at the time of termination.

4.2 Result of SAR Electrical Signal using Dynamic Module

In order to systematically implement a Universal Middleware engine with an open structure, independence between the system engine and the application service must be ensured. In particular, the system engine implemented in this study is part of the electrical signal data processing of the SAR circuit, which consists of two independent modules and the execution of applications based on dynamic modules to link the internal and external systems of the system simultaneously. These two application modules adopted a method of allocating the system middleware to the domestic and external systems, with the SAR electrical signal prioritized around the module in the run state. In the experimental system, it can be confirmed by displaying the granularity time. As a result, a standardized user interface module had to be implemented to support both GUI-type applications and web services. In addition, each of these dynamic modules had to be able to run and manage on the same host as a console. Among these, console management was limited to the level of support from traditional systems or supporting interworking in the form of packages, such as communication, service, service distribution, and external system authentication, payment, approval, and user management. ACME is a system environment that is executed after receiving a command from the application GUI through the controller. ACME's performance evaluation is possible only when the hosts for the test are placed on the same subnet and the internal IP address is used. In addition, the same version of Java may not work properly if there is a version difference between hosts. Fig. 7 and Fig. 8 show the results of a launch experiment of several internal applications using Universal Middleware-based engine and an external system, ACME command launch experiment.

In order to perform stress tests in the flight mode, the system middleware's private protocol and public protocol can be used to secure the module of the probe corresponding to the external system. In particular, Remote Method Invocation (RMI) requires surroundings and is an environment in which testing is performed on multiple worker nodes through this RMI to one controller node. The worker nodes are sending a request to the target system. After that, log information can check the status of the

system to check again whether the worker node is working. The experimental results confirmed that the system resources of distributed internal and external application services operate as dynamic services in an integrated environment. Looking at the elapsed timetable item on the right side of Fig. 7, it can be seen that the memory consumption is constantly compared to the CPU resources after the application module is executed.

