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LIVE-VIRTUAL-CONSTRUCTIVE ARCHITECTURE ROADMAP IMPLEMENTATION

COMMON GATEWAYS AND BRIDGES EXECUTION PLAN

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Live-Virtual-Constructive Architecture Roadmap Implementation

Common Gateways and Bridges Execution Plan

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EXECUTIVE SUMMARY

The Live-Virtual-Constructive Architecture Roadmap (LVCAR) Study developed a vision for achieving significant interoperability improvements in live, virtual, or constructive (LVC) simulation environments. The study recommended several activities intended to reduce the time, effort, and cost required to integrate multi-architecture events.

Three of the key LVCAR Phase I recommendations were to determine whether existing gateway and bridge[1] applications were effective in meeting user requirements, whether improvements in gateway/bridge capabilities were necessary to address identified gaps, and how these improvements could be best implemented to maximize the Department of Defense (DoD) return on investment (ROI). To address this recommendation, the LVCAR Phase II Common Gateways and Bridges task began with three major activities: performing gateway and bridge literature research, augmenting this research with the team's own gateway and bridge usage and development experience, and developing formal gateway and bridge operation terminology. With this starting point, the team was able to create an initial delineation of gateway/bridge[2] capabilities.

Starting with this initial capability description, the team compiled a Gateway Capabilities Matrix Template. This template allowed the team to create two structured questionnaires. The first was for commercial and government-funded gateway developers, for which an online web interface was provided. The second was for site visits to users of gateways within DoD, mainly selected from large-scale exercise coordinators for the United States military services and joint operations. Although the questionnaires were written for different audiences, they were written in a parallel fashion that allowed a correlation of answers across the two audiences. The background literature research also aided the team in creating a candidate list of developers and users to fill out the questionnaires. In addition to the developer questionnaire and the gateway user site visits, the team also held a one-day workshop, the "LVCAR Common Gateways and Bridges Workshop," to present the findings of those questionnaires. The workshop was held at the Virginia Modeling, Analysis, and Simulation Center (VMASC) in Suffolk, VA, on 4 March 2010.

At the completion of the data gathering and analysis aspects of this task, the gateway characteristic assessment points were identified and documented in the project's initial

[1] The term "bridge" in this context refers to intelligent translators that link together enclaves of simulations that use the same underlying simulation architecture. A "gateway" is also an intelligent translator, but it is designed to link simulation enclaves that use dissimilar architectures.

[2] It became clear during the team's preliminary investigations that the distinction between "gateway" and "bridge" was insignificant from a development and usage standpoint. Both are used for translating between architectures; the difference between a gateway and bridge was primarily a matter of how the system was configured rather than how the system was coded. For that reason, the term "gateway" is used for both types of applications in this document. This terminology was accepted by all of the developers and users with which the team interacted.

deliverable, the "Live-Virtual-Constructive Architecture Roadmap Implementation Common Gateways and Bridges Characterization Report."

As indicated in that report, there is wide agreement that there are several potential improvements that can be made to lower the technical and cost risks generally associated with the use of gateways. Such improvements, along with the team recommendation, are presented in this document as three strategies for execution: *informing* the community as to gateway existence and capabilities; *enhancing* the efficiency and effectiveness by which existing and future gateway products are applied; or *creating* new gateways components or systems. For completeness, the team also included a *status quo* strategy, which describes the impact on the DoD modeling and simulation communities if no action is taken. Below is a description of these strategies.

The first strategy presented involves taking a *laissez-faire* approach to the growth and maturation of the development and use of gateways in the modeling and simulation community, aptly named the "Status Quo" strategy. This strategy acts as a base case for the other strategies. It describes what the team determined as the outcome of not taking any action and allowing the current market forces to continue shaping the industry. The immediate benefit of using the Status Quo strategy is the lack of any new requirements for DoD investment and the fact that it minimizes any potential disruption to the existing LVC community.

The second strategy ("Inform") focuses on educating the user community about existing gateway availability and capabilities. This knowledge would assist potential gateway users in making better-informed decisions when considering use of a gateway. Understanding what gateways are available and what capabilities they have could reduce proliferation of gateways by promoting reuse of existing products vice building additional one-off gateway solutions. The execution of this strategy involves a number of education options, such as workshops, tutorials, and training courses.

The third strategy ("Enhance") incorporates several of the fundamental elements defined in the previous strategy but extends the purely educational focus with several products intended to make more effective use of the gateway capabilities that exist today. Examples of products identified in this strategy include a Common Gateways Description Language (CGDL) to allow gateway capabilities to be described in a machine-readable form, a set of Gateway Performance Benchmarks (GPBs) that would provide a common way of assessing the relative ability of competing gateways to provide needed capabilities, and a Common Gateway Configuration Model (CGCM) that would provide a standard means of initializing, tailoring, and configuring gateways. Widespread adoption of these products in the LVC community will result in users making much better choices as to the gateway products they use in their applications, and will also assist users with how to best employ these products to minimize technical and cost risks to their projects.

The fourth strategy (“Create”) is focused on creating new capabilities to meet the gateway needs of users. These new capabilities can range from relatively minor extensions or enhancements to existing gateways to whole new gateways (or gateway capability libraries) to address capability gaps and provide users with a common interface and common configuration processes/tools. While representing the most expensive option, it also provides the highest potential return. However, achieving this return is dependent on the degree of market penetration that is achieved with new gateway products.

Of the four strategies, the team recommended that the “Enhance” strategy be executed, given that it has the highest perceived ROI. A project plan is presented that details the duration and dependencies of the various tasks in this strategy and estimates the level of effort for execution of this strategy.

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1. INTRODUCTION

Modeling and simulation (M&S) has long been recognized as a critical technology for managing the complexity associated with modern systems. In the defense industry, M&S is a key enabler of many core systems engineering functions. For instance, early in the systems acquisition process, relatively coarse, aggregate-level constructive models are generally used to identify capability gaps, define systems requirements, and examine/compare potential system solutions. As preferred concepts are identified, higher-fidelity models are used to evaluate alternative system designs and to support initial system development activities. As design and development continues, very high-fidelity models are used to support component-level design and development, as well as developmental test. Finally, combinations of virtual and constructive M&S assets are frequently used to support operational test and training requirements.

The advent of modern networking technology and the development of supporting protocols and architectures has led to widespread use of distributed simulation. The strategy behind distributed simulation is to use networks and support simulation services to link together existing M&S assets into a single unified simulation environment. This approach provides several advantages as compared to development and maintenance of large monolithic stand-alone simulation systems. First, each individual simulation application can be collocated with its resident subject matter expertise rather than having to develop and maintain a large stand-alone system in one location. It facilitates efficient use of past M&S investments, as new, very powerful simulation environments can be quickly configured from existing M&S assets. It provides flexible mechanisms to integrate hardware and/or live assets into a unified environment for test or training, and it is much more scalable than stand-alone systems.

There are also some disadvantages of distributed simulation. Many of the issues related to distributed simulation are related to interoperability concerns. Interoperability refers to the ability of disparate simulation systems and supporting utilities (e.g., viewers, loggers) to interact at runtime in a coherent fashion. There are many technical issues that affect interoperability, such as consistency of time advancement mechanisms, compatibility of supported services, data format compatibility, and even semantic mismatches for runtime data elements. The capabilities provided by today's distributed simulation architectures are designed to address such issues and allow coordinated runtime interaction among participating simulations. Examples of such architectures include Institute of Electrical and Electronics Engineers, Inc. (IEEE) 1278.1-1995 Distributed Interactive Simulation (DIS), the Test and Training Enabling Architecture (TENA), and the IEEE 1516 High Level Architecture (HLA).

In some situations, sponsor requirements may necessitate the selection of simulations whose external interfaces are aligned with more than one simulation architecture. This is what is known as a *multi-architecture simulation environment*. There are many examples of such environments within the DoD (see references[3] for examples). When more than one simulation architecture must be used in the same environment, interoperability problems are compounded by the architectural differences. For instance, middleware incompatibilities, dissimilar metamodels for data exchange, and differences in the nature of the services that are provided by the architectures must all be reconciled for such environments to operate properly. This not only raises additional technical risk but, in addition, the additional resource consumption necessary to adjudicate these architectural differences affects cost and schedule risk.

Because of perceived increases in the number of multi-architecture simulation events anticipated in the future, along with the associated increase in costs, the DoD sponsored an initiative to examine the differences among the major simulation architectures from a technical, business, and standards perspective, and to develop a time-phased set of actions to improve interoperability within multi-architecture simulation environments in the future. This initiative is called the Live-Virtual-Constructive Architecture Roadmap (LVCAR). The first phase of this effort began in the spring of 2007 and continued for approximately 16 months. The result of this activity was a final report and supporting documentation that collectively totaled over 1000 pages. The second phase of this initiative is focusing on the implementation of the recommended actions from this report.

One of the key actions from the LVCAR Phase I Report focused on development of a common suite of gateway and bridge capabilities. The term “bridge” in this context refers to intelligent translators that link together enclaves of simulations that use the same underlying simulation architecture, such as a bridge between two existing HLA federations. A “gateway” is also an intelligent translator, but it is designed to link simulation enclaves that use dissimilar architectures, such as a gateway between simulations that use TENA as its external interface on one side of the translator and DIS on the other. Since LVCAR Phase I was primarily focused on multi-architecture interoperability, most of the emphasis in this area of this Phase I study was with respect to gateways. However, both gateways and bridges are ubiquitous in the LVC community today and continue to represent one of the most widely used means of addressing interoperability concerns in multi-architecture LVC environments.

The difference between “gateways” and “bridges” became a subtle distinction depending upon which architectures were being translated. Although this distinction may seem critical at a high level of understanding, at the point of development and usage, the distinction becomes practically moot. The crux of this reasoning is that gateway systems are written to translate from one system (whatever that system may be) to another, so the distinction between translating between different architectures and the same architectures, as is the case with bridges, is really a matter of configuration. For this reason the team consistently referred to both gateways and

[3] References may be found in Appendix A.

bridges as "gateways." Thus, throughout the remainder of this document, the singular word "gateway" is used to refer to both gateways and bridges.

Although there are many success stories with respect to the use of gateways on multi-architecture developments, there have also been some reported problems. Since there is no such thing as a "common" gateway across (or sometimes, even within) user communities, managers of some LVC environments find themselves to be generally unaware of reuse opportunities for needed gateway capabilities. Thus, from a historical perspective, many programs have built their own gateways from scratch based on their immediate needs, with little or no attention being paid to potential reuse. This has led to an unnecessarily large number of gateways in the LVC community today, many of which have little documentation and no visibility outside the projects for which it was designed. This is, of course, very inefficient from a DoD corporate perspective, as much of the same basic functionality keeps getting developed over and over again, and maintenance costs are spread over a large set of redundant capabilities. Also, the continuous consumption of valuable project resources to design, develop, and test new gateways increases technical, schedule, and cost risk to user programs.

