

# GENI Federation Scenarios and Requirements

G E N I: Global Environment for Network Innovations

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## 1 Summary

[TBD]

### 1.1 Document Revision History

The following table provides the revision history for this document, summarizing the date at which it was revised, who revised it, and a brief summary of the changes. This list is maintained in reverse chronological order so the newest revision comes first in the list.

Revision	Date	Revised By	Summary of Changes
0.1	July, 2010	S. Jeong A. Bavier	Completed draft

## 2 Introduction

Currently, there exist various network testbed infrastructures for developing and experimenting innovative network technologies [1][2][3]. The testbeds are managed by their own control frameworks and administered by local policy, such as authentication and authorization of users, resource allocation policy, and so on. So, it is hard to build large scale testbeds in the global scale. It is known that federation can provide large scale, diverse, and realistic network testing environments. Resources must be able to appear and be useful on more than one testbed in order to increase utilization and resource diversity rather than exclusive use. This document investigates federation scenarios and problems which will occur during federating multiple heterogeneous testbeds. The problems include considerations for authentication and authorization mechanism, control framework, description and management of testbed components. Also, several requirements to mitigate the identified problems are discussed.

### 2.1 Definition

The terminology of federation in GENI architecture is defined as follows [4].

“Resource federation permits the interconnection of independently owned and autonomously administered facilities in a way that permits owners to declare resource allocation and usage policies for substrate facilities under their control, operators to manage the network substrate, and researchers to create and populate slices, allocate resources to them, and run experiment-specific software in them.”

Based on the above description, there are two broad categories of the federation scenarios, federation with aggregates and with suites, respectively [4][5].

- The aggregates federation allows the inclusion of various components and aggregates into a GENI suite so that the users can make use of the federated resources. The federated aggregates may or may not use GENI control frameworks.
- The infrastructure suites federation enables the creation and utilization of slices over autonomously administered testbed infrastructures. The infrastructures may or may not use GENI control frameworks.

### 3 Problem Statement for GENI Federation

#### 3.1 Problem Description

Currently, there exist various testbeds for developing and experimenting innovative network technologies [1][2][3]. The testbeds are managed by their own control frameworks and administered by local policy, such as authentication and authorization of users, resource allocation policy, and so on. Since the control frameworks performs the main roles of managing the testbeds, it is necessary to investigate the problems and issues of federation from the viewpoint of control framework. The problems of federation may be classified into three types, identity and authority management, control procedures of testbed, resource and experimentation description, respectively. It is noted that the identity and authority management and resource and experimentation description can be within the scope of control procedures, but this document describes these two points as an independent categories because of their significance in the federation. The following list summarizes general problems with aggregate federation and infrastructure suite federation.

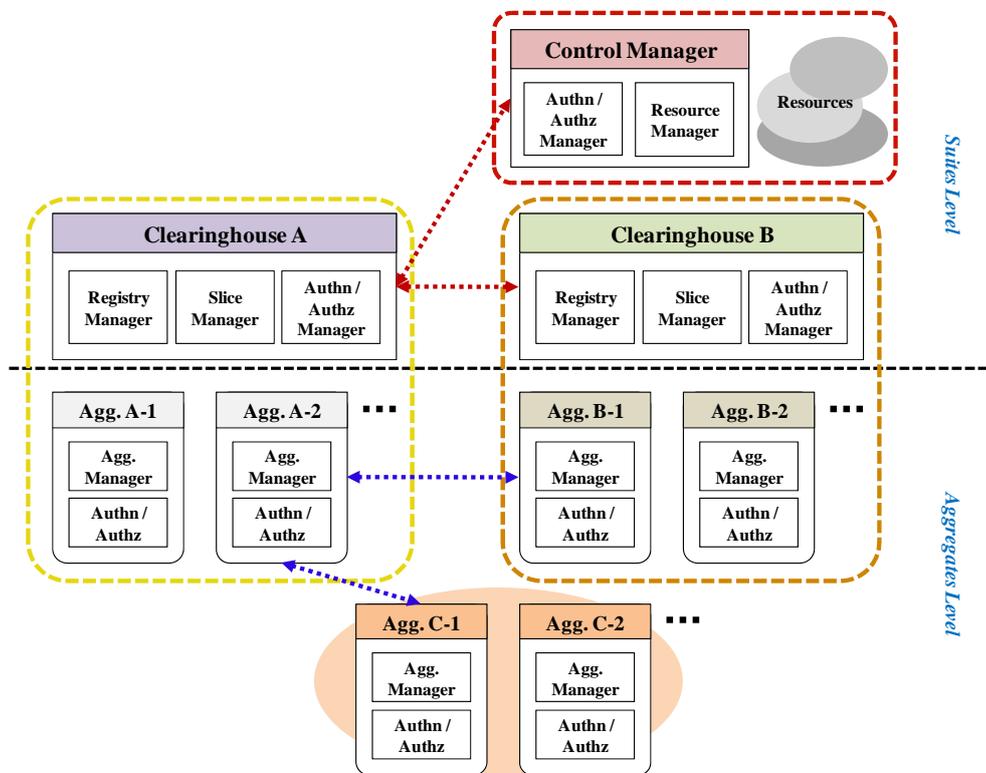
- Each aggregate or testbed may use different identity and authority management methods. The management methods include policy for identity allocation and authorization and mechanism for authentication and authorization.
- Different control procedures may be used for each aggregate or testbed. The issues related to control procedures can be further subdivided into control flow and different interfaces or APIs. The control flow specifies the procedures for resource discovery/allocation, slice creation/management, and experiment management. Even though two testbeds adopt the same control flow, the internal functions in the control flow may have different interfaces, such as, parameters. Therefore, it may not be possible to directly access the resources in other testbeds without modifying or adapting the control flow or interfaces.
- Different resources and experimentations description methods may be used. Each testbed may have their own resource description scheme, for example, RSpec in GENI suite [6][7]. The resource description schemes can vary not only the syntax and context of the formats, but also the entities included in the description scheme. Similarly, the description of experimentations/services and experimental results also may be different.

