IDUG VIRTUAL

Summer 2020 NA **Db2** Tech Conference

Db2 for z/OS Know your Limits!

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Platform: Db2 z/OS

#IDUGDb2

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Agenda

- Limits through the machine
- Limits through logic
- Limits through design
- Future directions

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- Limits through the machine
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Limits through the machine

They say that space is infinite - up to a point

The same is true for Db2!

If you can imagine having infinite disk space and infinite memory, what limits could there possibly be?

Limits through the machine

In the beginning was the VSAM Cluster...

Well before Db2 saw the light of day

Older than me!

Size limit of 4GB per dataset - that is HUGE!

We will never get that much data...

Remember Bill Gates and the apocryphal story about 640KB of RAM...

Limits through the machine

The VSAM limit is actually split into different limits that the DBA and Db2 must work with:

- Simple/Segmented VSAM Linear Dataset (LDS from now on) is limited to 2GB
- Partitioned Space 1GB, 2GB, 4GB, 8GB, 16GB, 32GB, 64GB

For larger than 4GB objects you must have a data class in SMS with the Extended Format and Extended Addressability set (If in Db2 12 then check out APAR PH10015 UI64089)

Limits through the machine

Index sizes are dependent on what they are and how they, and their table, are defined:

- Partitioned Indexes only have one dataset but their maximum size varies with usage of LARGE, DSSIZE and the number of PARTITIONs
- Non-partitioned Indexes can have PIECESIZE to enable multiple datasets which start at 256KB and then binary step all the way up to 268,435,456KB! The number of these is also dependent on LARGE, PIECESIZE and the number of PARTITIONS

Limits through the machine

Here you can see that a seemingly simple question:

How big can my partitioned index get?

Gets a rather complex answer:

MIN (Table space DSSIZE , 2^{32} / (Max No. Parts * IX PGSIZE))

Eg: 64GB DSSIZE with 32KB TS Page Size give 2048 as Max No. Parts and 4KB IX Page size gives you 8GB as a maximum dataset size.

All clear on that??

Limits through the machine

With NPIs you also see that another seemingly simple question:

How many pieces can my non-partitioned index get?

Gets another rather complex answer:

MIN (4096 , 2^{32} / (PIECESIZE / IX PGSIZE))

Eg: Tablespace with more than 64 partitions or DSSIZE used, IX with 8GB PIECESIZE and with a 4KB IX page size gives you 2048 datasets

All clear on that??

Limits through the machine

Hooray for Db2 12 FL500!

In Db2 12 we get the Relative Page Numbering (RPN) PBR with variable DSSIZE and *also* a variable DSSIZE for the partitioning indexes. Plus the DSSIZE GB does not have to be a binary number.

To do this the RID has increased to seven bytes but it completely decouples the number of partitions from the equation - which is a very good thing!

However, the rule is still true that for larger than 4GB objects you must have a data class in SMS with the EF and EA set.

Limits through the machine

These dataset limits then go into the LDS arena:

- A simple or segmented space can have 32 LDSs
- A non-partitioning index can have a “number” of pieces
- A LOB space can have 254 LDSs
- A partition can only have one LDS of course!

Limits through the machine

This is then the first set of limits for us.

You must monitor how many LDSs all of your simple, segmented and LOB objects have and you must get warned well before you hit the buffers! If you have 32 LDSs the REORG might take a while…

Partitioned objects are of course different…

Here you must monitor how ***full*** each partition is and how ***full*** each index is and how many pieces there are. Is that all?

Limits through the machine

No! Of course not…

The Partition By Growth (PBG) Universal Table Space (UTS) construct brought with it some "new" problems:

1) No partitioning index allowed – only NPSIs on these
2) MAXPARTITIONS is the new LDS limit

So, for all your PBGs you must monitor not only ***how many*** partitions they currently have, but also how ***full*** is that very last partition when you have it allocated!

Limits through the machine

Ok, so now you are checking how many LDSs of which size for all of your different objects – Everything must be ok now??

Limits through the machine

No! Of course not…

Think EXTENTS… many years ago the limit was 255 extents for a dataset but nowadays it is 7,257.

Nearly all shops are now running with ZPARM MGEXTSZ = YES which means that Db2 handles secondary allocation for all datasets with a **positive** secqty using a sliding scale.

Note that implicitly created tablespaces always work as if MGEXTSZ = YES.

Limits through the machine

While thinking about EXTENTS remember that these all live on VOLUMES…

So you now have the 59 Volume limit to worry about (7,257 extents is 59 * 123 extents per volume which is the limit for a dataset on a volume).

