Advanced Simulation Architecture as a ROK-US OPCON Transformation Enabler

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ABSTRACT

In this paper, we discuss the advanced simulation architecture for KSIMS (Korea Simulation System) models. Thus far, ROK models have participated in ROK-US combined exercises as members in a single combined ROK-US federation. Now facing the transformation era, ROK Armed Forces is preparing the Wartime Operational Control Authority Transfer between ROK-US in the year 2012. It is essential to design and implement the advanced simulation architecture to fulfill its specific needs and requirements—the new architecture should enable us to conduct various exercises independently with its own models while remaining able to conduct ROK-US bilateral (currently called combined) exercises interdependently in an interoperable and need-to-know basis. To achieve this purpose, we have designed the hierarchical federations to assure the fulfillment of functionality aligning with our requirements focused on the interoperability and security issues. We present our current results and on-going efforts to confirm the pros and cons of the design.

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INTRODUCTION

We stand before the start of a new era, an era of transformation which will be triggered by Wartime Operational Control (OPCON) Authority Transfer planned on April 17, 2012 between the Republic of Korea (ROK) and United States (US). Current ROK-US combined defense system will be transformed into a new cooperative "ROK Supported, US Supporting" defense system. At that time, CFC (Combined Forces Command) will be disestablished. The new ROK/US military alliance will establish separate but complementary national commands. ROK Joint Forces Command (JFC) has OPCON of all ROK forces and is the supported command. US Korea Command (KORCOM) has OPCON of all US forces and is the supporting command.

Aligning with the changes, the ROK will proactively assume a leading position in the ROK-US combined exercises currently led by the US. All of the changes brought by the transfer urge us to construct a new independent exercise simulation system in order to economically conduct exercise and training as well as to devise an Operation Plan (OP) and verify its reliability.

In the current combined exercise simulation support structure, all ROK models are joined in a single federation and the US manages all of that federation system. But it will be not suitable for ROK-led simulation support to accomplish the operational requirements of OPCON transfer. We believe that the simulation architecture should be improved to reflect the bilateral concept to fulfill the real world operational requirement.

In addition to that, it is essential to consider interoperability with US simulation systems while developing an independent ROK simulation support system. One of those is the necessity of a hierarchical federation to conduct bilateral exercises which will replace ROK-US combined exercises after OPCON transfer. To meet the operational requirements after OPCON transfer, the hierarchical federation has to provide the capabilities with ROK-US bilateral exercises on an interoperable and need-to-know basis (Guangya LI, Stephen TURNER, Wentong CAI03).

This paper will present a design of an advanced simulation architecture as the ROK-US OPCON Transformation Enabler. Part 2 will take a background on the ROK-US OPCON transformation and then current status will be explained. Part 3 will describe the background of the reasons that we have to choose a hierarchical federation and the previous research results of a multi-federation design. Part 4 will present the design of our advanced simulation architecture that will be applied for future bilateral exercises. Part 5 reviews the results of prototyping and testing. Part 6 will discuss the confronted challenges. Conclusions are provided in the final part.

ROK-US OPCON TRANSFORMATION

ROK-US CFC, organized in 1978, has contributed to deter North Korea's aggression and maintained defense readiness posture. According to CODA (Combined Delegated Authority), the CFC commander takes the responsibility of conducting combined exercises to maintain combat readiness posture for deterring war and Korean peninsula defense. CODA describes six authorities delegated to the CFC commander including planning and execution of ROK-US combined exercises during armistice time for wartime operation.

Another main turning point came from the EASI (East Asia Strategic Initiative) planning based on the law of Nun-Warner. One of the main contexts in that was to redefine OPCON—wartime and armistice time—and transfer armistice OPCON to ROK resulted in the foundation to start ROK Armed Forces' playing a role as the leading (supported) Forces and US Forces as the supporting forces.

In the 38th ROK-US SCM(Security Consultative Meeting) held in October 2006, the ROK and US sides agreed to transfer the wartime OPCON authority to ROK Armed Forces in a proper time from 15th October 2009 to 15th March 2012. ROK Minister of Defense and US Secretary of Defense finalized the transfer time on 17th April 2012 during their meeting held at Washington DC in February 2007.

Therefore, when wartime operation control is transferred, a new independent exercise support system will have been constructed to meet newly emerged operational requirements. In order to achieve this, closer coordination between ROK and US is required, and interoperability must be provided.