The core purpose of the LVCAR Phase II effort is to implement the roadmap defined in the LVCAR Phase I Final Report. The overarching goal is to improve the technical quality of multi-architecture simulation environments in the future while lowering costs and decreasing development time. Gateways are a key enabler of multi-architecture simulation environments; thus the LVCAR Phase II Gateways and Bridges task was designed to address the problems stated above and, more generally, to provide the LVC user community with improved mechanisms for gateways discovery, configuration, and employment. The overarching strategy that was implemented on this task consisted of eight main activities:

1. Develop a template of gateway characteristics based on existing documentation and the background and experiences of study team members. Include "soft" factors such as usability and availability.
2. Conduct a literature search to identify case studies of past multi-architecture LVC environment developments for the purpose of identifying a representative set of gateway developers and users.
3. Based on the literature search (as augmented with existing team member contacts), work with the identified gateway developers to properly characterize the existing gateways according to the template format.
4. Conduct a series of site visits with gateway user organizations to further characterize existing capabilities and to elicit future gateway requirements.
5. Assess the data from the developer questionnaires and site visits to identify capabilities that are either over-served (i.e., duplicative capabilities) or under-served (i.e., gaps) according to current and future user requirements.

6. Conduct a workshop with gateway developers and users to verify the findings of the gateway characterization effort and to solicit input for the common gateways implementation strategy.
7. Deliver a report documenting the gateway characterizations based on the findings from the questionnaires and site visits and the feedback received at the workshop.
8. Based on perceived user requirements, develop and deliver a plan for providing improved gateway capabilities in the future, including distribution and maintenance strategies for new software.

Execution of steps 1 through 7 was discussed in an earlier deliverable, the "Common Gateways and Bridges Characterization Report." The purpose of this document is to describe the plan identified in step 8. The objective of this plan is threefold:

- Identify a potential set of strategies for achieving the desired objectives (including relative advantages and disadvantages), and describe the specific tasks that would be necessary to implement the defined strategy.
- Identify the recommended strategy, with associated rationale.
- Define a multi-year project plan for execution of the recommended strategy that incorporates task dependencies and provides needed capabilities in user hands as quickly as possible.

2. REPORT FORMAT

This report is constructed in five major parts: (a) the executive summary, introduction, and report format; (b) the analysis of each of the execution strategies evaluated in this project; (c) the recommended strategy, including the reasoning for the recommendation; (d) the associated project plan; and (e) a summary of the conclusions.

This report has two appendices: Appendix A is a list of referenced documents and Appendix B is a list of abbreviations and acronyms.

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3. EXECUTION OPTIONS: FOUR STRATEGIES

The execution options presented in this document are an outcome of the analysis performed during this project. The steps taken in this project are illustrated in Figure 3-1 and Figure 3-2.

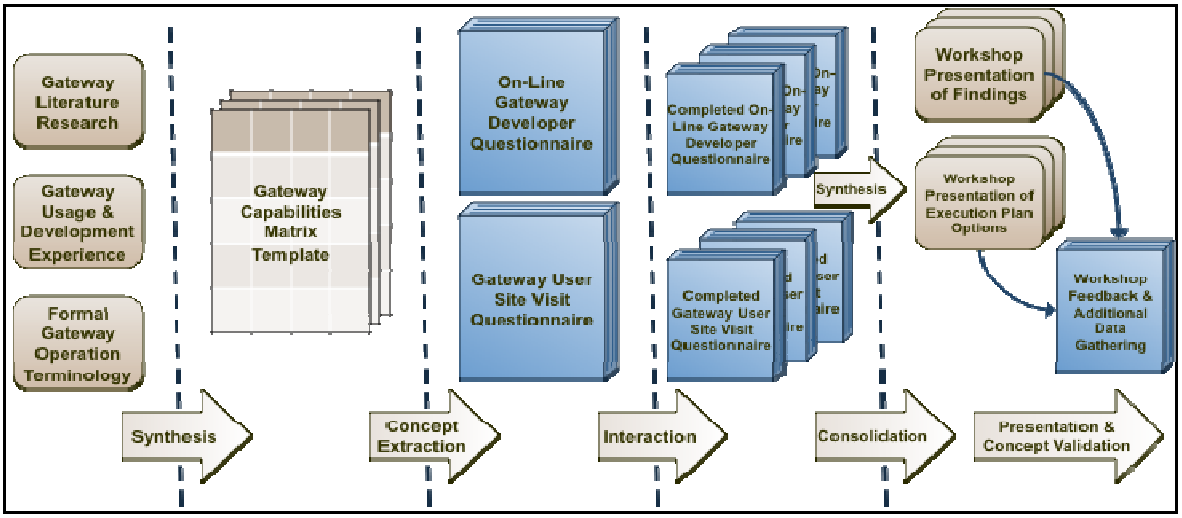

Figure 3-1. Initial Data Gathering and Synthesis Methodology

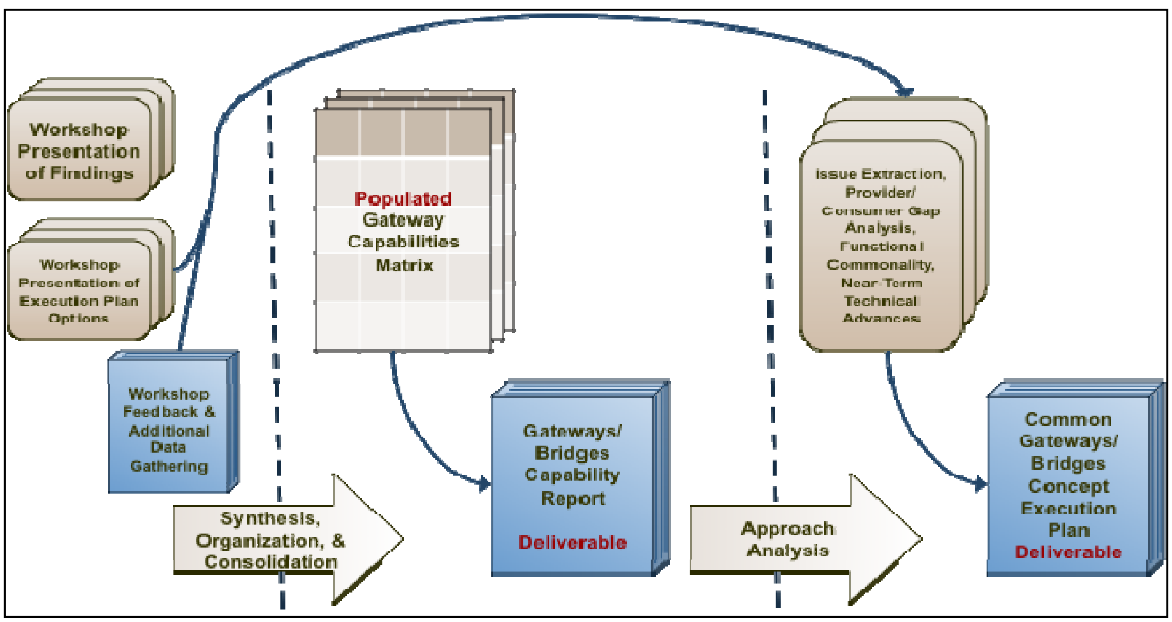

Figure 3-2. Organization, Consolidation, and Analysis Methodology

The initial work for this project was composed of three major activities: performing gateway literature research, compiling the team's gateway usage and development experience, and developing formal gateway operation terminology. With this starting point, the team was able to create a delineation of gateway capabilities based on its members' backgrounds and experience. From this delineation, the team compiled a Gateway Capabilities Matrix Template. This template allowed the team to create two structured questionnaires. The first was for gateway developers, for which an online web interface was provided. The second was for site visits to users of gateways within the DoD. Even though the questionnaires were written for different audiences, they were written in a parallel fashion that allowed a correlation of answers across the two audiences. The background literature research also aided the team in creating a candidate list of developers and users to fill out the questionnaires.

The capabilities that were of interest comprised three general areas: functional capabilities, operational capabilities, and, finally, a general question about additional capabilities or functionality. To ensure consistent answers from the community, the team formalized its terminology to the degree that it can be understood across different gateway designs and usages.

At the completion of the data gathering and analysis aspects of this task, a number of gateway characteristic assessment points were identified, which are described in detail in the initial project deliverable, "LVCAR Common Gateways and Bridges Characterization Report." As indicated in that report, there was wide agreement that there are several potential improvements that can be made that will lower the technical and cost risks generally associated with the use of gateways. Such improvements, along with the team recommendation, are presented in this document as three strategies for execution: *informing* the community as to gateway existence and capabilities; *enhancing* the efficiency and effectiveness by which existing and future gateway products are applied; or *creating* new gateways components or systems. For completeness, the team also included a *status quo* strategy, which describes the impact on the DoD M&S communities if no action is taken. These strategies are presented in sections 4 through 7 of this document.

For each of the strategies, a description of the problem the strategy is addressing, a description of the strategy, itself, and the desired end state is provided. Other than the status quo strategy, a delineation of tasks associated with each strategy is also provided. Each strategy is further described according to its benefits, impact, cost/duration, deliverables, task dependencies, and risks. Task dependencies are presented as a temporal relationship between the tasks. In the case that a task is chosen for execution, then the task's precursor tasks should also be executed. The risk description is stated such that if the task were executed, what is the likelihood that the task's planned benefits would still not be realized. By providing this information for each task, the intent is to explain the team's recommended execution plan and also give the government enough detail to allow tailoring of the execution plan, if desired.

4. STRATEGY: STATUS QUO

The first strategy presented involves taking a *laissez-faire* approach to the growth and maturation of the development and use of gateways in the M&S community and is aptly named the Status Quo strategy. This strategy acts as a base case for the other strategies. It describes what the team determined as the outcome of not taking any action and allowing the current market forces to continue shaping the industry.

4.1 OUTCOME OF A STATUS QUO STRATEGY

The Status Quo strategy reflects a belief that the government and commercial gateways currently in the LVC marketplace are effectively meeting user needs and will continue to do so in the future. It also reflects a belief that no additional supporting products or even educational initiatives can improve the efficiency and effectiveness by which existing gateways are being used in the LVC community. In short, it suggests that there is nothing that can be or should be done to the practice of how users apply gateways to address the unique issues associated with multi-architecture development because the funding required to make a significant change would not be justifiable. Based on this reasoning, the return on investment (ROI) would be diminished to the extent that non-interference in the gateway marketplace is the safest course.

The outcome of taking a Status Quo strategy is that the gateway marketplace would continue as it has. There would continue to be no organized or maintained central marketplace for gateways or central information repository about gateways. Team observations indicate that M&S integrators primarily commit to building or reusing their own gateways that are used within their enclaves. Because of this, the gateways tend to be built for specific needs within these enclaves and not for extensibility or reuse external to these enclaves. This leads to an increase in DoD's financial and intellectual expenditure on ad hoc solutions specific to these enclaves. This has also led to developer and integrator "lock-in." Simply put, this lock-in creates difficulty in exchanging, upgrading, or replacing gateways.

The team's data gathering showed that many of the characteristics and algorithms used within these gateways are, in fact, similar enough to be reusable across different user communities. There have been efforts to create reusable gateways, such as Joint Simulation Bus (JBUS) and Gateway Builder. However, very little market force has been observed to cause these systems to be used in other communities.

Other industries have broken through this type of proliferation through a number of market forces, the simplest of which is a Darwinian process by which less favored products are either not purchased or left unused in favor of "better products." This works well in an environment where there is a large enough customer base and there is not a controlling monopoly that inhibits the Darwinian process from taking place. However, with the U.S. government playing the primary role as the customer, unless it provides the market forces to enact the change, the current state of gateway proliferation should be expected.

4.2 BENEFITS

The immediate benefit of using the Status Quo strategy is the lack of any new requirements for centralized DoD investment and the fact that it minimizes any potential disruption to the existing LVC community. Since new DoD investments in this area would not be necessary, even very modest benefits (e.g., no new licensing fees) can make this option look attractive from an ROI perspective.

