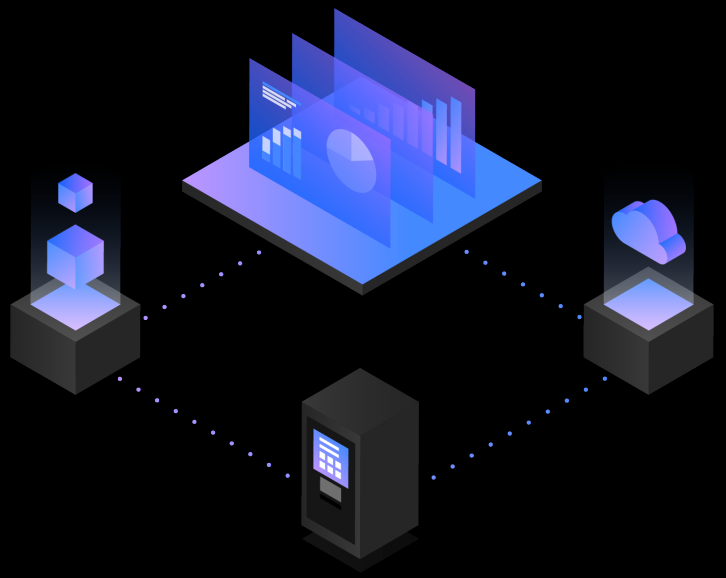
Securing Db2 for z/OS Data: Encryption, and Much More



TRIDEX

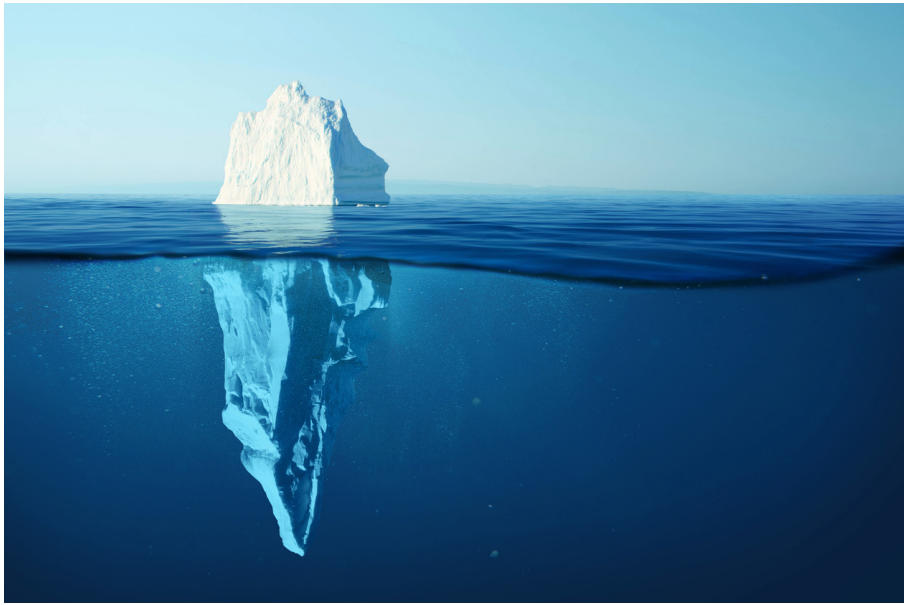
September 21, 2023

Robert Catterall, IBM
Principal Db2 for z/OS Technical Specialist

Agenda

- Encrypting Db2 for z/OS data
- Privilege management
- Row permissions and column masks
- Client authentication (for client-server applications)
- Auditing
- Application architecture
- Test data management
- RACF management of Db2-internal security

One more thing before we get going...



Because I'll be covering a lot of ground, I won't be able to go into a lot of depth on everything – the presentation contains links to useful sources of additional information

Encrypting Db2 for z/OS data

One primary area of Db2 data encryption: at rest

- "At rest" generally means, "on disk"
- Recently, huge increase in interest/activity in this area – here's why:
  - Regulatory requirements
  - z/OS data set encryption functionality (introduced with z/OS 2.3)
    - Application-transparent: data automatically encrypted when written to data set on disk, automatically decrypted when read into memory
  - Enormous improvement (like, 7X) in CPU efficiency of encryption with z14 vs. z13 (reason: encryption functionality went from card to chip)
  - Db2 12 function level 502 provided a new option for enabling z/OS encryption for Db2 data sets (more on this to come)