Way Ahead for an Exercise Support System for ROK-US OPCON Transformation

Figure 1 represents the roadmap, which the ROK and US sides agreed, for the OPCON transfer in terms of combined/joint exercises. During the remaining four years and combined exercises, transformation will occur in each area.

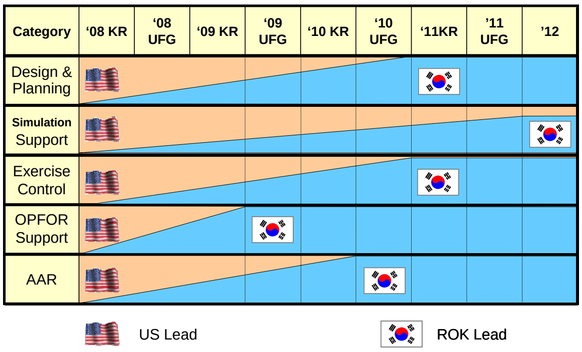


Figure 1. Road Map for OPCON Transfer

There are five categories to meet the requirement of OPCON transfer in the area of simulation support system such as exercise design and planning, simulation support, exercise control system, OPFOR(Opposing force), and AAR(After Action Review). Currently, CFC leads the exercise design and planning to create an exercise environment identical to the actual operation environment.

ROK organizations are participating in each combined exercise in order to gain knowledge and experience to lead the planning. On the other hands, while ROK simulation models are being more and more employed, there is still a lot of preparation necessary for ROK-led simulation support. In addition, separate ROK Wide Area Network (WAN) needs to be constructed and also confederate with that of the US. ROK has been using the US WAN, but after the OPCON Transfer the need for separate ROK WAN will arise upon which an exercise control system will be constructed. OPFOR support is more flexible than other areas and will be led by ROK starting from UFG '09. The area that requires the most thorough preparation, simulation support will be led by ROK no later than in 2012.

Current Simulation Architecture for ROK-US Combined Exercises

The simulation architecture for ROK-US combined exercises such as KR/FE and UFG 08 has a complex structure applied by various confederation protocols. As shown in Figure 2, the simulation components are sorted out as the JTTI+K (Joint Training Transformation Initiative + KSIMS) main models, special models, interfaces, and C4ISR systems. The models and C4ISR systems are linked to each other by various interfaces. From those interfaces, the simulated situations are feeding to C4ISR systems through interfaces and all information are gathered on the COP (Common Operation Picture). Therefore, the training audience can use their C4ISR systems and evaluate the current situation on the COP just like wartime.

In the current combined exercise simulation support structure, all of the ROK models are joined just in a single federation, which the US manages all federation systems. In order to be suitable for ROK-led simulation support after OPCON transfer, the simulation architecture should be improved to reflect the bilateral concept for fulfilling the real world operational requirement. To achieve this, we design and implement hierarchical federations.

