Earth System Grid Authentication Infrastructure: Integrating Local Authentication, OpenID and PKI

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1. Introduction

Climate scientists face a wide variety of practical problems, but there exists an overarching need to efficiently access and manipulate climate model data. Increasingly, for example, researchers must assemble and analyze large datasets that are archived in different formats on disparate platforms, and must extract portions of datasets to compute statistical or diagnostic metrics in place. The need for a common virtual environment in which to access both climate model datasets and analysis tools is therefore keenly felt. The software infrastructure to support such an environment therefore not only must provide ready access to climate data but also must facilitate the use of visualization software, diagnostic algorithms, and related resources. To this end, the Earth System Grid [2] Center for Enabling Technologies (ESG-CET) was established in 2006 by the Scientific Discovery through Advanced Computing program of the U.S. Department of Energy through the Office of Advanced Scientific Computing Research and the Office Biological and Environmental Research within the Office of Science. ESG-CET is working to advance climate science by developing computational resources for accessing and managing model data that are physically located in distributed multiplatform archives [1].

Earth System Grid Scale-up. In coming years, the ESG-CET will scale up existing capabilities to meet the needs of the following scientific projects:

• The North American Regional Climate Change Assessment Program (NARCCAP) will disseminate high-resolution regional climate model data through ESG portals located at both the Program for Climate Model Diagnosis and Intercomparison (PCMDI) at Lawrence Livermore National Laboratory (LLNL) and the National Center for Atmospheric Research (NCAR).

• The Computational Climate End Station (CCES) at the DOE leadership computing facility at Oak Ridge National Laboratory (ORNL) will advance climate science through both an aggressive model development activity and an extensive suite of climate simulations.

• Phase 5 of the Coupled Model Intercomparison Project (CMIP5) will support the challenging climate data needs of the planned Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC).

These projects, and especially CMIP5, will drive future development of ESG technologies in order to connect a large number of users with geographically distributed climate model archives and to provide them with advanced data analysis tools. Together with its institutional collaborators, ESG-CET will extend its present capabilities in order to supply additional types of climate model data and metadata, to provide more powerful server-side access and analysis services, to enhance interoperability among commonly used climate analysis tools, and to enable end-to-end simulation and analysis workflow.

National and International Collaborations. Future ESG-CET activities will be framed by relationships with other institutions that share common data-management interests, organized as the Global Organization for Earth System Science Portal (GO-ESSP) consortium. GO-ESSP will develop a common software infrastructure for acquisition and analysis of climate model data. ESG-CET consortium members that will take leading roles as gateways and/or data nodes in the CMIP5 (IPCC AR5) testbed include PCMDI, NCAR, ORNL, and LANL. Other members that will play a vital role in the CMIP5 effort include the Geophysical Fluid Dynamics Laboratory (GFDL), the British Atmospheric Data Centre (BADC), the World Data Center for Climate (WDCC), and the University of Tokyo Center for Climate System Research. Because GO-ESSP extends beyond U.S.-based partnerships, it will need to develop software to accommodate components from the U.K. Natural Environment
Research Council (NERC) DataGrid (NDG), the European Union (EU) MetaFor project, and the German C3-Grid initiative.

**Future Usage.** Under the current ESG system, a user first accesses and queries a remote database by means of a Web browser and then retrieves desired data records via the ESG data portal, a Data Mover Light (DML) tool [2], or a Web “get” scripting-operation (wget/curl). After downloading these records to the local site, the user usually regrids, reduces, and further analyzes the data. This process often requires many data movements that can overtax network, storage, and computing resources. With the next-generation ESG architecture, the user instead will browse, search, and discover (i.e., determine the properties of) distributed data on remote sites. These may include nontraditional data products (e.g., biogeochemical and dynamical vegetation variables simulated by CMIP5-coupled climate–carbon cycle models).

The user then will be able to regrid and analyze the desired data in place before downloading the data to the local site. This approach will place new data-management demands on ESG hosting sites but will allow scientific issues, rather than the organization and movement of data, to receive primary attention. In future ESG services, the existing Web portal capabilities will be augmented by applications to streamline data download, as well as provide powerful analysis and visualization capabilities. For example, it will be feasible to use popular and free climate analysis and visualization tools (e.g., CDAT, NCL, GrADS, and Ferrret) directly within the ESG system.

**Functional Specification and Architecture Design.** Computer processing capabilities of the order of $10^{15}$ floating-point operations per second (petaflops) are expected to be the norm by 2010. In order to meet these petascale computational needs, the future ESG architecture must allow for the networking of a large number of distributed sites with varying capabilities. Such “federation” implies that users will have to authenticate only once in order to gain access to data across multiple systems and institutions. In order to accomplish this objective, the future ESG architecture will be based on three tiers of data services.

Tier 1 services will operate across the entire ESG-CET federation. These include user registration and management, common metadata and notification services to communicate data changes, and global monitoring services to detect data problems. Because all ESG-CET sites will share a common database, a user will be able to find data of interest throughout the entire federation, independent of the site where a data search is initiated. However, access to specific datasets and related resources will still require approval by the data “owners.”

