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Real-Time z/OS DB2 Database Activity Monitoring from the CorreLog Agent with dbDefender™

Database Activity Monitoring (DAM) is defined by Gartner as "... tools that can be used to support the ability to identify and report on fraudulent, illegal or other undesirable behavior, with minimal impact on user operations and productivity..."[i] This paper describes how the CorreLog Agent for z/OS (CZAGENT), in conjunction with the CorreLog Correlation Server or other SIEM console, may be used to integrate real-time DAM into a corporate SIEM solution, with minimum impact on DB2 performance.

CZAGENT DAM can be part of a compliance program for PCI DSS, Sarbanes-Oxley, HIPAA, Graham-Leach-Bliley (GLB), and/or FISMA. All of these regulatory standards are concerned with the integrity and security of data, and CZAGENT may be used to audit file and database access. The following are some of the activities that must be audited under one or more of these regulatory standards.

Privileged User Monitoring

The PCI DSS standard (10.2) requires automated audit trails for all actions taken by any individual with root or administrative privileges, such as a system programmer or database administrator. By default, CZAGENT creates a real-time automated audit trail for all privileged users using DB2 audit IFCID[ii] 361. This is a minimally intrusive trace type as it is only activated for administrative actions, not routine database accesses. From then on, all actions by privileged users will be logged to your SIEM console. The log message will include the user ID, the text of any command or SQL statement executed, a code for the specific action taken ("Priv: SELECT" or "Priv: Stop or Start Trace"), the job or CICS transaction name, and the name of the specific database object affected. Two examples are as follows:

1. A privileged user displaying the entire list of database tables from the DB2 instance. This action might be benign and it might be a malicious "fishing expedition." (CorrID: RU018BD3 shows the z/OS job name.)

```
DB2: Subsys: DA1L - IFCID: 361 - UserID: RU018B - AuthID: RU018B -
CorrID: RU018BD3 - Auth: SYSADM - Priv: SELECT - ObjType: Table or
view - Cmd: SELECT * FROM SYSIBM.SYSTABLES - SrcQual: SYSIBM - Src:
SYSTABLES
```

[i] http://www.gartner.com/it-glossary/database-activity-monitoring-dam/

[ii] DB2 SMF trace record types are identified by "IFCID number." IFCID stands for "instrumentation facility component identifier," which is simply another way of saying "trace record type." There are about 400 record types or IFCIDs, numbered between 1 and 511. Each IFCID type record has a specific layout and describes a specific event.

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2. A privileged user stopping all DB2 traces. This action is extremely suspicious as it indicates someone trying to "cover their tracks."

```
DB2: Subsys: DA1L - IFCID: 361 - UserID: None - AuthID: SYSOPR - CorrID:
022.CKPA0201 - Auth: SYSADM - Priv: Stop or Start Trace - ObjType: User
Auth - Cmd: -STOP TRACE(*)
```

Invalid Logical Access Attempts

The PCI DSS standard requires that you "implement automated audit trails for … invalid logical access attempts." By default, CZAGENT audits invalid logical access attempts by forwarding IFCID 140 messages in real time to your SIEM console. IFCID 140 is a low overhead trace because it is only invoked for failed accesses, not every access. For example, note the logging of the user ID, job name (RU018ADS), and the submitting user's JES2 node, RACF group, and "Port of Entry" (POE, the terminal name or other source of the attempted access). Notice that the specific failed privilege (SELECT) and object type is identified. (Many of these "human-readable" descriptions are also available from CZAGENT as numeric codes if that form is preferred.)

```
DB2: Subsys: DA1L - IFCID: 140 - UserID: RU018A - AuthID: RU018A -
CorrID: RU018ADS - Priv: SELECT - ObjType: Table or view - SrcQual:
CORE1010 - Src: NEWPHONE - ExitRet: -1 - Lang1: Dynamic - Lang3: None
- Node: JES2SYSB - Group: RESTRICT - POE: INTRDR - Sql: SELECT * FROM
CORE1010.NEWPHONE
```