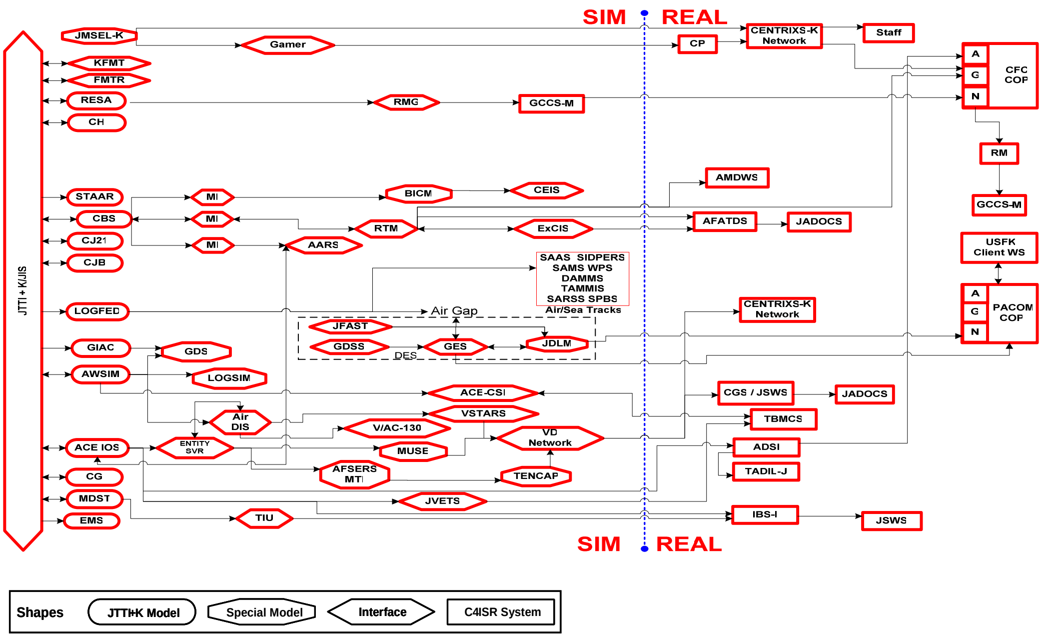


Figure 2. Simulation to C4ISR Architecture for ROK/US Combined Exercises

BACKGROUND OF HIRARCHICAL FEDERATION

Limitation in the HLA

The HLA provides a common simulation infrastructure called a federation to share necessary information transparently among various individual simulation models called federates. Also it provides demanding requirements from various different users, which are limited if one individual model tries to satisfy all users' requirements. The inherent feature of the HLA can make participated federates interact each other while heterogeneous federates supported by runtime components defined by Run-Time Infrastructure are unaware of each other. As the result of the coherent feature of so-called asynchronous communication—sending (publishing) and receiving (subscribing) the events without depending on each other's identity and location in a sense of loosely coupled way—enhance reusability and interoperability.

In the HLA, a federate can play a role as a publisher or subscriber or both using its own information defined in the Simulation Object Model (SOM) while a federation maintains the Federation Object Model (FOM) collected from the SOM to be shared among federates.

A shortcoming of the current implementation of the RTI is that it is restricted for publishers to inform only some interested subscribers on a need-to-know basis. Also, once the RTI establishes the intent from publishers to declare what they want to publish and prepare to disseminate the published information, there is no way to prevent a subscriber from receiving whatever it wants to receive. Thus, using a single level of federation, information hiding between groups of federates cannot be realized (Wentong CAI, Stephen J. TURNER, Boon Ping GAN, 01, Jae-Hyun Kim and TagGon Kim, 05, Gerry Magee, Dr.Pete Hoare, 99).

Type of Hierarchical Federation

A federation community is a group of federations and RTIs working together to achieve a common goal. The term hierarchical federations refers to a special type of federation community in which federations are organized into hierarchies so that a federation appears as a federate in an upper level federation (Wentong CAI, Stephen J. TURNER, Boon Ping GAN, 01).

Various issues on interoperability and heterogeneity of a federation community have been addressed by the RTI Interoperability Group. Combinations of FOM and RTI types, based on integration schemes of existing federations, can be sorted into 4 kinds: homogeneous

FOM and RTI, homogeneous FOM and heterogeneous RTI, heterogeneous FOM and homogeneous RTI and heterogeneous FOM and RTI (Michael D. Myjak, Duncan Clark and Tom Lake, 99, Michael D. Myjak, Russell L. Carter, Douglas D. Wood , Mikel D. Petty, 99). Primary consideration will be given to the heterogeneous FOM and RTI scheme that can be applied in general application environments. Federation Gateway, Proxy federate, RTI broker, and RTI-to- RTI protocol are the four kinds of connections between federations that will also make it possible to construct a multi-federation (Michael D. Myjak, Sean T. Sharp, 99).

The hierarchical federation architecture used in this paper is illustrated in Figure 3, where two user federations (one federation for ROK and another for US) form a super-federation. It adopts, as an interface, a hybrid approach using a combination of both gateway and proxy for interoperability and information hiding between simulation federations (Wentong CAI, Stephen J. TURNER, Boon Ping GAN, 01)

