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SCAAS: A Secure Authentication and Access Control System for Web Application Development

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ABSTRACT

User authentication and data access are becoming two of the most common areas for web attacks. Most security vulnerabilities occur in areas of coding where Web security has lapsed. This paper describes the design and development of a Secure Authentication and Access Control System (SCAAS) implemented as a reusable library that provides data driven and encryption based authentication and access control for the use with ASP.NET applications.

INTRODUCTION

Web sites today face many threats to the confidentiality and integrity of the data used and the functionality provided by the application. This problem is compounded by the fact that Web developers are simply lack of either adequate knowledge and skills in writing secure Web application codes (Huang et al., 2005) or sufficient testing methodologies for the audit and control of Web development (Mansouir and Houri, 2006). Works in the design and implementation of security measures for Web applications are greatly in need.

User authentication and data access are becoming two of the most common areas for web attacks when procedures such as single sign-on and authentication delegation have become practically indispensable for e-business environment (Paulus, 2001). These two types of on-line vulnerability can be counterattacked by securing user account database that opens the gate of the application and by encrypting SQL connection that leads to the data store.

This paper describes the design and development of a Secure Authentication and Access Control System, herein referred to as SCAAS, implemented as a reusable library that provides data- driven and encryption-based authentication and access control for the use with ASP.NET applications. SCAAS employs Microsoft SQL Server to persist the security definitions that the SCAAS run-time system utilizes. The SCAAS database will be herein referred to as the SCAAS User Registry. The system also provides an ASP.NET based administration application that is used to maintain the data in the SCAAS User Registry.

SCAAS COMPONENTS

SCAAS consists of four major components. Their definition and functionalities are described as follows:

SCAAS Framework

This is the core of the SCAAS run-time application and a .NET library written in C#. Included in the namespace are four classes that make up the SCAAS Framework: *SCAASManager*, *SCAASManagerHelper*, *SCAASDataProtector*, and *SCAASException*. These classes will be further discussed in Section 3.

SCAAS User Registry

This is a Microsoft SQL database named *UserAccounts* that provides the basis for the SCAAS User Registry. The SCAAS Framework works closely with the *UserAccounts* database. Any connectivity between the SCAAS framework and the *UserAccounts* database is done securely with .NET enabled encryption and decryption procedures. The SCAAS User Registry can be updated through the *SCAASAdmin* ASP.net application included in the system.

SCAAS Admin ASP.NET Application

This is the ASP.NET application developed to update the SCAAS User Registry. This application utilizes the *FormsAuthentication* mode of the SCAAS Framework. Because of this, the application also serves as a good example of an implementation of the *FormsAuthentication* mode of the SCAAS framework.

DPAPIClientWeb ASP.NET Application

This is the utility application that is vital to get the SCAAS run-time to operate correctly. This ASP.NET application is used to generate encrypted connection strings used by both the SCAAS run-time as well as client applications that wish to use the SCAAS secure database connection management SCAAS API.

THE SCASS FRAMEWORK

The SCAAS framework is the core component of the SCAAS system and is based on Microsoft's Forms Authentication model for authentication and authorization of ASP.NET applications. Microsoft's Forms Authentication model is not a complete security solution but rather the bits and pieces required to be built upon. A key component of the model is the *System.Web.Security* namespace included in the .NET framework. This namespace includes several classes, enumerations, and delegates that can be used to develop secure ASP.NET applications (Curphey, 2003). However, implementing this model requires a lot of customization in ASP.NET applications. For example, when using the authentication aspects of the model, a Web developer must create a user defined User Registry. Furthermore, if more than one application were to be using the same custom security implementation, it would be prudent to abstract that functionality to an independent library to gain the leverage of reusability. This is exactly what the SCAAS Framework was built to achieve: a security model implemented in a reusable library.

There are two operational modes that SCASS offers: the *FormsAuthentication* mode and the *PassiveAuthentication* mode. The *FormsAuthentication* mode accommodates the traditional need to secure all pages of an ASP.NET application. It is the mode to be used in an "all or none" fashion, where only one page can be offered for everybody to view without being authenticated. Typically, this would be the "Logon.aspx" page. While this is certainly a secure scenario, it can sometimes be inefficient in building recurring Web applications. In other words, some applications require that a particular page can be viewed in a "generalized" manner while running in a "specialized" manner once a user is authenticated. Think of the "specialized" state as being one of an elevated privilege level depending on who is running the application and whether or not they have been authenticated. For example, consider an application that displays product prices to a retail user. If the user has logged on as a member of a certain role such as the "WholesaleUser" role, the page will display prices with a 20% discount. The SCAAS Framework can accommodate this sort of requirement by using the *PassiveAuthentication* mode. This mode is to be used when the need arises to selectively elevate the privilege level for a web application user to offer a "specialized" view or functionality of the application.