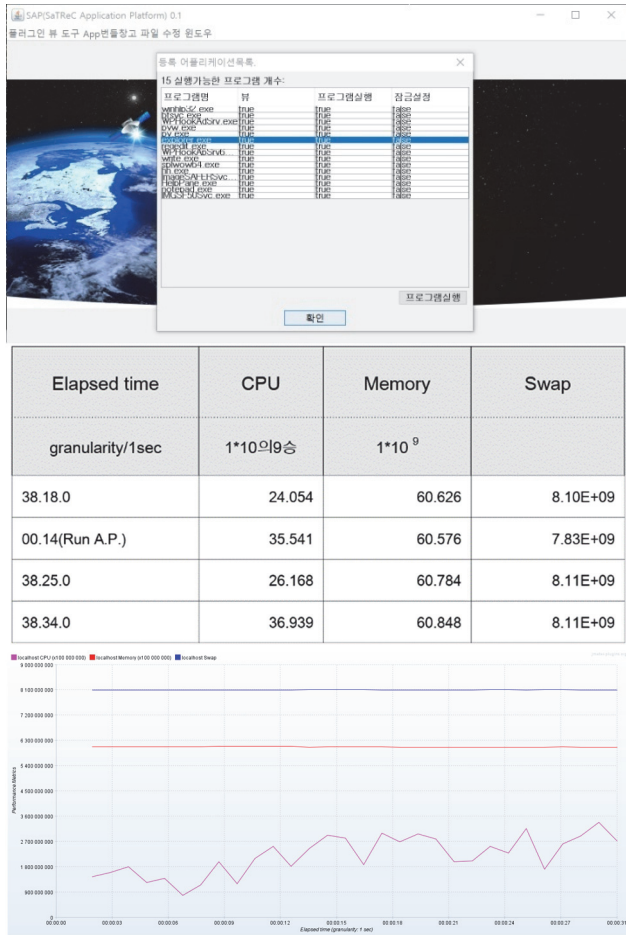


Figure 7 Running ACME application and results measured by JMeter

In order to perform stress tests in the flight mode, the system middleware's private protocol and public protocol can be used to secure the module of the probe corresponding to the external system. In particular, Remote Method Invocation (RMI) requires surroundings and is an environment in which testing is performed on multiple worker nodes through this RMI to one controller node. The worker nodes are sending a request to the target system. After that, log information can check the status of the system to check again whether the worker node is working. The experimental results confirmed that the system resources of distributed internal and external application services operate as dynamic services in an integrated environment. Looking at the elapsed timetable item on the right side of Fig. 7, it can be seen that the memory consumption is constantly compared to the CPU resources after the application module is executed. The dynamic module presented the effects of reuse and scalability services through a study of modules that support the convenience of Universal Middleware-based application platforms and network system methods with external systems like Medium Resolution Spectral Imager (MERC I) and Portal for Earth Observation Cal/Val

(Calvalus) [32]. The resolution processing algorithm for resolution as well as satellite SAR images requires the use of an image framework that takes into account the expected range of output image information. For image data fusion, spatial information, high-altitude, and high-spectrum resolution images of multi-spectrum (MS) images are converted. In the process of convergence from multiplexed linear projections, we focused on dynamically constructing the algorithm research method and performed imaging by referring to SAR electrical signal data. In other words, image fusion performance is corrected and processed by excluding optical characteristics in which the spectral response of actual equipment is different from that of SAR processor, like optical image fusion. This approach is effective in how computational algorithms for new imaging modalities involving large amounts of image processing can be converged. Compressed spectral data fusion using unique correlations focuses on supporting state-of-the-art algorithms that require high-performance systems [33]. Looking at the execution time distribution in the internal application execution experiment in Fig. 7, the difference between application service execution time gradually disappeared as the time series progressed, and the gap between system execution and termination decreased, maintaining the continuity of the gap for execution service.

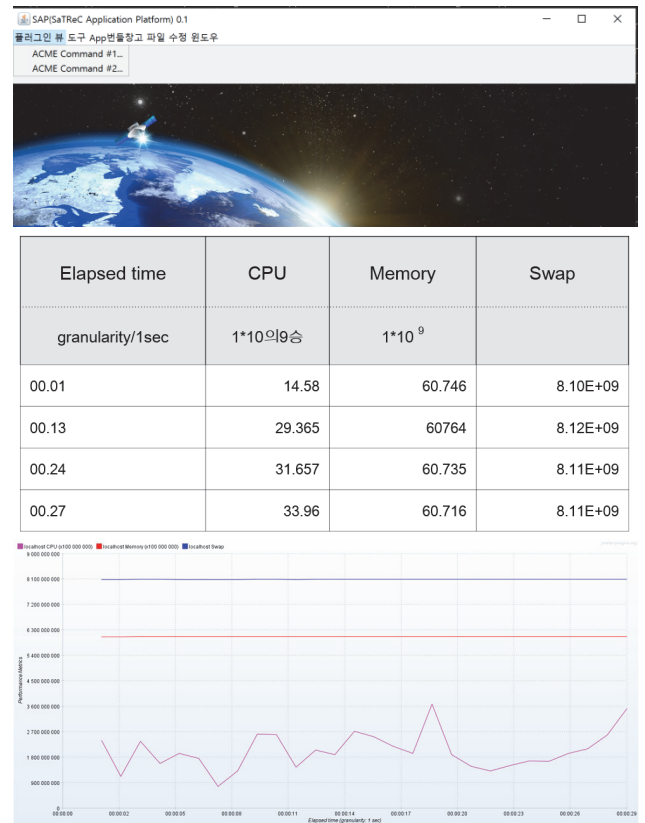


Figure 8 Running MERC I application and results measured by JMeter

Looking in the ACME Command execution experiment could be better efficiency around 18.7% from ACME to MERC I dynamic module using in Fig. 8, the distribution of internal application execution time in Fig. 7 maintains continuity because the application service execution time is constant, and there is no system execution gap. The estimation of stable performance about dynamic module could get 18% better system efficient rate that runs on the execution time with an application service for an

elapsed step in compared granularity per second in case of MERCI. Therefore, the mutual correlation provided by the Universal Middleware system was processed on the platform as a static module from system resources, and Circuit's Signal Electric algorithm data was processed as a dynamic module and maintained as an efficient system.