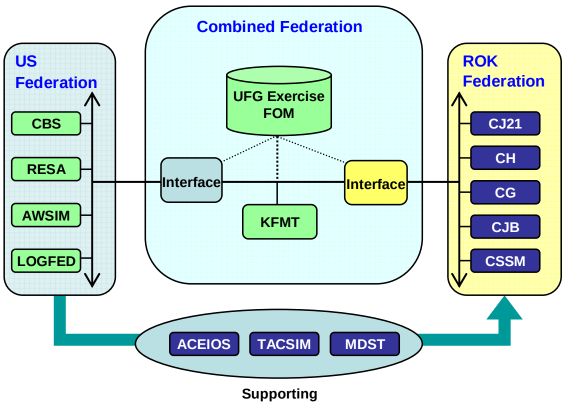


Figure 3. Architecture under the Lead of ROK after OPCON transfer

Hierarchical federations have also been studied in a previous IITSEC paper (Seung-Lyeol Cha, Thomas W. Green, Chong-Ho Lee, 04). Previous work has mainly focused on improving the current simulation architecture for ROK-US combined exercises to provide a great level of enhancement in the exercises while reducing costs. But to prepare for OPCON transfer, the ROK Armed Forces should construct its own simulation system to meet newly emerged operational requirements and confederate with the US system based on its purpose and usage. To enable the bilateral exercise as well as a combined exercise according to its requirement, it is imperative to construct a hierarchical federation—reflecting the concept of system-to-system confederation approach—in an interoperable and need-to-know basis. In other words, both ROK and US should create their own federations separately and finally confederate their federations to share the demanded information to both while protecting their information where appropriate. At the same time, the hierarchical architecture also guarantees that effective data sharing as well as consistent data understanding is maintained as before. In addition to that, Figure 3 also shows US assistance will be necessary after OPCON transfer. The specific models of ISR simulation systems such as ACE-IOS, TACSIM, and MDST will still be needed to be supported by the US.

The US has already evolved into the concepts of multi-federation through an interface called WARSIM (War fighters Simulation) Bridge or RIALTO (The MITRE Corporation, 2008). For example, there are a total of four federations in three security enclaves in Figure 4.

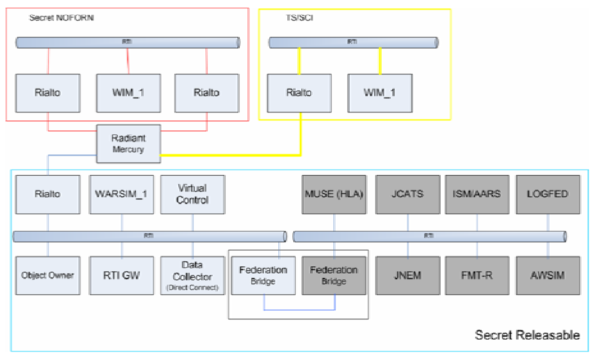


Figure 4. Notional Architecture of Multi-Federation

Hence, our research objective is to focus on the interoperability and security issues in hierarchical federation to fulfill the bilateral concept of fulfilling the real world operational requirement.

AN ADVANCED SIMULATION ARCHITECTURE DESIGN

Required Simulation Architecture for ROK-US Bilateral Exercises

To achieve the goals of bilateral exercise after OPCON transfer, the following requirements are needed.

First, the interoperability between ROK and US models needs to be assured especially from an operational perspective. Defined FOMs, such as each FOM for ROK, US and another one for combined FOM must interoperate fully to confederate with ROK-US models to meet the new exercises goals.

Secondly, the system development and maintenance should be easy. User requirements should be reflected easily in the phase of system development. Also, to add new models during the system operation and to maintain the existing system, system extensibility and flexibility should be considered.

Thirdly, the resource reusability should be maximized through minimizing the modification of existing systems. The issues in designing our hierarchical federation should echo the reusability addressed in the HLA—minimize additional redundant development and maximize the use of the existing model's functionality.