You must watch out for message DSNP030I which is your “last volume allocated” warning. Running out of volumes is “sub-optimal”…

Limits through the machine

Ok, so now you are checking how many LDSs of which size with how many extents on how many volumes for all of your different objects

– Everything must be ok now??

Limits through the machine

No! Of course not…

Think SMS Copy Pool sizes…When you are using flashcopy or just normal Image Copy you must guarantee that you have enough space to actually do all the copies you want to do…

Limits through the machine

This job is usually done by the storage team but I think it would be a good idea if the DBA also checked whether or not the copy pool lives up to its name

or is it only a puddle?

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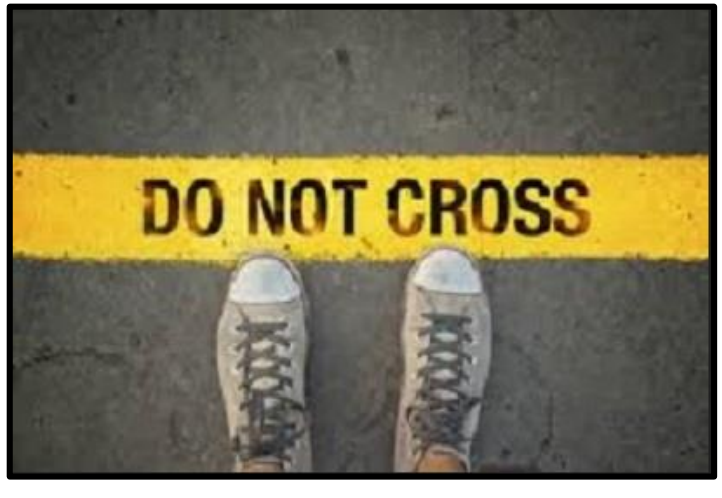

Limits through logic

Now we get to the part where Db2 constructs start saying “no”

Think SEQUENCEs here… A quick look in the SQL guide will show you that when you create a SEQUENCE:

```
CREATE SEQUENCE ROY_TEST_SEQ_ASC
         START WITH 1
         INCREMENT BY 1
         MAXVALUE 9999
         CACHE 10;
```

Limits through logic

You actually get:

```
CREATE SEQUENCE ROY_TEST_SEQ_ASC
         START WITH 1
         INCREMENT BY 1
         MAXVALUE 9999
         NO CYCLE
         CACHE 10;
```

The “NO CYCLE” is the, by default, bad guy here…

This is a -904 waiting to happen…

Limits through logic

For all of SEQUENCEs you must periodically see how close to the top or the bottom of your available range they are.

This is also true for Identity columns and XML DOC Ids:

```
SEQTYPE CHAR(1) NOT NULL
Type of sequence object:
     A Alias for a sequence
     I An identity column
     S A user-defined sequence
     X An implicitly created DOCID
       column for a base table that contains XML data.
```

You want to get these *way* before they hit the buffers!

Limits through logic

Now in the time before SEQUENCEs lots of shops were using SMALLINT, INTEGER or DECIMAL defined fields in their tables' Primary Keys doing exactly what a modern sequence does.

Naturally no-one has "updated" these pre-sequence sequences to use proper sequences and so you have another layer of danger lurking out there…

Limits through logic

You must find all your numerically defined primary key fields and see if they are approaching the Db2 numeric limits…

Item	Limit
Smallest SMALLINT value	-32768
Largest SMALLINT value	32767
Smallest INTEGER value	-2147483648
Largest INTEGER value	2147483647
Smallest BIGINT value	-9223372036854775808
Largest BIGINT value	9223372036854775807
Smallest DECIMAL value	$1 - 10^{31}$
Largest DECIMAL value	$10^{31} - 1$

Limits through logic

But what are you checking?

Are you looking at just the Db2 Catalog values after a RUNSTATS?

Or

Are you selecting all the columns dynamically from the User Data so that you get real values?