More on z/OS data set encryption

- z/OS data set encryption and “pervasive encryption”: not the same thing
  - “Pervasive encryption” is more all-encompassing than data set encryption
- z/OS data set encryption: associate an encryption key label (external “handle” associated with an encryption key) with a data set at create time
  - How that can be done:
    - A RACF (or equivalent) data set profile
    - Via the IDCAMS process that creates a data set
    - Via and SMS data class specification
    - With new option of ALTER/CREATE TABLE and STOGROUP, and a new ZPARM – delivered via function level 502 of Db2 12 for z/OS (see next slide)
- Helpful IBM redbook: *Getting Started with z/OS Data Set Encryption*

The Db2 12 FL502 encryption enhancement

- A new ZPARM: ENCRYPTION_KEYLABEL
  - Encryption key label used for catalog/directory objects, and for archive log data sets when you archive to disk (data set stays encrypted if HSM-migrated to tape)
- New option, KEY LABEL, for ALTER/CREATE TABLE/STOGROUP
- No matter how a key label gets associated with a Db2 data set, if a Db2 object (e.g., a table space) already exists and contains data, encryption is typically accomplished via execution of online REORG
  - Shadow data sets created by Db2 will have key label associated with them
  - If a key label is associated with a table or STOGROUP, online REORG of table space encrypts everything, including indexes and LOB/XML table spaces (if any)
- More information in Db2 12, Db2 13 online documentation

A little more on z/OS data set encryption for Db2

- What about Db2 active log data sets?
  - Can't convert existing unencrypted active log data sets – have to replace them
    - One option: dynamically add new encrypted log data sets with NEWLOG option of -SET LOG command, remove old ones with DSNJU003 utility
    - Db2 13 (FL500) option: same as above, but dynamically remove old unencrypted log data sets with REMOVELOG option of -SET LOG command
- With z/OS data set encryption, ID of a process needs to be RACF-permitted to use encryption key
  - For access to Db2 data sets, IDs of Db2 database services and system services address spaces are only ones that need RACF permission to use encryption key(s)
  - Reason: when ID SMITH selects data from table T1, z/OS perceives that Db2 – not SMITH – is accessing data set

Other main area of Db2 encryption: on the wire

- "On the wire" refers to encryption of data flowing between DDF-connected application (DRDA requester or REST client) and Db2 for z/OS server
- Often referred to as "SSL encryption" – more accurate term is AT/TLS (application transparent/transport-layer security)
- Multiple actions required to enable AT/TLS security for Db2 client-server applications: these relate to Db2 for z/OS, RACF, z/OS, client-side server…
  - Very useful redbook: *IBM DB2 for z/OS: Configuring TLS/SSL for Secure Client/Server Communications*
- Relatively recent change: fix for Db2 APAR PH08188 (April 2019) made it possible for Db2 subsystem's only SQL listener port to be secure port
  - Effect: only clients that support SSL encryption can connect to subsystem

Db2 SSL encryption: a lesson learned

- In my experience, #1 source of client-side problems is mistakes in connection string used to request SSL connection to Db2 for z/OS server
  - Lots of ways you can get this wrong
  - One way I have seen these problems overcome: do not try to specify required information in connection string
    - Instead, put required information (e.g., name/location of host certificate file) in entry for Db2 for z/OS system in IBM Data Server Driver's db2dsdriver.cfg file
    - Then, have client application simply request connection to the named Db2 for z/OS server, with nothing about SSL in the connection string
    - Data Server Driver will check entry for Db2 for z/OS system in db2dsdriver.cfg, and that is where it will find required info: specification that request is for SSL connection, Db2 system's secure SQL port, host certificate file name/location…

Privilege management

Especially important for a Db2 for z/OS system

- Here's why: with at-rest and on-the-wire encryption in effect, only "in the clear" Db2 data is in z/OS memory (i.e., Db2 buffer pools), and thanks to z/OS key-protected memory, only way to access that data is through Db2
- So, only IDs that can access data are those that have requisite Db2 privileges – you need to make sure those privileges aren't abused
  - One way that is being done: organizations are more careful than they used to be in granting SYSADM (Db2 "super-user" authority) to users
  - For example, DBA who had SYSADM authority might instead get system DBADM authority, and system DBADM authority can be granted WITHOUT DATA ACCESS
    - In that case, if DBA needs to access data in table T1 to accomplish some task, SELECT ON T1 can be temporarily granted to DBA until task is completed
    - Hassle for DBA? Yes, but that can come with tighter data access controls