4.3 IMPACTS

The impact of taking a Status Quo approach goes beyond the cost of gateways. The proliferation of specialized, ad hoc, and project-specific gateways is a key contributor to the lack of interoperability between many LVC simulation components. This lack of interoperability leads to long integration efforts for simulation-based training and testing. This may have an adverse effect on military readiness, as the established need for rapidly deployed training environments may be unfulfilled.

4.4 RISKS

The risk sections describe the potential of not meeting the stated benefit of the strategy. In the case of the Status Quo strategy, the primary benefit is the absence of any new expenditure to address known issues related to gateway access and utilization. There is very little risk of that benefit not being met.

5. STRATEGY: INFORM

A second strategy involves informing and educating the user community about existing gateway availability and capabilities. It is referred to as the Inform strategy.

This strategy would assist potential gateway users in making better-informed decisions when considering the use of a gateway. Understanding what gateways are available and what capabilities they have could reduce proliferation of gateways by promoting reuse of existing products vice building additional one-off gateway solutions. The success of any technology adoption is heavily dependent on education of the community in which the technology will be employed. Success with the HLA and with the TENA can be largely attributed to community education outreach efforts. A gateway community outreach and education program could take a number of forms as outlined in the subsections below.

5.1 PROBLEMS ADDRESSED

Increased gateway knowledge could reduce gateway proliferation, address a lack of understanding of existing gateways and their capabilities, and provide a centralized resource for gateway information. In addition, the knowledge could promote gateway reuse and reduce misuse of, and dissatisfaction with, gateways. Dissatisfaction with gateways could be the result of either selecting a gateway that did not offer required capabilities, or lack of knowledge about how to configure and deploy the gateway in a federation integration setting.

5.2 TASKS

Gateway community outreach and education efforts could take a number of forms, as outlined below.

5.2.1 Workshops

Gateway workshops would offer opportunities for potential gateway users to gain knowledge about existing gateways through exposure to other users, gateway developers, technical papers, and federation integration experiences with gateways. Gateway subject matter experts (SMEs) could offer tutorials, hands-on exercises, and take-away tutorials. Gateway developers could use workshop events to showcase and demonstrate their gateways. A team of two or three SMEs could conduct the workshop and provide tutorials or hands-on help to participants. This would be similar to the Hands On Training (HOT) offered by the TENA community that users can register for at https://www.tena-sda.org. Other workshop tutorials might provide management-level overview of gateways focusing on selection and procurement knowledge.

Workshops could be held in conjunction with established events such as The International Test and Evaluation Association (ITEA), Interservice/Industry Training, Simulation and Education Conference (I/ITSEC), or the Simulation Interoperability Workshop (SIW), or they could be held as stand-alone events. Stand-alone events could be scheduled periodically or on an as-requested basis. Some consideration might be given to virtual or "distance learning" workshops executed in a distributed manner allowing students to participate from remote sites.

Several types of workshops are envisioned: A high-level overview of gateways could be given in a brief 2- to 4-hour tutorial, while a more in-depth workshop might last a day or more. The in-depth workshops could focus on using gateways in realistic settings or on developing components to extend gateway capabilities. Hands-on exercises using gateways would allow participants to gain realistic training on gateways. Both TENA and HLA provide extensive user training.

Benefits

Workshop experiences would help potential users make more informed decisions about gateway employment. Potential users would better understand what gateways are available, how to procure and configure them, and how well those gateways might meet their particular needs. Gateway developers could use workshops to capture user needs in order to improve their products. Lessons learned could be captured and used to enhance gateway capabilities. Gateway knowledge gained at the workshop would allow more efficient and effective use of gateways and would further enhance the reuse of existing gateways.

Impact

A lack of knowledge about existing gateway capabilities is likely a major factor in project managers approving development of new gateways to meet their immediate needs. This lack of knowledge might have several consequences; project managers either do not know that gateways exist or how to acquire them. They may also not be familiar with gateway capabilities and think that their requirements are unique. All these factors will drive project managers toward developing ad hoc solutions to their particular problems. Workshops are an efficient and effective way to address those problems.

Cost/Duration

Gateway workshops could be held in conjunction with ongoing conferences and workshops such at ITEA, SIW, or I/ITSEC. For the initial three years, at least six events per year could be conducted at ongoing events, or stand-alone workshops as requested, or on a periodic basis. The typical workshop would be one-half to one day in duration. A cost estimate is as follows:

- Three SMEs for 3 days per event (72 hours per event)
- Anticipate six events per year (432 hours per year)
- Planning, travel, and setup: 100 hours per year plus travel and conference fees

- Total: 532 hours per year plus travel and conference fees if applicable

A stand-alone workshop not associated with an established conference would require securing facilities that might charge a fee for usage and a much more significant effort to organize the workshop. A cost estimate for a stand-alone workshop is as follows:

- Six events per year:
  - One event coordinator for 2 weeks per event, including planning, travel, and setup (80 hours per event)
  - Three SMEs for 3 days per event (72 hours per event)
  - Total: 152 hours per event
- Total: 912 hours per year plus travel expenses if required; this assumes participants would assume the costs related to their attendance at the workshop.

Deliverables

Deliverables for this task would include the workshops, themselves, workshop training materials, lessons learned reports from conducting workshops, and general user feedback on gateway experiences and needs.

Task Dependencies

The workshop materials could be developed as tutorials or training courses. This would allow the courses to be used in workshop settings as well as stand-alone classroom or individual settings.

Risk

There is a very low risk that the gateway workshops would fail to achieve the desired goal of educating users about gateways. Poor attendance at the workshops would likely be the highest risk.

5.2.2 Tutorials and Training Courses

Tutorials and training courses could be used to provide a classroom or online resource to allow potential gateway users to better understand what particular gateways can provide and how to use them. Several types of courses are envisioned. Overview courses would help users understand the fundamental concepts of gateways. This course might use the “Common Gateways and Bridges Characterization Report” developed by the team to help users understand what capabilities gateways might offer. More in-depth courses might provide federation managers with best practices on using gateways, including potential pitfalls that need to be addressed in mixed architecture environments. In-depth courses could be provided on specific gateways to help users install, test, and fine-tune gateways for particular applications. This last type of course would need to be produced by the gateway developers. Training courses could also be used to "train the trainer" in order to recruit additional trainers.

Benefits

Tutorials and courses could be used in a variety of settings, including the workshops described above, downloadable tutorials, or online courses. If offered online, the courses could be made available at low cost and at convenient times for the trainee.

Impact

The lack of training materials will make educating the gateway user community much more difficult. All training would have to be done by SMEs working directly with users. This would negatively impact the ability to educate a large user community and would be very expensive and time consuming for the SMEs. It would also likely result in a large portion of the user community not getting adequate support with gateways.

Cost/Duration

A 2- to 4-hour gateway overview course could be developed in as little as 2 staff-months. With minimal additional effort, the course could be developed for both online and classroom delivery.

The in-depth course on best practices would initially take about 3 staff-months but would need more on-going maintenance based on inputs from workshops, classroom, and information desk personnel.

The gateway-specific courses should be left up to the gateway developers. Cost estimates are as follows:

- Gateway overview course: 320 hours to develop; cost to deliver the training by SMEs is already factored in under workshop costs in section 5.2.1. An online version would require approximately 120 additional hours to develop.
- In-depth course on gateway best practices: 480 hours to develop; 160 hours per year to maintain and update. An online version would require approximately 120 additional hours to develop. Cost to deliver the training by SMEs is already factored in under workshop costs in section 5.2.1.

Deliverables

A set of online or standalone courses for gateway users.

Task Dependences

The tutorials and training courses task could support the workshop task and could be used by a cadre or information desk personnel to help address user questions.

Risk

If training courses are developed, they can be widely used across the community. Well-developed courses would be critical to helping users understand how to best employ gateways. Based on HLA and TENA experiences, there is a high probability of success that well-developed courses will help inform the user community about gateways and improve their adoption.

5.2.3 Cadre Support

Much of the success of HLA and TENA adoption by the M&S community can be attributed to the pool of experts available to assist users in employing those architectures. The same would be true of gateway utilization. This gateway SMEs cadre would have knowledge of particular gateways and how to employ them in a federation. Their expertise would allow gateway users to avoid common pitfalls and make the best use of the gateway. Cadre support could take several approaches. Telephone support would allow gateway SMEs to answer questions and provide help with relatively minor disruption to the federation. In the same way, the cadre could provide email support. Cadre personnel would also be available for on-site support for larger or more complex applications. It is likely that this on-site support would be a one-time event for a federation with additional support paid for by the federation. Cadre personnel could work on an "on-call" basis, where minimal funding would allow them to respond to help requests as needed and as supported by budget constraints.

Benefits

The Gateway Cadre could provide focused support with minimal schedule impact to the federation. Their level of expertise, in particular, gateways, would allow the federation to avoid a steep learning curve and potential impact to schedule caused by a lack of expertise in gateways.

Some support could be provided remotely by the cadre, thus avoiding additional expenses related to travel. Cadre personnel might also be able to handle multiple requests simultaneously through telephone calls or email support. For example, some gateways are capable of being set up and monitored remotely. In these cases, and given their availability, the SMEs might be able to provide extensive help without having to travel to the site.

Impact

Without cadre support, users will have to depend on training courses, instruction manuals, or vendor/developer support to investigate, locate, procure, configure, and employ gateways. The ramp-up time necessary to understand a gateway and how to best employ it could outweigh the cost of building a custom solution.

Cost/Duration

There are at least two options with different cost structures:

- On-call support: three to five gateway SMEs assuming 100 total calls per year, 75 of which could be handled by phone in 4 hours and 25 requiring either travel or extended support averaging 5 days
  - 300 hours per year for short support tasks
  - 1000 hours per year for extended support plus travel expenses
- Email/phone support: three to five gateway SMEs assuming 100 total calls per year, all of which could be handled by phone or email averaging 4 hours each
  - 400 hours per year for email or phone support

Deliverables

The cadre would maintain logs of problems encountered and solutions to those problems. Those logs could become a part of the lessons-learned database used by an information desk, or they could be made available through the gateway wiki. The information could also be woven into the training courses described earlier.

Task Dependences

There are no dependencies on this task.

Risk

Using part-time cadre personnel would entail the risk of not having someone available when the need arises. However, the demand for that level of expertise will likely not be so high as to require full-time support. Unlike HLA and TENA, the gateway user community requiring this type of focused support is relatively small.

5.2.4 Gateway Information Desk

In both the user and developer gateway questionnaires, support services such as gateway documentation and information/help desks were identified as critical resources for gateway users. Information desks offer a one-stop source of information where gateway users can obtain information, request additional information, or register issues they are encountering. The lessons learned and Frequently Asked Questions (FAQs) would be compiled and could be made available through the information desk. The information desk could handle minor questions or requests for help while calling on the Gateway Cadre support personnel for more difficult requests. Schedules for ongoing training as well as registration forms would be available through the information desk.

Benefits

A gateway information desk would provide a centralized source for gateway users to obtain or request information or to request help.

Impact

Without some centralized information source such as a help desk, potential gateway users would not have easy access to information that would allow them to make better decisions. In addition, gateway users experiencing problems would be left on their own or would have to contact gateway developers to request support.