5 CONCLUSIONS

In this study, we focused on the implementation with dynamic service module development resources for the value-added data service based on Universal Middleware that applied the example of satellite SAR power modules. In a system export module of the outside, an open structure required for multiple protocols according to the network system with internal system devices, connection with application services, convergence between devices and import of other interfaces, service management, and sophisticated service configuration was presented and examined. It was able to organize a dynamic module that shared the memory of the kernel from the system middleware and the concept of service registration. The concept of constructing the Universal Middleware as a system middleware engine using an actual Linux kernel and a practical research method could be performed while porting the virtual machine.

The necessity of additional research was confirmed in the process of constructing the dynamic module around the SAR electrical signal presented in this work. The application program for the near future used the existing system software to build a subsystem experimental environment system using private and public protocols. It is also confirmed that it is effective in constructing dynamic services for the efficient fusion of SAR image data and metadata. Thus, we suggested that the standardized service state on the general-purpose service platform for inter-satellite linkage can be used as an efficient structure for a simultaneous multiplexed network system as a life cycle process. To maintain and manage static stability for each internal and external service of the satellite payload, various data collection and service creation, verification, and implementation when designing the system can be appropriately dealt with in the form of services linked to unexpected problems in a real-time execution environment.

We have been able to summarize a number of challenges for application to external electrical circuit modules for future research. The stability of dynamic modules and the CubeSat are more necessary in terms of power efficiency than the capacity of electrical power system with the main body. As a follow-up research project, it is necessary to develop a programmable interface that can link the existing simulation data model supported by MATLAB with the web service provided in this study. In particular, we are preparing a dynamic module study to change the operation mode of CubeSat, perform the Peak Voltage Array, and provide the Maximum Power Point Tracking (MPPT) impact analysis service. It is expected to play an important role in demonstrating the development of different simulations and new circuits depending on the usage time and operating trajectory of solar cells, converters, and power management boards. It is expected to contribute to discovering the exponentially increasing cube satellite service and service model in the future. In

addition, further research is needed to demonstrate the SAR power module and improve the system's usability and stability, which should have been covered in this study. This demonstration system presents a novel approach to SAR electric signal management in satellite systems using a universal middleware-based dynamic module. Our proposed architecture integrates Capsule Networks and Self-Attention Mechanisms to efficiently process SAR signals while providing flexible resource management.

From the perspective of various intelligent middleware systems, experimental results demonstrate improved processing speed and resource utilization compared to traditional methods. The dynamic module approach shows promise for enhancing the adaptability and efficiency of satellite payload operations. Future work should focus on further optimizing the system for real-world satellite deployments and exploring its applicability to other types of satellite payloads.