#### 3.2 Scenarios for GENI Federation

As mentioned in Section 2, this document considers two types of federation scenarios, aggregate federation and infrastructure suites or testbeds federation. These scenarios are shown in (Fig. 1).

- Aggregates federation: a clearinghouse provides federation with heterogeneous resources belonging to an aggregate. The federated aggregate may or may not use GENI control framework.
  - Federated aggregate uses GENI control framework. In this case, the federation issues are the same as the issues of infrastructure suites federation.
  - Federated aggregate does not use GENI control framework. In this case, the federation issues include previously mentioned three types of federation problems, identity and authority management, control procedures of testbed, resource and experimentation description.

- Infrastructure suites federation: a clearinghouse provides federation with infrastructure suites.
  - Federated infrastructure suite uses one of GENI control frameworks. In this case, there will be exist two or more autonomously administered clearinghouses.
    - If these clearinghouses use the same GENI control framework, the federation issues include identity and authority management issues only.
    - If these clearinghouses use different GENI control framework from each other, the federation issue with different clearinghouses can be occurred. Also, this federation issue includes previous considered 3 points for addressing federation problems.
  - Federated infrastructure suite does not use GENI control frameworks. In this case, the clearinghouse federates one and more control managers which have different control framework. Therefore, the federation issues include previously discussed all types of federation problems, identity and authority management, control procedures of testbed, resource and experimentation description.



(Fig. 1) GENI Suite federation scenarios

## 4 Requirements for GENI Suite Federation

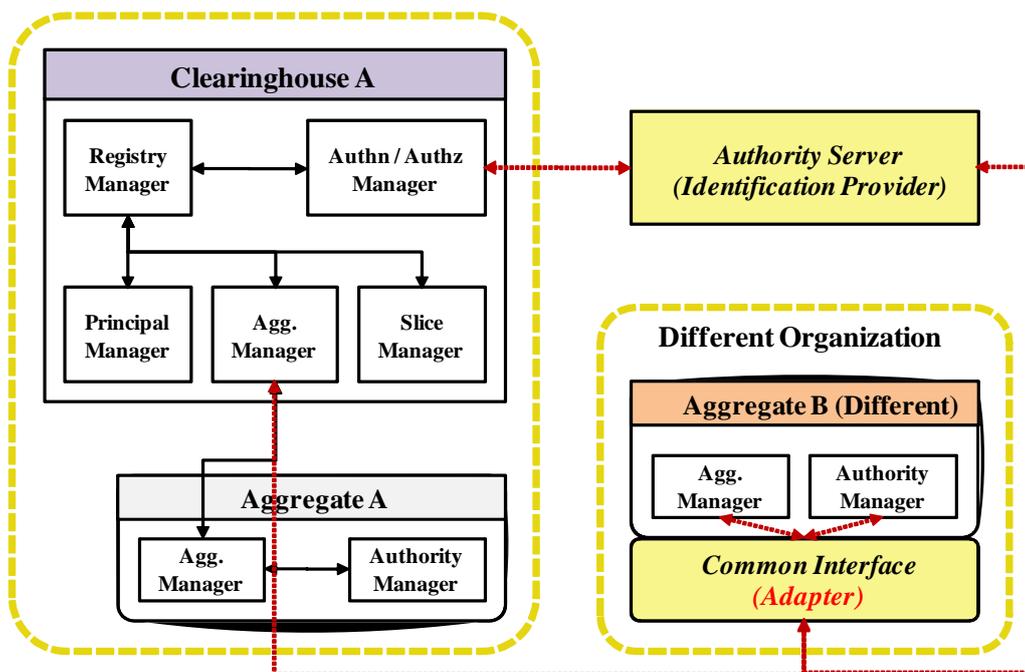
Several issues need to be considered and resolved by the infrastructure suites components before performing federation between GENI infrastructure suite and other infrastructure suites or aggregates. The following list summarizes some general observations, which needs to be considered.