Cost/Duration

This task assumes ongoing support for the foreseeable future. There are several options ranging from a full-time staffed help desk to a staffed manned email or phone-based support system.

- For a full-time help desk capability, estimate 1400 hours per year
- A part-time email/phone based help desk with a reasonable turnaround of no more than 1 day on help requests would likely be around 400 hours per year (based on an average of 1 day per week to support help requests) plus minimal costs for phone and email support
- Total: 1440 hours per year for full-time support, or 400 hours per year for part-time email/phone-based support

Deliverables

Detailed logs of issues registered and solutions offered would be kept. These logs could support cadre personnel and could be woven into training courses or a FAQ document available via the information desk.

Task Dependences

Although this task is not directly dependent on other tasks in this strategy, it is expected that the type of experienced practitioners who would staff the information desk are likely the same as would support the cadre, and the availability of course or tutorial materials would be a valuable resource to provide to users of an information desk.

Risk

There would be very high probability that an information desk would provide crucial support to gateway users in selecting a gateway to meet their needs or in addressing problems encountered using a particular gateway. Therefore, this task has a low risk of not delivering the desired benefit.

5.3 DESIRED END STATE

Having an orchestrated set of gateway SMEs as the Gateway Cadre is critical to all of the other tasks. The Gateway Cadre would directly support gateway users, develop tutorials and training materials for users, and support the information desk in addressing the more complex requests from users. Figure 5-1 describes the relationships between the Inform strategy tasks.

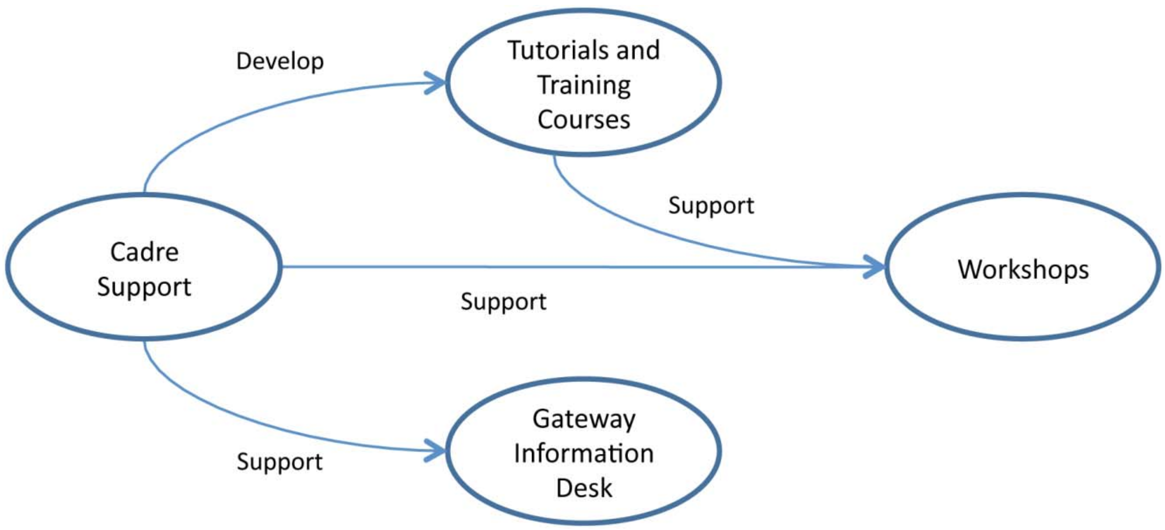

Figure 5-1. Dependency Relationships for the Inform Tasks

Because of the dependency of the tasks on an established Gateway Cadre, the recommendation would be to initially identify and fund the cadre support. The second priority would be to develop tutorial and training materials that could support workshops.

As the name of this strategy suggests, the Inform strategy would produce a more informed gateway user community. Gateway users would have better access to existing material on gateways. This information would allow them to make informed decisions about which gateways to use for different situations. This task would limit the number of new gateways created by making users more aware of existing capabilities.

6. STRATEGY: ENHANCE

The Enhance strategy incorporates several of the fundamental elements defined in the Inform strategy but extends these elements with several products intended to make more effective use of the gateway capabilities that exist today. Widespread adoption of these products in the LVC community will result in users making much better choices as to the gateway products they use in their applications and will also assist users with how to best employ these products to minimize technical and cost risks to their projects.

The Enhance strategy reflects a belief that existing gateway products are generally sufficient to meet the functional requirements of most gateway users but that those capabilities are not always being used in an effective manner. Thus, in addition to simply informing the community, this strategy defines a set of supporting products that gateway users can employ to reduce the time needed to identify, assess, and configure the gateways to the specific needs of their application.

6.1 PROBLEMS ADDRESSED

The main problem that this strategy addresses is that gateway users are not taking full advantage of the gateways that exist today. The causes of this problem are many, but include such issues as inconsistent descriptions of gateway capabilities, inconsistent descriptions of gateway configurations, limited gateway performance measures, and nonexistent gateway performance methodologies. These issues increase the costs associated with building multi-architecture simulation environments. These costs are not considered sustainable, given projected increases in the number of future DoD LVC events. Thus, supporting products that address these deficiencies are strongly needed to improve the efficiency and effectiveness of gateway utilization.

6.2 TASKS

The following tasks are part of the Enhance strategy.

6.2.1 Gateway Capabilities Description

As part of the LVCAR Implementation task, the Johns Hopkins University Applied Physics Laboratory (JHU/APL) collected information from developers and users of commonly used gateways and bridges. The desire was to gain a common architecture neutral baseline of gateway information. To support this objective, a Gateway Capabilities Matrix Template (GCMT) was developed to serve as a common communication mechanism to discuss gateway functionality and user needs. The GCMT was envisioned as an initial version of a specification intended as a common mechanism to document gateway capabilities across the gateway community.

The GCMT defined a set of gateway capabilities, organized by two primary categories: functional and operational. The complete set of categories included both functional capabilities (Simulation Data Exchange Model [SDEM] translations, SDEM behaviors, architecture translations, architecture behaviors, and exercise management behaviors) and operational capabilities (user interface, performance, operation modes, extension modes, platform, documentation/support, and maturity). This list of capabilities was sufficient for the initial "Common Gateway and Bridges Characterization Report"; however, it lacked the full level of detail and maturity required to support many other gateway-related tasks.

To satisfy many of the needs of the gateway community, a more complete, in-depth Gateways Capabilities Description (GCD) document is required. Having a common GCD is critical for the gateway community as it provides gateway developers a mechanism to promote and report gateway capabilities. For gateway users, the GCD is the first of its kind to allow direct comparison of gateway capabilities in sufficient detail to support gateway selection based on matching gateway capabilities to user need.

As improved mechanisms for effective gateway utilization are developed, it is apparent that additional enhancement is required to ensure that the GCD is appropriate for use as a common description mechanism. Initial feedback from earlier gateway characterization efforts was very favorable, but additional activities are needed to enhance the GCD to more fully support the needs of the community. There will be training and requirements for the Gateway Cadre to communicate and manage the GCD specification. Specifically, additional documentation, presentations, workshops, and interviews will be required to further socialize this critical data item. For the GCD to be an adopted specification, these activities are necessary to ensure that the GCD maintains accuracy, relevance, and viability.

Benefits

Having a common GCD is critical for the gateway community as it provides gateway developers with a mechanism to promote and report gateway capabilities in a clear and concise manner. For gateway users, the GCD is the first of its kind to allow direct comparison of gateway capabilities sufficient to support gateway selection based on gateway capability and user need.

Impact

A negative impact will be felt if the GCD is not recognized and adopted as a common specification to describe gateway capabilities. The negative impact would be a continued nonstandard specification to describe and evaluate gateways. This void would cause gateway users to conduct costly user-specific research, investigation, and tests to make an informed decision, or to make a less informed decision, possibly leading to the development of a new duplicative gateway.

Cost/Duration

This task involves refining the initial list of gateway capabilities (developed in support of LVCAR Phase II) with additional detail and incorporating new gateway capability descriptions. This requires some amount of outreach to gateway developers to determine how they characterize their own gateways and then an evaluation of collected inputs to define a unified set of common gateway capability descriptions. It is estimated that this task will require the following:

- Total: 6.0 staff-months to perform

Deliverables

- Gateway Capabilities Description Document

Task Dependencies

- This task does not depend on any other task beyond that of the initial GCMT.

Risk

The risk that stated benefits would not be realized is low since experience has shown that gateway developers are generally cooperative with sharing their documentation and discussing their gateway capabilities with LVCAR team members. The risk that the GCD will not be accepted is also considered low since there is no competing product to which gateway users can turn.

6.2.2 Common Gateway Language Definition

Currently there are several architecture-specific languages that describe the architecture constructs and the data being distributed in LVC multi-architecture environments. This varied lexicography causes potential issues when personnel from the various communities meet to discuss LVC environment requirements, design, and execution information. The Common Gateway Language Definition is a task designed to reduce confusion when gateway utilization is being discussed. The task will develop a set of common description "languages." These languages will not only be useful when describing gateway utilization, configuration, and initialization but will also allow common tool sets to be developed to enhance gateway usability across the gateway user community.

An example of mixed-architecture languages is the definition of the various architecturally specific SDEMs. The TENA community uses the TENA Definition Language (TDL) format as the standard TENA Object Model (OM) format. The TDL definition is based on the TENA meta-model to ensure that TENA OMs may be designed using the rich feature set of the TENA middleware. The TENA community (personnel and software systems) use TDL to archive and distribute TENA OM definitions. In addition, there are several TENA tools that import TDL to auto-generate software to support TENA-based LVC activities.

While TDL is fully supported in the TENA community, it is not as well understood in the HLA and DIS communities. The HLA and DIS communities use different languages to represent their OMs that are, understandably, based on the respective HLA or DIS meta-models. Having incompatible SDEM description languages causes unnecessary semantic and syntactic barriers when integrating multi-architecture LVC systems. The objective of the Common Gateway Language Definition task is to bridge a similar communication gap within the gateway community.

It has been recognized that technology enhancements may be achieved through the definition and use of information standards. One such potential standard, called the Architecture Neutral Data Exchange Model (ANDEM), is being developed by the Joint Composable Object Model (JCOM) project. The intent of ANDEM is to semantically and syntactically define a SDEM, also referred to as an ANDEM OM, in an architecture neutral format. The significance of ANDEM is that it would enable a common architecture independent format to enable passage of data exchange information between personnel and systems from the diverse multi-architecture community.

Applying the ANDEM concept to the gateway community would yield a set of gateway description languages that would allow users to describe, design, configure, and archive gateways while taking into account the varied service features of the multi-architectural environment. Having a common set of gateway description languages would also allow development of a common suite of tools would support the gateway developer and user community. The envisioned set of gateway description languages would be based on existing standards and extended to support the gateway user community, and would include the following:

- Common Gateway Description Language (CGDL)
  - Describes gateway capabilities in a machine-readable language
  - The Gateways Capabilities Description would be expressed in this language
  - Tools could be developed to allow developers to document their capabilities and users to research for capabilities
  - CGDL could be used for input to auto-generate gateway functionality
  - CGDL could be used for input to help automate Gateway Performance Benchmark measurement activities
- Common Gateway Configuration Model (CGCM)
  - Describes gateway SDEM translation requirements in a machine-readable format

- Describes gateway configuration and initialization parameters in a machine-readable format
- Allows gateway developers to configure and initialize gateways as defined in the CGCM
- Designed to help automate Gateway Performance Benchmark measurement activities
- Provides legacy information regarding SDEM translations, configurations, and initialization parameters for gateways

Benefits

The intent is to develop a gateway-specific set of description languages that would allow users to research, build, acquire, initialize, and execute gateways more effectively. Users would now have a common basis for discovering desired gateway capabilities, based on the capability descriptions embedded in the CGDL. Users would also have a common underlying mechanism for gateway configuration (the CGCM), which reduces development time and encourages the reuse of existing gateway products. The language would be based on an existing markup language (e.g., the Extensible Markup Language [XML]), so that a reusable set of tools could be developed to aid the gateway user community.