Tier 2 data services will comprise multiple ESG gateways that manage limited access to specified data (e.g., the CMIP5 database). Such gateway-deployed services will include the user interface for searching and browsing metadata, for requesting data products (including analysis and visualization tools), and for orchestrating complex workflows. Because the relevant software will require considerable expertise to maintain, Tier 2 gateways will be monitored directly by ESG-CET engineers.

Tier 3 will include the actual data holdings and the services used to access these data, which will reside on ESG data nodes. Tier 3 typically will host the services needed to publish data to ESG and to execute data product requests made through an ESG gateway that may serve data requests to many associated data nodes: for example, more than 20 institutions are expected to operate ESG data nodes for the CMIP5 database. Because personnel with varying levels of expertise will operate ESG data nodes, the Tier 3 software will come with extensive documentation.

**Security.** Maintaining the security of data and resources is crucial, but this should not place an undue burden on data users and administrators. A practical security protocol is to require only a single sign-on in order for a user’s browser or client software to gain access to distributed data. Single sign-on will allow the security function of the ESG portal to be split among multiple servers while users authenticate only within their home domain.

For this paper, we will focus on requirement details and solutions for the authentication architecture that is being implemented by the ESG team. This paper is organized as follows. Section 2 discusses more of the details of ESG’s requirements concerning authentication. Section 3 describes the single sign-on solutions that were chosen and are implemented. Section 4 briefly discusses the next technology choices concerning attribute and authorization facilities and services that are layered on top of the authentication infrastructure. Section 5 presents a summary of the paper.

**ESG and TeraGrid(TG).** The climate models require vast amount of compute resources and ESG plans to make the TG resources available to its users. Note that the PKI credentials issued by ESG’s Certification Authorities (CAs) are already compatible with those used by TG, but ESG’s CA has to be accredited. As far as a possible WebSSO between the ESG and TG-portals, we will work to ensure that ESG’s solution will somehow work with whatever TG’s SSO choice will be in the future.

2. **Authentication Requirements**

We discuss three aspects of authentication: single sign-on, public key, and security configuration.
Web Single Sign-On. ESG’s infrastructure consists of multiple Web portals and Web application servers that are hosted by the member organizations of the collaboratory. The main portals will manage their own user base, will require their users to login “locally,” and will expect those authentication credentials to be honored throughout the ESG-virtual organization. Each main portal should also have the option to integrate their authentication mechanism with the portal-organization’s existing Identity Management System, such that much of the user’s life-cycle management can be leveraged.

X509 Public Key Authentication. Besides the Web browser clients, there is also the requirement for the use of specialized clients for data-movement applications (GridFTP [4], OPeNDAP[10], DML, or the Live Access Server (LAS)[8] and for job-submission in compute-grid facilities, like TeraGrid [14]. In most of those cases, the application’s security infrastructure is based on the Globus Grid Security Infrastructure, GSI [3][6], and requires X509-public-key authentication credentials.

Security Configuration. All client and servers, whether Web or Grid applications, require the configuration of security-related parameters, such as the trusted Certification Authorities, revocation lists, trusted identity providers, and attribute and authorization authorities. This information is not static and will have to be updated for every revoked identity, and for any change in ESG’s membership as far as trust-roots, like identity providers and certification authorities are concerned. The timely and correct update of this security configuration information is crucial for the correct functioning and integrity of the whole ESG operation, Incorrect security configuration of for example, revoked credentials or CAs could lead to security compromises, while users of a new collaborating organization will only be able to access the ESG resource once their organization’s CA is part of the security configuration of all ESG’s resource providers.

3. Authentication Infrastructure

The basic authentication infrastructure of ESG is depicted in Error! Reference source not found.. It shows how both OpenID and X509 credentials are derived from a pluggable, primary authentication mechanism, such as username/password. This section presents details of the OpenID and X509 components and the associated security configuration management.

OpenID WebSSO. The Web Single Sign-On (WebSSO) solution chosen by ESG is OpenID [8][9]. It provides for a mechanism and trust infrastructure to transparently redirect unauthenticated web clients from a service provider (SP) to the identity provider (IdP) of their home-organizations to login. The client is then transparently redirected back to the SP’s application server, which will honor the IdP’s proof of authentication that is presented.

