Informix Update – New Features & Partnerships
IBM Data Server Day – Stockholm May 2017

Scott Pickett
WW Informix Technical Sales
For questions about this presentation contact: spickett@us.ibm.com

Agenda

- Informix Roadmap
- A New Partnership
- 12.10.xC8 – Highlights – released 12/01/2016
- 12.10.xC7 – Highlights – released 06/23/2016
- 12.10.xC6 – Highlights – released 11/24/2015
- 12.10.xC5 – Highlights – released 03/24/2015
- Appendices

Informix Roadmap

Informix Roadmap

	2Q17	3Q17	4Q17	Stretch
Delight the Customer	Backup to Object Store in Cloud	Benchmarks Smart triggers	Over The Air Upgrades Simplified Licensing	HTAP Recompress Data Dictionary
Cloud	DSX Analytics for Informix Self Service Provisioning for Cloud (PAYGO)	Managed Services – Various Cloud Platforms HA Offering	Elastic Scaling	IWA for Cloud
IoT	New IoT Gateway platforms	High frequency data ingest	Blockchain Integration Sensors in motion	Edge-2-Cloud Solution stack

Ongoing

- Simplify Solution Development, focus on ISVs – for IoT, Cloud and On Premise
- SQL Enhancements
- Ease of Use and Administration
- Developer Ecosystem and Community Engagement

IBM Informix & HCL Partnership

News for Informix Customers - HCL Global Partnership

- **World-class partner taking responsibility for Informix Development & Support**
  - ✓ Richer roadmap, delivered sooner
  - ✓ Co-marketing support
  - ✓ Co-tech sales support
  - ✓ IOT expertise
- **Capture IOT whitespace**

IBM and HCL Relationship to Expand Informix

- **HCL is now responsible for Informix Development and Support**
  - Full Informix development and support (L2,L3) transfers to HCL as part of the larger HCL development organization.
    - HCL employs more than 100,000 employees worldwide.
  - Seamless transition, ensuring Informix expertise is maintained.
  - License agreement provides the right to develop Informix only
    - **This is not a sale of the product and all that goes with it.**

- **No change to Informix client relationship and processes (e.g., sales relationships, passport advantage, quotes, invoicing and payments)**

- **IBM is responsible for Informix Sales, Tech Sales, Marketing, Lab Services and L1 Support**
  - In addition, HCL will help with co-marketing and tech sales support

- **HCL and IBM will co-manage the Informix Customer Roadmap**

- **Development is underway and xC9 is due at the end of this quarter.**

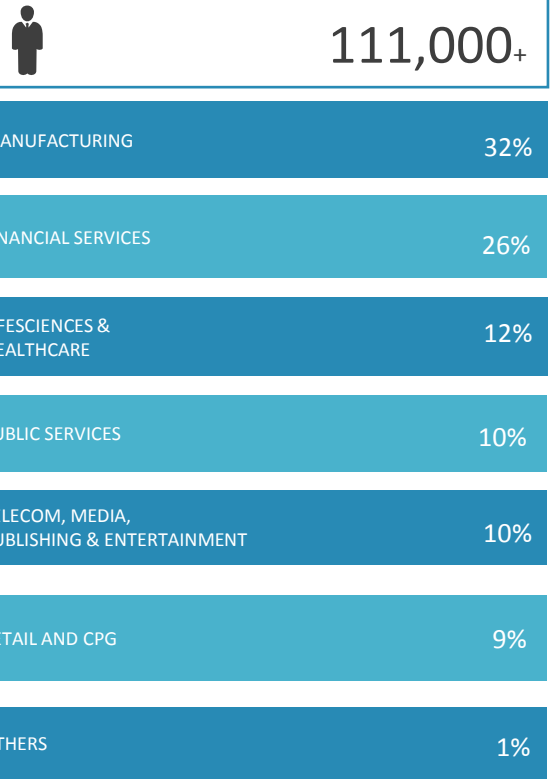
Informix Products Affected

- **Informix Server & CSDK**
- **Informix Connect Runtime**
- **Informix Warehouse Accelerator (IWA)**
- **Informix 4GL**
- **Informix SQL**
- **Informix on Cloud**