Impact

The impact of not having the gateway description languages would result in the continuation of gateway capability, configuration, and initialization information not being described or being described in non-common formats/languages. The status quo would continue with no/limited gateway user enhancement opportunities.

Cost/Duration

- 28 staff-months over a 16-month period. Some products under the Common Gateway Language Definition task will be available before others. Tool support for these products would be developed under the Gateways Testing Laboratory task.

Deliverables

- Common Gateway Description Language
- Common Gateway Configuration Model
- Examples of CGDL and CGCM
- Examples of how CGDLs and CGCMs could enhance existing gateway development, configuration, or initialization activities

Task Dependencies

This task is dependent on the creation of the GCD document because a common set of gateway capabilities is needed to reflect what needs to be included in the CGDL and CGCM languages.

Risk

The main risk to the success of this task is that the languages will not be widely implemented in tools, and since it is only through the increased use of automation that these task benefits can be realized; there is a risk that the language specifications can become "shelf-ware." This risk can be effectively mitigated through early tool prototypes that embed these languages and clearly demonstrate the benefits achieved through adherence to these specifications.

6.2.3 Performance Benchmark Specification

When the design of an LVC multi-architecture simulation environment is being established, the overarching system-level performance requirements must be considered when LVC resources are selected for use within the environment. The performance characteristics of the various LVC resources in the design must be well characterized so that an estimated performance envelope of the envisioned system can be calculated and compared with the required performance budget. If the calculated estimated budget exceeds that of the required performance budget, design alternatives must be investigated to reduce the estimated performance envelope.

When gateways are utilized in the system design of the LVC environment, gateway performance characteristics are required to establish the expected performance level for each gateway and use case pairing found in the LVC simulation environment design. The collection and subsequent utilization of gateway performance parameters may prove problematic as user questionnaires noted that gateway performance parameters were not readily accessible.

If the gateway performance data is unavailable, the system-level performance cannot be predicted during the design phase. This forces the performance measurements to occur after the integration activities, which potentially increases risk and lengthens the schedule if the gateways demonstrate an inability to support the performance requirements.

If gateway performance information is available, significant concerns can arise about the applicability of the performance parameters and the collection methodology of the performance data. The concerns include the following:

- Variances in performance parameter name
- Variances in performance parameters units
- Variances in the performance data collection implementation techniques

- Variances in the performance data collection methodologies
- Variances in test/use case definitions used during performance data collection

It is recommended that a Gateway Performance Benchmark (GPB) specification be developed to provide the LVC community with a consistent, repeatable, and comparable gateway performance measurement capability. The GPB specification must define a comprehensive performance parameter name list and unit pairing sufficient to characterize the gateway capability definition performance envelope. The GPB would include descriptions of functionality, test parameters, and methodologies to monitor gateway capabilities as listed in the GCD document.

The specification must also include a common methodology that can be applied by the community when measuring the performance parameter data. A partial listing of the gateway performance determination methodology includes a robust set of gateway configuration use cases, time determination and measurement, platform (operating system, random access memory, processor speed, network interface card configuration, etc.) requirements, and local- and wide-area network configurations.

Development of the GPB should also include coordination with the gateway user and developer community to ensure accuracy and adoption of the GPB by the community.

A suite of tools is also envisioned to stimulate the gateways so that the methodology may be consistently and effectively utilized when collecting performance data. Potential multi-architectural tool sets include entity/platform generator, data analysis and logging tools, and test management and configuration tools.

Once the GPB specification has been developed, it is suggested that verification take place to ensure that the GPB specification is properly defined. The verification process would step through the methodology of the GPB, utilize any developed GPB tools, and collect a set of performance data for a particular gateway. The intent of this verification is to ensure that there are no gaps in the methodology, performance parameter data set, and tool set. If gaps are identified, then the GPB would be modified and the verification process would be repeated. For technical and social reasons, a different member of the team/community would conduct subsequent verification efforts. This would be repeated until no gaps are identified in the GPB.

There will be training and requirements for the Gateway Cadre to communicate and manage the GPB specification. This activity is necessary to ensure that the GPB specification stays accurate and viable.

The powerful combination of the performance parameter set, methodology, and supporting tools defined in the GPB will increase the gateway-using community's ability to characterize and utilize current and future gateways.

Benefits

There are benefits to both the gateway user and developer communities. The developer community will benefit from a “standard” GPB specification, as it will allow developers to promote the high-performance aspects specific to their gateway. However, the benefit of the GPB specification primarily targets the user community. The GPB specification will enable the availability of gateway performance data during LVC environment design activities. This information will enable the designer to select the most appropriate gateway that meets use case and performance requirements. It will also provide additional flexibility of the LVC environment design, as the performance aspects can be incorporated to achieve the most efficient design possible.

Impact

Without a common GPB specification, a strong possibility exists that three negative impacts would occur. The first is that gateway performance data would be unavailable for most gateways, as is the case today. The second impact is that the available gateway performance data would be stylized by the developer, even without the intent to prejudice the data, to enhance performance aspects of a certain use case and gateway pairing. This makes the data incompatible for comparisons with performance data from other providers. The third impact is that the performance data provided by various sources may be collected using use cases that may or may not be compatible with customer use cases. Dissimilar use cases applied during performance testing makes resulting test data potentially not applicable.

Cost/Duration

- 8.0 staff-months to develop the GPB specification over a 12-month period. Tool support for this specification and GPB verification would be performed under the Gateways Testing Laboratory task.

Deliverables

There are two main deliverables for this task:

- The GPB specification (including performance parameters, functionality testing, and data collection methodology)
- GPB Use Case Definitions

Other deliverables to support tool development may be needed to implement the GPB in the Gateway Testing Laboratory (GTL).

Task Dependencies

Successful implementation of this task will depend on the following tasks:

- Gateway Capabilities Description
- Common Gateway Language Definition
    - Common Gateway Description Language
    - Common Gateway Configuration Model

Risk

Risk is estimated to be low as there are no common GPB-like specifications, methodologies, or tool sets that are currently available to the gateway user community. Thus, this task fills a need that has no competing product.

6.2.4 Gateway Testing Laboratory

Once a common specification like the GPB has been defined and adopted by a community, the next logical step is to develop a capability to conduct and present gateway performance measurements in a fair, accurate and comprehensive manner. It is proposed that all aspects of the GPB specification be adopted and implemented in a controlled environment so that performance measurements may be collected and presented for all publicly available gateways. The GPB Use Cases would serve as requirements to define, establish, and configure a GTL to conduct the GPB specification measurement activities. The tools suite developed under the GPB, will be adopted and used to enable consistent, repeatable measurement activities.

It is envisioned that the GTL configurations would support various LVC aspects including unclassified testing using a local-area network (LAN) and wide-area network (WAN) environment. It is also envisioned that GPB measurements could be conducted over a classified network such as the Joint Mission Environment Test Capability (JMETC) Virtual Private Network (VPN) to match Use Case requirements as much as possible. The GTL activities and configuration will be coordinated with the corresponding gateway developer to ensure that appropriate configurations are applied during gateway measurement activities.

All pertinent GPB feedback acquired during gateway measurement activities would be made publicly available with the intent of providing this information to the GPB definition team to optimize the GPB specification and tool suite.

In addition to performance testing, this laboratory would provide implementations of tools that support the CGCM and CGDL. These tools will be needed for gateway users to realize the full benefits of these products. The initial instantiation of tools within the GTL will incorporate the SDEM translation aspects of the CGCM within a selected set of widely used general-purpose gateways (e.g., JBUS, TENA Gateway Builder) and a repository (or portal to an existing repository) with automated discovery mechanisms based on the CGDL. The end goal is a "Consumer Reports" style laboratory to test gateways for compliance with the CGDL and CGCM and to access gateway performance data via the performance benchmarks.

There will be training and requirements for the Gateway Cadre to communicate and manage the GTL specification. This activity is necessary to ensure that the GTL configuration and process stays accurate and viable.

The results of the gateway measurement activities will be publicly posted so that the community can use this information for the publicly available gateways. This information will enable gateway users to select the most appropriate gateway for their requirement set.

Benefits

This task benefits the gateway user community by providing a comprehensive, independent, and trusted data source for gateway discovery, configuration, and performance testing. This data source would be invaluable to the LVC environment designer and gateway user to make informed decisions regarding gateway selection and configuration. These informed decisions would enable LVC environment design activities to be more efficient and less technically risky.

Impact

Given that the performance benchmark information is currently unavailable, the impact of not determining these benchmarks is to continue reinforcing uninformed gateway selection and configuration by simulation integrators, which causes inefficient LVC environment design and execution.

Cost/Duration

- 5 staff-years over an 18-month period of performance. Some additional capital expenditures may be required to establish the laboratory (e.g., GTL computer, software development tools, commercial off-the-shelf [COTS] gateways, COTS middleware, network materials, etc.). Longer-term maintenance costs to operate the laboratory are not included in this estimate.

Deliverables

- Gateway Testing Laboratory
- Gateway Testing Laboratory design documentation
- Gateway performance measurement results
- Training and informational material

Task Dependencies

This task involves the application of the performance benchmarks in a set of test tools, so there is a dependence on the development of the performance benchmarks. In addition, since the performance benchmarks are dependent on the GCD document, this task has an implied dependency on that task as well. Finally, the CGCM and CGDL must be sufficiently mature that initial tool implementations for these products can be developed.

Risk

The main risk for this task is that gateway developers would refuse to submit their gateways for testing against the performance benchmarks. This could be the case if developers feel that the common performance benchmarks would not showcase their product in a favorable light. The risk is estimated to be low, however, since the refusal to submit to benchmark testing could be perceived as "something to hide," and thus it is believed that most developers will be cooperative.

6.2.5 Cadre/SME Support

As noted in section 5.2.3, much of the success of HLA and TENA adoption can be attributed to the pool of experts available to assist users in employing those architectures. The same would be true of the gateway enhancement strategy.

The Gateway Cadre (described in the Enhance strategy) not only would have a deep knowledge of various gateways and how to employ them but also would be experts in the various Enhance strategy tasks. Their expertise would allow gateway users to avoid common pitfalls and would optimize the user experience for various gateways and associated Enhance strategy gateway products.

Cadre support could take several approaches. Telephone support would allow SMEs to answer questions and provide help with relatively minor involvement. In the same way, the Gateway Cadre could provide email support. SMEs would also be available for on-site support for larger or more complex applications. It is likely that this on-site support would be a one-time event for a federation. Additional support would be paid for by the LVC environment sponsor. Gateway Cadre personnel would work on an "on-call" basis, where minimal funding would allow them to respond to help requests as needed and as supported by budget constraints.

Gateway Cadre support would also include development and support of Enhance-specific training and information products to ensure that a consistent and accurate message is portrayed to the community. This type of support would also include briefing products from the Enhance strategy, workshop establishment and support, conference attendance, and other information exchange opportunities.