- Global name space may be required in order to access other domains transparently.
- Metadata services that supports to access, propagation, aggregation, and management of entity metadata across administrative domains may be necessary.
- Site autonomy may be considered so as to access resources across sites while respecting local control and policy.
- Collecting and exchanging resource usage, e.g., consumption data across domains may be necessary.
- Testbeds federation may need to separate the authentication and authorization: resource owners are responsible for authorization, i.e., local policy and authentication service providers are responsible for providing strong authentication tokens or certificates.

The following clauses describe more specific issues and requirements for each federation scenario.

### 4.1 Aggregate Federation

When a clearinghouse federates another aggregate, the aggregate can be managed by an independent organization whose control mechanism and authority policy are different from the clearinghouse. Since the aggregate to be federated with the clearinghouse uses a different control framework, it is needed to address federation issues under this situation. The scenario where the aggregate is managed by GENI suite is discussed in Section 4.2. Fig. 2 shows the aggregate federation scenario. In the scenario, Aggregate A is managed by testbed A and GENI suites are used as a control framework, whereas Aggregate B is owned by different organization with different type of control framework.



(Fig. 2) Aggregate federation scenario

The followings list several problems caused by this federation scenario considering the problems of federation discussed in Section 3. The problems happen because the federated aggregate is managed by an organization that uses different authorization policy and resource control mechanism.

- Identity and authority management
  - A different policy is used for identification and authority management.
  - A different method is used for identification, authentication, and authorization process.
- Control procedures
  - A different control framework is used.
- Resource and experimentation description
  - A different description language for resource information is used.
  - Different data structure and data access method are used.

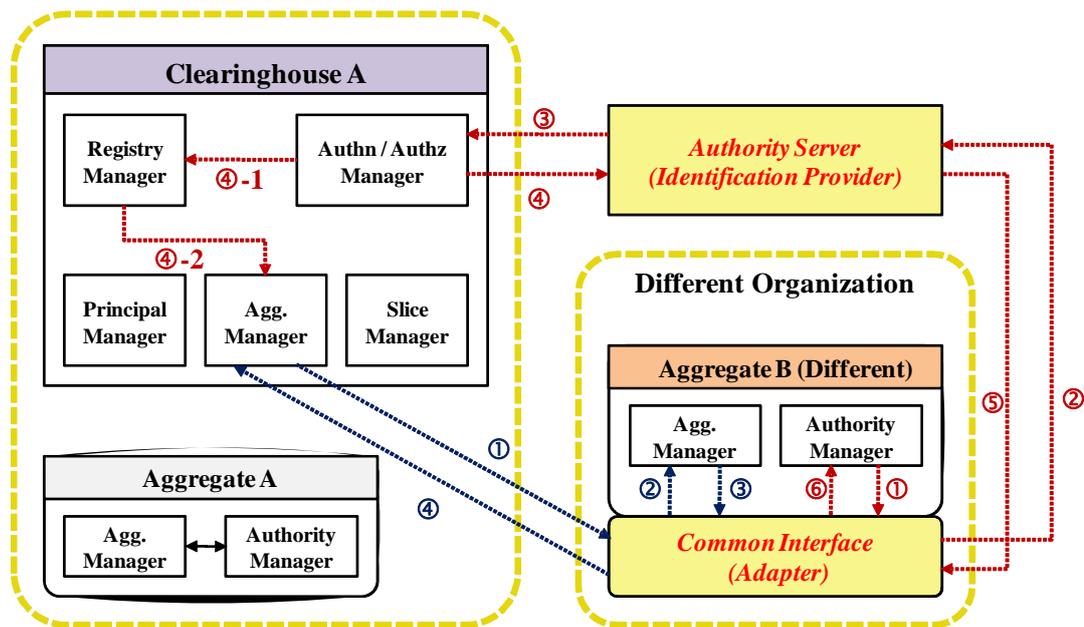
Several tasks need to be performed in order to mitigate the observed problems. The following list summarizes some key functions, which need to be performed by the GENI suite and the federated aggregate.

