Programmatic Management of Active Directory Groups

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Abstract  

Management of security group memberships in midsize and larger organizations has always been a problematic issue. If individuals are not in the correct groups, they usually need to call the company's security department, explain the issue, and get approval to gain access to the security group before they can perform job related tasks. For large companies with high turnover this can result in hundreds of security requests per week. The impact to the bottom line of a company due to lost productivity and salaries for the additional help desk personnel required to handle these requests can be significant. How much money a large company loses due to these inefficiencies can been seen in a recent article from CIO Magazine:  

"Jonathan Penn, a research director for Cambridge, Mass.-based Giga Information Group, says provisioning can save as much as 50 percent of all IT time spent on user account management, such as creating new accounts, changing accounts and disabling accounts."  

[1]  

Even if we ignore the additional cost required to manually process security requests, manually maintaining security rights can lead to an auditing nightmare. Few organizations actively monitor the membership of security groups. Even though an employee’s job responsibility may change over time, access to applications and data that is no longer required is seldom removed.  

I currently work at a company with a base of 160,000+ active computer users. Using some homegrown Perl code that I have written along with our metadirectory solution, we have automated our group provisioning/de-provisioning process where possible. We are currently averaging around 300 automated Windows 2000 group adds/deletes per day. This paper goes into some detail to explain the solution that was developed and includes the Perl code in the appendices (although more up to date code and documentation can be found at my website after September 10, 2003: www.donquigley.net). Although the code is designed to work with Critical Path’s MetaConnect product as a constructed attribute, I have also included a program that can be used to "manually" call the subroutine so the only real requirements to use the code is an LDAP [4] accessible data store and Perl.  

Before  

My company has a user base of well over 160,000 users. The users include employees, consultants (10,000+), and agents (users with system accounts and access to some of our systems but who are not direct employees). In an environment like this, some form of identity management is an absolute
necessity. The need for some manner of programmatically determining authorization based on business data is fairly well laid out in a recent white paper from PriceWaterhouseCoopers [4]:

"It’s not about just knowing who to let in and who to keep out. That decision is usually pretty clear. It’s also about control. Technology controls – like authorization or authentication, for example. Just as importantly, it’s about process controls – the rationalized business rules and logic that constrain users, attributes and roles are just as critical as the technical architecture."

To help address this need, we have implemented a fairly complete metadirectory system that automatically provisions and de-provisions ids to our 43 production NT 4.0 domains, miscellaneous NT 4.0 testing domains, UNIX, Lotus Notes, and our internal white pages. The information used to provision for these accounts is mostly derived from our HR database, our external associate database, and our subcontractors database.

As part of our provisioning process into NT 4.0, we have a customized Perl application that automatically provisions/deprovisions users into groups. This program is relatively straightforward and simple to use. It reads in a set of criteria files in a format similar to:

```
{attributeName1#attributeName2# ... #attributeNameN}
value1#value2 .... #valueN        NT4ProgrammaticGroupName
```

When a user's entry is processed by our metadirectory, the user's information stored in our metadirectory is compared to this list of criteria. If the user meets the requirements, the user is added to the group and the group name is added to the user's multi-valued grouplist attribute in the metadirectory. If the user has a group listed in the grouplist attribute and they no longer meet the requirements for this group, the user is automatically removed from the group.

Initially, this form of automated group population would only appear to have a limited impact. In practice, however, this simple piece of code is saving our company a lot of money every year. On an average day, the automated group process automatically provisions or deprovisions users into 100+ groups.

Programmatic groups have helped us to partially address an issue we call "group proliferation". Analysts on projects creating new web-based applications at my company often use NT groups to limit who has access to an application. If these analysts are not aware of an NT group or set of groups that already contain all of the users that need access to the group, they will have a new group created. It is extremely hard (especially with 3000+ system's employees actively working on creating new applications) to keep track of what groups have already been created and why.
Many times an analyst will find a group that contains all of the users that need access to the application in addition to a couple of extra users that do not need access to it. Rather than trying to figure out if the two extra users should no longer be in that group (which requires determining what the group was originally intended for), many analysts will take the easy route and have a new group created.

This group proliferation can quickly lead to an administrative and security nightmare. At one point in time we had 23,121 active accounts and 7273 groups in one of our production NT 4.0 domains. This type of group proliferation can lead to quite a few security risks. Determining what type of access is granted by each group and whether or not all of the users in that group should be there is a nightmare. Left to itself, group proliferation will result in a lot of users that have access to applications and data that they no longer need or should never have had access to in the first place.

Programmatic groups go a long way towards fixing the problem. With a programmatic group, the security analyst will try to determine if there is any information in any of our employee information stores (the HR database, the corporate white pages, etc) that all of the users needing access to an application or set of data have in common. This list of identifying information is then given to the directory team. More often than not, there will already be an existing programmatic group with the same set of criteria. This prevents an additional, unnecessary group from being created. Additionally, this means that anyone no longer needing access to data or an application because their job has changed will automatically be removed from the group. One of the major problems with manually maintained groups is that although organizations are really good at identifying groups a user needs to be added to (users will call the helpdesk to complain about lack of access), organizations usually do a very bad job of removing users from groups they no longer need to be members of (users almost never call the help desk to say they have too much access) [3].

**During**

Like many other organizations, my company has recently started migrating from Windows NT 4.0 to Windows 2000. As part of this migration, I have taken the opportunity to try to address some of the limitations of our existing NT 4.0 group code. Since Active Directory also gives us more options when dealing with groups, a lot more changes needed to be added to the programmatic group code. After developing a list of everything we wanted to change and all of the new features we wanted to add to the group code it was decided that I should just re-write the whole thing.

One of the first decisions we had to make was whether or not to always remove users automatically from groups if they no longer met the criteria or if we should...
only remove them programmatically if they had been added programmatically. In our NT 4.0 environment, we often had users manually placed into our programmatic NT 4.0 groups. According to our HR records, these users that were manually added to these groups had nothing in common with the users that were programmatically added. This was mostly due to one fact that has always plagued our metadirectory team and resulted in a lot of Perl code to handle special exceptions. Namely, the primary purpose of the information contained in the HR database is to determine how much a person gets paid and where in the organization's hierarchy they fit. A person's actual job responsibility is determined by their manager. This means we might have a programmer in one office that is also in charge of hiring consultants for the office even though he's not in management. HR does not know and does not care that one of his job responsibilities is hiring consultants -- this additional duty assigned to the programmer by his manager has no bearing on his pay or employee benefits. This means, however, that we cannot programmatically give him access to the application that we use to hire consultants since there is a disparity between his HR defined job responsibilities and his manager assigned job responsibilities.

Because there is (and never will be) a data store that accurately reflects all of an employee’s job responsibilities, it was decided that we should only programmatically remove users from groups that they were programmatically added to. This allows us to manually add users to a security group without having to worry about them getting taken out of the group every morning. To keep track of which groups a user was programmatically added to a new attribute in Active Directory called jegrouplist was created. This attribute would contain a list of all of the groups that a user had been added to programmatically. The jegrouplist attribute would also contain the group name and date of any groups that a user had programmatically been removed from.

Unfortunately, this also meant that users would not be removed from groups when their job positions changed if they were added manually. To help alleviate this, every group in our organization has at least two users assigned to monitor it’s membership for accuracy. This did not work very well when these group owners were supposed to monitor the membership of 10-20 groups with 2000+ users per group. Using programmatic groups, these group owners only need to verify that user’s added manually to these groups still need access. Needless to say, group owners are much more willing to thoroughly examine the access needs of a handful of users in a small number of groups than they were when they had to examine the access rights of hundreds or thousands of users. The end result is that, as an unexpected benefit of programmatic group management, manually maintained group memberships are monitored much more closely than they have been in the past.

Another decision we had to make was how flexible we wanted the code to be when finding groups to programmatically populate. By default, my code will always build programmatic groups in the ou=programmatic, ou=groups branch. If a group with the same name already exists in a different branch, the group
creation will fail. At this point in time, it would have been fairly easy to have the code add users to the pre-existing group even though the group was in the wrong location. It was decided that with the Win2k's ability to delegate, this would be a bad idea. If a not-so-trustworthy user knew we were going to create the UberUser group that has access to all date everywhere, they could create a group called UberUser in a branch that they had admin rights to (only a small number of users have any administrative rights to the programmatic group OU). This would allow that user to grant herself access to this group anytime she felt like. Although for the most part we believe that all of our 160,000+ users have the company's best interests at heart, there's that one person on the third floor with the shifty eyes that we don't quite trust so we decided that all groups not located in the programmatic group OU would have to have their DN fully specified before we would touch them. This way, if that person does create a group in an improper location, we'll notice in the error log that the code was not able to add anyone else to that group. And, as always, even if we do not notice all of the failed security group adds, our users will be more than happy to call us up and ask us why they don't have access to do their job.

Our new group code also needed to take into account several other options available to us with Active Directory. We had the option of creating 3 different types of groups (6 if we decided to include the ability to programmatically create mail groups), we could nest groups, and groups could be nested across domains. Since these are all good features, we felt that the new group code should be able to support them.

Finally, we also had to address the maximum group size limitation in Active Directory. An Active Directory group should not contain more than 5000 users [6]. With 160,000 users we have the potential to exceed this. To compensate for this limitation I added a check for a numeric group indicator. If this indicator is present, the code will add a number to the base name of the group specified. If more than 900 users are in that group, a new group will be created with the same name but a different number (i.e. AllEmployee1, AllEmployee2, etc). These numeric groups are then nested into another group (i.e. AllEmployees) that can be used to grant access to resources.