Creation and Deletion of System-Level Objects

The PCI DSS standard also requires the automated logging of "audit trails for … creation and deletion of system-level objects." CZAGENT logs an audit trail for the creation and deletion of DB2 data structures by formatting messages for IFCID 97. These messages audit DB2's use of IDCAMS[iii] commands to create system-level data objects. IFCID 97 is minimally intrusive because it is generated only for the deletion or creation of data spaces and similar system-level objects. The example below shows the deletion and creation of system objects for the CORED10U.NEWPHONE table.

```
DB2: Subsys: DA1L - IFCID: 97 - UserID: RU018B - AuthID: RU018B -
CorrID: RU018BDL - RC: 0 - Cmd: DELETE DA1LDB.DSNDBC.CORED10U.NEWPHONE.
I0001.A001 PURGE;
```

```
DB2: Subsys: DA1L - IFCID: 97 - UserID: RU018B - AuthID: RU018B -
CorrID: RU018BDL - RC: 0 - Cmd: DEFINE CL(NAME(DA1LDB.DSNDBC.CORED10U.
NEWPHONE.I0001.A001 ) NOERASE LIN OWNER(SY002A ) RUS SPEED CISZ( 4096))
DATA (NAME(DA1LDB.DSNDBD.CORED10U.NEWPHONE.
I0001.A001 ) KB( 00001440 00000720)
OWNER(SY002A ) SHR(3,3) RUS VOL('* ' ));
```

Data Access Monitoring

The PCI DSS standard (10.2) requires the logging of all accesses to cardholder data. HIPAA and GLB also regulate patient or account holder data access. CZAGENT by default logs all IFCID 143 and 144 records. These records audit critical table writes and reads respectively. To create an automated real-time audit trail for all

[iii] IDCAMS -- the AMS stands for Access Method Services -- is the z/OS utility that DB2 invokes to create the disk files that DB2 uses to store data and indexes.

accesses to specific DB2 tables you must specify AUDIT access where access is CHANGES to audit-only writes, or ALL to audit both reads and writes, for each DB2 table to be audited. You may specify AUDIT when the table is created or subsequently with an ALTER TABLE statement.

Once these commands are in effect, CZAGENT will forward a message every time one of the specified tables is read (IFCID 144) or written (IFCID 143) as requested by the ALTER. The following is an example of a message indicating a read of an audited database.

```
DB2: Subsys: DA1L - IFCID: 144 - UserID: RU018B - AuthID: RU018B -
CorrID: RU018BD3 - DBID: 265 - PSID: 4 - OBID: 18
```

Granted, this is not the most user-friendly message in the world. You can see the user ID and the job name (CorrID: RU081BDR) but the database object is identified only by a database ID, page set ID, and object ID. Fortunately, it is not hard to relate those to a specific table. You will probably be monitoring only a relatively small number of tables, and DB2 maintains them in an easily accessible table, SYSIBM.SYSTABLES. To relate those ID numbers to an actual table name, it is only necessary to refer to the results of the following query:

```
SELECT DBID, OBID, OWNER, NAME FROM SYSIBM.SYSTABLES
```

The results of the query are relatively stable and may be saved for future reference. For example, on the test system, DBID 265 and OBID 18 identify DSN81010.EMP, one of the tables we are auditing.

The amount of overhead is dependent on the number of tables audited and the frequency of access to those tables. DB2 minimizes the overhead by generating only one message per commit, not one for every SELECT, INSERT or UPDATE.

Other Audits

IFCID 24 and 25 record the execution of DB2 utilities. Utility execution is important to audit because in some cases utility access to DB2 tables is not recorded by other traces, and because Sarbanes-Oxley requires management controls assuring the viability data backups. Utility auditing is low overhead because utilities are only run for tasks such as loading or copying databases, and only a small number of records are written for each utility job.


```
DB2: Subsys: DA1L - IFCID: 24 - UserID: RU018B - AuthID: RU018B -
CorrID: RU018BDL - UtilID: DSNTEX - DBID: 274 - PSID: 5 - UtilNm: LOAD -
Phase: UTILTERM - DB: CORED10U - Obj: NEWPHONE - Items: 42
```