- Control framework that uses common interfaces or adapters. Throughout an adapter, the clearinghouse can communicate with the federated aggregate. It can translate control messages, which are unified with GENI control framework, into appropriate forms for the federated aggregate in order to use resources belonging to the federated aggregate. In this process, the appropriate translation rules are necessary.
- Unified profile for certificate authority management. For this purpose, an authority server may be needed. The authority server manages identification, authentication, and authorization processes. It provides authority policies for the federated aggregate, a unified identification process for the federated aggregate, and a unified authentication and authorization process for the federated aggregate.
- Common resource and experimentation description language.
- Common data access interfaces.

Fig. 3 illustrates an example procedures meeting the federation requirements above. When the clearinghouse A wants to federate the aggregate under the different organization (aggregate B), the aggregate B should be registered to the clearinghouse A. After registering to the clearinghouse A, information about aggregate B is stored in registry of the clearinghouse A and retrieved by registry manager of the clearinghouse A. The followings are requirements for this scenario.

- Registration of a target aggregate: The control messages of the clearinghouse A for the registration process can be translated into the proper formats by adapter. In the translation process, it is necessary to define and to apply appropriate mapping or translation rules.
  - The authority server authenticates certificate assertions and identification managed by different policies from each other, and authorizes principals registered in the clearinghouse A in order to use diverse resources in the aggregate B.
  - Since authority policies are different from each other, so they need to be negotiated with appropriate agreements. After negotiating authority policies between the clearinghouse A and the aggregate B, some resources in the aggregate B are limited by negotiated policies when a principal belonging to the clearinghouse A wants to use them.
  - The authority service is provided throughout unified profiles. For example, the unified profile based on SAML/Shibboleth SSO profile [8] may be used. In this case, the authority server is an identification provider and it provides certificate identity and assertion for the aggregate B.

- Usage of resources in a target aggregate: After registering the aggregate B, the information is managed by aggregate registry manager in the clearinghouse A. In addition, the information can be searched in aggregate registry and aggregate record in the clearinghouse A.
  - The adapter provides translation of control messages for experiment setup (e.g. resource discovery, resource sharing, and resource assignment) and experiment execution (e.g. slice management, experiment management, and data management) based on the proper mapping or translation rules.
  - Resource and experiment can be described by using common description language. For example, XML based specification language can be used.
    - Common data access interfaces can be included and it can be separated as an independent module.



(Fig. 3) Example procedures of aggregate federation scenario

## 4.2 Infrastructure Suites Federation

This section investigates federation scenarios between infrastructure suites. There are two sub scenarios within this category, federation between GENI suites and federation between GENI suite and non-GENI infrastructures. The federation scenario between testbeds using GENI suites can be further specified into either testbeds using the same control framework or testbeds using the different control frameworks. Most problems of the aggregate federation scenario can also be applied to testbeds federation scenarios. The problems happen because federated testbed can have their own control framework and administration policies.

- Identity and authority management
  - A different administration policy can be used for identification and authority management.
  - A different mechanism can be used for identification, authentication, and authorization process.
- Control procedures
  - A federated testbed can use different control frameworks that are not compatible with GENI suites.
- Resource and experimentation description
  - A different description language for resource information can be used.