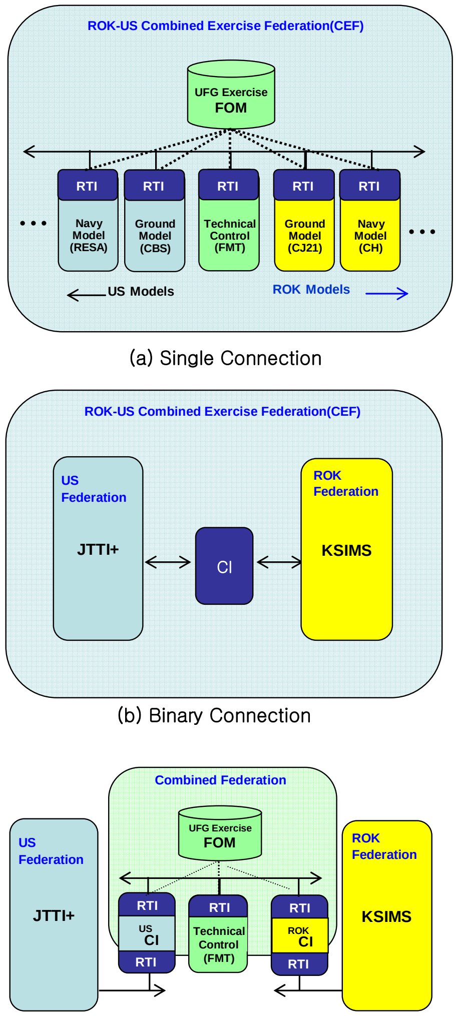
Fourthly, each country should apply its own specific security regulations considering the bilateral exercise as a nation-to-nation confederation of each one's simulation systems. Currently ROK-US combined exercises use a single federation. Because of inherent limitations of a single federation, it let ROK data such as the force structure, weapon system, and unit location flow to US side without filtering the crucial data required to be protected while it is difficult to review the US data. To avoid inborn features of a single federation architecture—all information of published objects is releasable, it is necessary not to fully expose its FOM to the other participants by classifying the information as explicit or implicit according to its own security regulations.

It is estimated that the early phase of a ROK-US bilateral exercise has a possibility to overlook the importance of security issues caused inevitably by putting emphasis on the necessity of simulation interoperability. But as the simulation interoperability settles down and the complexity of federation management grows exponentially when the number of federates increases, it requires more of a security mechanism to assure that only necessary data flows from one federation to its counterpart federation. Another difficulty is the weakness of single federations to protect data. The ability to see all the information attached to the RTI exposes all data which is easy for a hacker to draw information from the federation or infect the computer with a virus.

Last but not least, the design of the new architecture should minimize the influence of constraints occurring in one federation to the whole system. During ROK-US bilateral exercises, unexpected errors or crash effects must be limited to keep both ROK-US models staying robust. From previous experience participating in the large-scale combined exercises such as KR/FE or UFG, performance degrading and errors cause serious problems that were difficult to find.

Integration of ROK and US Simulation Systems

In Figure 5, Integration is classified into three possible methods considering current RTI functionalities which can provide the simulation architecture currently used or applicable in the future for OPCON transfer.



(a) Single Connection

(b) Binary Connection

(c) Hierarchical Connection

Figure 5. ROK-US Simulation Architecture

Figure 5(a) is the single connection architecture—called flat federation where all federates are joined to a single federation. Such a flat federation is easy for maintaining and managing the federation because, by sharing the homogenous FOM, all federates can join and interconnect. But this architecture shows its limitation by making all ROK-US federates in combined exercise depend on the FOM. Therefore its inherent condition makes changing objects on the FOM troublesome because of lots of effort by all sides results from changes and reaching an agreement and mutual consent.

In addition, the federates in ROK-US combined exercise which want to participate in their own nation's federation need to be updated. Especially it leads to the situation of opening one nation's information to the other and vice versa. As it appears, it is difficult to keep the vital information secure. Such a flat architecture can be applied in a short term for ROK-US combined exercises because it is easy to implement and maintain. But it is not suitable for a long term basis necessary for bilateral exercises because it demands too many resources for maintenance.

Figure 5(b) is a binary connection architecture directly connecting KSIMS and JTTI+ through a CI (Confederation Interface). This architecture confederates two federations directly through a confederation interface, also called gateway or proxy federate. Its main advantage comes from the use of existing federations directly. The disadvantage comes from the existence of its vulnerability of exposing one's own FOM. Figure 5(c) is a hierarchical Connection architecture indirectly connecting KSIMS and JTTI+ through a new combined federation, two CIs, and super FOM.

The single federation architecture is easier for ROK-US federates to apply in combined exercises if those are built capable of implementing the handing structure of confederating objects and HLA interface. On the other hand, as in Figure 5(b) or 5(c), to achieve their own goals, CI development for interconnecting ROK and US federations as well as mutual agreement for various issues of confederation are necessary. The US has already constructed and operated interconnected multi-federation (Figure 4, The MITRE Corporation, 2008).

The Schema of Hierarchical Federation

A hierarchical federation consists of an additional upper federation called a combined Federation with a combined FOM and lower federations in which each ROK and US federation interconnect through each CI independently. The combined federation forms a multi-federation with each ROK and US interdependently [Figure 5 (c)].