Restricting who can manage privileges

- Besides having fewer SYSADMs, you can reduce scope of SYSADM activity via the Db2 ZPARM parameter SEPARATE_SECURITY
  - When parameter set to YES (default value is NO), an ID with SYSADM authority…
    - Cannot create and manage security objects (e.g., roles, trusted contexts, column masks, row permissions)
    - Cannot grant privileges to others
  - Who can do those things, if SYSADM can't? An ID with SECADM authority
    - If SEPARATE_SECURITY=NO, SYSADM has implied SECADM authority
- A blog entry on this topic:

  http://robertsdb2blog.blogspot.com/2021/09/db2-for-zos-separatesecurity-and-secadm.html

RACF group IDs can simplify privilege management

- RACF group ID is ID to which multiple individual user IDs can be connected
- Db2 privileges and authorities can be granted to RACF group IDs
- Db2-supplied sample connection and sign-on exits make RACF group IDs to which primary authorization ID is connected *secondary authorization IDs*
  - Your Db2 privilege set (term used in Db2 documentation) is union of privileges granted to your primary authorization ID and to all of your secondary auth IDs
  - Authorization for most Db2 actions requires that privilege be in your privilege set
- Granting privileges to RACF group IDs can especially helpful if you follow best practice of granting the minimum privileges required to do a job
  - That can sometimes be a complex mix of privileges – OK, grant that mix to a RACF group ID associated with the job, then connect individual IDs to that group ID

Preventing “hijacking” of Db2 privileges

- DDF-using applications often connect to Db2 with ID and password
  - ID is application’s ID, and privileges granted to the ID are those required for successful execution of SQL statements issued by application
- ID and password will be known to some people – what prevents person from connecting to Db2 from laptop using application’s ID and password?
  - A defense against this: Db2 role and trusted context functionality
    - Grant Db2 privileges needed by application to Db2 role – not to application’s ID
    - Create Db2 trusted context that says, “Role ABC’s privileges can be used by process that connects to Db2 using ID XYZ, and from this set of IP addresses”
    - So what if someone connects to Db2 with application’s ID? ID has no privileges
- Blog entry: http://robertsdb2blog.blogspot.com/2019/03/a-case-study-implementing-db2-for-zos.html

Row permissions and column masks

Often preferable to “security views”

- At one time, about the only way to prevent ID SMITH from seeing data in certain rows or in a certain column of a table was via “security view”
  - SELECT in CREATE VIEW would have predicate that would filter out rows that SMITH shouldn’t see, or would not include “off limits” column in its select-list
  - Then grant to SMITH SELECT on view but not on underlying table
- Approach worked, but created some headaches for developers, DBAs
  - Developer: view could not have same fully-qualified name as underlying table – that could complicate programming
  - DBA: every view another database object to be managed – and, “views on views” could really complicate things (like the game Jenga – “Don’t touch that view!”)
- Row permissions and column masks, introduced with Db2 10 for z/OS, provided an alternative approach that is often a better way to go

Row permissions and column masks

- Example: for table T1, only process with secondary auth ID XYZ should see rows with DEPTNUM = ‘A01’ and actual values in column C1
- CREATE PERMISSION statement: check to see if ID associated with a SELECT from T1 is associated with group ID XYZ
  - If yes, data in rows with DEPTNUM = ‘A01’ is accessible
  - If no, predicate filtering out rows with DEPTNUM = ‘A01’ is automatically added to query, regardless of whether query is static or dynamic
- CREATE MASK: also check T1-reading process for secondary auth ID XYZ
  - If yes, process can retrieve actual data values from column C1
  - If no, data-masking CASE expression is automatically applied to C1 when referenced in query’s select-list, regardless of whether query is static or dynamic

Row permissions and column masks: advantages

- For developers: queries just reference the target table, and row permission or column mask does the security work based on ID of table-accessing process – no need to remember names of views
- For DBAs: easier to manage than a multiplicity of views
- For security team: strong protection, even against ID with SYSADM authority
  - If row permission or column mask looks to see if ID associated with query is connected to group ID XYZ (for example), and SYSADM's ID is not so connected, SYSADM will not be able to see rows and/or actual data values in column
- A related blog entry:

  http://robertsdb2blog.blogspot.com/2013/04/db2-for-zos-goodbye-security-views.html