Horses for courses - as we say in England…

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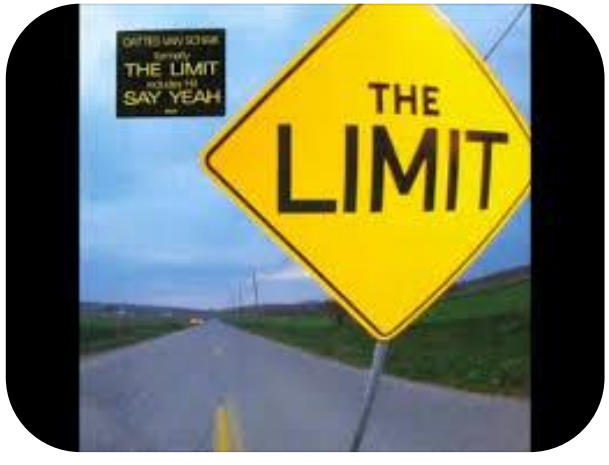
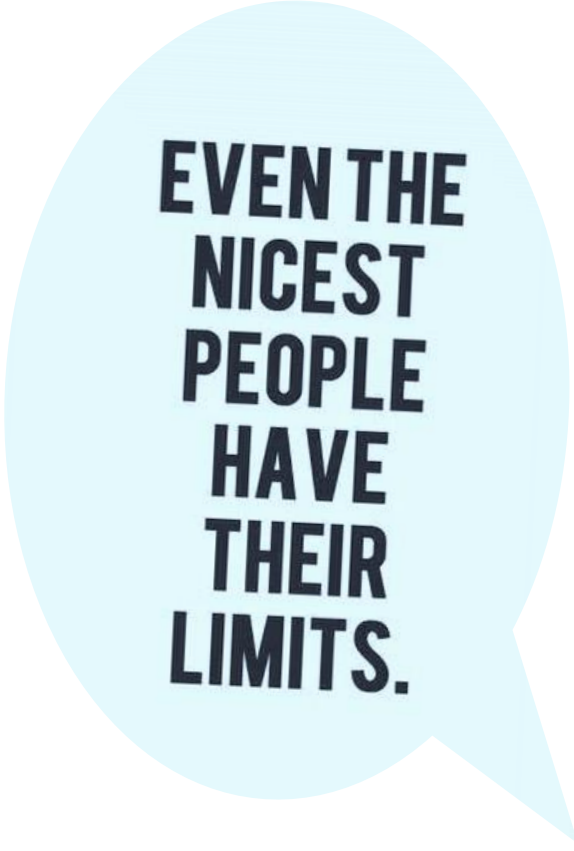


Limits through design

Design limits that require checking:

- How many columns in a table?
- How many columns in an index?
- How many bytes long is my index?
- Is there a Database limit?
- Is there an Object limit?
- Death by DBAT?



Limits through design

How many columns in a table?

From day one Db2 has allowed 750 columns as the absolute maximum. Depending on View definitions you can actually be forced to have less…

Something to check just in case that ALTER ADD COLUMN is gonna fail horribly…

Limits through design

How many columns in an index?

From day one Db2 has allowed 64 columns as the absolute maximum. However the byte count varies depending on whether or not the index is a good old partitioning index (PI) or any other index.

For a PI you get a maximum size for:

- PADDED indexes of 255 – n – 3d bytes
- NOT PADDED indexes of 255 – n – 2m – 3d bytes

Where:

n is the number of columns which are NULLable
m is the number of varying length columns
d is the number of DECFLOAT columns

Limits through design

For any other indexes you get a maximum size for :

- PADDED indexes of 2000 – n – 3d bytes
- NOT PADDED indexes of 2000 – n – 2m – 3d bytes

Where:

n is the number of columns which are NULLable
m is the number of varying length columns
d is the number of DECFLOAT columns

Limits through design

How many bytes long is my index?

In Db2 12 IBM came up with the Fast Traversal Block (FTB) which most people call Fast Index Traversal (FIT) and this comes with a bunch of limits:

1) Must be a unique index
2) Must have a total length <= 64 bytes
3) No TIMEZONE usage
4) No active versioning
5) Index partitions must have less than 2,000,000 leaf pages

Limits through design

So you can see that you might well be using a FIT and then do e.g.

ALTER INDEX x.y ADD INCLUDE COLUMN (col1)

and *__boom__* the index is no longer eligible for FIT usage…

Check before *every* ALTER INDEX whether or not the index is used by FIT and whether or not your ALTER will tip it over the edge!

Limits through design

Is there a Database limit?

Yes indeed there is, but nowadays at 65,217 (Back in DB2 V5.1 it was 32,511) it is pretty hard to reach!

However, if you have a lot of implicit Tables/Tablespaces where no-one tidies up and DROPs the implicitly created databases they can sum up quickly!

Limits through design

Is there an Object limit?

Actually yes there is!

- In a Database you can have a maximum of 32,767 OBIDs (Object Ids). Now remember the OBID is not 1:1 for any and all objects.
- Each tablespace, index or referential relationship takes two, whereas each table, check constraint, aux for LOB, XML for XML, trigger or view with INSTEAD OF takes one.