Before I step through how the group code functions, I need to mention a few things the metadirectory product that we are using: Critical Path's MetaConnect.

At a high level, the MetaConnect product has 3 parts that we will be concerned with in the paper. The first part are the connector views or CVs. The connector views are external systems that MetaConnect connects to. MetaConnect can read information from connector views, write information to connector views, or both. The metaview is MetaConnect data store. Information read in from the connector views is written to the metaview. Finally, we have the most important part which is the join engine. The join engine "joins" all of the data coming in from the CVs and writes it to the metaview. The join engine is also responsible
for updating information in the client CVs when information in the metaview changes.

MetaConnect uses a change based process rather than a batch based process. This means that user entries are only looked at if something changes. If a user’s HR information does not change for a month, MetaConnect will not attempt to do anything with the user’s entry for that month. The advantage of this is that our metadirectory only has to process 3000-4000 entries a day rather than all 160,000 entries every day. The disadvantage of this is that when we implement new criteria we need to force MetaConnect to look at any entries that might be impacted by the new criteria. To force MetaConnect to examine an entry, we usually just change the value of the entry's accountList attribute.

So to tie all of this together, let’s look at a user who has moved to a different job within the company. HR will enter the user’s new information into their database. Based on the database’s change log, MetaConnect will notice that the entry has changed. So the join engine will read in the user’s entry from the HR CV, process it, and write the change to the metaview. MetaConnect will now notice that the information for the user has changed in the metaview. This will trigger the join engine to look at the user’s metaview entry. The join engine will then determine which client CVs contain that user’s information and will update those data stores based on the information contained in the metaview and any special rules (like our group code logic).

Although the information we retrieve from HR does not always contain all of the information we wish it would, using HR as a data source does have one advantage and allows us to avoid what appears to be a common problem at other companies.

"We typically find that about 40 percent of the valid users in the enterprise are people who no longer work there," says Jeff Drake, director of security strategy at IBM Tivoli in Austin, Texas. "Companies are very good at getting you out of the payroll system when you leave, but they’re very poor at removing accesses to apps that you were granted." [2]

As this quote from Jeff Drake shows, payroll is very good at removing users in a timely fashion. Since our id and group provisioning process is tied into our payroll/HR system, our list of active users is always very accurate. Even if HR cannot provide you with any user information other than employment status, it has been our experience that it is worth whatever effort is required to get HR tied into your provisioning system.

So now that we know how MetaConnect works at a very high level, we can start looking at how the code works and how it could be used at your organization.
The programmatic group program first reads in its configuration file (b2econfig.txt). The file looks like this:

```plaintext

    [cv].default_base = [Base name of directory]
    [cv].default_user_base = [Default location for programmatic groups]
    [cv].win2kdc = [Server name or IP for this cv]
    [cv].username = [User to connect to cv as]
    [cv].password = [Encrypted password for this cv]
    [cv].description = [Human readable description of cv]
    [cv].cvname = [Internal Join Engine name for cv]
    [cv].fileextension = [File extension for cv's group criteria files associated]
    [cv].timeout = [LDAP connection timeout for this cv]
```

The first block of lines are universal settings and will appear only once in the configuration file. The second set of lines are CV specific. Most of the settings are pretty much self-explanatory. The [cv] name is intended to be the user friendly name of the CV. Anything that doesn't contain a '.' or '=' can be used as the [cv] name. The [cv].timeout value is the total amount of time that a connection is assumed to be valid in seconds. So if this were set to 600 seconds, then any operation occurring more than 600 seconds after the last bind will automatically drop the old connection to the CV and create a new one. The group code also detects invalid LDAP handles and will re-bind on any connection related errors so, in theory, a timeout value isn't absolutely essential to the code but it makes me feel better to have one.

One additional item to note is that the [cv].fileextension is actually used in a regular expression match against files in the group criteria directory. This means that instead of

```plaintext
    CorporateDomain.fileextension = 2kCDgrp
```

you could use:

```plaintext
    CorporateDomain.fileextension = (2kCDgrp|2kallcvgrp|2kallprodgrp)
```

Once the configuration file is read in, the program will examine the user attributes passed to it by the join engine. One of the attributes passed to the join engine is the destination CV. Unfortunately, the maximum length of an internal CV name in MetaConnect is limited to 6 characters. To make the configuration file a little
easier to read we define a friendly CV name for each CV. If there is no
[friendlycv].cvname = [unfriendlycv] setting corresponding to the unfriendly cv
that the code is currently looking at, the code will return. Otherwise, it will use
the friendly cv name to determine which settings should be used while
processing the current user.

Now the code will look at all of the files in the group criteria directory and will read
in any files with file extensions matching the [cv].fileextension setting and build a
list of programmatic groups that the user should be populated into.

Group Criteria File Parsing

Group Criteria files will look like this:

{employeeType}
10 == PRIMARY ! NAME:BLAH_G ! TYPE:G ! NUMERIC:Y \
== SECONDARY ! NAME:EMPLOYEE_DLG

{officeNum#locationNum#unitNum}
12#02#LGL  ==  PRIMARY ! NAME:CORPLAW_G ! NUMERIC:N

{companyNum#unitNum}
1#5  ==  PRIMARY ! NAME:ACCOUNTING
2#5  ==  PRIMARY ! NAME:PHYSICAL_SECURITY
5#5  ==  PRIMARY ! NAME:HR

{departmentNum}
398673  ==  PRIMARY ! NAME:A_TEST_NONNUM_G ! NUMERIC:N \
== SECONDARY ! NAME: B_TEST_NONNUM_DLG

{st#mgrCode}
IL#3[157]  ==  PRIMARY ! NAME:UNIT_%UNITNAME% ! NUMERIC:N

The first line ({st#mgrCode}) is the header line. This contains the list of attributes
that we are trying to match for separated by a '#'.

Underneath that we have one line for each set of criteria that we are using to
determine group membership.

In the last example, if a user had an st value of IL and a mgrCode of 37, then our
constructed header would be IL#37. So our constructed regular expression
would be:

IL#37 =~ /IL#3[157]/i
In this example, the regular expression match would be successful so the user would be added to the group.

After the first set of ‘==’ we will have a list of primary and secondary groups along with some information on how they should be built.

The Primary Group is the group that users are added to. The Secondary Group(s) are the group(s) that the Primary Group will be nested into.

We can only have one Primary group listed for each set of criteria. We can have multiple Secondary groups associated with a Primary group (in other words we could have a Primary global group that gets nested into 35 Secondary domain local groups).

The format for a group criteria line is:

regex == primary group specifications == secondary1 specs == secondary2 specs == ... == secondary specs

Each group that is specified in the group criteria line is separated by an '=='. Each specification within a group’s specs is separated by a '!'.

To specify a Primary group, we need to indicate that it is a primary group by putting the word PRIMARY by itself in the specs. At a minimum, we also need to specify the name of the group by adding a spec that looks like: NAME: GroupName.

{empType#officeNum}
G#68 == PRIMARY NAME: IllinoisInternal_G

Optionally, we can also specify the group type (Global, Local, Universal, Mail Global, Mail Local, Mail Universal => G|L|U|MG|ML|MU), a unique base dn for the group, and whether or not the group is numeric (Y/N).

{empType#officeNum}

For the Primary Group, we will default to Numeric Global and create the group in the default group dn specified in our configuration file.

To specify a Secondary group, we need to indicate that it is a secondary group by putting the word SECONDARY by itself in the specifications. We must also specify the name of the group by adding a specification like: NAME: GroupName

{empType#officeNum}
We can also optionally specify a BASE and TYPE for any Secondary groups. Secondary Groups will default to a domain local group built in the default group dn specified in the configuration file.

As you can probably guess, these lines could start getting really long if we fully specify everything and we're nesting into one or more groups. To help with this, you can use the line continuation symbol by itself to indicate that the line is continued on the next line. So we could have a line like:

```
10 == PRIMARY ! NAME: A_ATTRIB_%OFFICENUM%_G \\
    SECONDARY ! NAME: A_ATTRIB_%MANAGERID%_DLG \\
```

This should make things a bit easier to read. We can also add comments at the end of each continuation:

```
10 == PRIMARY ! NAME:A_ATTRIB_%OFFICENUM%_G \ # Blech
    SECONDARY ! NAME:A_ATTRIB_%MANAGERID%_DLG \ # Double-Blech
```

You can have white space between the '\' and the '#'. The downside to being able to use line continuation characters is that we will not be able to build any groups that have a '\' or '#' in their name or their base dn.

**NUMERIC GROUPS**

If a Primary group is specified as numeric or numeric is left undefined (the code defaults to Numeric:Y), the group code will add a number to the specified group name in front of the last '_' or, if there is no '_', it will append the number to the end of the group name. The group code always begins searching for groups with available space starting at the number 1. The group code will add the user to the first numeric group that has less than the maximum number of users in it.

**ATTRIBUTES IN GROUP NAMES**

You can also specify one or more attributes in group names (both Primary and Secondary groups). To do this, place a '%' before and after the attribute name.
The group code will substitute the value of the user’s attribute when creating the group name.

For multi-valued attributes, multiple groups will be created. If a multi-valued attribute is specified for both a primary and secondary group, the values for the attributes will be 'tied' together. For instance, if we had a Primary group of:

Multi_State_%st%_G

and a Secondary group of:

State_%st%_DLG

and the user's st values were IL and MO, we would get:

Multi_State_IL_G    nested into    State_IL_DLG
Multi_State_MO_G    nested into    State_MO_DLG
Multi_State_IL_G    NOT nested into State_MO_DLG
Multi_State_MO_G    NOT nested into State_IL_DLG

This will also work if a Primary and one of it's Secondaries contains multiple multi-valued attributes.