Benefits

The positive impact to the gateway user community through the Enhance Cadre is expected to be substantial. Having well-spoken SMEs has proven extremely beneficial when working with the community to enhance technical solutions to the LVC interoperability mission space.

Impact

Without cadre support, users will have to depend on documentation such as training courses, instruction, or manuals to employ gateway Enhance products. The reduced ramp-up time needed to understand an Enhance product or a gateway and how to best employ it could outweigh the cost of building a custom solution.

Cost/Duration

- Variable, depending on anticipated community need.

Deliverables

The following is a list of possible deliverables, depending on anticipated community need:

- Classroom training
- Hands-on training
- Workshop
- On-site event-specific instruction
- Help desk support
- Gateway fact sheets and reports

Task Dependencies

All tasks listed in the Inform strategy would be applicable in this strategy as information is a key to enhance the experience of the gateway user.

The artifacts produced via the tasks listed in the Enhance section of this document would be the core data used by this support task.

Risk

The main risk to success for the Gateway Cadre would be if they were generally unable to address the issues raised by users. This would be a barrier to success, as users may get bad advice and not use the cadre in the future. This risk should be considered low, however, assuming careful selection of the cadre membership and the ability to reach out to the actual gateway developers to address issues that transcend the cadre's knowledge of specific gateway applications.

6.3 DESIRED END STATE

The desired end state for the Enhance strategy is an LVC community that uses common descriptive languages, terminology, definitions, and product development patterns to increase efficiency when selecting, designing, developing, and using gateways. With the exception of cadre/SME support, all tasks depend upon the updated GCD task, as this information is key to having a common definition of gateway capabilities. The GCD task is the technical cornerstone of all other product-driven tasks. The CGDL task focuses on developing a common specification for gateway users to describe, configure, archive, and even develop gateways. The Performance Benchmark Specification uses the GCD document to provide a consistent, repeatable, and comparable gateway performance measurement. The Gateway Testing Laboratory task provides independent gateway performance data by using the metrics and processes defined in the Performance Gateway Specification, and provides initial tool implementations for products produced under this strategy. This enables users to intelligently select gateways that best support the capability and performance requirements as defined in their particular use case. The Cadre/SME support would use the products from the aforementioned tasks to inform and instruct the gateway communities to best enhance the understanding and utilization of the existing gateway solution set.

The dependencies for the Enhance strategy are illustrated in Figure 6-1.

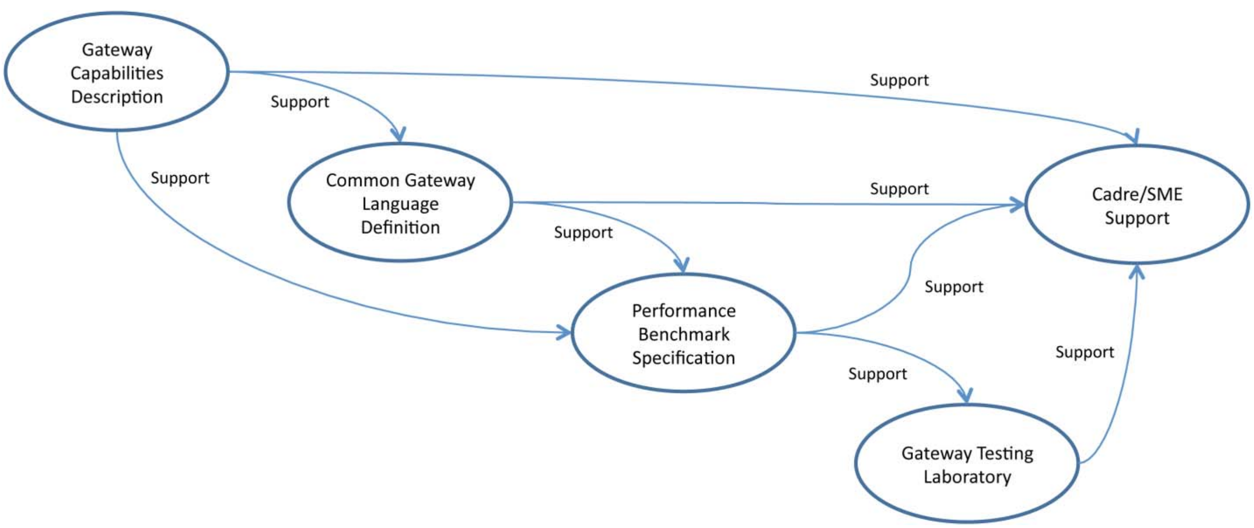

Figure 6-1. Dependency Relationships for the Enhance Tasks

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7. STRATEGY: CREATE

The Create strategy is focused on creating new capabilities to meet the gateway needs of users. Some of the tasks start with existing products and expand them. For this strategy to be effective, the majority of users would need to use the products created by this strategy.

7.1 PROBLEMS ADDRESSED

This strategy addresses several problems raised in the LVCAR study. The first is to reduce investment by limiting the number of gateways being developed and used. Currently there are a large number of gateways in use. Some of these have a large number of users and others are developed for very specific cases. This strategy seeks to reduce the number of gateways in use. Second, this task seeks to increase commonality among the gateways in use. The increased commonality also reduces costs over time. Finally, this strategy seeks to reduce confusion among users as to the best gateway approach by limiting the number of gateways.

7.2 TASKS

The following tasks are part of the Create strategy.

7.2.1 Common Gateway Framework Definition

Currently, gateways are developed in an ad hoc fashion and are designed to meet the needs of a particular federation. Typically, little or no thought is given to reuse. Developers work from a set of requirements with no guidelines for consistent interpretation of the requirements or consistent implementation of gateway functionality to satisfy the requirement. The result is that different gateway developers might interpret a requirement differently and their implementations could provide different results. This inconsistent development approach has led to a large number of gateways purporting to provide the same functionality to the end user with no way to verify that the functionality is consistent.

As the Gateways team examined gateway functionality, they found a number of common patterns, and the team felt that capturing these design patterns along with code examples might provide a consistent approach and starting point for gateway developers. The design patterns could also be used to develop a framework for gateway implementers to use when starting a gateway project.

Patterns would be described using the characteristics in the GCD document to ensure a consistent understanding and implementation of gateway functionality. These patterns could then be used to develop a gateway framework, providing a starting point for gateway developers.

Benefits

A set of design patterns representing common practices in gateway functionality would allow developers to start from a set of well-defined and consistent patterns of use. A common set of patterns would support consistent interpretation and implementation of gateway functionality. They would make gateways easier to understand and evaluate.

The community of developers could be involved in defining best practices based on a common set of patterns. All this would lead to gateways with consistent functionality and enhanced reusability.

Impact

Without a common set of design patterns, gateways will continue to be developed independently and a significant duplication of effort will be expended. Common algorithms and services will be redeveloped for each gateway and will likely be redeveloped in an inconsistent manner.

Cost/Duration

Phase 1 would consist of a 12-staff-month effort spread over 6 months. Several commonly used gateways could be leveraged in order to identify a consistent set of design patterns. Best practices for the design patterns would also be included in the Phase 1 documents.

Phase 2 would consist of a 36-staff-month effort spread over 1 year to extract and document code samples for the design patterns.

Deliverables

Phase 1

- Design patterns mapped to the characteristics in the GCD document
- Best practices recommendations for design patterns
- Design patterns documented

Phase 2

- Extracted and documented code samples

Task Dependencies

This task does not depend on other Create strategy tasks.

Risk

There is a minimal risk that, given a relatively small number of gateways to examine, it might prove difficult to precisely identify and define gateway patterns. The well-defined characteristics described in the GCD document will help reduce this risk.

7.2.2 Build Gateway Components

One way to reduce costs and increase commonality is to create a common set of components used to build gateways. This approach would create a series of modules that could be assembled by government or contractor organizations. The components would be freely available to any organization subject to the United States DoD regulations.

The first activity would be to identify the needed components. This process would be based on the gateway's capabilities list. Ideally, each component would implement a single capability. This may not be realistic in all cases and some components would implement more than one capability. A requirements document would be generated based on the capabilities selected for implementation.

Once the list of components is created, a reference architecture (based on the Common Gateway Framework) will need to be defined. This activity will evaluate the different types of gateway architectures documented in the Gateways Study (this activity be performed as Phase I of the Common Gateway Framework Definition task described in section 7.2.1, and is not shown in the cost for this task). The gateway reference architecture will be used to create the structure for the components.

The next activity would review existing gateways to determine if they could be used as a source for components. In some cases the component may be taken directly from existing gateways. In other cases they may serve as the foundation for the new component. This activity will require negotiations with the organization that owns the gateway.

Once the list of components that can be built based on source code from existing gateways has been completed, the remaining components will have to be built. This will follow standard software engineering processes.

A test plan will be created for all components. The components will then be tested according to the test plan. Any issues identified will be corrected.

Once the components are created and tested, a set of user documentation will be created. This documentation will be used to promote the use of the gateway components to gateway building organizations. This will include outreach to the organizations in the form of site visits and user support.

Benefits

The creation of gateway components will reduce the cost of building a new gateway and introduce commonality across gateways. Gateway-developing organizations would be able to focus on key specializations they require rather than building basic gateway functionality.

This approach works for both government off-the-shelf (GOTS) and COTS developers. COTS developers could continue to create and sell value-added gateways. DoD organizations could build GOTS gateways based on the common components.

Impact

The impact of not performing this task is that the large number of gateways currently in use will continue to duplicate functionality. Thus, the DoD will continue to pay for the development and maintenance of redundant gateway capabilities.

Cost/Duration

This task will require 8 staff-years of labor over an 18-month period. This estimate is based on the number of functional capabilities identified in the study.

Deliverables

The following deliverables will be produced by this task:

- List of gateway components and requirements
- Implemented set of gateway components
- Test plan and results
- User documentation

Task Dependencies

Successful implementation of this task will depend on the Common Gateway Framework Definition task.

Risk

The primary risk to this task's benefits not being realized is the lack of adoption of the components by gateway development organizations. For cost reductions to be realized, development of baseline gateway functionality by DoD-funded organizations would have to end. If DoD gateway development organizations do not produce gateways using the components that will be employed by gateway users, it will prevent commonality across gateways.

7.2.3 Prototype Components

This task is a proof-of-concept for the use of common gateway components. This task would select an existing gateway and replace current functionality with functionality based on common gateway components. This task would be used to demonstrate the usefulness of the common gateway components.

The first activity of the task is to select a gateway to use for the prototype. The selected gateway should have an existing user base. The organization owning the gateway will also have to support the prototype activity.

Once the target gateway is selected, it will be reviewed for the best application of the gateway components. Ideally, the users of the gateway will have expressed a need for a capability that the gateway does not support and for which a gateway component exists. This would best demonstrate the value of the gateway components to the user community. In the absence of a missing capability, the target gateway will be reviewed to determine if one of the gateway components provides a higher level of capability than is currently implemented. On the basis of this type of analysis, five to ten gateway components will be selected for integration with the target gateway.

The next activity is the integration of the selected components into the target gateway. This will require the organization owning the gateway to provide the target gateway source code and documentation. An updated design document will be created for the target gateway.

The target gateway and integrated gateway components will be tested against a written test plan. The test plan will focus on the capabilities provided by the gateway components. A test report will be prepared to document the results.