6 REFERENCES

- [1] Patera, L., Garbugli, A., Bujari, A., Scotece, D., & Corradi, A. (2022). A Layered Middleware for OT/IT Convergence to Empower Industry 5.0 Applications. *Sensors*, 22(1), 190. <https://doi.org/10.3390/s22010190>
- [2] Chan, Y. K., Yung, C. L., & Voon, C. K. (2022). Design and Implementation of Synthetic Aperture Radar (SAR) Field-Programmable Gate Array (FPGA)-Based Processor. *Applied Sciences*, 12(4), 1808. <https://doi.org/10.3390/app12041808>
- [3] 6th International Workshop on Lean Satellite. https://lean-sat.org/2023-2_nets-regist/images/6thWLS_program_final.pdf.
- [4] Masmoudi, M., Karray, M. H., Lamine, S. B. A. B., Zghal, H. B., & Archimede, B. (2020). Memon: Modular environmental monitoring ontology to link heterogeneous earth observed data. *Environmental Modelling & Software*, 124, 104581. <https://doi.org/10.1016/j.envsoft.2019.104581>
- [5] Ji, M. X. (2018). Tiantong-1 satellite mobile communication system market and application analysis. *Satellite and Internet*, 12, 42-43.
- [6] Chen, M. X. & Tzeng, T. C. (2011). Integrating service discovery technologies in OSGi platform. *Computer Standards & Interfaces*, 33(3), 271-279.
- [7] Lee, H. J. (2023). Dynamic Context Awareness of Universal Middleware based for IoT SNMP Service Platform. *Tehnički glasnik*, 17(2), 185-191.
- [8] Zhang, B. et al. (2022). Progress and Challenges in Intelligent Remote Sensing Satellite Systems. *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing*, 15, 1814-1822. <https://10.1109/JSTARS.2022.3148139>
- [9] Ferreira, L. C. B. C. et al. (2022). Edge Computing and Microservices Middleware for Home Energy Management Systems. *IEEE Access*, 10, 109663-109676. <https://10.1109/ACCESS.2022.3214229>
- [10] Bayless, A. J., Fryer, C. L., Wollaeger, R., Wiggins, B., Even, W., de la Rosa, J., Roming, P. W. A., Frey, L., Young, P. A., & Thorpe, R. (2017). The Supernovae Analysis Application (SNAP). *The Astrophysical Journal*, 846(2). <https://doi.org/10.3847/1538-4357/aa831d>
- [11] Razzaque, M. A., Milojevic-Jevric, M., Palade, A., & Clarke, S. (2015). Middleware for internet of things: a survey. *IEEE Internet of things journal*, 3(1), 70-95. <https://doi.org/10.1109/JIOT.2015.2498900>
- [12] Ilahi, R., Admodisastro, N., Mohd Ali, N., & Md. Sultan, A. B. (2018). Middleware-based Model for Dynamic