About HCL

PEOPLE & INDUSTRIES

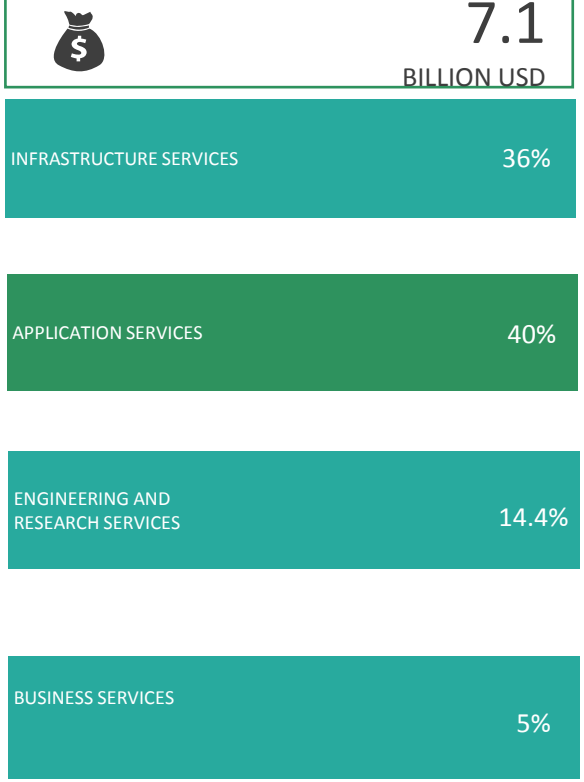
111,000+



Vertical Mix
REVENUES

REVENUE & SERVICE LINES

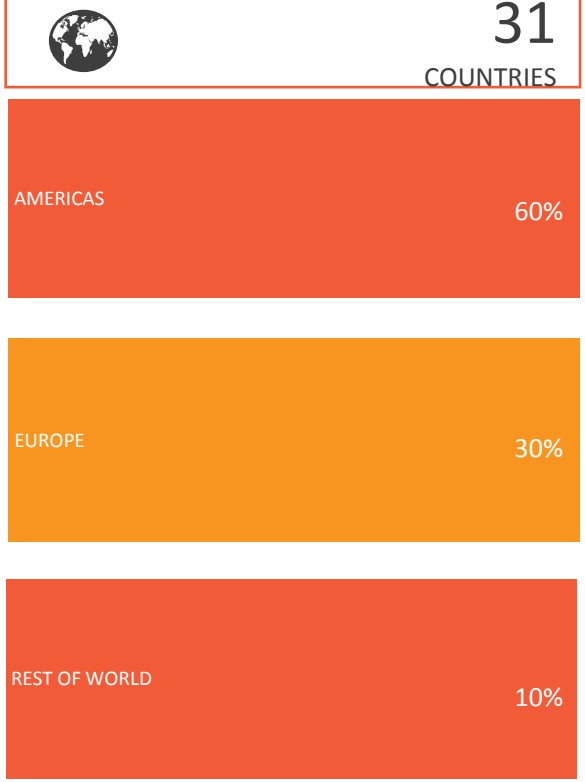
7.1
BILLION USD



Service Mix
REVENUES

GLOBAL COVERAGE

31
COUNTRIES



Geo Mix
REVENUES

IBM – HCL Partnership (1)

Key Points

- These offerings are strategically important to IBM.
- IBM recognizes the need to increase capacity and to innovate in these areas.
- IBM intends to deliver additional capabilities to our clients.
- This partnership has been made to secure the long-term success of our DevOps solution.
- IBM is expanding the existing partnership for 15+ years with HCL to accelerate the product roadmap innovation and extend these products to IOT.

IBM – HCL Partnership (2)

Key Points

- **IBM will continue to sell these products as it does today**
  - No change to contracts.
  - Sales contact is still with IBM.
  - Executive, technical and advocate relationships are unchanged.
  - IBM will continue to be the first point of contact for support and work with HCL who will provide advanced support (L2, L3) and development.
  - Support management will be through the PMR process, you will not be required to manage the transition in support between IBM and HCL.
  - IBM license, pricing, sales and support channels are unchanged.
  - Our client commitments remain the same.