IFCID 62 audits the execution of DDL statements. (DDL is Data Definition Language: statements used to define tables and similar DB2 objects.) IFCID 62 is a very low overhead trace as it is invoked only for the execution of DDL.

```
DB2: Subsys: DA1L - IFCID: 62 -
UserID: RU018B - AuthID: RU018B -
CorrID: RU018BDL - StmtType: Drop
storage group - ObjType: Storage
group - Name: COREG10U
```

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IFCID 90 and 91 messages audit DB2 console commands and their completion return and reason codes.

```
DB2: Subsys: DA1L - IFCID: 90 - AuthID: RU018B - CorrID: 023.GCSCN602 -
Cmd: -STA TRA(AU) C(30) IFCID(247,350)

DB2: Subsys: DA1L - IFCID: 91 - UserID: None - AuthID: RU018B - CorrID:
023.GCSCN602 - RC: 0 - Reas: 0
```

IFCID 141 messages audit explicit grants and revokes of DB2 object access:

```
DB2: Subsys: DA1L - IFCID: 141 - UserID: RU018B - AuthID: RU018B
- CorrID: RU018BD3 - Grantor: RU018B - Access: Grant - ObjType:
Application plan - AuthType: AuthID - Lang1: Dynamic - Lang3: None -
Sql: GRANT BIND, EXECUTE ON PLAN RU018PHN TO RU018A
```

Digging Deeper on Audited Tables

Suppose that you require more detail regarding the accesses to an audited table. Consider this IFCID 144 message again:

```
DB2: Subsys: DA1L - IFCID: 144 - UserID: RU018B - AuthID: RU018B -
CorrID: RU018BD3 - DBID: 265 - PSID: 4 - OBID: 18
```

We know from the IFCID 144 message that job RU018BD3 running on behalf of user RU018B reads Database 265 Object 18, and we can tell by querying SYSIBM.SYSTABLES that it means DSN81010.EMP, but what exactly did it do? The answer is found in IFCID 145, also audited by CZAGENT. IFCID 145 shows us, for audited tables, the exact SQL statement that was executed:

```
DB2: Subsys: DA1L - IFCID: 145 - UserID: RU018B - AuthID: RU018B -
CorrID: RU018BD3 - Loc: NA01DA1L - Collection: DSNTEP4 - Prog: DSN@
EP4L - Token: 1914f7b21db184f0 - StmtType: SELECT QUERY Lang1: Dynamic
- Lang3: None - Isolate: CS - DBID: 265 - OBID: 18 - Sql: SELECT * FROM
DSN81010.EMP WHERE EMPNO = 36
```

(IFCID 145 tracing can also economical because a record is written only for the specific tables you choose to audit, and because the preparation, as opposed to the execution, of SQL statements is often relatively infrequent.) You can relate the IFCID 145 message to the IFCID 144 message that follows it because both will have the same Correlation ID (CorrID).

Static and Dynamic SQL

If you have been exposed to SQL primarily through ODBC then you are probably used to SQL statements such as the above SELECT. DB2 supports SQL like this, but it may be the exception rather than the rule in most mainframe shops. DB2 refers to this type of statement as “dynamic SQL” because the SQL is constructed “dynamically,” moments before it is executed. (Notice “Lang1: Dynamic” in the message above.) On the other hand, much or most of the SQL in mainframe shops is what DB2 terms “static SQL.”

Static SQL is embedded in a COBOL or other mainframe source language program and compiled into a binary form and fixed when the program is built – hence the term "static" – for reasons of performance and security. DB2 refers to this process of "fixing" SQL as "preparation" and "binding."

Auditing static SQL is somewhat more complex than auditing dynamic SQL. If the programmer could only write statements like the above in which something like EMPNO = 36 was hard-coded then the resulting program would be inflexible and not very useful. Instead, a COBOL programmer would write a static DB2 SQL statement (inside a COBOL program) something like

```
UPDATE VEMPLP SET PHONENUMBER = :NEWNO WHERE EMPLOYEENUMBER = :ENO
```

For readers unfamiliar with static SQL, the colon prefixes on :NEWNO and :ENO indicate that they are COBOL program variables rather than SQL keywords, and that the run-time contents of NEWNO and ENO are to be used as though they were part of the SQL statement. DB2 refers to NEWNO and ENO as "host variables." Adding to the complexity, notice also that the programmer has referred to the monitored table, DSN81010.EMP by means of a DB2 View, VEMPLP.