After the testing is completed, an integration lessons learned document and briefing will be prepared. This will document the insights gained from integrating the gateway components into an existing gateway. The prototype integration and documentation will be used to educate the community on the use of the gateway components. The results of the prototype integration will be presented at various community forums.

Benefits

This task demonstrates the utility of the gateway components. The lessons learned from this task will be useful in convincing gateway developers to use the gateway components. The prototype will be an example for other developers to follow.

Impact

The impact of not performing this task is that the users may not see the full benefit of using the gateway components. This could adversely affect the benefits achievable by having a common set of modular gateway capabilities.

Cost/Duration

This task will require 6 staff-years of labor over a 9-month period. This is based on integrating between five and ten components into an existing gateway that is similar to the gateway components' reference architecture.

Deliverables

This task has the following deliverables:

- Prototype gateway using gateway components
- Software design documentation
- Integration lessons learned documentation

Task Dependencies

This task depends on the Common Gateway Framework Definition and Build Gateway Components tasks. The prototype requires a set of gateway components.

Risk

The primary risk to this task's benefits not being realized is that the prototype fails to meet user needs. This risk is low. The target gateway integrated with gateway components should meet user needs.

7.2.4 Select and Improve Gateways

This task selects several existing gateways and supports updating them to incorporate any missing capabilities. The existing gateways will be reviewed against the gateway capabilities list. The modified gateways would be distributed to the widest audience possible. The goal would be expand the capabilities of the gateways to allow their use by a wider audience, thus reducing the desire to build new ad hoc gateways.

The first activity of the task will be to review existing gateways to determine candidates for modification. The data collected in this study will form the initial basis for this activity. Once an initial cut has been made using the current data, a more detailed review will be conducted of the gateways. This will include negotiating with the owner organizations to gain access to their source code. The number of candidate gateways selected will depend on the research. It is anticipated that initially one to three gateways will be selected. The criteria for selection will include current capabilities, user base, owner cooperation, and quality. The gateways selected may be targeted at different applications.

Once the candidate gateways are selected, another detailed review will be conducted to determine which capabilities will be added to which gateways. All capabilities may not be added to all of the candidate gateways. If more than one gateway is selected, the candidate gateways may be targeted at different applications, thus not requiring all capabilities.

A design document will be created for each gateway based on the addition of the new capabilities. Part of the design process would review the capabilities that are being added to each gateway to determine common capabilities. These common elements would be developed once and integrated into each gateway.

A standard software development process would be followed for each gateway. The development process will introduce as much commonality into the selected gateways as feasible. A formal test plan will be created for each gateway. Tests results for each gateway will be documented.

Complete user's manuals and training material will be developed for each modified gateway. Training classes will be conducted. If more than one gateway is modified, material will be created to help the end user select the correct one for their needs.

The modified gateways will have to be maintained over time to support changes in architectures, SDEMs, and new requirements. A plan will be generated to specify how this maintenance should be performed.

Benefits

This task reduces the overall cost of gateways by providing a limited choice to users. This will eliminate duplication of funding across multiple gateways. It also reduces the cost of operation, as the end user will only need training in a limited number of gateways. This task also increases the commonality between gateways by having a single group produce a limited number of gateways.

Impact

The impact of not performing this task is that certain capability gaps will continue to be present in all gateways, leading to the continued proliferation of gateways caused by the perception that there is no gateway that is truly full-featured.

Cost/Duration

This task will require 10 staff-years of effort over 18 calendar months. This assumes that two existing gateways will be selected for modification.

Deliverables

The following deliverables will be generated by this task:

- Design documents for selected gateways
- Modified gateways with increased capability
- Test plan and test results
- User manuals and training materials
- Maintenance plan

Task Dependencies

This task is not dependent on any other tasks. However, a viable option is to perform the Build Gateway Components task and use the results to modify the gateways.

Risk

The primary risk to this task's benefits not being realized is that users will not switch to using only the modified gateways. If the large majority of gateway users do not switch to the modified gateways, the full cost savings and commonality projected for this task will not be realized. There is a high risk that users will not switch to the new gateways unless they were already using the pre-modified versions.

7.2.5 Build a New Gateway

This task creates a new gateway based on the collective experience of previous gateways. The capabilities implemented in this gateway would be based on the capabilities defined by this study. This gateway will be a general-purpose gateway intended to address all of the gateway capabilities.

The first activity is to determine the architecture for the gateway. During the study several types of architectures were noted, including code generation, plug-in, and monolithic. These architectural approaches and others will be evaluated to determine the best one. User feedback will be one factor in the architecture selection.

Once the architecture is selected, the overall design of the gateway will be completed. The design will be based on research into the design of existing gateways. Development of the new gateway will benefit from the lessons learned in previous gateway programs. The design will incorporate all of the capabilities defined in the gateway study.

Development of the gateway will follow standard software development processes. A test plan will be created for the gateway, and test results will be documented.

Complete user's manuals and training material will be developed for the gateway. Training classes will be conducted.

The gateway will have to be maintained over time to support changes in architectures, SDEMs, and new requirements. A plan will be generated to specify how this maintenance should be performed.

Benefits

The major benefit of this task is that a single gateway would be available to meet all user requirements. This could lower DoD costs over time as a result of the elimination of the need for DoD programs to develop their own gateways. A second benefit is increased commonality across users. This task will provide a single gateway for all users. Over time, maintaining and updating a single gateway will save money and resources.

Impact

The impact of not performing this task is that maintenance costs for the large number of gateways in use across the DoD will continue to accrue.

Cost/Duration

This task will require 18 staff-years over 24 months to complete. This estimate is based on building a new general-purpose gateway that meets all user needs.

Deliverables

The following deliverables will be generated by this task:

- Gateway design
- Gateway
- Test plan and results
- User manuals and training material
- Maintenance plan

Task Dependencies

This task does not depend on any other tasks.

Risk

The primary risk to this task's benefits not being realized is if users did not switch to the new gateway. If all users of a particular existing gateway do not switch to the new one, development and maintenance of the gateway will have to continue. The maximum cost savings and gateway commonality will only be achieved if all users switch to the new gateway. Based on input from users, the risk is high that the benefits of this task will not be realized.

7.3 DESIRED END STATE

The Create strategy provides three principal options. The first is to perform the Common Gateway Framework Definition task, Build Gateway Components task, and Prototype Components task. The second is to perform the Select and Improve Gateways task. The third option is to perform the Build New Gateway task. Only one of these options should be selected. A variant on the second option is to perform both the Build Gateway Components and Select and Improve Gateways task. This option would integrate the components into the existing gateways.

The option selected for this strategy is dependent on the desired level of commonality. The first option still allows for many gateways, but they would be built using common components. The second option and its variant potentially reduce the number of gateways in use to two. The final option reduces the gateways in use to one.

The dependencies of the Create tasks are shown in Figure 7-1 and relate to the options described above. The solid line connections represent the dependencies associated with the first option, and the dotted line connection represents the dependency associated with the variant on the second option.

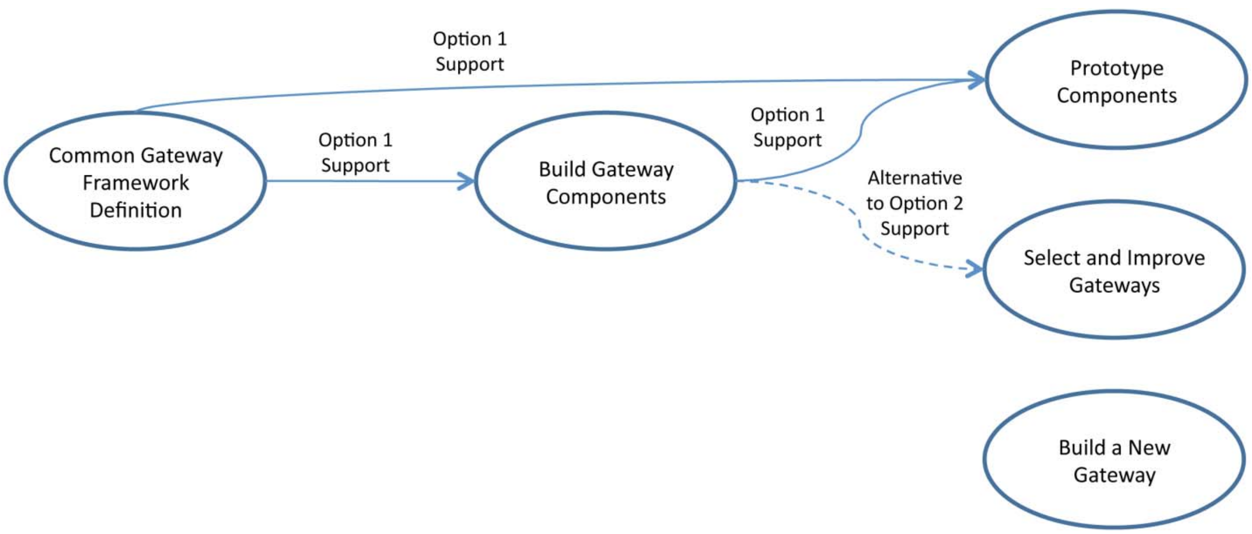

Figure 7-1. Dependency Relationships for the Create Tasks

The desired end state of this task is to drastically reduce the number of gateways in use. By selecting any of the three options in this strategy, the number of unique gateways would be reduced. Some of this reduction will be based on the technical merit and cost savings of the products developed by these tasks. However, the full benefits will only be realized by policy changes requiring users to switch to these gateways. The amount of coercion required increases with each option.

8. RECOMMENDED STRATEGY

This section defines the rationale for why strategies were or were not selected.

8.1 CONTINUE WITH THE STATUS QUO?

While the absence of any new DoD investment to address known gateway problems is obviously a low-cost solution that doesn't impact current LVC communities, these problems are adversely affecting the costs and technical quality of multi-architecture LVC simulation environments, and the inherent risks will continue to get worse. Since the LVC Architecture Roadmap strongly recommended that actions be taken to address these problems, the Gateways Team does not recommend that the "do nothing" strategy be followed.

8.2 IMPLEMENT THE INFORM STRATEGY?

While the team felt that better informing the gateway user community was important, and while the investment required to execute this strategy is relatively small, the overall ROI was perceived to be low compared to alternative strategies. Thus, while some aspects of this strategy will carry forward into the chosen strategy, the Gateways and Bridges Team did not feel that simply informing the community would sufficiently move the LVC community toward its desired end state. Thus, this strategy, taken alone, is not recommended.

8.3 IMPLEMENT THE CREATE STRATEGY?

The Create strategy has the potential for the most cost savings over time by reducing the number of gateways being developed and maintained. However, the costs to create the products of this strategy are also expensive. The third option discussed in this strategy should produce a long-term high ROI. The risk on the ROI is that the return is only realized if the number of unique gateways in use is significantly reduced. This investment has little to no return if gateway users do not discontinue the use of their current gateways and switch to the products developed by this strategy. While the return on this strategy is not literally all or nothing, it is close. The investment level is the same if the number of adapters is small or large. There is almost no return on the investment if the number of adopters is small. Past experience in getting developers to switch software programming languages, distributed simulation architectures, or SDEMs is not good. Developers and users tend to stay with what they know. There is little reason to believe that enough users will make the switch. Prior examples have shown that neither large incentives nor harsh coercion have convinced reluctant users to switch. The strategy has a high potential ROI, but a very high risk. For this reason this strategy is not recommended.