The SCAAS Framework is housed in the SCAAS .NET namespace which contains four classes. Figure 1 shows a conceptual model of the four classes with the SCAAS components and databases. The functionalities of these four classes are discussed as follows:

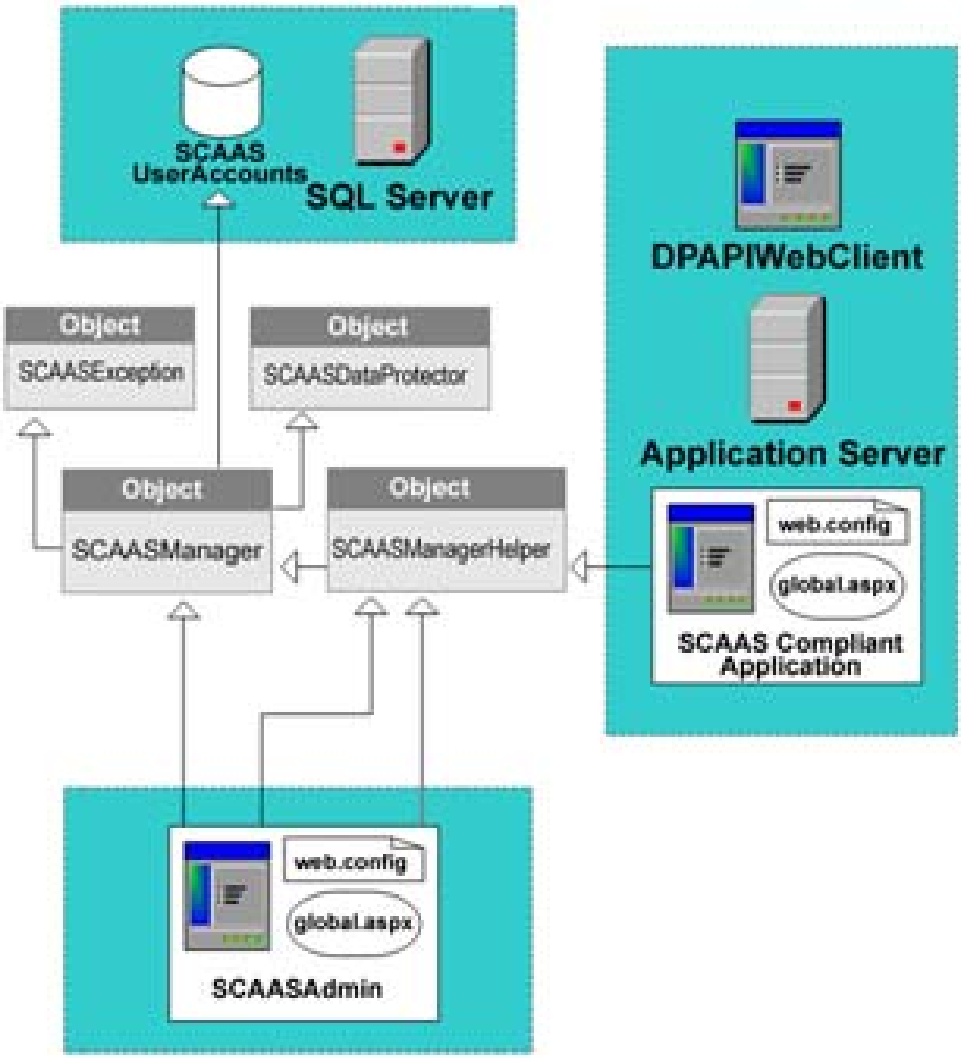
SCAAS.SCAASManager

This is the core class of the SCAAS Framework functionalities. Most of the authentication, authorization, role setting, credential management, exception generation, database connection management, and other core functions are found in this class. The two core methods in the *SCAASManager* for secure database connection management are *GetSqlConnection* for Microsoft SQL Server and *GetOleDbConnection* for other generic databases such as Oracle, Microsoft Access, and so on. A Web developer can use this class for secure database connection by hiding plain text connection strings behind encryption. The two methods work in concert with the encrypted strings generated by the *DPAPIClientWeb* ASP.NET application.