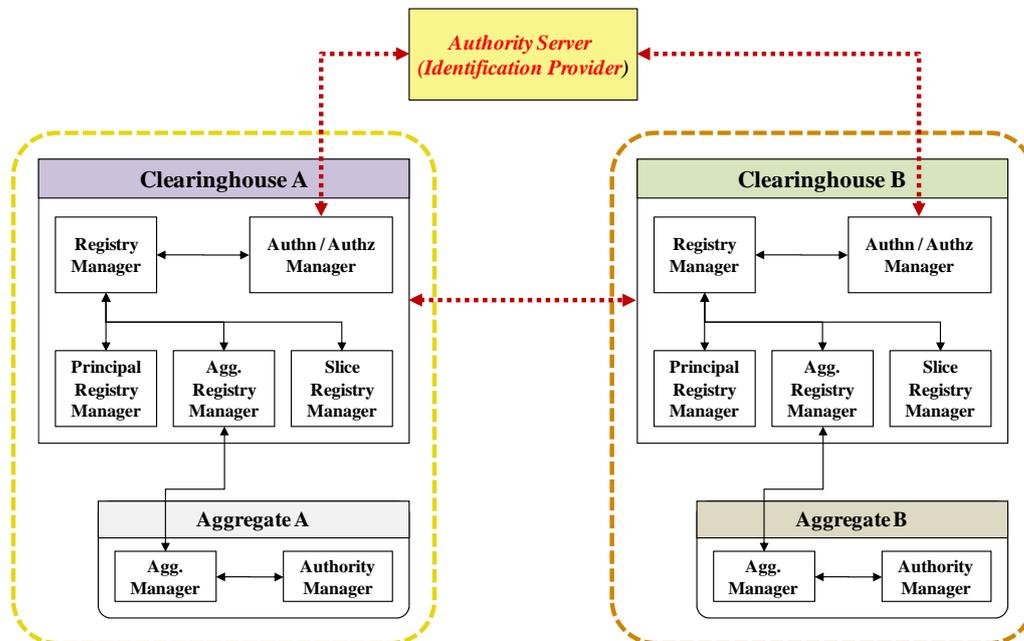
- Different data structure and data access method can be used.

#### 4.2.1 Federation with Infrastructure Suites using Same GENI Control Framework

When the testbeds use the same control framework, they are likely to be the geographically distributed testbeds and may apply different local authentication and authorization policy. The federation between testbeds using one of GENI control frameworks is a typical example. Fig. 4 depicts federation scenario between testbeds using same GENI control framework. The followings issues can be raised during the federation because the testbeds use same control framework but may have different local policy for authentication/authorization.

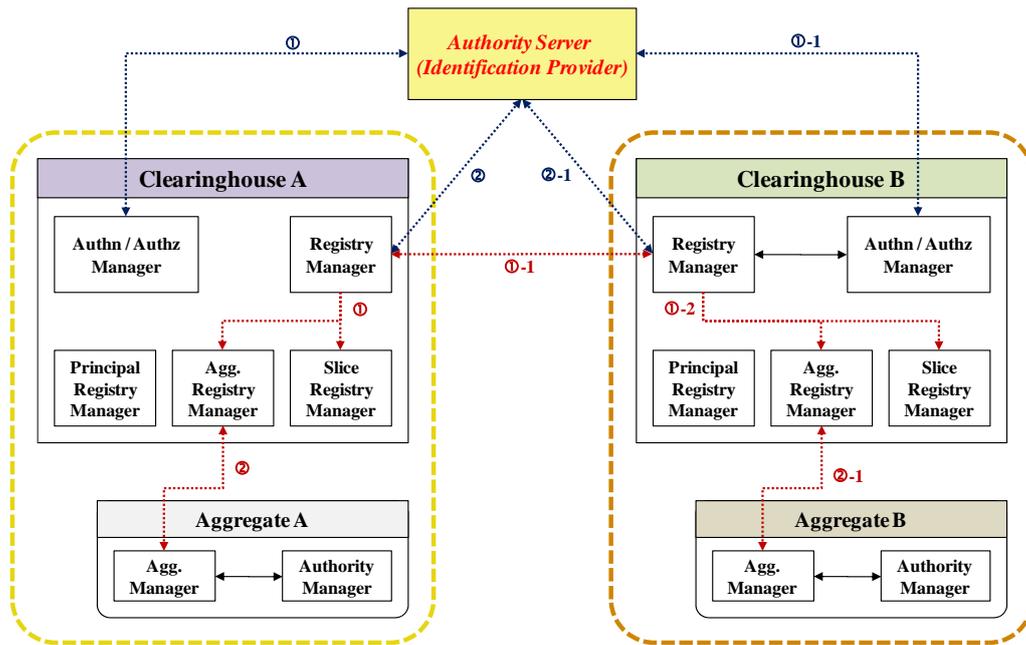
- Identity and authority management
  - Handle identity and authority management with different local policy
- Control procedures, resource and experimentation description
  - Does not occur control procedures, resource, and experimentation description issues

Those issues may be resolved by providing a common certification mechanism for different policy authority.