8.4 IMPLEMENT THE ENHANCE STRATEGY?

The Enhance strategy represents the approach that the Gateways and Bridges Team believes will provide the highest ROI for the DoD. It incorporates several of the fundamental elements defined in the Inform strategy but extends these elements with several products intended to make more effective use of the gateway capabilities that exist today. Widespread adoption of these products in the LVC community will result in users making much better, more informed choices about the gateway products they use in their applications and will also assist users with how to best employ these products to minimize technical and cost risks to their projects.

The Enhance strategy provides the community with information and products designed to drastically improve the developer experience when selecting, designing, configuring, and even creating multi-architectural gateways. This strategy was designed to provide significant benefit to the community while minimizing risk and cost. As such, this strategy has a very high potential ROI and is viewed as the optimal choice when balancing cost, risk, and benefit to the gateway community. The combination of usable independent information and product set based on proven technology will enable the community to make great strides toward gateway convergence.

The Enhance strategy also has a low risk of not realizing the benefits for each task. This low risk is the result of striking a balance between providing new capabilities to gateway users without requiring them to drastically change their operations. The Inform strategy also has low risk for similar reasons, but the ROI is much lower. The Enhance strategy has a low risk of not realizing benefits, unlike the Create strategy, which has a high risk.

Base on the high potential ROI and low risk of not realizing its benefits, the Enhance strategy is the recommended strategy.

9. PROPOSED PROJECT PLAN

Implementation of the Enhance strategy requires the recognition of the various temporal dependencies listed among the various tasks that collectively define the strategy. The recommended approach is defined in Figure 9-1.

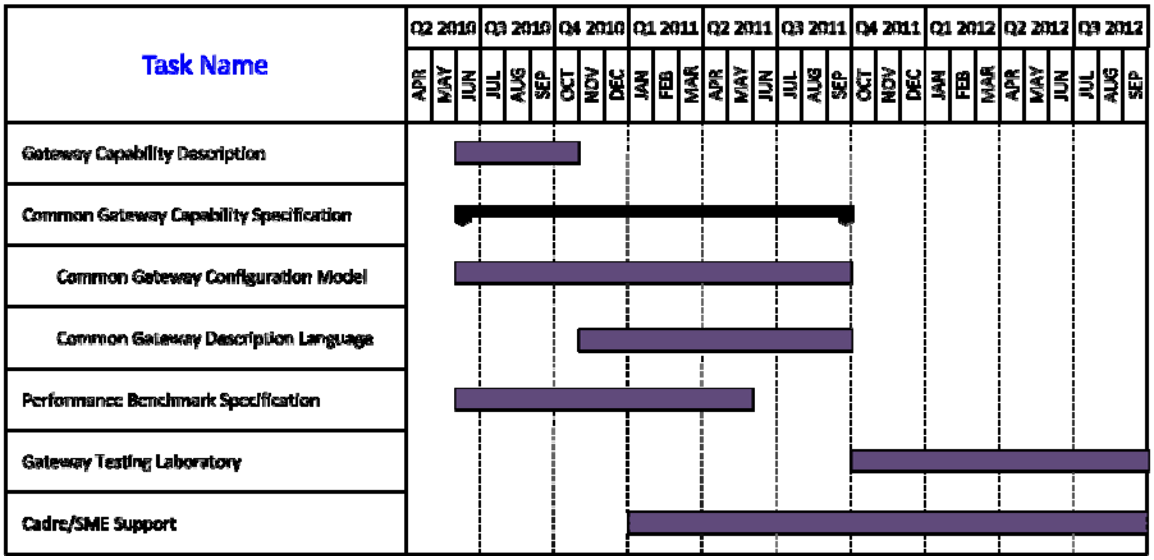

Figure 9-1. Enhance Strategy Project Plan

Several of the tasks listed in this plan have a dependency on the first task identified in this Gantt chart (the Gateway Capabilities Description task). Thus, this particular task would need to be the first to be performed. It is estimated that this task will have a duration of approximately 5 months, with a level of effort (LOE) of 6 staff-months. In parallel, work can begin on the Common Gateway Configuration Model task and the Performance Benchmark Specification task. Although both have some dependency on the Gateway Capability Description, both can proceed on aspects of the task that do not have dependencies. For instance, the Common Gateway Configuration Model task can begin with its assessment of ANDEM and its suitability to serve as an underlying SDEM translation model for gateways. The Performance Benchmark Specification task can begin with an assessment of the benchmarks used by current developers, for the purpose of defining a common set. In both cases, the final products will be influenced by the final Gateway Capability Descriptions.

The Common Gateway Configuration Model task has a total duration of 16 months at a total LOE of 16 staff-months. The Performance Benchmark Specification has a total duration of 12 staff-months, with a total LOE of 8 staff-months. Note that in this latter case, this is for the specification only, with tool support beginning in Fiscal Year 2012 (FY12).

The other major gateway specification included in this strategy implementation is the Common Gateway Description Language. The start date of this task has been aligned in this plan to correspond with the completion of the Gateway Capabilities Description. This is because of the strong reliance that this task has on this particular product. The end date for this task is late-September 2011, corresponding to an 11-month period of performance. The total LOE for this task is 12 staff-months.

Note that the strategy that underlies this plan is to have a reasonably complete set of specifications in place by the end of FY11 to provide a common community-wide basis for gateway capability discovery and configuration. While some initial prototypes of implementations of these specifications can certainly be supported in FY11, they have not been included as part of this plan.

The only other task that would begin prior to FY12 is the Gateway Cadre/SME support. In order to allot time to determine who the proper personnel would be for this task, it does not start until February 2011. This is considered to be a continuous task from that point forward and can be staffed at whatever level the sponsor believes is appropriate. It is recommended that this task be staffed at a level of 1 staff-month per month, and staffing can be adjusted higher or lower depending on the level of user engagement.

The main focus of the FY12 effort is to develop an initial set of tools to implement the specifications developed during FY10 and FY11. In this plan, this all falls under the Gateway Testing Laboratory task. The focus of this task is to provide a single independent testing service to measure the degree to which existing gateways support advertised capabilities, which would be based on the performance benchmarks. However, this task also includes the desired "gateway search and discover" capabilities based on the Common Gateway Description Language, and the tools needed to configure and initialize gateways based on the Common Gateway Configuration Model. Taken together, it is estimated that the total LOE required to achieve the desired degree of automation is approximately 5 staff-years over an 18-month period. Of course, the time required to build this capability can be stretched over a longer timeframe, which would allow new capabilities to be developed in a slower but more incremental manner. However, because of the strong perceived need for these tools in the LVC community, it is recommended that the timeline for production of these tools be kept as short as possible.

This plan represents the collective opinion of the Gateways Team, based upon the knowledge and experience of team members achieved through extensive interaction with gateway developers and users over the past year and in previous years. Any of the tasks in this plan can be removed or deferred (subject to task dependencies), based on sponsor interests and resource limitations. In addition, any of the tasks identified in the other two core strategies could potentially be incorporated into this plan, again depending on sponsor direction. However, it is believed that the implementation of the tasks currently defined in this plan will move the LVC community much closer to its desired end state while providing best value for the investments required.

10. SUMMARY

This study has defined four strategies for dealing with issues resulting from gateways in LVC environments. Each strategy has been extensively discussed, including a set of tasks for each. Based on the analysis in this document, the Enhance strategy is recommend for execution.

This document has defined a structured plan for executing the Enhance strategy. This represents the approach that the Gateways and Bridges Team believes will provide the highest ROI for the DoD with the lowest risk in realizing its benefits. This strategy incorporates several of the fundamental elements defined in the Inform strategy but extends these elements with several products intended to make more effective use of the gateway capabilities that exist today. Widespread adoption of these products in the LVC community will result in users making much better, more informed choices as to the gateway products they use in their applications and will also assist users with how to best employ these products to minimize technical and cost risks to their projects.

The project plan presented in this document provides a temporal sequencing of the tasks defined for the Enhance strategy that preserves all task dependencies while allowing for a gradual buildup toward the desired end state. While this plan represents the recommendation of the Gateways Team, it is important to recognize that the pace at which these tasks are executed, as well as the selection of the tasks themselves, can be altered depending on external factors. For instance, if more or less funding is available to execute a specific area of the plan, the duration of the associated tasks can be made either shorter or longer to fit the available resources. Also for instance, if a greater emphasis is desired for user education, or if sponsoring organizations wish to create a new gateway based on new emerging technologies, this can be all accommodated in the plan. The specific Execution Plan defined in this document is based on the team's best understanding of the needs of the LVC community as they exist today but should be considered to be flexible enough to address changing user requirements and/or variable resource levels.

One notable "external factor" is architecture convergence. As recommended activities in the architecture convergence area are executed and demonstrable progress is made toward desired goals, it is possible that the role of gateways and bridges in allowing coherent interaction among enclaves of simulations using different simulation architectures will diminish over time. This possibility is inherent in the project plan presented in this document, as the Enhance strategy focuses on a series of relatively low-cost but high ROI activities that improves utilization of existing gateway capabilities in the near- to mid-term while avoiding larger, longer-term investments that be may be unnecessary if architecture convergence objectives can be achieved. However, if architecture convergence happens either faster or slower than predicted, this plan can be easily adjusted to account for this situation.

Many of the products that will be produced under the Enhance strategy are specifications that will provide a common basis for describing, selecting, configuring, and employing gateways in the future. Since they are intended to be “common” across user communities, it is fully expected that several of these products will lend themselves to formal standardization. This document does not address the utility of standardization for these products and does not address the funding resources that would be needed to conduct such standardization activities in the future. However, where standards are appropriate, the team strongly recommends that appropriate resources be identified and provided as necessary to support such activities as the identified products become available. Only then will the value of these products to the LVC community be fully realized.

APPENDIX A: REFERENCES

The following documents were the sources for the technical details in this report.

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APPENDIX B: ABBREVIATIONS AND ACRONYMS

ANDEM	Architectural Neutral Data Exchange Model
CGCM	Common Gateway Configuration Model
CGDL	Common Gateway Description Language
COTS	Commercial Off-the-Shelf
DIS	Distributed Interactive Simulation
DoD	Department of Defense
FAQ	Frequently Asked Question
FY	Fiscal Year
GCD	Gateways Capabilities Description
GCMT	Gateway Capabilities Matrix Template
GPB	Gateway Performance Benchmark
GOTS	Government Off-the-Shelf
GTL	Gateway Testing Laboratory
HLA	High Level Architecture
HOT	Hands On Training
IEEE	Institute of Electrical & Electronics Engineers, Inc.
I/ITSEC	Interservice/Industry Training, Simulation and Education Conference
ITEA	International Test and Evaluation Association
JBUS	Joint Simulation Bus
JCOM	Joint Composable Object Model
JHU/APL	The Johns Hopkins University Applied Physics Laboratory
JMETC	Joint Mission Environment Test Capability
LAN	Local-Area Network
LOE	Level of Effort
LVC	Live-Virtual-Constructive
LVCAR	Live-Virtual-Constructive Architecture Roadmap
M&S	Modeling and Simulation
OM	Object Model
ROI	Return On Investment
SDEM	Simulation Data Exchange Model
SIW	Simulation Interoperability Workshop
SME	Subject Matter Expert
TDL	TENA Definition Language
TENA	Test and Training Enabling Architecture
US	United States
VMASC	Virginia Modeling, Analysis, and Simulation Center
VPN	Virtual Private Network
WAN	Wide-Area Network
XML	Extensible Markup Language

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