From a SIEM point of view, static SQL presents two major challenges:

1. By the time the RDBMS action is actually performed, the original SQL statement is gone, having been compiled before; and
2. In addition to the text of the SQL UPDATE statement, you might want to know the run-time contents of the host variables NEWNO and ENO.

If the appropriate audit and IFCID 145 tracing are in effect at the time the COBOL program is compiled, then CZAGENT would log a message something like

```
DB2: Subsys: DA1L - IFCID: 145 - UserID: RU018B - AuthID: RU018B
- CorrID: RU018BDC - Loc: NA01DA1L - Collection: RU018PHN - Prog:
DSN8BC3 - Token: 1958afbc1a3c8a1a - StmtType: 234 - Isolate: S -
Lang1: See Lang3 - Lang3: IBM COBOL - Stmt#: 541 - StmtID: 11860 -
DBID: 265 - OBID: 18 – Sql: UPDATE VEMPLP SET PHONENUMBER. = : H WHERE
EMPLOYEENUMBER = : H
```

Notice the DBID: 265 and OBID: 18, identifying this statement as accessing DSN81010.EMP, even though it is accessed through a View. Notice that the host programming source language (IBM COBOL) is identified. Also, in the message, the host variables NEWNO and EMPLOYEENUMBER are indicated with the placeholder ": H."

What about those host variables? Without the contents of the host variables we only know that some row of the audited table was updated to some value. If you really want the complete story, then it is necessary to use CZAGENT to also audit IFCID 247. An example of the two IFCID 247 messages resulting from execution of the above statement follow:

```
DB2: Subsys: DA1L - IFCID: 247 - UserID: RU018B - AuthID: RU018B -
CorrID: RU018BDR - Loc: NA01DA1L
- Pkg: RU018PHN - Prog: DSN8BC3 -
Token: 1958afbc1a3c8a1a - Stmt#:
541 - Type: 452 - SQLDA#: 2 - Data:
"000230"
```

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```
DB2: Subsys: DA1L - IFCID: 247 - UserID: RU018B - AuthID: RU018B -
CorrID: RU018BDR - Loc: NA01DA1L - Pkg: RU018PHN - Prog: DSN8BC3 -
Token: 1958afbc1a3c8a1a - Stmt#: 541 - Type: 452 - SQLDA#: 1 - Data: 00
“4265”
```

In the above formatted messages we can see the contents of the two host variables: 4265 and 000230. We know which is the first and which is the second host variable because the message includes the “SQLDA#.” So we know that the run-time contents of ENO (the employee number) was 000230 and therefore that the DB2 row for employee 000230 was updated to a phone number of 4265.

On a busy system, we can relate the IFCID 247 run-time messages to their corresponding IFCID 145 compile-time messages because both contain the same Token value – a unique value assigned by DB2 – and both reference the same line number of the original COBOL program (Stmt#: 541).

Performance and Resource Utilization

CorreLog realizes the importance of having a minimal impact on DB2 performance and z/OS system utilization. The above traces were all chosen with consideration of the impact on DB2 performance. CZAGENT facilitates limiting traces to particular plans, user IDs, etc., a technique that is recommended for improving the performance of the traces. In addition, CZAGENT has the unique ability to further reduce the impact of DB2 trace records by instructing SMF, on a record by record basis, to suppress logging installation-specified records to the SMF data sets. So, for example, if you enable IFCID 145 strictly for CZAGENT, and do not require IFCID 145 records in your SMF logs, then you can instruct CZAGENT to tell SMF not to write IFCID 145 records to disk. By not logging these SMF records to disk, the performance impact is further reduced.

Additional Options

Additional real-time auditing options are available in CZAGENT for use as desired.

IFCID 3 shows accounting counters by DB2 instance:

```
DB2: Subsys: DA1L - IFCID: 3 - AuthID: LDAPSRV - CorrID: LDAPSRV - Plan:
DSNACLI - OpID: LDAPSRV - UserID: LDAPSRV - Trans: LDAPSRV - WrkSta:
RRSAF - Loc: NA01DA1B - LU: NA01DA1B - Conn: RRSAF - SQL: {Create
Synonym: 1 - Create Store Group: 1 - Drop Index: 1}
```

IFCID 58 audits the completion of every SQL operation. Error and warning conditions are indicated. The IFCID message may be correlated to other message numbers by means of the Token, Stmt#, and StmtID fields.