(Fig. 4) Federation scenario between testbeds using same GENI control framework

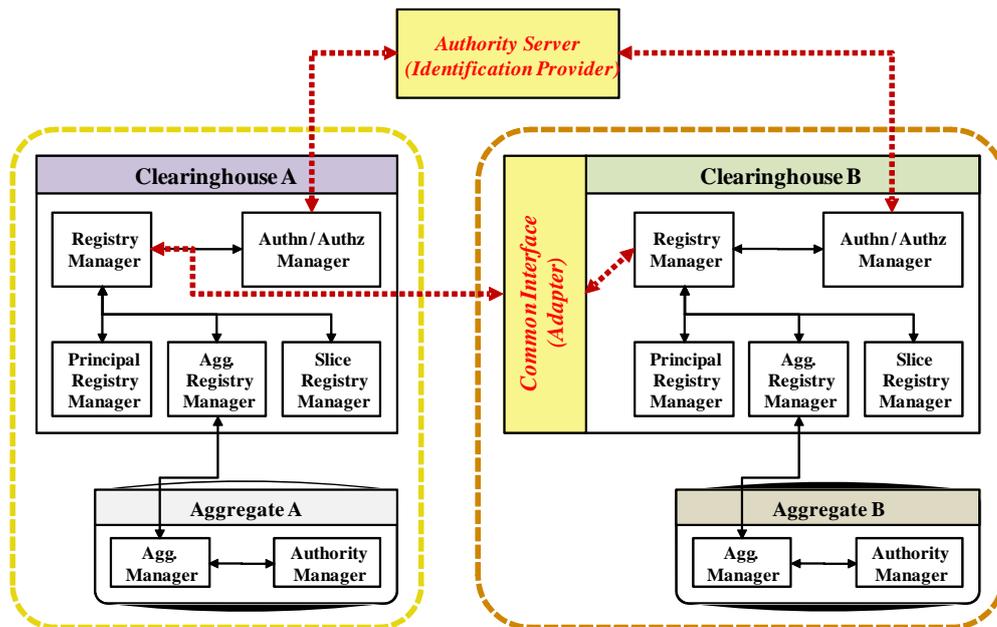
Fig. 5 illustrates an example procedures meeting the federation requirements above. Since the same control frameworks are in use, the basic control functions can be used without consideration. Authority server can provide authentication of certificate assertion and identification which are managed by different local policy and can authorize users. The authority server includes the roles of identification provider and certificates identity and assertion of clearinghouse B.



(Fig. 5) Example procedures of federation scenario between testbeds using same GENI control framework

#### 4.2.2 Federation with Infrastructure Suites using Different GENI Control Frameworks

Although different control frameworks are used in the testbeds, the control frameworks confirm GENI architecture. Thus, there exist authorization, data management problems rather than the problems related to the control procedures. An example shown in Fig. 6 is the federation scenario between testbeds using different control frameworks in GENI.



(Fig. 6) Federation scenario between testbeds using different GENI control framework

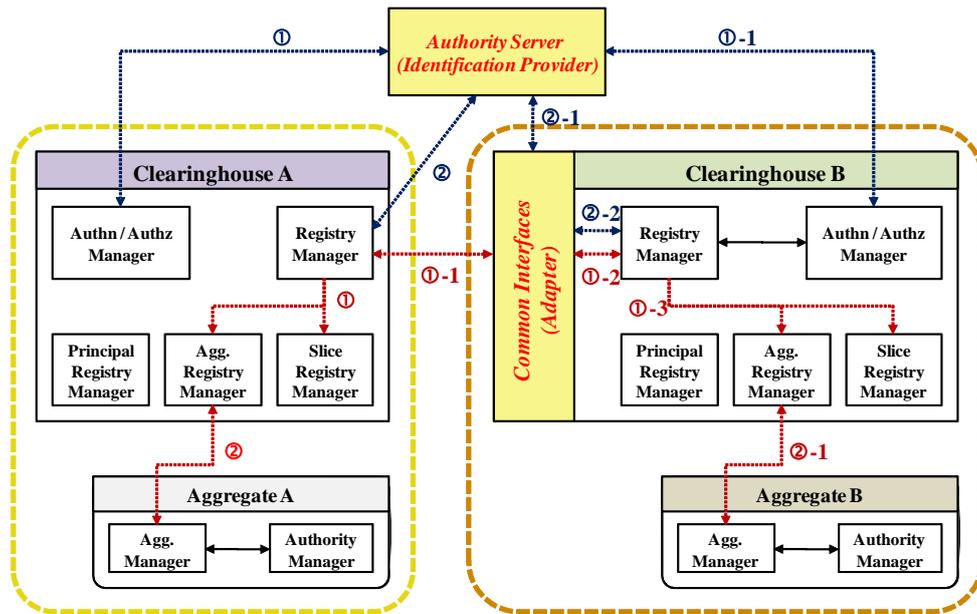
The followings list several issues caused by the federation scenario. The issues happen because the federated testbed is managed by an independent organization and uses different GENI control framework.