Cross Domain Nested Groups

We also have the need to nest global groups in one domain into local groups in another domain. This can be accomplished with:

{workcode}.*== PRIMARY ! NAME:P_%workcode%_G ! TYPE:G \n== SECONDARY ! NAME:External\P_%workcode%_DLG

Basically, we're just putting the name of the domain in front of the group name.

NAME: [Domain_Name\]GroupName

In the example above, if we have a user with a workcode of 121234 in the Corp domain, the userid will be placed into the global P_121234_G global group in the Corp domain. The P_121234_G domain local group in Corp will then be nested into the P_121234_DLG group in the External domain.

The domain name specified must either be the user friendly CV name (as defined in the b2econfig.txt file) or it can be the actual CV name as used by the Join Engine.
It should be noted that the groups are not immediately nested. If the global group has just been created by the group program in Corp, the External domain may not know that it exists yet and Active Directory will not allow you to add the Corp P_121234_G group to the External P_121234_DLG group. To account for this, we store the nesting relations in a .db file that is processed by our crossdom-group.pl script. When crossdom-group.pl is run, it will nest all of the groups that it can. Any groups that it cannot nest will not be deleted from the .db file so we can attempt to nest them again after replication has occurred.

After parsing through the group criteria files, we now have a proposed group list of all of the Primary programmatic groups that a user should belong to. We also have another list of Secondary groups that the Primary groups should be nested into.

Now we compare this proposed group list to the list of groups that user is currently in. If the user is currently in a group that is not listed in the current jegrouplist attribute, we will add the group to the jegrouplist attribute (no need to do an ldap modify).

If the user is not currently in a group listed in jegrouplist, the group code will attempt to add the user to the group. If the add fails because the group does not exist, the group code will attempt to create this group and then add the user account to it. If the creation attempt succeeds, the group code will attempt to nest the newly created group into any Secondary groups associated with it. If the nesting fails because the Secondary group does not exist, the group code will create the Secondary group and then nest. If the nested group is in a separate CV and the nesting operation fails (due to replication delays between the two domains), the nesting information will be written out to a DB file that can later be processed by our crossdom-group.pl script.

It should be noted here that normally the group code will only attempt to nest Primary groups into Secondary groups if the Primary group has just been created by the group program. This also that Secondary group(s) will not be created if the Primary group already exists. If the Primary group already exists, the group code will not do an LDAP search to verify that the Secondary group exists and has been nested into. This is by design to allow the Join Engine to run faster. If you intend to use this code in a smaller environment, you can modify the code so it always performs this check. In our environment, we are occasionally required to perform a check on all 160,000+ users. Even adding a quarter of a second to the time required to process a user can add more than two hours to our run time (assuming we have four threads running at the same time). If we are doing this full refresh during the day because of enterprise wide security issues, this additional 2 hours can have a quite an impact the company’s bottom line.

The group code can be forced to check for proper nesting and Secondary group existence, however. If the user’s MV accountList attribute has a value of 2112 or
2113 when the user entry is processed by the Join Engine, the group program will attempt to create the Secondary group and nest the Primary group into it whether or not the Primary group already exists.

Next, the Group code will remove the user from any groups listed in the current jegrouplist attribute that have criteria the user no longer meets. When the group is removed, the value is replaced with the group name and a timestamp for auditing purposes. If the user cannot be removed from a group (i.e. directory error or the group was deleted manually), the group will not be removed from the jegrouplist attribute. We do this so that the next time the user is processed the group code will attempt to remove the user again. For this reason, groups should not be manually deleted until all of their users are removed programmatically. If you make it a habit to delete groups manually before all users are removed by the join engine's group code, you can end up with a lot of orphaned jegrouplist entries.

Manual Group Runs

Group population can occur programmatically outside the MetaConnect process. This can be useful if you do not want the Join Engine's performance to be affected during a mass group update. This can be even more useful if you don't have a Join Engine. To manually update a group of users you will need to use the program man-jegrouplist2.pl. The program will prompt you to specify the target's user-friendly CV name (as listed in the b2econfig.txt file) and an LDAP search filter. The LDAP search filter will be used to search the Metaview and retrieve a list of users. If you don't have a Metaview, you can have the program use any LDAP directory by setting the mv.* parameters in the b2e_config.txt file to point to your LDAP directory. The users found as a result of this search will be run through the same group code. This will perform all of the standard group maintenance tasks on these users that the join engine's group code normally would and will update their jegrouplist attribute.

AFTER

We have currently had our programmatic group code in production for almost 6 months now. Although we are only halfway through our Windows 2000 roll out, we have already programmatically created and populated over 32,700 programmatic groups with a little over 90,000 migrated Windows 2000 users.

Many of the security groups are based on an office's physical location so confidential customer information cannot be shared between different offices. The company I work at actually has more physical locations to provide customer support than there are McDonalds in the U.S. These locations usually have 3-5 users in them and experience a turnover rate of more than 110%. Because of the high turnover, we usually have over 100 group adds and 100 group deletes for the groups associated with these physical locations every day. These are
users that, in the past, would have had to request access and have it manually granted by an administrator.

Not only has the automatic population of physical location groups resulted in a cost savings of at least $5000 per work day (it costs the company approximately $25 for any internal technical support calls), but this has made our environment much more secure. It is not uncommon for a single user to move from one physical location to another multiple times in the year. In the past, these users were only removed from their old physical location groups if the manager at the location remembered to fill out the forms to get their access removed or during an audit. This resulted in some users retaining access to confidential customer information even though there was no longer any business need for them to have that access. With our new automated group provisioning process, these users are automatically being removed in a timely manner if they move offices or quit. This has also eliminated the problem of users being manually added to the wrong group. Additionally, a simple ldap search:

```
((&(!(jegrouplist=groupName))(memberof=FQDN_of_group)))
```

can help us identify any users in a group that were not added programmatically (the rogue admin problem).

We have also had a similar success with groups that are being populated based on job information rather than physical location. Although these groups make up less than 2% of the total groups managed to date, these have historically been the most difficult groups to manage. With the new group code, we have already doubled the number of groups that we are able to programmatically manage even though we are not quite to the half-way point in our migration. As a result of being able to use regexes in our group criteria and having more options available to us (such as cross-domain nesting), we are currently managing programmatically a little over 80% of our groups that are not based on physical locations.

Now that manually maintained access groups have become the exception rather than the rule, we are better able to audit the membership of these groups on a periodic basis. For example, in one of our old NT domains we had over 6000 groups that were manually maintained. In the equivalent Windows 2000 domain, we now have only 117 groups that are manually maintained despite the fact that the Windows 2000 domain has more users in it.

Another benefit of the new code is how the user base views our security department. In the past, if a user did not have access to an application, the help desk would need to determine what security group restricted access to that application. Then the help desk would need to find the individuals responsible for the membership of that group and get their approval to add the user to the group. For a new employee or an employee that had changed jobs, this process could
be repeated several times before the user had all of the access they needed. With the new group code, the user has access to almost everything they need for their new job just as soon as HR enters the user's new information into their database. From the user's perspective, the security department is now a helpful department that gets all of their access set up before they need it instead of a department that is preventing them from being able to do their job. Since these users are now happy (or, at the very least, less angry) with security, they are also more willing to work with security when issues arise rather than trying to work around security.

In summary, the programmatic group code has done quite a few things for my company. It is saving a lot of money every year in administrative costs. Users are rarely in security groups that they should not be in. We rarely encounter users that cannot get work done because they are not in the security groups that they need to be in. And, finally, users are much happier with the security department.
References


Appendix A: Win2kgroups.pl

This is the primary program used to programmatically add and removed users from Active Directory groups. This program is designed to be used as a constructed from within Critical Path’s MetaConnect program. It can also be used in conjunction with the man-jegrouplist2.pl program found in Appendix B.

```perl
package ProgGroup2;
require "ldap-conn.pl";
use Net::LDAP;
use Net::LDAP::Util qw( ldap_error_name ldap_error_text );

# Need to add ability to nest groups across domains
# Need to create negative name generation routines (I tried using an anti-name generation routine, but every time an anti-name touched a name it blew up the join engine).
# Ought to add a check for EOF at a continuation line in the criteria file

sub sf2kGroup {
  my @returned_list;
  eval {
    my %Details = (); # User attributes passed from join engine
    my %Setting = (); # Configuration settings from config file
    my %CVNames = (); # Map of Join Engine CV name to user friendly CV name
    my %proposed_groups = (); # Groups MetaConnect thinks user should be in
    my %negative_groups = (); # Groups MetaConnect should not place user into
    my %current_jegrouplist = (); # Groups MetaConnect has placed user into
    my %current_memberof = (); # All groups that the user is currently a member of
    my %primary_group = ();
    my %secondary_group = ();
    my %constructed_secondary_info = ();
    my %constructed_primary_info = ();

    # GET USER INFO #

    # Read in all of the attributes passed to us by the join engine
    # Multi-valued attributes are stored in the key as a tab delimited string
    foreach $element (@_) {
      $element =~ tr/a-z/A-Z/;
      my ($attrib, $val) = split(/:/, $element);
      $val =~ s/\s+$//;
      if (exists $Details{uc($attrib)}) {
        $Details{$attrib} .= "\t" . $val;
      } else {
        $Details{$attrib} = $val;
      }
    }

    # These are added in so we can use CV/MV names as a criteria
    my $userdn = $Details{'CV.DN'};
    $Details{'CV.CV'} = $Details{'CV'};
    $Details{'MV.MV'} = $Details{'MV'};
```

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### Configuration File Reading