More Information

- **From Matthias Funke, IBM:**
  https://www.linkedin.com/pulse/explaining-new-ibm-hcl-partnership-informixand-why-good-funke?trk=v-feed&lipi=urn%3Ali%3Apage%3Ad_flagship3_feed%3B2wUdozQhS66GTZQO9pliQQ%3D%3D

- **From Daniel Hernandez, IBM:**
  http://www.iiug.org/en/2017/04/17/ibm-and-hcl-strategic-partnership-to-jointly-develop-and-market-ibm-informix/

HCL VP of Development - Darren Oberst - Statement

Welcome Letter – Darren Oberst

Executive Vice President, HCL Products & Platforms

Dear IIUG Member,

Building on a history of collaboration between the two companies, HCL and IBM have entered into a 15 year partnership that takes the best of their shared knowledge and experience to jointly develop and market the Informix product family.

Effective May 1st, HCL will take on development, technical support, and product management teams, and will work jointly with IBM on product strategy, marketing, and sales.

HCL and IBM recognize the importance that data plays in today's business environment and have committed to investing in, and growing, the capabilities for data and analytics. HCL will build additional features and functionalities based on business realities and client priorities. With this renewed energy and commitment, HCL plans to improve the roadmap and enhance Informix.

Clients who are using Informix will continue to engage with IBM as the primary partner, with HCL broadening the reach to the user community. HCL's specialized customer advocacy group fosters collaboration with HCL technical and engineering teams to advance customer interests and develop product roadmaps for new releases.

This partnership plays on both companies' strengths. IBM data and analytics is the world's strongest brand in this category, with well-known product families and market reach.

HCL is a global leader in IT services, Application services and Engineering & Research capabilities. Under the new digital ecosystem, the agreement enhances each partner's ability develop new and innovative data-driven applications that enhance customer operations and competitiveness.

Both companies have enjoyed a longstanding and successful partnership across technology, software and services. With a history of collaboration and innovation, we're excited about the opportunity to jointly address your needs for business-critical data and analytics solutions.

Most importantly, all of you have many years of experience and dedication on Informix. We encourage you to share your ideas and energy, so Informix continues to drives value for many years to come.