By making the simulation architecture of bilateral combined exercises form hierarchical architectures, the ROK and the US can reuse the federation used in bilateral exercises, which minimizes the additional development cost. In addition to that, it gives each model more flexibility to participate in other federations when necessary.

In the hierarchical Architecture, the ROK and the US reorganize the object model to meet combined FOM for ROK-US bilateral exercises and both sides create their own federations and FOM separately based on the concept of a system-to-system confederation approach. By doing that, ROK and US sides can have positive effects that provide a mechanism to protect their information and also to give each nation more flexibility to change or update easily whenever user requirements are changed. Another advantage of the CI is data flowing restriction. Because of CI's role, responsibility and collaborations focus mainly on the effective data sharing including information filtering and consistent data interpretation like a single federation, it will be useful to minimize data traffic—only necessary data flows from one federation to its counterpart.

CI also keeps both federations flowing data in a need-to-know basis, which that role is located on a super FOM and each independent FOM will be used only for each nation's own requirement. Also, both federations are physically separated so that both can make sure that their important data is maintained properly in a secure condition.

Moreover, when a new federate joins in federation, the data communication amount can not be increased compared with a current single federation architecture. By only flowing necessary data, the amount of data traffic can be minimized, because a new federate communicates with only models in its federation. Also, when a model is modified in the hierarchical architecture, the other models' modification not in the same federation is not required more than the current architecture. More than these merits, the most important meaning of the future architecture is that the hierarchical architecture meets the concept of a future confederation system. We believe that the simulation architecture should fulfill the real world operational requirement. ROK Armed Forces has the primary responsibility of Korean peninsula defense as the leading forces. USFK and augmenting forces take the supporting role for ROK Armed Forces. Therefore, the ROK side should take charge of simulation support. Also the federation architecture should be same as the real world operational architecture in terms of leading forces and supporting forces.

An hierarchical federation also provides an option to choose heterogeneous vendor and RTI version. By replacing only one side's surrogate suitable for the other federation's vendor and version, it can be possible to use different ones from each side's federation. In that sense, hierarchical federations also solve annoying situations that have to choose RTI vendors (Anthony Cramp, John P. Best, and Michael J. Oudshoorn 2002), freeing the technical, political, and economic considerations (Michael Imbrogno, Wayne Robbines and Gerard Pieris, 2004). Moreover, as hierarchical federations can decrease the number of federates in its federation, time advancing will be more efficient compared to a single federation architecture.

Confederation Interface Design

Figure 6, shows CI structure consisting of configuration elements such as Surrogate, Transformation Manager (TM), CI Initialization Data (CIID) and a Mapping Table.

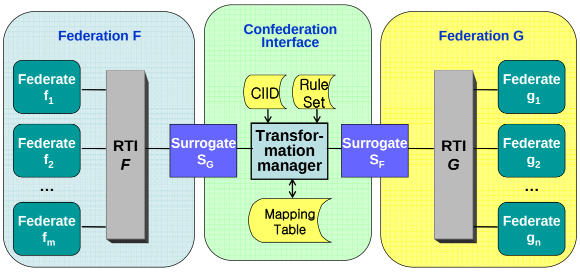


Figure 6. Confederation Interface Structure

A surrogate acts as any other federate within the domestic federation and represents that part of a foreign federation which must be communicated "outside" the foreign federation(Wesley Braudaway, Reed Little, 97). The surrogate becomes an interface with the federation execution process to transfer HLA functionalities—Federation Management, Declaration Management, Object Management, Ownership Management, Time Management and Data Distribution Management.

CIID (Confederation Interface Initialization Data) contains the initialized information of the CI operation such as SOM, mapping information, name of federation/federate, filename of FED, etc. The mapping table saves and refers the object handle value, interaction handle value and data conversion information necessary to inter-map between the two federations. That information will be collected after two surrogates join each federation.

Each side, ROK and US, should be responsible for its own security. The rules set table defines rules that provide a way to enforce security. Each rule represents a method to decide whether data can flow from one direction to the other.