One more thing about column masks

- A DBA might tell me: “We need to encrypt data in column C1 of table T1”
  - My initial response: “If you’re talking about at-rest encryption, just use z/OS data set encryption and encrypt the whole table space (and indexes, etc.)”
  - DBA: “We need to make sure that only certain users can see data in column C1”
  - Me: “That’s not necessarily an encryption situation”
- One option: encrypt at column level, using Db2 built-in function ENCRYPT_DATAKEY, but that approach is NOT application-transparent
- Application-transparent solution: create a mask for column C1 of table T1
  - Does not involve encryption, but enables only certain users to see values in C1
  - Request that DBA got was for data protection – column-level encryption is a way to achieve objective, but so is column mask, and latter is application-transparent

Client authentication (for client-server applications)

Changing the password for a DDF-using application

- As previously mentioned, DDF-using applications often authenticate to Db2 using an ID and a password
- In times past, not unusual for an application's ID to have a "never expires" password – increasingly unacceptable for security auditors
- If the password for an application's ID has to be changed periodically, can that be done without impacting application availability?
  - YES – I have seen that done through the use of two IDs for an application
    - The privileges needed by the application are granted to both IDs
    - When password of ID1 about to expire, application is changed to connect to Db2 using ID2 (same done in reverse when password of ID2 is about to expire)
    - If application running on at least two servers, ID switch does not cause outage

Alternatives to password for authenticating to Db2

- Besides password, how can client-server application authenticate to Db2?
  - One alternative is to use RACF PassTickets
    - z/OS doc: https://www.ibm.com/docs/en/zos/2.5.0?topic=guide-using-passtickets
  - Another alternative: certificate-based client authentication
    - Some folks get this mixed up with SSL encryption
    - SSL encryption involves use of certificate, but usually that is certificate of host system, stored on client system and presented to complete “SSL handshake”
    - Application that gets SSL connection to Db2 for system typically authenticates with password, but use of authentication via client certificate is an option
    - See redbook *IBM DB2 for z/OS: Configuring TLS/SSL for Secure Client/Server Communications* – “Client access to Db2 using TLS/SSL client authentication”

Also related to client authentication: TCPALVER

- This ZPARM parameter answers question, “Is client process requesting a TCP/IP connection to Db2 subsystem considered to be already verified?”
- Default is NO – client must authenticate to Db2 with password or certificate
- At some sites, value of TCPALVER is YES – that means Db2 does not require client to authenticate
  - Though not a gaping security hole (RACF will almost certainly require client authentication), TCPALVER=YES is not recommended
  - Sometimes, TCPALVER=YES is a remnant of time when only systems requesting TCP/IP connections to Db2 for z/OS were other Db2 for z/OS subsystems
    - If subsystem DB2A is DRDA requester (over TCP/IP) to DB2B, and DB2A is not sending a password when connecting to DB2B, update DB2A’s communications database to send password before going to TCPALVER=NO for DB2B

Auditing

Auditing: the complement to privilege management

- Even if privileges managed carefully, some IDs will have access to sensitive data – guarding against misuse of access is what auditing is about
- Db2 10 delivered audit policy functionality – here are things you can track:
  - Data access attempts that failed due to inadequate authorization
  - Occurrences of a user changing SQL ID
  - ALTER TABLE actions
  - Read or update actions targeting a particular table
  - Utility execution
  - Privilege GRANT and REVOKE actions
  - System administration "super-user" activity (e.g., SYSADM, SYSOPR)
  - Database/security administration "super-user" activity (e.g., DBADM, SECADM)

A little more on Db2 audit policy functionality

- Define audit policy with insert into SYSIBM.SYSAUDITPOLICIES table
- Audit policy, once defined, put into effect with -START TRACE command
- An activated audit policy will cause Db2 to generate trace records (the particular IFCIDs generated will depend on what is being audited)
  - The generated trace records can be formatted using your Db2 monitor (report might have a name like, “record trace report”)
- Db2 12 FL509 introduced tamper-proof audit policy functionality – permission to modify or delete tamper-proof policy must be provided by RACF administrator
- Audit policy information in online Db2 for z/OS documentation:

  https://www.ibm.com/docs/en/db2-for-zos/13?topic=db2-audit-policy

Application architecture

Application architecture and Db2 data security

- Security advantage of static SQL: think about a SELECT… FROM TABLE_XYZ
  - If static query, auth ID (usually, of application) requires only execute authority on Db2 package of which static query is a part – no table access privileges needed
  - If query is dynamic, auth ID requires SELECT privilege on TABLE_XYZ
- What if DBAs want static SQL for security reasons, but application developers want to use a generic SQL interface such as JDBC or ODBC?
  - SQL in JDBC or ODBC form is dynamic from Db2 for z/OS perspective
  - An approach that can satisfy DBAs and app developers: put “table-touching” SQL statements in Db2 stored procedures that are called via JDBC or ODBC
    - This approach enables dynamic invocation of static SQL statements
    - Developers who know JDBC or ODBC usually familiar with stored procedures