#### Read in Configuration File

Open up our file that contains all of the configuration information we need.
```perl
open(IN, "b2e_config.txt") || ProgError(4,"Can't open b2e_config.txt");
```

Read in the b2e_config.txt configuration settings while `<IN>`:
```perl
while (<IN>) {
    if (/\^[^\[]*\] or /^\s*$/) {next;}
    chomp;
    s/\s*#.*$//;
    my @line = split(/\s*\=\s*/,$_,2);
    $line[0] =~ tr/a-z/A-Z/;
    $line[1] =~ tr/a-z/A-Z/;
    $Setting{$line[0]} = $line[1];
    if ($line[0] =~ /(^\S+)\.cvname/i) {
        my $temp = uc($1);
        $CVNames{uc($line[1])} = $temp;
    }
}
```

Close the configuration file.
```
close(IN);
```

#### Define CV Specific Settings

If (! exists $CVNames{$Details{CV.CV}}) {
    return "";
    # We don't know nothing about this CV. It ain't not in our config file
}

my $cvname = $CVNames{$Details{CV.CV}};
my $server = $Setting{"$cvname.WIN2KDC"};
my $username = $Setting{"$cvname.USERNAME"};
my $basedn = $Setting{"$cvname.DEFAULT_BASE"};
my $userbasedn = $Setting{"$cvname.DEFAULT_USER_BASE"};
my $fileextension = $Setting{"$cvname.FILEEXTENSION"};
my $maxsize = $Setting{"MAX_GROUP_SIZE"};

my $ldap = B2EGenLDAP::GetLDAP($CVNames{$Details{CV.CV}});

#### Get File Names of Group Criteria Files

Change directories to the working directory defined in the config file unless (chdir($Setting{GROUP_CRITERIA_DIRECTORY})) {
    ProgError(1,"Can't change to directory $setting{WIN2KGROUP_DIRECTORY}"");
    die;
}

Open up the directory that all of the group files are in and populate the @files array with the names of all of the group files unless (opendir(GROUP_DIR,$Setting{WIN2KGROUP_DIRECTORY})) {
    ProgError(1,"Can't open directory $setting{WIN2KGROUP_DIRECTORY}"");
    die;
}

Get a list of all of the 2kgrp files in the group directory:
```perl
foreach my $file (sort readdir(GROUP_DIR)) {
    if ($file !~ /$fileextension$/i) {next;}
    $file = $Setting{WIN2KGROUP_DIRECTORY}.${file};
    push(@files,$file);
}
```

#### Initialize Group Lists


###

```perl
foreach my $temp (split (/\t/, $Details{'CV.JEGROPLIST'})) {
    %current_jegrouplist{uc($temp)} = 1;
}

foreach my $temp (split (/\t/, $Details{'CV.MEMBEROF'})) {
    $temp =~ s/\s+//;
    $temp =~ s/cn=//i;
    %current_memberof{uc($temp)} = 1;
}
```