SCAAS.SCAASHelper

This is the developer's helper class that groups functionalities of the *SCAASManager* class and simplifies the integration of the SCAAS Framework into an ASP.NET application. The *SCAASManagerHelper* class has some key methods such as Logon, Logout, Authentication Processing, Error Handling, and SCAAS Application Initiation. Also, the class constructor is where the determination of whether the *FormsAuthentication* mode or *PassiveAuthentication* mode is implemented.

Figure 1: SCAAS conceptual diagram.



SCAAS.SCAASException

Many different exceptions can be generated in the *SCAASManager* class and subsequently handled by the *SCAASManagerHelper* class. SCAAS attempts to reframe as many exceptions as possible by initiating some variant of a *SCAASException* class. The key to the SCAASException class is the internalized *SCAASExceptionType* enumeration and the declaration of private variable of this type. When an exception is generated in the *SCAASManager* class, this enumeration is always set in the *SCAASException* class for error processing to occur at a higher level from the thrown exception. Again, much of this is automatically handled by the *SCAASManagerHelper* class, but a developer working directly with the *SCAASManager* class will need to be aware of this custom exception generation mechanism.

SCAAS.SCAASDataProtector

This class is generally used for the secure database connection mechanism for SCAAS. In particular, the *DPAPIClientWeb* ASP.NET application uses this class to generate encrypted connect strings for the *web.config* file, and the *SCAASManager* database connection methods also use this class to provide secure database connections by reading the same encrypted strings created with the *DPAPIClientWeb* ASP.NET application. This class leverages

the Windows DPAPI (Crypto32.dll) security framework and contains two primary methods: the *CryptProtectData* method and the *CryptUnprotectData* method for the data encryption and decryption procedures.

IMPLEMENTING SCAAS FRAMEWORK

Implementing the SCAAS framework requires the SCAAS User Registry, the *SCAASAdmin* ASP.NET application, and the *DPAPIClientWeb* ASP.NET application to be properly installed and configured.

The SCAAS User Registry is implemented as a Microsoft SQL Server based database named *UserAccounts*. Note that the *SCAASAdmin* ASP.NET application and the SCAAS User Registry don't have to be installed on the same machine running the SCAAS compliant ASP.NET applications. However, it is a must that the *DPAPIClientWeb* ASP.NET application should be on the same machine as the SCAAS compliant ASP.NET applications, because this is a system requirement of the underlying Microsoft DPAPI technology as the encryption/decryption algorithm using the DPAPI is machine specific.

Installing the SCAAS User Registry first requires the UserAccounts.mdf and UserAccounts_log.mdf of the SCAAS system to be attached to the local machine running a Microsoft SQL Server. Using the SQL Server Manager, a Web developer will create an instance level user named "SCAASAllPrivs," add this user to the UserAccounts database, and create a Role to the UserAccounts database named "SCAASAllPrivs_Role". Once the role is available, the Web developer will grant the SCAASAllPrivs user to the SCAASAllPrivs_Role role and all privileges for the UserAccounts database to the SCAASAllPrivs_Role.

The DPAPIClientWeb ASP.NET Application also needs to be installed on every machine running SCAAS compliant ASP.NET applications because of the requirements for DPAPI encryption/decryption procedures. Folder that houses the application needs to be registered with the Internet Information Services server.

Figure 2: DPAPIClientWeb string encoder.

Finally, the SCAASAdmin ASP.NET Application needs to be installed to maintain the SCAAS User Registry. There is one unique configuration step to this application and all SCAAS compliant applications to be developed using the SCASS system. Because the SCAASAdmin ASP.net application is itself a SCAAS compliant application (using the FormsAuthentication mode), one encrypted string must be created for secure database connections by running the string encoder page of the DPAPIClientWeb ASP.NET application. As shown in figure 2, after correct parameters for the SQL database name, SQL database server name, database user name (*SCAASAllPrivs*), and password are entered and an appropriate database type is chosen, the system produces an encrypted connection script that is unique for every machine. The string then needs to be saved for the web.config file of the SCAASAdmin application. Here is an example of the <appSettings> section of the *Web.config* file for the SCAASAdmin application:

```
<!—Custom settings for SCAASAdmin Application-->
<appSettings>
  <add key=”SHOW_ALL_ERRORS” value=”true”/>
  <add key=”SCAAS_SESSION_TIMEOUT” value=”30”/>
  <add key=”SCAASAllPrivs_UserAccounts”        value=”AQAAANCMnd8fDerOW…”>
</appSettings>
```

Take notice of the key located in the <appSettings> section in the entry of *<add key="SCAASAllPrivs_UserAccounts value=">*. What it dictates is that the value in the *<appSettings>* section of the entry *<add key="SCAASAllPrivs_UserAccounts value=">* is the encrypted connection string that the SCAAS

Framework uses to create a SQL Server connection for the *SCAASAllPrivs* user for the *UserAccounts SqlServer* database. This is a key concept not only for the *SCAASAdmin* ASP.NET application but also for all applications that are using encrypted connection strings.