- Identity and authority management
  - Manage identification and authority that uses different policy
    - Ex) ProtoGENI vs. PlanetLab
  - Use different mechanisms for authentication and authorization
    - Ex) ProtoGENI: Public Key Infrastructure (PKI) and XML-SIG (XML signature) based Credential
    - Ex) PlanetLab: Public Key Infrastructure (PKI) and X.509 based Certificates
- Control procedures
  - Incompatibility between control procedures
    - Ex) Interfaces and APIs of control procedures
- Resource and experimentation description
  - Use different scheme for resource and experimentation description

The following requirements should be considered in order to resolve the observed problems. The same requirements discussed in Section 4.1 can applied here.

- Control frameworks that support common interfaces or adapters
- Unified profile for certificate authority management
- Common resource and experimentation description language
- Common data access interfaces

Fig. 7 illustrates example procedures of the federation between testbeds using different GENI control frameworks. For the authority service, unified profile for each clearinghouse is required. For example, it may be possible to provide unified profile based on SAML/Shibboleth SSO profile. Also, common interfaces need to support the interface to authority server. By using the common interfaces or adapter, it is possible for clearinghouse A to execute control procedures of clearinghouse B. After the certification, clearinghouse A can request the use of aggregates registered to clearinghouse B through the common interfaces or adapter. During the experiment setup and execution process, the adapter performs the translation of control functions that can be happen due to the difference in data description schemes and data structure. It is possible to remove the translation by defining common description scheme e.g., XML based specification language, and by describing resources and experiments. Regarding data access scheme, each testbed can either define independent data access interfaces and translate the interfaces by using adapter or utilize common data access interfaces.



(Fig. 7) Example procedures of federation between testbeds using different GENI control frameworks

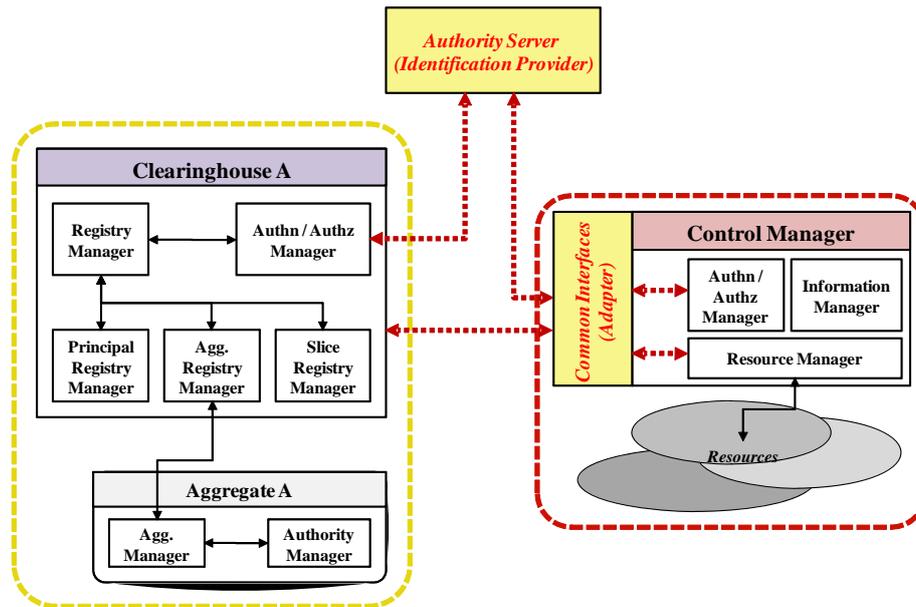
#### 4.2.3 Federation between GENI Suite and Non-GENI Suite

When the federation between GENI and non-GENI testbeds happens, the two testbeds will use different control frameworks. Fig. 8 shows the federation scenario between GENI and non-GENI testbed. Since the testbeds are managed by different control frameworks not compatible with GENI suite, all the issues that are related to authorization, control procedures, and data management problems will occur. The list below describes problems caused by the federation between GENI and non-GENI testbed.