So make sure you check these counts on a regular basis as well.

Limits through design

Death by DBAT?

You all know what happens when you run out of DBATs right?

It is not pretty…

Just a –DISPLAY DDF DETAIL is all you need…

Limits through design

Sadly not…

The problem here is that the DBAT counts that are output when you do a -DISPLAY are, of course, only the *local* counts…

With Datasharing you only see the data of the Member that you are directly connected to which is pretty useless…

Limits through design

Here is an example output from a datasharing system:

```
DSNL080I  -SB11 DSNLTDDF DISPLAY DDF REPORT FOLLOWS:
DSNL081I STATUS=STARTD
DSNL082I LOCATION           LUNAME            GENERICLU
DSNL083I xxxxxxxx           xxxxxxxx.xxxxxxxx -NONE
DSNL084I TCPPORT=xxxx  SECPORT=0     RESPORT=xxxx  IPNAME=-NONE
DSNL085I IPADDR=::xxx.xxx.x.xx
DSNL086I SQL    DOMAIN=xxxx.fritz.box
DSNL086I RESYNC DOMAIN=xxxx.fritz.box
DSNL087I ALIAS              PORT  SECPORT STATUS
DSNL088I TEST110            0     0       STOPD
DSNL089I MEMBER IPADDR=::xxx.xxx.x.xx
DSNL090I DT=A  CONDBAT=  10000 MDBAT=  200
DSNL091I MCONQN=    0 MCONQW=   0
DSNL092I ADBAT=    0 QUEDBAT=      0 INADBAT=      0 CONQUED=      0
DSNL093I DSCDBAT=      0 INACONN=      0
DSNL094I WLMHEALTH=100 CLSDCONQN=      0 CLSDCONQW=      0
DSNL100I LOCATION SERVER LIST:
DSNL101I WT IPADDR            IPADDR
DSNL102I 32 ::xxx.xxx.x.xx
DSNL102I 32 ::xxx.xxx.x.xx
DSNL105I CURRENT DDF OPTIONS ARE:
DSNL106I PKGREL = COMMIT
DSNL099I DSNLTDDF DISPLAY DDF REPORT COMPLETE
```

Limits through design

So you have two choices…

- Write a little REXX that runs a round robin style of –DISPLAYs
- Get all warm and cuddly with IFI processing to do it all in one call…

However you get the data, the interesting numbers are in the following two lines of output:

```
DSNL090I DT=A  CONDBAT=  10000 MDBAT=  200
DSNL092I ADBAT=    0 QUEDBAT=    0 INADBAT=    0
```

The MDBAT is your MAXDBAT value and ADBAT is the current number of DBATs. You *must* monitor this all the time to see if any member is running out of DBATs!

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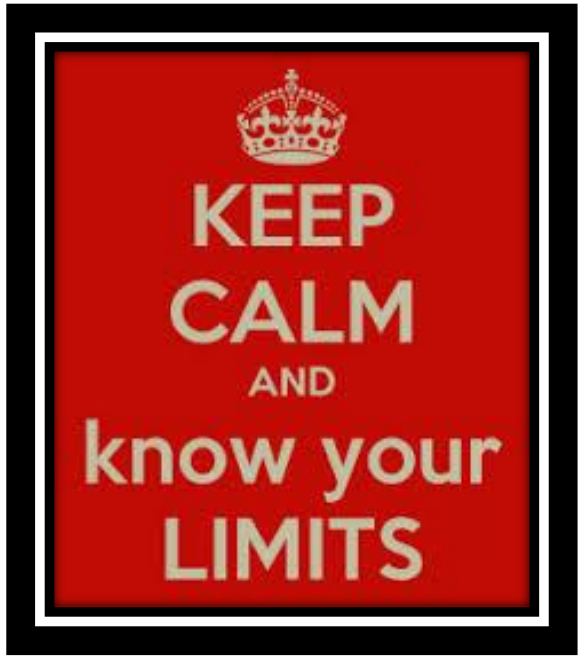

Future directions

IBM keep lifting the limits of Db2.

Now with RPN the last big bottleneck has been broken – You still must do a TS Level REORG with TP level inline image copies to migrate to it and you need a new Mapping table but when you are there it is a much better green than where you are standing now!

Will they ever raise the other limits?

I do not know of course, but I hope they raise the eligibility of FITs soon! And keep an eye on this APAR:

PH23238: DB2 12 FOR Z/OS FTB NEW FUNCTION

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