# READ IN CONFIG FILES AND FIND MATCHING LINES #

```perl
foreach $file (@files) {
    my $builtline = "";
    my @headers = ();
    my $user_header_values = "";
    open (IN, $file) || ProgError(1, "Can't open file $file");
    while (<IN>) {
        if (/^\s*$/) { next; }
        if (/\{\}/) { # If line starts with '{', then it's telling us attribute names
            @headers = split (/#/, $_); # List of attributes names are delimited by a #
            # We replace all of the attribute names with the attribute values for the user
            # so we can then use the string to do a regex match. It should be noted that if
            # we have a multi-valued attribute, there will be tabs in this string since we're
            # storing multi-valued attributes in %Details as a tab delimited string
            $user_header_values = "";
            foreach $header (@headers) {
                if ($header =~ /^CV./i or $header =~ /^MV./i) {
                    $header = 'MV.' . $header;
                }
                if ($user_header_values eq "") {
                    $user_header_values = $Details{$header};
                } else {
                    $user_header_values = $user_header_values . $Details{$header};
                }
            }
            next;
        }
    }
}
# If we get here, we're looking at a criteria line.
if (\s*$ || /\s*$/) { # This criteria line continues onto the next line
    $line = $_;
    $builtline = $builtline.$line;
    next;
}

# If we get here, we're looking at a fully built criteria line.
if ($line =~ ^\s*$) {next;}
$builtline = "";
$line = uc $line;

# Now we see if the criteria match.
# We wrap the regex evaluation in an eval so that an invalid regex in an
# input file doesn't crash the program.
eval {
    if ($user_header_values =~ /$regex/i) {
        $primary_group{$actions}{'ACTION'} = 1;
    }
}
if ($@) {
    ProgError(3, "Error in regex group check: $user_header_values compare to $regex");
}

close(IN);

############################
# DONE WITH REGEX COMPARES #
############################

# Now we have a list of group lines that matched the regex criteria. Now we
need to act on the information contained in the group lines.

# FULLY POPULATE HASHES #

# Cycle through each line that was read in that meets the regex criteria
foreach my $line (keys %primary_group) {
    my %temp_primary_group = ();
    my %temp_secondary_group = ();
    # Split out the specifications for each group listed
    foreach my $specs (split (/\s*==\s*/,$line)) {
        my ($setting,$value) = split (/\s*:\s*/,$_);
        $setting = uc $setting;
        if ($setting =~ /^PRIMARY$/i) { # primary group stuff
            my ($primary_setting,$value) = split (/\s*\s*/,$_);
            $primary_setting = uc $primary_setting;
            if ($primary_setting =~ /\^PRIMARY$/i) {
                next;
            }
            $primary_group{$line}{$primary_setting} = $value;
        } else { # assume secondary group
            my %temp_temp_secondary_group = ();
            foreach (split (/\s*\s*/,$specs)) { # Look at each of the specs
                my ($setting,$value) = split (/\s*\s*/,$_);
                $setting = uc $setting;
                $temp_temp_secondary_group{$setting} = $value;
            }
            my $basename = $temp_temp_secondary_group{'NAME'};
            my $temp_userbasedn = $userbasedn;
            if ($basename =~ /(.+)\/) {
my $temp_cv = $1;

if (exists $Setting("$temp_cv.DEFAULT_USER_BASE")) {
    $temp_userbasedn = $Setting("$temp_cv.DEFAULT_USER_BASE");
} elsif (exists $CVNames{$temp_cv}) {
    $temp_cv = $CVNames{$temp_cv};
    $temp_userbasedn = $Setting("$temp_cv.DEFAULT_USER_BASE");
} else {
    ProgError(3,"$basename does not have a valid cv");
    exit;
}

$primary_group{$line}{'TYPE'} = $primary_group{$line}{'TYPE'} || "G"; # Default to Yes
$primary_group{$line}{'NUMERIC'} = $primary_group{$line}{'NUMERIC'} || "Y"; # Default to global
$primary_group{$line}{'BASE'} =~ s/\s*,\s*/,/g;
$primary_group{$line}{'BASE'} =~ s/\s*\=\s*/=/g;
$primary_group{$line}{'BASE'} = $primary_group{$line}{'BASE'} || $userbasedn;

foreach $group (keys %primary_group) {
    $primary_group{$line}{$group}{'TYPE'} = $temp_secondary_group{$group}{'TYPE'};
    $primary_group{$line}{$group}{'BASE'} = $temp_secondary_group{$group}{'BASE'};
    $primary_group{$line}{$group}{'GROUPS'} = []; # Default to DLG
    $nesting_relationships{primary-group} = ();
    foreach my $group (keys %proposed_groups) {
        # Call out to get a list of groupnames.
        &BuildGroupName(%Details,%Setting,%{$primary_group{$line}},%$secondary_group{$line},
        %nesting_relationships,%negative_groups,%proposed_groups,
        %constructed_secondary_info,%constructed_primary_info,$line);
        my %nesting_relationships = ();
        foreach $line (keys %primary_group) {
            # Now we have all of the group names created.  We also have the nesting
            # relationships defined.
            %$nesting_relationships{primary-group} = { groups to be nested into }
        }
        foreach my $group (keys %proposed_groups) {

if ($group =~ /^\s*$/) { # Ok, this is the cheap way to do it
    next;
}
if (exists $current_memberof{$group} && $Details{'MV.ACCOUNTLIST'} !~ /211[23]//) {
    # User is already in this group
    next;
}
my $numeric_flag = 0;
if ($constructed_primary_info{$group}{'NUMERIC'} =~ /^Y/i) {
    foreach my $current (keys %current_memberof) {
        $current =~ /\d(\w)\$/;
        $current = $1.$2;
        if (exists $current_memberof{$current}) {
            $numeric_flag = 1;
        }
    }
}
if ($numeric_flag == 1 && $Details{'MV.ACCOUNTLIST'} !~ /211[23]//) {
    # THIS MAYBE NOT A GOOD IDEA
    next;
}
my $res = Luser2Group($userdn,$group,%constructed_primary_info,%constructed_secondary_info,
                      %nesting_relationships,%Setting,scvname,%Details,%CVNames,%maxsize,%proposed_groups);
if ($res ne "YEP") {
    ProgError(3,"Can't add $userdn to $group: $res");
    # Take the user out of the proposed groups list so we'll try to add them again
    delete $proposed_groups{$group};
    next;
} else {
    my $tempid = $userdn;
    $tempid =~ s/,.*//;
    my $tempgroup = $group;
    $tempgroup =~ s/,.*//;
    ProgError(5,"ADD: $tempid ==> $tempgroup : $userdn ==> $group");
}
else {
    $proposed_groups{ $key } = 1;
    next;
}

foreach $key (keys %current_jegrouplist) {
    if ($key =~ /^\d$/) { # If group name has a date in it, that means we were removed
        $proposed_groups{$key} = 1;
        next;
    }
    if ($key =~ /^cn=/) { # The old jegrouplist had the FQDN of the group
        $key =~ s/^cn=//;
        $key =~ s/,.*//;
    }
    if (!exists $proposed_groups{$key}) {
        # If a value is returned from the delete user subroutine, that means the user wasn't
        # really removed so we won't remove the group from the list of programmatic
groups
    }
}
# We should probably check periodically to see if any programmatic groups were manually deleted.  Otherwise the
# group will always be in this list
my $temp = DeleteUserFromGroup($key, $Setting, $userdn, $cvname);
if ($temp != 1) {
    $proposed_groups{$key} = 1;  # If delete fails keep group in list
} else {
    my $tempdate = &GetDate;
    $tempdate =~ s/ .*$//;
    $key = $key."$tempdate";
    $proposed_groups{$key} = 1;
    my $tempid = $userdn;
    $tempid =~ s/,.*//;
    my $tempgroup = $key;
    $tempgroup =~ s/,.*//;
    ProgError(5, "$DELE: $tempid ==> $tempgroup : $userdn ==> $group");
}

# Now we want to get rid of any duplicate group#date entries (we only want to keep the most recent removal).
my $prevkey = "";
foreach $key (sort keys %proposed_groups) {
    if ($key =~ /#$\d+\-\d+\-\d+$/) { next; }
    my $prevtemp = $prevkey;
    my $newtemp = $key;
    $prevtemp =~ s/#\d+\-\d+\-\d+//;
    $newtemp =~ s/#\d+\-\d+\-\d+//;
    if ($newtemp eq $prevtemp) {
        delete(%proposed_groups{$prevkey});
    }
    $prevkey = $key;
    foreach $key (keys %proposed_groups) {
        push(@returned_list,$key);
    }
    # Return a list of all MetaConnect managed groups that the user should be in
    my $count = @returned_list;
    # Return nothing if we don't have any programmatic groups.  This will make
    MetaConnect # remove the attribute from the user's entry
    if ($count == 0) {  # No programmatic groups
        return("";
    }
}
if ($@) {
    ProgError(2,"sub died with $@");
} return(@returned_list);

sub BuildGroupName {
    my ($Details_ref,$Setting_ref,$primary_group_ref,$secondary_group_ref,
        $nesting_relationships_ref,$negative_groups_ref,$proposed_groups_ref,
        $constructed_secondary_info_ref,$constructed_primary_info_ref) = @_;
    my ($primary_group_base = $$primary_group_ref{'BASE'});
    my ($primary_group_basename = $$primary_group_ref{'NAME'});
    my ($primary_group_type = $$primary_group_ref{'TYPE'});
    my ($primary_group_numeric = $$primary_group_ref{'NUMERIC'});
my %group_attributes = (); # Used to keep track of attributes used to
construct global group

# names. These values will be used when
naming secondary groups

my $test = $primary_group_basename;
my $test = s/,.*//;
my $test = s/\^\w+=//;

if (exists $$negative_groups_ref{$test}) { return "";

my @primary_groups =
PrimaryGroupConstruct($primary_group_basename,$Details_ref,%group_attributes);

foreach $group (@primary_groups) {
  my $test = $group;
  my $test = s/,.*//;
  my $test = s/\^\w+=//;
  if (exists $$negative_groups_ref{$test}) {
    next;
  }
  $$proposed_groups_ref{$group} = 1;
  $$constructed_primary_info_ref{$group}{'TYPE'} = $primary_group_type;
  $$constructed_primary_info_ref{$group}{'BASE'} = $primary_group_base;
  $$constructed_primary_info_ref{$group}{'NUMERIC'} = $primary_group_numeric;