- Reconfiguration of Web Service. *International Journal of Grid and Distributed Computing*, 11(3), 89-98. <https://doi.org/10.14257/ijgcd.2018.11.3.08>
- [13] Protic, Yang, T., Xu, Q., Meng, F., & Sun, G. (2021, December). The distributed imaging processing method of space-borne SAR based on embedded GPU. *2021 CIE International Conference on Radar (Radar)*, 255-258. <https://doi.org/10.1109/Radar53847.2021.10028192>
- [14] Chen, M. C., Chen, J. L., & Chang, T. W. (2011). Android/OSGi-based vehicular network management system. *Computer Communications*, 34(2), 169-183. <https://doi.org/10.1016/j.comcom.2010.03.032>
- [15] N. Ishikawa, 3 - Middleware platform for smart home networks, Editor(s): Nobuo Saito, David Menga, (2015). *Woodhead Publishing Series in Electronic and Optical Materials, Ecological Design of Smart Home Networks*, Woodhead Publishing, 29-48, <https://doi.org/10.1016/B978-1-78242-119-1.00003-5>
- [16] Smart Things. <http://www.smartthings.com/>
- [17] Liu, Y., Cheng, Y., & Bao, K., Li, H., & Wan, Z. (2022). Design of power supply system for high power SAR satellite. *Journal of Physics: Conference Series*, 2361, 012016. <https://doi.org/10.1088/1742-6596/2361/1/012016>
- [18] Tang, Q. & Wu, B. (2024). A digital twin-driven multi-resource constrained location system for resource allocation. *The International Journal of Advanced Manufacturing Technology*, 130, 1-27. <https://doi.org/10.1007/s00170-023-12886-w>
- [19] Dhaou, I. B. (2023). Design and Implementation of an Internet-of-Things-Enabled Smart Meter and Smart Plug for Home-Energy-Management System. *Electronics*, 12, 4041. <https://doi.org/10.3390/electronics12194041>
- [20] Luo, X., Dooner, M., He, W., Wang, J., Li, Y., Li, D., & Kiselychnyk, O. (2018). Feasibility study of a simulation software tool development for dynamic modelling and transient control of adiabatic compressed air energy storage with its electrical power system applications, *Applied Energy*, 228, 1198-1219. <https://doi.org/10.1016/j.apenergy.2018.06.068>
- [21] Xu, X., Xia, T., Ma, Z., & Huston, D. (2019). An integrated synchronous data acquisition subsystem for high speed GPR system. *IET Circuits, Devices & Systems*, 13. <https://doi.org/10.1049/iet-cds.2018.5113>
- Wang, J., Jing, F., Xia, Y., & Xu, C. (2020). Study on model-based system engineering in satellite layout. *MATEC Web of Conferences*, 316, 04001. <https://doi.org/10.1051/mateconf/202031604001>
- [22] Wang, Z. C., Chen, C., Wang, H. D., Wang, C. Y., Wang, Z. F., & Ye, X. R. (2023). A modelling method of the on-state resistance of p-channel power MOSFETs under NBTI stress. *Microelectronics Reliability*, 150, 115157. <https://doi.org/10.1016/j.microrel.2023.115157>
- [23] Homaeinezhad, M. R. & Farzannasab, M. (2021). Switching position-torque control system for increasing servo PMDC positioning precision in presence of intense external disturbance loading. *Mechanical Systems and Signal Processing*, 158, 107816. <https://doi.org/10.1016/j.ymsp.2021.107816>
- [24] Kwon, T. & Jun, S. (2018). Small-cell base station power allocation to guarantee quality of service of macro-cell mobile station in hierarchical cell structure. *International Journal of Energy, Information and Communications*, 9(3-4), 13-18. <https://doi.org/10.21742/IJEIC.2018.9.3-4.03>
- [25] Honey, C. J., Newman, E. L., & Schapiro, A. C. (2017). Switching between internal and external modes: A multiscale learning principle. *Network Neuroscience*, 1(4), 339-356. https://doi.org/10.1162/NETN_a_00024
- [26] Kilcik, A., Demir, N., & Horzum, T. (2021). How do sentinel-1 SAR images match with the existing maps. *Turkish Journal of Remote Sensing*. <https://doi.org/10.51489/tuzal.854252>
- [27] Doerry, A. W. (2006). *Performance limits for synthetic aperture radar*. United States: N. p., Web. <https://doi.org/10.2172/878591>
- [28] Piccioni, A., Alesii, R., Santucci, F., & Graziosi, F. (2022). Software-defined Corner Reflector for Satellite SAR Systems. *2022 IEEE Aerospace Conference (AERO)*, 1-7. <https://doi.org/10.1109/AERO53065.2022.9843608>
- [29] Brovelli, M. A., Boccardo, P., Bordogna, G., Pepe, A., Crespi, M., Munafò, M., & Pirotti, F. (2019). Urban geo big data. *International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences*, XLII-4/W14, 23-30. <https://doi.org/10.5194/isprs-archives-XLII-4-W14-23-2019>
- [30] Ghose, A., Lissandrini, M., Hansen, E., & Weidema, B. (2021). A core ontology for modeling life cycle sustainability assessment on the semantic web. *Journal of Industrial Ecology*, 26. <https://doi.org/10.1111/jiec.13220>
- [31] Korhonen, O., Syrjänen, A. L., Kinnula, M., Isomursu, M., & Kuutti, K. (2017). Service Interaction flow analysis technique for service personalization. *8th Scandinavian Conference on Information Systems*, 83-97. https://doi.org/10.1007/978-3-319-64695-4_7
- [32] Lee, H., Ryu, S., Ryu, S., & Kim, B. (2018). A development of folded dipole antenna for 26.5~29.5 MHz band for immunity test by portable transmitters on vehicle components. *International Journal of Energy, Information and Communications*, 9(5-6), 1-6. <https://doi.org/10.21742/IJEIC.2018.9.5-6.01>
- [33] Rueda-Chacon, H., Rojas, F., & Arguello, H. (2021). Compressive spectral image fusion via a single aperture high throughput imaging system. *Scientific Reports*, 11, 10311. <https://doi.org/10.1038/s41598-021-89788-y>

Contact information:

Hae-Jun LEE, Associate Professor
IWCR, Kang Nam University, Republic of Korea
E-mail: haejuna@gmail.com