- Identity and authority management
  - Manage identity and authority based on different local policy
  - Use different mechanism for authentication and authorization
- Control procedures
  - Incompatibility between control procedures
- Resource and experimentation description
  - Use different scheme for resource and experimentation description

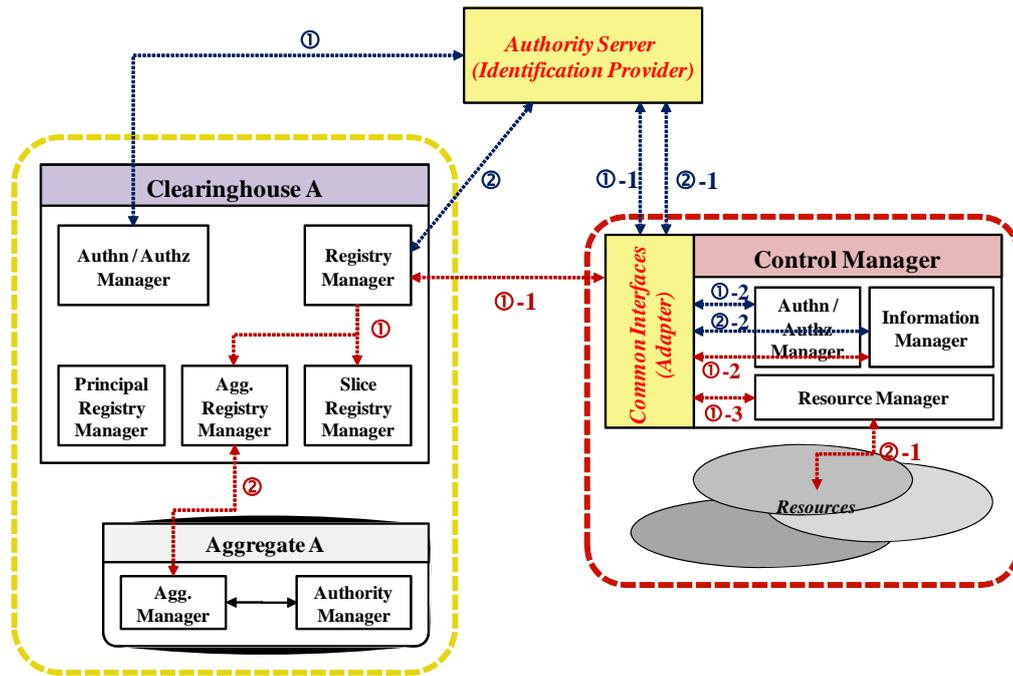
The following requirements should be considered in order to resolve the observed problems.

- Common interfaces or adapters for different control framework
- Common interfaces or adapter for authority service
- Unified profile for certificate and authority management
- Common resource and experimentation description language
- Common data access interface



(Fig. 8) Federation scenario between GENI and non-GENI testbed

Fig. 9 depicts example procedures of the federation between GENI and non-GENI testbed. It is assumed that there exists a control manager which performs similar functions of GENI control framework. In this example, the control manager consists of authentication/authorization manager, information manager, and resource manager. Clearinghouse A and authentication/authorization manager in non-GENI testbed can mutually authenticate and authorize the identities and certificates of users and resources within their testbeds, respectively. The authority server may provide the mutual authentication and authorization services. For the authority service, unified profile for each testbed is necessary. Also, common interfaces or adapters are necessary so that clearinghouse A and control manager can translate their own interfaces/APIs used in authentication/authorization scheme into the interfaces of the common authority server. By using the common interfaces or adapter, it is possible for clearinghouse A to execute control procedures of non-GENI testbed. After the certification, clearinghouse A can request the resources registered to information manager of non-GENI testbed through the common interfaces or adapter. During the experiment setup and execution process, the adapter performs the translation of control functions that can be happen due to the difference in data description schemes and data structure. It is possible to remove the translation by defining common description scheme and by describing resources and experiments.



(Fig. 9) Example procedures of federation scenario between GENI and non-GENI testbed

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