  foreach my $secondary_group (keys %$secondary_group_ref) {
    my @secondary_groups = SecondaryGroupConstruct($group,$secondary_group,$Details_ref,%group_attributes);
    foreach my $sec_group (@secondary_groups) {
      if ($sec_group =~ /\s*$/) { next; } # Shouldn't need this, but
doesn't hurt to have it
      $$nesting_relationships_ref{$group}{$sec_group} = 1;
      $$constructed_secondary_info_ref{$sec_group}{'TYPE'} = $$secondary_group_ref{$secondary_group}{'TYPE'};
      $$constructed_secondary_info_ref{$sec_group}{'BASE'} = $$secondary_group_ref{$secondary_group}{'BASE'};
    }
  }
}

sub PrimaryGroupConstruct
{
  my ($group,$Details_ref,%grp_atr) = @_; # me
  if ($group !~ /%[^%]+%/) { # Group name doesn't contain any attributes
    return ($group);
  }

  $group =~ /%([^%]+)%/; # We get the attribute name from the previous match
  my $attr = $1;
  if ($attr =~ /CV\.\//) { $attr =~ /MV\.\//; }

  my @groups;
  foreach $val (split(/\t/,$Details_ref{$attr})) {
    my $tempgroup = $group;
    $tempattr = $attr;
    $tempattr =~ s/\^[MC]V\.\//; $tempgroup =~ s/\^[MC]V\.\?$tempattr%.?/\$val/1;
    push(@groups,$tempgroup);
    foreach $tempkey (keys %$grp_atr) {
      $$grp_atr{$tempgroup}{$tempkey}=$$grp_atr{$group}{$tempkey};
    }
  }

  my @final_groups;
  foreach $group (@groups) { # me
    my $final_groups = PrimaryGroupConstruct($group,$Details_ref,%grp_atr);
    }
```perl
517  push @{$final_groups, @$temp_groups};
518  }
519  return @{$final_groups};
520 }
521
522 sub SecondaryGroupConstruct
523 {
524  my ($primary_group, $secondary_group, $Details_ref, $grp_attr) = @_;  
525  if ($secondary_group =~ /%(^%)+%/i) {  # Group name doesn't contain any
526    my @temp_group;
527    $temp_group[0] = $secondary_group;
528    return (@temp_group);
529  }
530  
531  my $attr = $1;  # We get the attribute name from the previous match in the if statement
532  if ($attr =~ /CV\./i && $attr =~ /MV\./i) {
533    $attr = 'MV.'.$attr;
534  }
535  
536  my @groups;
537  
538  if (exists $$grp_attr{$primary_group}{$attr}) {
539    my $tempattr = $attr;
540    $tempattr =~ s/^[MC]V\./;/
541    $secondary_group =~ s/%[MC]?V?\.?$tempattr%/$$grp_attr{$primary_group}{$attr}/i;
542    push (@groups, $secondary_group);
543  } else {
544    foreach $val (split (/\t/, $$Details_ref{$attr})) {
545      my @tempgroup = $secondary_group;
546      my $tempattr = $attr;
547      $tempattr =~ s/^[MC]V\./;/
548      @tempgroup =~ s/%[MC]?V\.?$tempattr%/$val/i;
549      push (@groups, @tempgroup);
550    }
551  }
552  
553  my @final_groups;
554  foreach $group (@groups) {
555    my @temp_groups = SecondaryGroupConstruct ($primary_group, $group, $Details_ref, $grp_attr);  # me so clever
556    push (@final_groups, @temp_groups);
557  }
558  return (@final_groups);
559 }
560
561 sub DeleteUserFromGroup
562 {
563  my ($group, $Setting_ref, $userdn, $cv) = @_;  
564  my $ldap = B2EGenLDAP::GetLDAP($cv);
565  
566  my $filter = "(cn=$group)";
567  my $scope = "sub";
568  my $basedn = $$Setting_ref{ "$cv.DEFAULT_BASE" };
569  my $res = $ldap->search (base => $basedn, scope => $scope, filter => $filter);
570  if ($ldap->connect_error($res->code)) {  # Will return false if there's a problem
571    $ldap = B2EGenLDAP::RefreshLDAP($cv);
572    $res = $ldap->search (base => $basedn, scope => $scope, filter => $filter);
573  }  
574  if ($res->is_error) {
575    $mesg = ldap_error_name ($res->code).": ". ldap_error_name ($res->code). ": ". ldap_error_text ($res->code).
576  }
```

ProgError(3,"Search $filter to delete $userdn from -- not removing user from $group: $mesg\n");
return();
}
my $count = $res->count;
if ($count != 1) {
  ProgError(3,"Got back $count results for $filter. Not removing user from $group\n");
return();
}
my $entry = $res->pop_entry;
my $group_dn = $entry->dn;
$res = $ldap->modify($group_dn, delete => {'member' => $userdn});
if (&ldap_connect_error($res->code)) {
  # Will return false if there's a problem with the ldap handle
  $ldap = B2EGenLDAP::RefreshLDAP($cv);
  $res = $ldap->modify($group_dn, delete => {'member' => $userdn});
}
if ($res->is_error) {
  $mesg = ldap_error_name($res->code).": ".ldap_error_name($res->code)."-".
  ldap_error_text($res->code)."\n";
  ProgError(3,"Delete call $filter to remove $userdn from -- not removing user from $group: $mesg\n");
  return();
}
return(1);
}
sub Luser2Group {
  my ($userdn, $group, $constructed_primary_info_ref, $constructed_secondary_info_ref,
       $nesting_relationships_ref, $setting_ref, $cv, $Details_ref, $CVNames_ref, $maxsize,$
       proposed_groups_ref) = @_;
  my $ldap = B2EGenLDAP::GetLDAP($$CVNames_ref{$$Details_ref{'CV.CV'}});
  # Now that we're adding, we'll check to see if the group is numeric. If it is,
  # figure out which number should be added to the group name
  my $groupnum = "";
  if ($$constructed_primary_info_ref->{$group}{'NUMERIC'} =~ /\d+/) {
    $groupnum = "";
    if ($$constructed_primary_info_ref->{$group}{'NUMERIC'} =~ /\d+/) {
      $groupnum = DetermineGroupNum($group, $maxsize, $cv, 0, $setting_ref, $$constructed_primary_info_ref->{$group}{'BASE'});
    }
    if ($groupnum eq "FAIL") {
      return "fail";
    }
    my $newgroup = $group;
    $newgroup =~ s/\([^_]*\)\$/\$groupnum$1/;
    if ($newgroup ne $group) {
      $$proposed_groups_ref{$newgroup} = 1;
      delete $$proposed_groups_ref{$group};
    }
    $newgroup =~ s/.*\//;
    # Get rid of cv if groupname is something like opr\P_StupidGroup_G
    my $group_dn = "cn="$newgroup","cn="$cv,$constructed_primary_info_ref->{$group}{'BASE'};
    my $res = $ldap->modify($group_dn, add => {'member' => $userdn});
    if (&ldap_connect_error($res->code)) {
      # Will return false if there's a problem with the ldap handle
      $ldap = B2EGenLDAP::RefreshLDAP($cv);
      $res = $ldap->modify($group_dn, add => {'member' => $userdn});
    }
if ($res->code && $res->code != 68) || $$Details_ref{'MV.ACCOUNTLIST'} =~ /211[23]/) {
  # 68 is LDAP_ALREADY_EXISTS == someone else has added the user already so we're good
  $msg = ldap_error_name($res->code) . ": " . ldap_error_text($res->code) . "\n";
  my $type = $$constructed_primary_info_ref{$group}{'TYPE'};
  my $local_group_dn = "cn="$nested;"\n";
  $local_group_dn = $$constructed_secondary_info_ref{$nested}{'BASE'};
  my $local_group_add_dn = $local_group_dn;
  $local_group_add_dn =~ s/\./"/g;  
  if ($local_group_add_dn !~ /^cn=/i) {  
    $local_group_add_dn = "cn="$local_group_add_dn;  
  }  
  $res = $nestedldap->modify($local_group_add_dn, add => {'member' => $group_dn});  
  if ($res->code && $res->code != 68) {  
    # If we can't add, maybe the group doesn't exist so let's try to create it 
    my $results = BuildADGroup($nested_cv, $local_group_add_dn, $type, $setting_ref);
    if ($results =~ /CREATED/i) {  
      # If we created the secondary (nested) group, let's go ahead and try to add 
      # the primary group to it again.
      $res = $nestedldap->modify($local_group_add_dn, add => {'member' => $group_dn});
      if (ldap_connect_error($res->code)) {  
        # Will return false if there's a problem with the ldap handle
        $nestedldap = B2EGenLDAP::RefreshLDAP($nested_cv);
        $res = $nestedldap->modify($local_group_add_dn, add => {'member' => $group_dn});
      }  
      if ($res->code && $res->code != 68) {  
        ProgError(3, "Can't nest $group_dn into $local_group_add_dn");  
      }  
    }  
    elsif ($results =~ /EXISTS/i && $nested_cv ne $cv) {  
      ProgError(3, "Probably domain replication issue -- creating batch\n");  
      my $dbfile = $cv."2"."$nested_cv.".nested.db";  
      my $db;
      dbmopen ($db, "e:\data\cp\scripts\$dbfile", 0666);
      $db->{$group_dn} = $local_group_add_dn;
      dbmclose $db;
    } else {  
      ProgError(3, "Can't create nested group $local_group_add_dn");  
    }  
  } else {  
    # Add primary to nested group
    $res = $nestedldap->modify($local_group_add_dn, add => {'member' => $userdn});
  }
}
if (ldap_connect_error($res->code)) { # Will return false if there's a problem with the ldap handle
    $ldap = B2EGenLDAP::RefreshLDAP($cv);
    $res = $ldap->modify($group_dn, add => ['member' => $userdn]);
}

if ($res->code && $res->code != 68) { # 68 is LDAP_ALREADY_EXISTS -- someone else has added the user already so we're good
    $mesg = ldap_error_name($res->code).": ".ldap_error_name($res->code).": ".ldap_error_text($res->code)."
    ProgError(3,"Can't put user $userdn into $group_dn -- continuing processing: $mesg\n")
    return("fail");
}

return('YEP');

sub DetermineGroupNum
{
    my ($group,$maxsize,$cv,$num,$Setting_ref,$basedn) = @_;
    my $testgroup = $group;
    $num++;
    $testgroup =~ s/(.*)(_[^_]*)$/$1$num$2/;

    if ($num > 150) { # Depending on how many users you have and your max group size setting, you may need
        # need to change this number.  This is just here to keep us out of an infinite loop
        # It should be safe to remove this check, but it doesn't hurt to have it.
        ProgError('3',"Numeric Group Max LimitReached: 150 for $group\n")
        return("FAIL");
    }

    my $ldap = B2EGenLDAP::GetLDAP($cv);
    my $scope = "sub";

    my $filter = "(cn=$testgroup)";

    my $res = $ldap->search(base => $basedn, scope => $scope, filter => $filter);
    if (ldap_connect_error($res->code)) { # Will return false if there's a problem with the ldap handle
        $ldap = B2EGenLDAP::RefreshLDAP($cv);
        $res = $ldap->search(base => $basedn, scope => $scope, filter => $filter);
    }

    if ($res->is_error) {
        $mesg = ldap_error_name($res->code).": ".ldap_error_name($res->code).": ".ldap_error_text($res->code)."\n        ProgError(3,"Search $filter to add user to numeric $testgroup -- $mesg\n")