Once the above three system components are installed and configured for the SCAAS framework, the Web developer needs to determine which mode the application is to be implemented between the *FormsAuthentication* mode and the *PassiveAuthentication* mode. The key to using a particular mode lies in the *SCAASManagerHelper* constructor which is implemented in the Global.asax file as part of any ASP.NET application. In fact, outside of the actual programming logic involved to secure the application, making the application SCAAS compliant is merely a matter of implementing the correct structure of the *Global.asax* file and the *Web.config* file and adding the application's users/roles using the *SCAASAdmin* ASP.net application.

For *FormsAuthentication* mode, the Global.asax with C# code file will look like this:

```
Protected void Application_Start(Object sender,
  EventArgs e)
{
 // Initialize all SCAAS specific
    HttpApplicationState level items
 SCAASManagerHelper.ApplicationStartWrapper
    (this.Context.Application);
}
Protected void Session_Start(Object sender, EventArgs e)
{
 // Initialize all SCAAS specific
    HttpApplicationState level items
 SCAASManagerHelper.SessionStartWrapper
 (this.Session);
}
Protected void AuthenticateRequest(Object sender, EventArgs e)
{
 // Implement the FormAuthentication SCAAS
    security mode
 SCAASManagerHelper scassManagerHelper = New
 SCAASManagerHelper(SCAASManagerHelper.
 FormsOrPassive. FormsAuthentications);
}
```

The *web.config* section concerned with authentication and authorization will look like this:

```
<!—Authentication Setting - FormsAuthentication-->
<authentication mode="Forms">
  <forms loginURL="Logon.aspx" name=
  "SCAASAdminAuthCooki" Timeout="30" path="/" />
</authentication>
<!—Authentication Setting - FormsAuthentication-->
<authorization>
  <deny user="?" />
  <allow user="*" />
</authorization>
```

Note that the setting "Logon.aspx," under FormsAuthentication mode, is the only page that will be able to be viewed by the users until a successful authentication is transacted. In addition to handling logon sequences, this page will also host all the error handling, logout messaging, and other SCAASException driven events.

Lastly, the web.config section concerned with application specific settings will look something like this:

```
<!—Custom settings for FormAuthentication-->
<appSettings>
  <add key=”SHOW_ALL_ERRORS” Value=”true” />
  <add key=”SCAAS_SESSION_TIMEOUT” value=”30” />
  <add key=”SCAASAllPrivs_UserAccounts”
        value=”AQAAANCMnd8fDerOW…” />
  <add key=”MyAppAllPrivs_MyDatabase”          value=”AQAAANCMnd8fDerOW…” />
</appSettings>
```

Note that because the application is a SCAAS compliant application, it will always need the *SCAASAllPrivs_User* Accounts encrypted string. The SHOW_ALL_ERRORS settings will enable more detailed error reporting on exceptions. The Web developer would want its value to be “true” for development but likely set it to “false” for a production implementation.

For *PassiveAuthentication* mode, the Global.asax file with Visual Basic code will look like this:

```
Sub Application_Start(ByVal sender As Object, e As EventArgs)
  // Initialize all SCAAS specific
    HttpApplicationState level items
  SCAASManagerHelper.ApplicationStartWrapper
  (Application)
End Sub
Sub Session_Start(ByVal sender As Object, e As EventArgs)
  // Initialize all SCAAS specific
    HttpApplicationState level items
  SCAASManagerHelper.SessionStartWrapper(Session)
End Sub
Sub Application_AuthenticateRequest(ByVal sender As Object, e As EventArgs)
  // Implement the FormAuthentication SCAAS
    security mode
  Dim scassManagerHelper As SCAASManagerHelper =
    New SCAASManagerHelper(SCAASManagerHelper.
    FormsOrPassive.FormsAuthentications)
  scassManagerHelper.Application_
    AuthenticateWrapper(Context)
End Sub
```

The *web.config* section concerned with authentication and authorization will look like this:

```
<!— Setting for PassiveAuthentication-->
<authentication mode=”None”>
<!— Setting for PassiveAuthentication-->
<authorization>
  <allow user=”*” /> <!—Allow all users -->
</authorization>
```

Obviously, the *Global.asax* and the section in the *Web.config* are significantly different from those for a *FormsAuthentication* application. In short, any page can be viewed regardless of whether a user is authenticated or not in the *PassiveAuthentication* model.