The OpenID technology is similar to, but arguably less heavy-weight than, the Shibboleth/SAML WebSSO solution. The ESG team performed an in-depth evaluation of both solutions and concluded that OpenID would be a viable WebSSO solution if a number of concerns were addressed, which resulted in a definition of an OpenID secure usage profile for the ESG federation. This profile required enforcement of a white list of IdPs, that ensured that only a trusted set of IdPs, agreed upon by the ESG federation are accepted by the SPs. Furthermore all communication between the IdP-SP must be
ESG leverages OpenID4Java[13], an open source Java implementation of the OpenID protocol. We have actively participated in the open source effort by contributing code for the features and patches that address the perceived shortcomings. Those contributions are:

- **IdP Whitelisting Extension.** This extension is designed to allow developers to plug-in their own IdP validation during the discovery phase. A well-defined IdP Validator interface is provided that allows arbitrary parameters to be configured. Developers can leverage this interface to define their own validation algorithm. Similarly, a configuration interface allows deployers to choose one or more IdP validation mechanisms to be used for a given deployment. Both as an example and to meet the ESG use case, an implementation of the IdP Validator interface that takes a plain text file with a list of IdP endpoints to trust, is provided. This validator implementation will check if the IdP used for asserting the user’s identity is a member of the IdP-whitelist. Another contributed Validator implementation provides a whitelist for individual identities that can be asserted only by a defined set of IdPs.

- **Attribute Provider extension.** This IdP-extension provides a pluggable interface to obtain attributes from external sources and communicates those to the SPs as part of the OpenID protocol communication. An Attribute Provider interface has been defined that can be configured with arbitrary parameters and used to obtain the attributes for a given identity. To meet the ESG use case, an implementation that extracts the attributes from a back-end database has been provided as an example.

**Short-Lived Credential Services.** The issuing of long-lived X509 public key end-entity certificates to individual users is notoriously heavy-weight and would put a substantial extra burden on ESG’s user management. For that reason, ESG has chosen a short-lived credential services (SLCS) solution [13] based on the deployment of an online-CA that issues short-lived X509 EE-Certificates derived from a pluggable primary authentication mechanism. The implementation choice for the online-CA is MyProxy [9], which leverages the standard Pluggable Authentication Module (PAM) for the primary authentication mechanism. This allows the ESG infrastructure to plug-in a primary local authentication service that is used by both an OpenID IdP as well as the backend to an Online CA. This setup allows for the sharing of a single username-password database by the OpenID IdP and the MyProxy-CA.

In addition, the MyProxy server can be configured to consume attributes from arbitrary sources and embed them as non-critical extensions in the X.509 EE-Certificate. These attributes will be transparently communicated to a relying party during the authentication process. Note that this feature is equivalent to the before mentioned OpenID attribute provider extension, where the attributes can be obtained by the OpenID IdP and communicated to the SPs. Both the Open IdP and the MyProxy online-CA will obtain the attributes from the same source.

**Autoprovisioning.** To ease the burden of the system administration to maintain the security configurations on all clients and servers, ESG is deploying the autoprovisioning feature of the MyProxy service for both clients and servers.

After successful authentication, in addition to the short-lived X509 credentials, a client also receives security configuration information from MyProxy. In this way, the system administrator can centrally maintain the correct and updated security configurations for the clients with MyProxy, and the clients will receive the updated information with every login. In addition, ESG has contributed code to the MyProxy effort that enhances that service such that servers can obtain the trust-root information in a similar fashion, which again facilitates the system administration of the server’s configuration.

**Figure 2. MyProxy Autoprovisioning Integrated with Login**

4. **Current and Future Work**

We have several activities planned or under way to enhance ESG.

[18] The Americas Grid Policy Management Authority (TAGPMA) Accreditation [18]. In order for clients to use their ESG-issued short-lived X509 credentials to submit jobs to, for example, TG’s compute services, ESG’s online-CA signing policy must conform to the resource owner’s, i.e. TG’s, policy. We are investigating how to obtain the requires TAGPMA-accreditation.
Attribute Assertions. Currently, we are leveraging OpenID’s mechanism to communicate attribute information with the authentication assertion from IdP to SP. However, we recognize the issue that the IdP does not always has the option to access and communicate the relevant VO-associated attributes. An extra, optional attribute service call-out may be needed, and we are looking to leverage GridShib’s [6] experience in that area. We plan to deploy some of MyProxy/GridShib’s mechanisms to embed attributes in the issued X509 EE-certificates. Furthermore, we’re investigating the use of SAML-formatted attribute statements for OpenID’s attribute values. The latter would allow us to deploy a single attribute assertion format that can optionally be signed.

SAML/Shibboleth [14][15] Federation. Although we do not have the requirement currently, future collaborating organizations may have a WebSSO infrastructure based on SAML/Shibboleth. We are therefore following the technological developments concerning federation of the WebSSO.

Autoprovisioning of WebSSO trust roots. We see the need for an autoprovisioning service for the Web server’s trust root configuration and the IdP-whitelisters. We’re investigating whether we can enhance MyProxy to provide that service.

5. Summary
In this paper, we present an update of ESG’s development and implementation efforts concerning its authentication infrastructure. ESG’s requirements are to leverage existing primary authentication mechanisms, to deploy a lightweight but secure WebSSO, to deploy a lightweight X509-PKI, and to ease the burden of security configuration management. We believe that our choice of OpenID, Short Lived Credential Services, and autoprovisioning meets those requirements and we’re close to completing the associated development and deployment.

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References
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