        return("FAIL");
    }

    my $count = $res->count;

    if ($count == 0) {
        return($num);
    }

    my $entry = $res->pop_entry;
    my @temp = $entry->get_value('member');
    my $size = @temp;
    if ($size > $maxsize) {
        $num = DetermineGroupNum($group,$maxsize,$cv,$num,$Setting_ref,$basedn);
    }

    return($num);
}

sub ProgError
{
    my ($level,$msg) = @_; 
    chomp($msg);
my $time = &GetDate;
$time =~ /([^\s]+)\s+(.*)/;
$date = $1;

if ($level == 5) {
    my $file = ">>MDS-JEGRP-INFO-$date.log";
    open(PROGERR,$file);
    my $fh = select(PROGERR);
    $| = 1;
    select($fh);
    print PROGERR "$time: Group: $msg\n"
    close(PROGERR);
} else {
    my $file = ">>MDS-JEGRP-ERR-$date.log";
    open(PROGERR,$file);
    my $fh = select(PROGERR);
    $| = 1;
    select($fh);
    print PROGERR "$time: Level: $level  Error: $msg\n"
    close(PROGERR);
    if ($level == 2) {
#print OUT "Level 2 -- die now\n";
    }
    return;
}

sub GetDate {
    # If you're not putting this in MetaConnect log folder or if you are not using
    # MetaConnect
    # you may want to change the gmtime call to localtime
    my @localtime=gmtime(time()); # Get time and don't convert it from GMT but still
call it localtime to be confusing
    $localtime[5] += 1900;  # Add 1900 to year.
    $localtime[4]++;        
    if ($localtime[4] < 10) {
        $localtime[4] = "0".$localtime[4];
    }
    if ($localtime[3] < 10) {
        $localtime[3] = "0".$localtime[3];
    }
    if ($localtime[2] < 10) {
        $localtime[2] = "0".$localtime[2];
    }
    if ($localtime[1] < 10) {
        $localtime[1] = "0".$localtime[1];
    }
    if ($localtime[0] < 10) {
        $localtime[0] = "0".$localtime[0];
    }
    my $date = $localtime[5].$localtime[4].$localtime[3].
    "$localtime[2]."."$localtime[1]."."$localtime[0];
    return($date);
}

sub ldap_connect_error {
    my $code = $_[0];  # ldap return code
    my @connect_errors = (0x30,0x31,0x32,0x33,0x34,0x35,0x36,0x50,0x51,
    0x52,0x55,0x58,0x59,0x5a,0x5b,0x5c,0x5d);
    my $errflag = 0;
    foreach $err (@connect_errors) {
        if ($code == $err) {
            $errflag = 1;
        }
    }
    return $errflag;
    # Probably don't need most of these, but hey, can't hurt
    # LDAP_TIMELIMIT_EXCEEDED (0x03)
    # LDAP_ADMIN_LIMIT_EXCEEDED (0x0b) # V3
sub BuildADGroup
{
  my ($cv,$group,$grouptype,$setting_ref) = @_; 
  if ($grouptype =~ /^G/i) {  # AD Global Security group
    $grouptype = '-2147483646';
  } elsif ($grouptype =~ /^L/i) {  # AD Local Security group
    $grouptype = '-2147483644';
  } elsif ($grouptype =~ /^U/i) {  # AD Universal Security group
    $grouptype = '-2147483640';
  } elsif ($grouptype =~ /^MG/i) {  # AD Global Distribution group
    $grouptype = '-4294967294';
  } elsif ($grouptype =~ /^ML/i) {  # AD Local Distribution group
    $grouptype = '-4294967292';
  } elsif ($grouptype =~ /^MU/i) {  # AD Universal Distribution group
    $grouptype = '-4294967288';
  } else {
    ProgError(3,"Invalid grouptype $grouptype specified for $group");
    return();
  }
  $object = B2EGenLDAP::GetObj($cv);
  my $base = $$setting_ref{"$cv.DEFAULT_BASE"};
  $group =~ s/,$base//i;
  if ($group !~ /^cn=/i) {
    $group = "cn=".$group;
  }
  my $groupobject = $object->Create("Group",$group);
  if (Win32::OLE->LastError()) {
    $error = Win32::OLE->LastError();
    ProgError(3,"Can't create Win32::OLE group object to create group $group --
    continuing run: $error");
    return();
  }
  $groupobject->Put("Description","Metaconnect Managed Group");
  if (Win32::OLE->LastError()) {
    $error = Win32::OLE->LastError();
    ProgError(3,"Can't put description into Win32::OLE group object to create group
    $group -- continuing run: $error");
    return();
  }
  my $cn = $group;
  $cn =~ s/^[^CN=]//i;
  $cn =~ s/,\,*//;
  $groupobject->Put("cn",$cn);
  if (Win32::OLE->LastError()) {
    $error = Win32::OLE->LastError();
    ProgError(3,"Can't put description into Win32::OLE group object to create group
    $group -- continuing run: $error");
    return();
  }
}

# LDAP_UNAVAILABLE_CRITICAL_EXT 0x0c
#sub LDAP_INAPPROPRIATE_AUTH () { 0x30 }
#sub LDAP_INVALID_CREDENTIALS () { 0x31 }
#sub LDAP_INSUFFICIENT_ACCESS () { 0x32 }
#sub LDAP_BUSY () { 0x33 }
#sub LDAP_UNAVAILABLE () { 0x34 }
#sub LDAP_UNWILLING_TO_PERFORM () { 0x35 }
#sub LDAP_LOOP_DETECT () { 0x36 }
#sub LDAP_OTHER () { 0x50 }
#sub LDAP_SERVER_DOWN () { 0x51 }
#sub LDAP_LOCAL_ERROR () { 0x52 }
#sub LDAP_TIMEOUT () { 0x55 }
#sub LDAP_USER_CANCELED () { 0x58 }
#sub LDAP_PARAM_ERROR () { 0x59 }
#sub LDAP_NO_MEMORY () { 0x5a }
#sub LDAP_CONNECT_ERROR () { 0x5b }
#sub LDAP_NOT_SUPPORTED () { 0x5c }
#sub LDAP_CONTROL_NOT_FOUND () { 0x5d }
916    ProgError(3, "Can't put CN into Win32::OLE group object to create group $group -- continuing run: $error");
917    return();
918 }
919 $groupobject->Put("sAMAccountName", $cn);
920 if (Win32::OLE->LastError()) {
921    $error = Win32::OLE->LastError();
922    ProgError(3, "Can't put sAMAccountName into Win32::OLE group object to create group $group -- continuing run: $error");
923    return();
924 }
925 $groupobject->Put("groupName", $grouptype);
926 if (Win32::OLE->LastError()) {
927    $error = Win32::OLE->LastError();
928    ProgError(3, "Can't put groupName into Win32::OLE group object to create group $group -- continuing run: $error");
929    return();
930 }
931 $groupobject->SetInfo();
932 if (Win32::OLE->LastError()) {
933    $error = Win32::OLE->LastError();
934    if ($error =~ /The object already exists/i) {
935        return "EXISTS";
936    }
937    ProgError(3, "Can't SetInfo on Win32::OLE group object to create group $group -- continuing run: $error");
938    return();
939 }
940 undef $groupobject;
941 return "CREATED";
942 }
943 1;
Appendix B: Man-jegrouplist2.pl

# ma-jegrouplist2.pl
# V 1.1
# Created by Don Quigley
# quigley@techie.com
# 4/1/2003

package SF2KGROUP;

use Net::LDAP;
use Net::LDAP::Util qw( ldap_error_name ldap_error_text);
use Carp;
use Win32::OLE;
require "win2kgroups.pl";

open(IN,"b2e_config.txt");
while (<IN>) {
    chomp;
    s/#.*$//;
    my @line = split(/s*=s*/$_,2);
    $line[0] =~ tr/a-z/A-Z/;
    $setting{$line[0]} = $line[1];
}
close(IN);

print "Enter search filter to find users to process:\n";
$filter = <STDIN>;
chomp $filter;

print "Valid CV's are: ";
foreach $key (sort keys %setting) {
    if ($key =~ /DESCRIPTION/i) {
        $view = $key;
        $view =~ s/.DESCRIPTION//i;
        print "$view: $setting{$key}\n";
    }
}

print "Enter the name of the CV you wish to populate: ";
my $cv = <STDIN>;
chomp $cv;
$cv = uc $cv;
print "\n\nServer: $setting{$cv.'WIN2KDC'}\nBaseDN: $setting{$cv.'DEFAULT_BASE'}\nIs this correct? [yN]: 
$temp = <STDIN>;
if ($temp !~ /^y*/i) { die; }

my ($server,$username,$password,$ldap,$basedn,$userbasedn);

# GET INFO FOR DESTINATION SERVER
$server = $setting{$cv.'WIN2KDC'};
$username = $setting{$cv.'USERNAME'};
$password = $setting{$cv.'PASSWORD'};
$ldap = Net::LDAP->new($server, port => '389');
$basedn = uc($setting{$cv.'DEFAULT_BASE'});
$userbasedn = uc($setting{$cv.'DEFAULT_USER_BASE'});

# Decrypt password
# @pad is our 'one-time' pad that we use over and over. Note: Passwords longer than 1000 characters will be problematic
my @pad = ();
my $i = 0;
my @c = split(/\s+/, $password);
my @d;
foreach $padval (@c) {
    if ($padval =~ /^[0-9a-z]+$/) {
        $pad[] = ($padval);  # Keep password
    } else {
        $pad[] = ($padval);  # Discard password
    }
}

# Let's ignore blank lines and header lines with [ text ]
# The politically correct implementation of chop chop
s/#.*$//;
my @line = split(/s*=s*/$_,2);

$padval = $padval - $pad[$i];
$d[$i] = $padval;
$i++;
}
$password = pack("C*",@d);
@end = ();
@c = split(/\s+/,@setting->{'MV.PASSWORD'});
@d = ();
foreach $padval (@c) {
    $padval = $padval - $pad[$i];
    $d[$i] = $padval;
    $i++;
}
@setting->{'MV.PASSWORD'} = pack("C*",@d);
# THIS IS THE HASH THAT WILL STORE GROUP NAMES AND MEMBERS
# The key will be the group name and the value will be an array reference.
# The array will contain a list of users.
my @prop_programmatic_groups = ();
my %nested_ldg = ();
my $ldpuser = $username;
$ldpuser =~ s/\[^\\]*\\//;
$ldap = Net::LDAP->new(@setting->{'MV.WIN2KDC'},port => '389') || die "cannot mv"
    || die "Bind failed
erk
";
# NOW WE WANT TO SEARCH THROUGH AND FIND USER ENTRIES.
print "searching on $filter
";
$searchobj = $ldap->search(scope => 'sub',filter => $filter,base => 'o=state farm,c=us');
foreach $entry ($searchobj->entries) {
    # Put all of the attributes into a hash.  We add MV. so it fits better with our
    # existing criteria logic
    my @attrs;
    push(@attrs,"cv: $cv"/thumb: $thumb");
    my $dn = $entry->dn;
    print "$dn
";
    foreach $attr ($entry->attributes) {
        my @temp = $entry->get_value($attr);
        foreach $val (@temp) {
            push(@attrs,"MV.$attr: $val"/thumb: $thumb");
        }
    }

    @jegrouplist = SF2KGROUP::sf2kGroup(@attrs);
    $res = $ldap->modify($dn,replace => {'sfjegrouplist' => \@jegrouplist});
    if ( $res->code && $res->code != 68) { # 68 is LDAP_ALREADY_EXISTS ==
        if ( $res->code & $res->code != 68) { # 68 is LDAP_ALREADY_EXISTS ==
            someone else has added the user already so we're good
            $mesg = ldap_error_name($res->code)."|ldap_error_text($res->code).\"\n";
        }
    }
}

Appendix C: Ldap-conn.pl

This subroutine is used to make LDAP connections to all of the directories specified in the b2e_config.txt file. These connections will be persistent across calls to the subroutine so that if win2kgroups.pl is used as a constructed attribute within MetaConnect, there won't any performance degradation caused my multiple binds/unbinds.