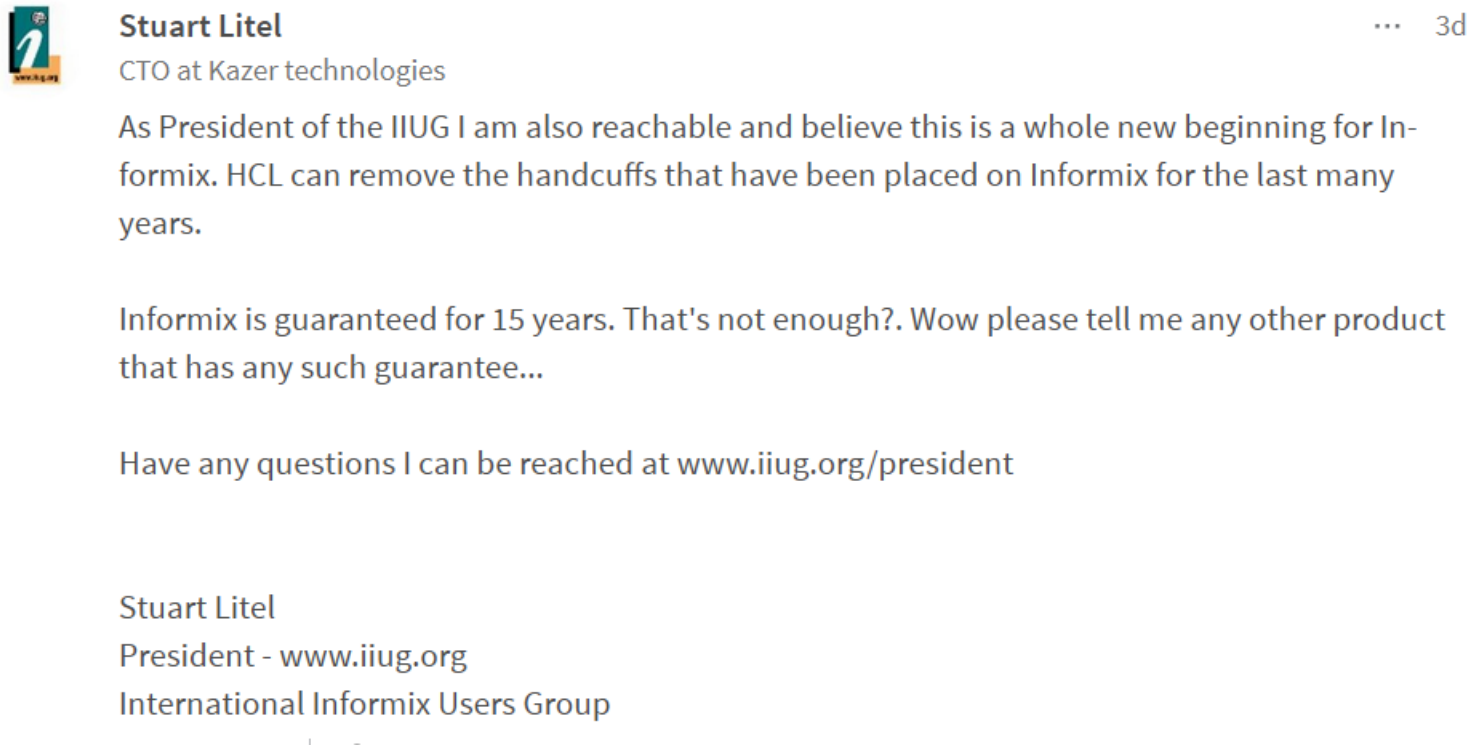
Warm Regards,

Darren

Darren Oberst
Executive Vice President
HCL Products & Platform

https://www.hcltech.com/products-and-platforms

International Informix User Group President Comments



Stuart Litel ··· 3d

CTO at Kazer technologies

As President of the IIUG I am also reachable and believe this is a whole new beginning for Informix. HCL can remove the handcuffs that have been placed on Informix for the last many years.

Informix is guaranteed for 15 years. That's not enough?. Wow please tell me any other product that has any such guarantee...

Have any questions I can be reached at www.iiug.org/president

Stuart Litel
President - www.iiug.org
International Informix Users Group

https://www.linkedin.com/pulse/explaining-new-ibm-hcl-partnership-informixand-why-good-funke

Contacts – WW Informix – IBM & HCL Partnership

- IBM Informix Technical Sales
  - Scott Pickett
- IBM Informix, Cloud & DB2 Sales
  - Tomas Escobar
- IBM Partner & Embed Sales
  - Joseph Costabile
- IBM Director Core Database & Data Warehouse Offering Mgmt & Strategy
  - Matthias Funke
- IBM VP, Hybrid Platform Development and Client Success, Hybrid Cloud
  - Albert Martin
- HCL Informix Sales Director
  - Marcelo Cabane
- HCL Informix Offering Mgmt.
  - Karen Qualley
- HCL Informix Product Development
  - Pradeep Muthalpuredathe
- HCL Informix Tech Support Mgr.
  - Michael O'Brien
- HCL Vice President of Sales, Lab Services and Client Advocacy
  - Doug Snadecki
- HCL Development Vice President
  - Darren Oberst

Informix 12.10.xC8 – New Features

Agenda

- Encryption at Rest
- Consistent sharded insert, update, and delete operations
- List Enterprise Replication definition commands
- Complex text search with regular expressions
- Suspend validation of check constraints
- Advanced time series analytics

Encryption at Rest (EAR)