Finally, the *web.config* section concerned with application specific settings will look this:

```
<!—Custom settings for PassiveAuthentication-->
<appSettings>
  <add key=”SHOW_ALL_ERRORS” value=”true” />
  <add key=”SCAAS_SESSION_TIMEOUT” value=”30” />
```

```
  <add key="SCAAS_ERROR_PAGE"
     value="ErrorPage.aspx" />
  <add key="SCAASAllPrivs_UserAccounts"
     value="AQAAANCMnd8fDerOW…" />
  <add key="OleDbUser_Application"
          value="AQAAANCMnd8fDerOW…" />
  <add key="OleDbUser_UserAccouints"  value="AQAAANCMnd8fDerOW…" />
</appSettings>
```

Like the *FormsAuthentication* example, the SHOW_ALL_ERRORS settings will enable more detailed error reporting on exceptions. The value needs to be set to "true" for development but would likely to be set to "false" for a production implementation. However, unlike the *FormsAuthentication* mode, the *PassiveAuthentication* mode can name any page needed for the error handling page. This is because under *PassiveAuthentication* mode, the Web developer will not be bounded by only one page being free to view despite authentication.

The final step in implementing the SCAAS framework is to add users/roles with the SCAASAdmin ASP.net Application. Internal to the SCAASAdmin ASP.net application there are four roles: *SCAASAdmin, RoleAdmin, UserAdmin,* and *PasswordAdmin*. Once logged on to the SCAASAdmin ASP.net application, the Web developer can add roles, delete roles, add users, delete users, grant roles to users, and revoke roles from users.

For instance, assume the application to have two roles such as *WholesaleUser* and *WholesaleAdmin*. Before the application is coded, the Web developer needs to thoroughly understand what these two roles mean in the context of the application usability and design. The *WholesaleUser* role may mean that the user will get a certain type of discount on selected products or quantities. It may also mean that the user will access pages other than those non-authenticated users aren't allowed to see. The idea that non-authenticated users can see any part of the application implies that the application will be using the *PassiveAuthentication* mode of the SCAAS system. In addition, the Web developer may want one page available for only users that have the *WholesaleAdmin* role. This may be used for special users that are designated to alter prices on certain products and quantities for other logged on users that have the aforementioned *WholesaleUser* role.

Because the SCAAS Framework is tightly integrated with Microsoft's Forms Authentication model (not to be confused with the SCAAS FormsAuthentication mode), many of the inherited ASP.NET features are needed to work with the SCAAS Framework. The key to making SCAAS Framework a security implementation is found with the ASP.NET's intrinsic object called *User*. The intrinsic *User* object is actually a member of the *HttpContext* class, and the ASP.NET intrinsic object *Context* is an instance of an *HttpContext* class that the ASP.NET Framework also automatically provides (hence the word "intrinsic"). Examples of the *User* object methods Include *User.Identity.IsAuthenticated*(), *User.Identity.Name(),* and *User.IsInRole()*.

For example, if a user logged on and was granted the *WholesaleUser* role by the SCAASAdmin ASP.net application, then the User.IsInRole("WholesaleUser") would return true or false. It can be easily seen how this can be used in the SCAAS compliant applications. Another example is the utilization of the User.Identity.IsAuthenticated()method. The application can completely control access to a particular page by just calling this method in the PageLoad() ASP.NET event handler. If true, allow access. If not, redirect to the error page with the proper SCAASException.
As the users/roles have been added and the roles have been assigned to the users with the SCAASAdmin ASP.net application, Web developers can now use SCAAS to enhance the security of their Web applications through secured authentication and access control.

CONCLUSIONS

Recent computer programming languages have enabled more effective development of secure web applications. For instance, Java technology allows one to construct applications by using a large set of APIs, tools, and implementations of commonly used security algorithms, mechanisms, and protocols. Microsoft's recent .NET technology also provides a variety of security features commensurate with the breadth of the framework itself.

SCAAS presents a security implementation that leverages the .NET intrinsic libraries and makes the implementation a reusable component.

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