```perl
package B2EGenLDAP;

BEGIN {    # Hopefully the begin will force this to run when metaconnect starts up
    use Net::LDAP;
    use Net::LDAP::Util qw( ldap_error_name ldap_error_text );
    use Carp;
    use Win32::OLE;
    my $ldap = ();
    my %Setting = ();
    my %CVNames = ();
    my %object = ();

    ####################################################################
    # READ IN CONFIGURATION FILE #
    ####################################################################
    # Open up our file that contains all of the configuration information we need.  
    open(IN,"b2e_config.txt") || ProgError(4,"Can't open b2e_config.txt");
    # Read in the b2e_config.txt configuration settings
    while (<IN>) {
        $line = chomp;
        s/\s*#.*$//;    # Get rid of whitespaces in front of #
    (beginning of comments)
        my @line = split(/\s*\=\s*/,$_,2);
        $line[0] = uc $line[0];
        if ($line[0] !~ /^(\S+)\.(password)/i) {
            $line[1] = uc $line[1];
        }
        %Setting{$line[0]} = $line[1];
    } # Let's ignore blank lines and header lines (lines with [ text )
    chomp;
    s/\s*#.*$//;
    my @pad = ();

    foreach $cv (values %CVNames) {    
        my $server = $Setting{'$cv.WIN2KDC'};
        $ldap{$cv}{'port'} = $Setting{'$cv.PORT'} || 389;
        $ldap{$cv}{'password'} = $Setting{'$cv.PASSWORD'};
        $ldap{$cv}{'username'} = $Setting{'$cv.USERNAME'};
        $ldap{$cv}{'timeout'} = $Setting{'$cv.TIMEOUT'} || 120;
        $ldap{$cv}{'time'} = 0;    # used to be time
        $ldap{$cv}{'ldpuser'} = $ldap{$cv}{'username'};
```

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# Decrypt password
# @pad is our 'one-time' pad that we use over and over.

# Note: The @pad array needs to be defined as a set of numbers between 1-999.
# The array needs to contain at least as many elements as there are characters
# in the longest password that will be used.

# Obviously, the more passwords you use this pad to "encrypt", the less secure
# it will be. Plus the pad that you use is stored in plain text in all of the
# programs.
# At least it's better than being in cleartext in the config file. The best
# solution is to tie the passwords to a hardware crypto device.

my $i = 0;
my @c = split(/\s+/, $ldap{$cv}{'password'});
my @d;
foreach $padval (@c) {
    $padval = $padval - $pad[$i];
    $d[$i] = $padval;
    $i++;
}
$ldap{$cv}{'password'} = pack("C*", @d);
sub GetLDAP {
    my $cv = $_[0];
    foreach $key (keys %CVNames) {
        if ($key =~ /^$cv$/i) {
            $cv = uc $CVNames{$key};
        }
    }
    $cv = uc $cv;
    $a = time;
    $b = $ldap{$cv}{'time'};
    $c = $ldap{$cv}{'timeout'};
    if ($a - $ldap{$cv}{'time'}) > $ldap{$cv}{'timeout'}) {
        RefreshLDAP($cv);
    }
    return ($ldap{$cv}{'ldap'});
}
sub RefreshLDAP {
    my $cv = uc $_[0];
    # If passed friendly name, need to convert to unfriendly name
    foreach $key (keys %CVNames) {
        if ($key =~ /^$cv$/i) {
            $cv = uc $CVNames{$key};
        }
    }
    my $server = $Setting{"$cv.WIN2KDC"};
    $error = 0;
    if ($ldap{$cv}{'time'} != 0) {
        if ($ldap{$cv}{'ldap'} != unbind) {
            $ldap{$cv}{'time'} = 0;
        }
    }
    $error = 0;
    $ldap{$cv}{'ldap'} = new Net::LDAP($server, port => $ldap{$cv}{'port'}) or $error = 1;
    if ($error == 1) {
        B2EGenLDAP::ProgError(3, "Can't connect to $server on cv $cv-- continuing");
    }
    $ldapuser = $ldap{$cv}{'username'};
    $ldapuser = s/\"/\'\'/;
136 $ldap{$cv}{'ldap'}->bind(dn => $ldpuser, password => $ldap{$cv}{'password'},
version => 3) or
B2EGenLDAP::ProgError(3,"Can't bind to $server");
138
139 $ldap{$cv}{'time'} = time;
140
my $adspath = "LDAP://".$server;
142
$object = $object or <<"$error"

sub GetObj
{
    my $cv = $_[0];
    foreach $key (keys %CVNames) {
        if ($key =~ /^$cv$/) {
            $cv = uc $CVNames{$key};
        }
    }
    $a = time;
    $b = $ldap{$cv}{'time'};
    $c = $ldap{$cv}{'timeout'};
    if ( ($time - $ldap{$cv}{'time'}) > $ldap{$cv}{'timeout'}) {
        RefreshLDAP($cv);
    }

    return $object{$cv};
}

sub ProgError
{
    my ($level,$msg) = @_;    
    chomp($msg);
    my $time = &GetDate;
    $time =~ /\d+/s*\d+/s+.*;    
    $date = $1;
    if ($level == 5) {
        my $file = ">$DS-JEGRP-LDP-$date.log";
        open(PROGERR,$file);
        my $fh = select(PROGERR);

41        select($fh);
print PROGERR "$time: Group: $msg\n$";
close(PROGERR);

} else {
    my $file = ">>MDS-JEGRP-LDP-$date.log";
    open (PROGERR,$file);
    my $fh = select (PROGERR);
    $| = 1;
    select ($fh);
    print PROGERR "$time: Level: $level Error: $msg\n$";
close (PROGERR);

    if ($level == 2) {
        die;
    }
    return;
}

sub GetDate {
    my @localtime = gmtime (time()); # Get time and don't convert it from GMT but still call it localtime to be confusing
    $localtime[5] += 1900; # Add 1900 to year.
    $localtime[4]++;
    if ($localtime[4] < 10) {
        $localtime[4] = "0".$localtime[4];
    }
    $localtime[3]++;
    if ($localtime[3] < 10) {
        $localtime[3] = "0".$localtime[3];
    }
    $localtime[2]++;
    if ($localtime[2] < 10) {
        $localtime[2] = "0".$localtime[2];
    }
    $localtime[1]++;
    if ($localtime[1] < 10) {
        $localtime[1] = "0".$localtime[1];
    }
    $localtime[0]++;
    if ($localtime[0] < 10) {
        $localtime[0] = "0".$localtime[0];
    }
    my $date = $localtime[5].$localtime[4].$localtime[3]." 
    "$localtime[2]." 
    "$localtime[1]." 
    "$localtime[0];
    return ($date);
}

1;
Appendix D: Genpwd.pl

This program is used to create the "encrypted" passwords stored in the b2e_config.txt file. It is important that the @pad array is identical to the ones stored in ldap-conn.pl and man-jegrouplist2.pl.

```perl
#!/genpwd.pl
#
# V 1.1
# Created by Don Quigley
# quigley@techie.com
# 4/1/2003
#
# Used to generate the "encrypted" passwords stored in the b2e_config.txt file
# used by the Win2kGroups.pl program.
#
# Note: The @pad array needs to be defined as a set of numbers between 1-999.
# The array needs to contain at least as many elements as there are characters
# in the longest password that will be used.
#
# Obviously, the more passwords you use this pad to "encrypt", the less secure it
# will be. Plus the pad that you use is stored in plain text in all of the
# programs.
#
# At least it's better than being in cleartext in the config file. The best
# solution is to tie the passwords to a hardware crypto device.
#
# Usage: perl genpwd.pl "password_to_encrypt"

@pad = ();
$a = $ARGV[0];
@b = unpack("C*", $a);
$i = 0;
@c;
foreach $letterval (@b) {
  $letterval = $letterval + $pad[$i];
  $c[$i] = $letterval;
  $i++;
}
print join " ", @c;
```
Appendix E: Sample b2e_confix.txt File

# Location of required perl scripts and log files
group_criteria_directory = e:\groups\scripts
# Location of group criteria files
win2kgroup_directory = e:\groups\scripts
# Set max. size of numeric groups to 900
max_group_size = 900
# Server name of LDAP instance storing our join of user information
mv.win2kdc = bigdude.mycomp.com
# LDAP user to bind to directory as
mv.username = cn=manager
# "Encrypted" password for user to bind as
mv.password = 157 910 403 205 930 454 1047 386

# Information for our connector view
# This connector view is the employee domain in our forest
# Base dn for domain
employee.default_base = dc=employee,dc=mycomp,dc=com
# Default dn under which programmatic groups are created
employee.default_user_base = ou=prog,ou=groups,dc=employee,dc=mycomp,dc=com
# DC in employee domain to which all updates will be made
employee.win2kdc = superdude.employee.mycomp.com
employee.username = employee\MetaDirAcct
employee.password = 122 914 404 187 910 454 1043 396 415 199 354 562
employee.description = Production AD Connector to the Employee Domain
# Define the internal CV name used by MetaConnect
employee.cvname = emp
employee.fileextension = empgrp
# How many seconds we should use an LDAP handle to this CV before
# unbinding and binding again. Any setting over 5 minutes or so should
# have a negligible impact to performance.
employee.timeout = 300

agent.default_base = dc=extagents,dc=mycomp,dc=com
agent.default_user_base = ou=prog,ou=groups,dc=extagents,dc=mycomp,dc=com
agent.win2kdc = coffeedude.extagents.mycomp.com
agent.username = extagents\MetaDirAcct
agent.password = 122 914 404 187 910 454 1043 396 415 199 354 563
agent.description = Production AD Connector to the External Agent Rep Domain
agent.cvname = ext
agent.fileextension = extgrp
agent.timeout = 300
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<th>Location</th>
<th>Dates</th>
<th>Type</th>
</tr>
</thead>
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<td>Live Event</td>
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<td>MGT521 Beta One 2019</td>
<td>Crystal City, VAUS</td>
<td>Nov 12, 2019 - Nov 13, 2019</td>
<td>Live Event</td>
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<td>GridEx V 2019</td>
<td>Online,</td>
<td>Nov 13, 2019 - Nov 14, 2019</td>
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<td>SANS Austin 2019</td>
<td>Austin, TXUS</td>
<td>Nov 18, 2019 - Nov 23, 2019</td>
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<tr>
<td>Pen Test HackFest Summit &amp; Training 2019</td>
<td>Bethesda, MDUS</td>
<td>Nov 18, 2019 - Nov 25, 2019</td>
<td>Live Event</td>
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<td>Atlanta, GAUS</td>
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<td>Bangalore, IN</td>
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<td>Frankfurt, DE</td>
<td>Dec 9, 2019 - Dec 14, 2019</td>
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<td>Austin, TXUS</td>
<td>Jan 6, 2020 - Jan 11, 2020</td>
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<td>Amsterdam, NL</td>
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<td>Online, FLUS</td>
<td>Oct 28, 2019 - Nov 2, 2019</td>
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<tr>
<td>SANS OnDemand</td>
<td>Books &amp; MP3s OnlyUS</td>
<td>Anytime</td>
<td>Self Paced</td>
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