More on application architecture and data security

- Besides enabling use of static SQL in a JDBC/ODBC situation, Db2 stored procedures provide another security benefit: database schema obfuscation
  - Because table and column names only referenced in SQL statements coded in stored procedures, client-side developers do need to know that information
    - The smaller the number of people who are familiar with a database schema, the better from a data security perspective
- Speaking of static SQL, keep in mind that Db2's REST interface is about invocation of static SQL statements via REST requests
  - What you're REST-enabling is Db2 package associated with static SQL statement (SELECT, INSERT, UPDATE, DELETE, TRUNCATE or CALL [of stored procedure])
  - Besides security advantage of static SQL, REST interface extends programming language options: if program can issue REST request, program can access Db2

Test data management

Db2 dev/test, and the data security “threat area”

- You probably have sensitive data values in your production Db2 for z/OS environment, and you probably have protections in place for that data
- Question: how do you populate tables in development/test Db2 systems?
  - If these tables contain data copied from production (very common), are sensitive data values as well-protected in dev/test as they are in production?
  - Maybe not – maybe more IDs have access to the data in dev/test
  - Even with comprehensive data protection in effect for dev/test, just having copies of production data increases the data security “threat area”
  - Often, best risk-mitigating action is to mask sensitive data values in dev/test systems

Options for masking Db2 data in dev/test systems

- Do-it-yourself
  - Could be done programmatically, or potentially with Db2 column masks
  - Development effort could be significant, and some approaches can substantially increase CPU and elapsed time for processes that populate dev/test Db2 tables
- Data masking software (from IBM, other vendors) can deliver a lot of value:
  - CPU-efficiency (some can mask large volumes of data with little overhead)
  - Time-efficiency (setting up tool for a masking operation can be pretty quick)
  - Masking choices, including (but not limited to):
    - Generation of values (e.g., credit card numbers) that look like "the real thing"
    - Value "shuffling" – actual values are unmasked, but switched from one row to another (often, value is sensitive only in combination with other values in row)

RACF management of Db2-internal security

There is often confusion about this

- Note: Db2 external security is concerned with, “Which IDs can connect to this Db2 system, and how?” while Db2 internal security is concerned with, “Once ID has successfully connected to Db2 system, what can that ID do?”
- If asked, “Do you use RACF to manage Db2-internal security?” some Db2 DBAs will say, “Yes,” when the answer is, in fact, “No” – why is that?
  - Sometimes, it’s because person gets Db2 internal and external security mixed up
  - Sometimes, it is because RACF is *involved* with Db2 internal security (“We grant privileges to RACF group IDs”)
- Simplest way to figure this out: if you use GRANT and REVOKE SQL statements to assign privileges and authorities to IDs, you are using Db2 – not RACF – to manage Db2 internal security

How RACF can manage Db2 internal security

- Done by way of Db2-provided exit, DSNXRXAC
- When that exit is activated, and ID SMITH wants to (for example) SELECT data from table T1, Db2 drives the exit and asks RACF if SMITH can do that
  - RACF checks to see if a) it has a resource defined that maps to SELECT privilege on T1, and b) if ID SMITH has been permitted access to that resource profile
  - If a and b are true, RACF tells Db2 that SMITH can SELECT from T1
    - If a is true and b is not, RACF tells Db2, “SMITH cannot do that”
    - If a is not true (no applicable resource defined), RACF defers to Db2
  - Note: when RACF management of Db2 internal security is fully implemented, the authorization tables in the Db2 catalog (e.g., SYSUSERAUTH, SYSPACKAUTH) can be empty, because Db2 is not using them

More on RACF management of Db2 internal security

- Why do some organizations go this route?
  - Often related to desire for one team to manage Db2 internal and external security
- Does it work?
  - Absolutely – if you tell me, “We’re going to do this,” I’ll say, “That’s fine”
- In my experience, biggest challenge is the transition – partly because Db2 people and RACF people use different terminology
  - Once transition is done, Db2 DBAs often pretty happy (one less thing to manage)
- Useful links:
  - Db2 doc: https://www.ibm.com/docs/en/db2-for-zos/13?topic=db2-managing-security-racf-access-control-module
  - Blog entry: http://robertsdb2blog.blogspot.com/2020/01/db2-for-zos-and-racf-part-2-db2.html

Robert Catterall

rfcatter@us.ibm.com