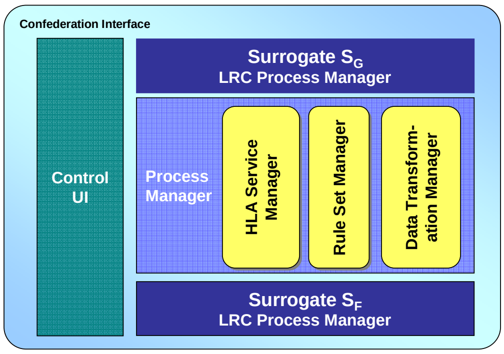


Figure 7. Transformation Manager Structure

As Figure 7 pictures, the TM (Transformation Manager) functions to transfer data between each federation and to convert data transferred in shared memory. It has three other rules—HLA service manager, rule set manager, and data transformation manager such as time synchronization between two federations, transaction of services such as SAVE and RESTORE, security guard through rule sets.

As shown in Figure 4 and 6, the US uses a Rialto-Radiant Mercury-Rialto combination for the information hiding. It has the capability to support bi-directional flow and MLS (Multi-level security) (Jarrellann Filsinger, 97, LouAnna Notargiacomo, Linda M. Schlipper, 01). Rialto is responsible for connecting two federations with a homogeneous federation object model (FOM) with different security classifications. It also assumes that the representation of time is the same cross federation and that federation policies are the same. It expects the data encoding scheme to be the same. Basically the Rialto-Radiant Mercury-Rialto combination is used to prevent unauthorized data from traversing the cross federation barrier.

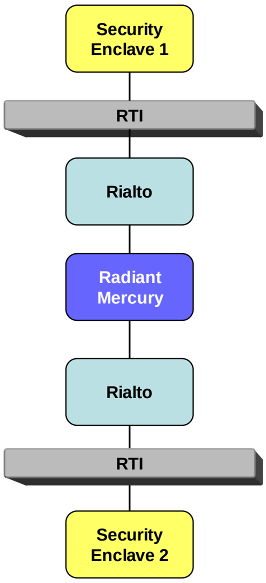


Figure 8. Rialto-Radiant Mercury-Rialto Combination for the implementation of MLS

The Rialto takes data from one enclave and translates it to an intermediate format that Radiant Mercury can process. Radiant Mercury applies a rule set to the data to determine if it should be allowed to be sent to the other enclave. If the data is allowed to pass then Rialto takes the data and applies it to the other enclave.

Proposed Hierarchical Federation

Currently, the US side has already constructed and operated to interconnect federations that make data flow bi-directional. Figure 9 suggests bilateral exercise federation architecture to meet our operational requirement after OPCON transfer as well as to align with the evolution direction of the US.

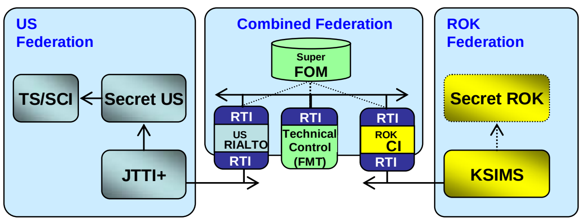


Figure 9. Suggested Bilateral Exercise Federation Architecture

This architecture shows that the ROK-US reorganizes the object model for the combined FOM and creates its own federations and FOM separately. It enhances security by information hiding and minimizes the influence from the other nation's federates.

To meet our operational requirement after OPCON transfer and align with the evolution direction of the US, it is essential to develop CI to fulfill requirements of OPCON transfer. Therefore it will be important to change the simulation architecture from a single federation to hierarchical federation after developing CI and super FOM by ROK-US mutual agreement.

PROTOTYPING AND TESTING

The CBSC (Combined Battle Simulation Center) developed a pilot system of the hierarchical federation architecture using CI as shown in Figure 10(ROK-US CBSC, 08).

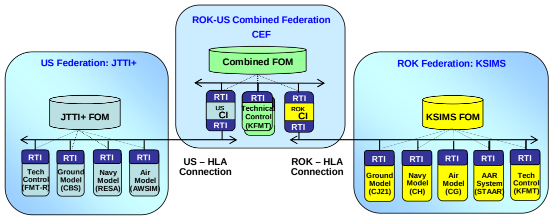


Figure 10. System Configuration of a Pilot System

The pilot system consisted of three federations: the Joint Training Transformation Initiative (JTTI+) for the US Federation, the Korean Simulation System (KSIMS) for the ROK Federation and the Combined Exercise Federation (CEF) for ROK-US Combined Federation.