```
DB2: Subsys: DA1L - IFCID: 58 - UserID: RU018B - AuthID: RU018B -
CorrID: RU018BDR - SQLcode: 0 - SQLerrm: None - SQLerrp: DSN - SQLwarn:
None - Stmt#: 541 - Loc: NA01DA1L - Collection: RU018PHN - Prog: DSN8BC3
- Token: 1958afbc1a3c8a1a - StmtType: Static - StmtID: 11928
```

IFCID 63 and IFCID 350 audit the SQL text for all SQL requests, not just audited tables (dynamic SQL at execution

time and static SQL at compile time). IFCID 63 is somewhat easier to parse than IFCID 350, but IFCID 63 messages truncate SQL statements at 5000 bytes, whereas one or more IFCID 350 messages contain the complete text of every SQL statement no matter how long (as do IFCID 145 messages).

```
DB2: Subsys: DA1L - IFCID: 350 - AuthID: RU018B - CorrID: RU018BD3
- Plan: DSNTP410 - OpID: RU018B - UserID: RU018B - Trans: RU018BD3 -
WrkSta: BATCH - Loc: NA01DA1L - NetID: USASG - LU: NA01DA1L - Conn:
BATCH - StmtType: Dynamic - StmtID: 0 - StmtSeg: Only - Sql: DECLARE
TELE3 CURSOR FOR SELECT * FROM VPHONE WHERE LASTNAME = : H AND FIRSTNAME
LIKE : H
```

IFCID 107 messages audit every table open and close, not just audited tables. They are also an additional source of correlation between DBID/OBID pairs and their corresponding database and table names.

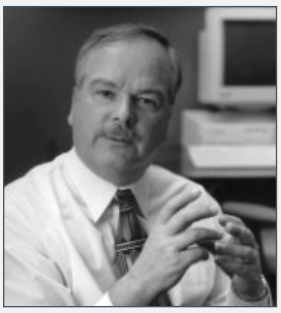
```
DB2: Subsys: DA1L - IFCID: 107 - UserID: RU018B - AuthID: RU018B -
CorrID: RU018BDL - Type: Open - DBID: 274 - DBName: CORED10U - PSID: 5 -
ObjName: NEWPHONE
```

IFCID 239 messages audits plan usage by collection and program name:

```
DB2: Subsys: DA1L - IFCID: 239 - Subsys: DA1B - AuthID: LDAPSRV -
CorrID: LDAPSRV - Plan: DSNACLI - OpID: LDAPSRV - UserID: LDAPSRV -
Trans: LDAPSRV - WrkSta: RRSAF - Loc: NA01DA1B - NetID: USASG - LU:
NA01DA1B - Conn: RRSAF - Pkg: {Collection: DSNAOCLI - Prog: DSNCLIC1}
- Pkg: {Collection: DSNAOCLI - Prog: DSNCLIMS} - Pkg: {Collection:
DSNAOCLI - Prog: DSNCLINF} - Pkg: {Collection: DSNAOCLI - Prog:
DSNCLIC1} - Pkg: {Collection: DSNAOCLI - Prog: DSNCLIMS} - Pkg:
{Collection: DSNAOCLI - Prog: DSNCLINF}
```

The Cost of Corporate Breach...

Each week brings news of another embarrassing corporate data breach at an average per-incident cost of $6.75 million, as reported by the Ponemon Institute. Regulatory standards require that companies monitor their data for suspicious activity. The CorreLog Agent with dbDefender provides that monitoring with minimal impact on performance or your existing operations, and integrates it with the SIEM console you already use. “It’s not a matter of if, but when,” says Anne De Vries of Wells Fargo Special Risks.



About the Author

Charles Mills is the Director of Advanced Projects for CorreLog. He has been developing mainframe software products since 1973. He founded a software company in 1975 and sold it in 1998. Since then he has offered consulting in software company acquisition due diligence, and in 2009 returned to software development with CorreLog.

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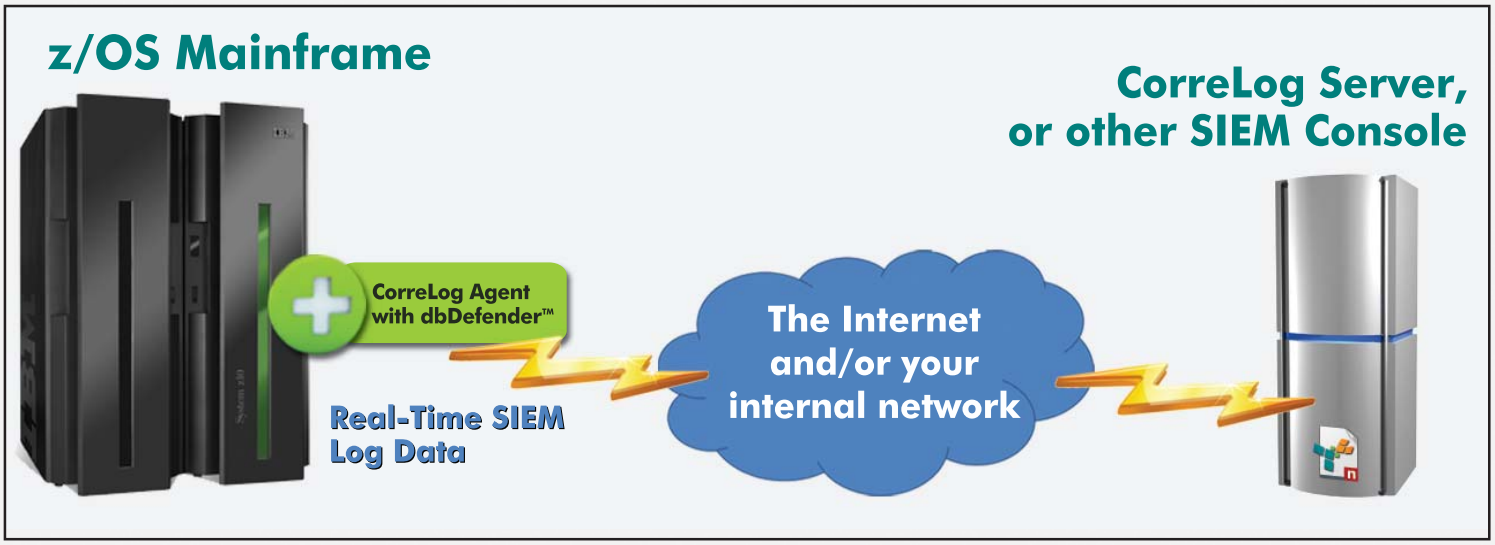

The CorreLog Agent for IBM z/OS converts SMF messages in real time to Syslog and delivers them directly to your SIEM console.

About CorreLog, Inc.

CorreLog, Inc. delivers security information and event management (SIEM) combined with deep correlation functions. CorreLog's flagship product, the CorreLog Security Correlation Server, combines log management, Syslog, Syslog-NG, SNMP, auto-learning functions, neural network technology, proprietary semantic correlation techniques and highly interoperable ticketing and reporting functions into a unique security solution. CorreLog furnishes an essential viewpoint on the activity of users, devices, and applications to proactively meet regulatory requirements, and provide verifiable information security. CorreLog automatically identifies and responds to network attacks, suspicious behavior and policy violations by collecting, indexing and correlating user activity and event data to pinpoint security threats, allowing organizations to respond quickly to compliance violations, policy breaches, cyber attacks and insider threats. CorreLog provides auditing and forensic capabilities for organizations concerned with meeting SIEM requirements set forth by PCI/DSS, HIPAA, SOX, FISMA, GLBA, NCUA, and others. Maximize the efficiency of existing compliance tools through CorreLog's investigative prowess and detailed, automated compliance reporting. CorreLog markets its solutions directly and through partners.
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