The development environment was consisted of C++ and JAVA language on Windows XP and Linux Redhat Enterprise 3.0. VTC RTI NG-Pro v3.0.2.4, currently used in ROK-US combined exercises, was applied. The models which participated in KSIMS are as follows: CJ21 (Ground model), Chung-Hae (Naval model), Chang-gong (Air force model), Sim-Test (events generator) and STAAR (System for Theater level After Action Review). Because it was restricted for each model to participate directly, we used a load generator called Sim-test, which generated a log file from each model. CBS, RESA and AWSIM participated in the JTTI+, and KFMT (Korean Federation Management Tool) participated in the upper CEF, which was confederated through CIs.

The CI simultaneously joined two different federations and then executed the Transformation Manager (TM) function, which undertook the RTI service relays and data conversion. The current CI implemented federations, declaration, object and time management services, but the relay functions of ownership and data distribution management services are not yet implemented.

The actual test was divided into an integration test and load test. In the integration test, KSIMS, JTTI+ and CEF were successfully integrated into a hierarchical federation using a ROK CI and US CI. From this test, we found all 4 functionalities—federation, declaration, object, time management—were implemented successfully. The load test was conducted using the log generated during the ROK-US combined federation test (Combined Battle Simulation Center (CBSC, 08). STAAR, which collected all data and confirmed the results. Several different size log files in various testing environments were used in the execution of these tests. The log file used was approximately 15,000 object instances with 2,000 messages updated per minute for 30 hours of simulation time. Those object counts are typical in a Korean theater exercise.

During the test, the game to real-time ratio objective, based on combined exercise requirements (2:1), was met. On the other hand, speed latency happened depending on the data overloading and phases with three steps being required in each federation's event transmission. The performance issues largely resulted from the overloading of CI to handle the events. For example, if KSIMS creates a certain event, then that event will be transmitted to the ROK CI then to the combined Federation, which will process the event and transmit it to the US CI and finally to the JTTI+.

Based on the test result, we confirmed again that the hierarchical federation architecture could be positively considered as actual exercise simulation architecture. But the hierarchical federation constructed based on developed CI still has performance issues compared with a single federation.

CONFRONTED CHALLENGES

The results showed that the hierarchical federation using CI provided useful solutions for ROK-US bilateral exercises after OPCON Transfer.

We also realized that a couple of areas are needed to be studied and further tested to guarantee that hierarchical federation can support all of HLA/RTI functionalities transparently like that of a single federation. Also it will be required to develop CI, which has never been used before reaching an agreement between ROK and US.

First, it is crucial in ROK-US combined/bilateral exercises to make certain that our hierarchical federation architecture conform to stability and sustainability requirements and guarantee ROK-US models' interoperability and robustness enough to handle large traffic of data without unexpected deadlocks (Juergen Dingely, David Garlanz, Craig A. Damonx, 2001). To accomplish that, our approach of the hierarchical federation must provide effective data sharing and consistent data interpretation (Judith S. Dahmann, Richard M. Fujimoto, Richard M. Weatherly, 98) in the areas such as the federation save and restoration, the federation synchronization, data distribution management and ownership management.

Secondly, in order to meet the concept of a system-to-system confederation approach with information hiding, we should deploy the capability of CI to downgrade or sanitize information based on ROK and US security policies (David Andrews and David Stratton, 02). As the requirements for ROK-US combined/bilateral exercises have increased, it is easy to predict, in some cases already realized like Figure 4, which federations with varying levels of security classification can participate. So the design of CI should be considered to ensure performance, robustness and functionalities such as the support of bi-directional flow and MLS when interconnecting with US side, which has used RIALTO as a guard interface.

Thirdly, a super FOM needs to be designed carefully and guaranteed to transfer simulation data transparently while promising information hiding and consistent data interpretation between ROK and US separate federations.

Lastly, we emphasize it is imperative that respective ROK and US organizations that are involved in this actively participate and provide support.

CONCLUSIONS

This paper has presented the hierarchical federation architecture to fulfill specific needs and requirements preparing for OPCON transfer. We believe that the suggested architecture can replace the current single federation system to reflect ROK-led simulation support after OPCON transfer. It satisfies the bilateral concept to fulfill the real world operational requirement and alleviates the modification requirements, and the security issues of each side.

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