poiunponorwborwbbgr

- **Cvvebvfrbnnym,.i/.oi/o/.,utnjtrrewfevhj64u79i0-[-htjyuyoiuomffddbcxbvdgdcnbcncncmcds;x.vcmbvmglknbmvfmvfvjveijveevvvovovvovovdvodvdvonvdovndvodnvovdnvovvovnfdovdnvodnvovnvodnvdovdnvovnvodnvovnvovndovnvoewjfdpvke[v[rjfoegfjerijeiejveiviewjfijveqivjfieivieqnveivenveinvevinmevienviveviveivjviejveivjviejveivjviejvijeviejviejeijfuyu43y6364387498h095h09=ke0vj0bijb0ije0ijv0ikjv0iv oikjv0ivjvvkjv0jk0idekv0ikjbve0ibvkj0ekfkif0-if0-fi0-ffif0-ngngngngngnif0oifiefief0kif0ev0kibv0ekjekjbv0jjkbjbjbjjbjbjbjbbjbjbjbjbbjbjbjbjbjbjjbjbjbjbjbjbjbjjbjbjbjbjbbjbjbjbjbbjbjbjbbbjbjbjbjbbjbjbjbjbjbjbjbjbjbjbbjbjjbjbjbjbjbjjbjbjbjbjbjbj9'/njtvgfeds2q2`fr42hy,mmrernbygmjkpo?0[0hhj6jj7km7km7,.,.9l9l;l9ll98;l98liu,miu,mumn443r32vrebrref3vg nbtrggr nrgr gigo ntrnbrtnytnnby.i;l8loijarshagnmy,uil/.fbt[5lkpbkrpb,mg,br;,brb,rb,rl,,bLnb, n,n,brw,brw,rw,rb[r,.brwl,brwNbl,r n, nbrwB,w ,n[,n[N,tr[nn[,rn[rhbrhbjbkjbfbfkbgf b kbgbbg bg bg bbbgb b bgbgbbgbb bg;.,./??**

Encrypt Storage Spaces or a Whole Instance

- **Encrypting storage spaces is an effective way to protect sensitive information that is stored on media**
  - Data in encrypted storage spaces is unintelligible without the encryption key
    - Customer is responsible for managing the keys
- **Enable storage space encryption by setting the new DISK_ENCRYPTION configuration parameter**
  - Subsequently, storage spaces created are default automatically encrypted
- **Create an unencrypted storage space with onspaces -c or SQL Admin API commands**
- **Encrypt or decrypt storage spaces during a restore with the ON-Bar or ontape utilities**
- **Check if storage spaces are encrypted with the onstat -d and oncheck -pr commands**

DISK_ENCRYPTION configuration parameter

- **Controls the encryption of storage spaces**
  - Not set by default
  - Not dynamic
- **Once enabled, any storage spaces created are encrypted by default**
  - Previously created storage spaces will not be encrypted.
    - Can be encrypted via backup/restore
- **Set the encryption file names, cipher to use, the configuration parameter to enable storage space encryption**
- **When storage space encryption is enabled, you can restore a storage space as encrypted or unencrypted, regardless of whether the space was encrypted at the time of the back up**
- **Backup data and Restore data are encrypted/decrypted via the BACKUP_FILTER and RESTORE_FILTER parameter**

DISK_ENCRYPTION configuration parameter

```
>>-DISK_ENCRYPTION--keystore--=--keystore_name----------------->

>--+----------------------+----------------------------->
   '-,--cipher--=--+-aes128-+-'
                   +-aes192-+
                    '-aes256-'

>--+-----------------------------------+----------------><
   '-,--rollfwd_create_dbs--=--+-encrypt-+-'
                               '-decrypt-'
```

DISK_ENCRYPTION configuration parameter

- **keystore**
  - The **keystore** specifies the name of the **keystore** and **stash file** names.
  - The files are created in the **INFORMIXDIR/etc** directory:
- **keystore.p12**
  - The keystore file that contains the security certificates
- **keystore.sth**
  - The stash file that contains the encryption password
- **You must manually back up (via operating system backup) the keystore and password stash files**
  - Files are not backed up when **ON-Bar** or **ontape** backs up

DISK_ENCRYPTION configuration parameter

- **cipher**
  - The encryption cipher:
    - **aes128** - **Default.** Advanced Encryption Standard cipher with 128-bit keys
    - **aes192** - Advanced Encryption Standard cipher with 192-bit keys
    - **aes256** - Advanced Encryption Standard cipher with 256-bit keys

- **rollfwd_create_dbs**
  - Whether to encrypt a storage space created by the rolling forward of the logical log during a restore:
    - **encrypt** - Encrypt the newly created storage space
    - **decrypt** - Do not encrypt the newly created storage space
  - Default, storage spaces that are created by the rolling forward of the logical log have the same encryption state as the original storage space

onspaces Unencrypted Option

- **To create an unencrypted storage space, even if DISK_ENCRYPTION is turned on:**

  onspaces –c –d unencrypted_space –p /usr/storage/unencrypted_dbs1 –o 0 –s 2000000 –k 2 –u

  execute function task("create unencrypted dbspace…

  execute function task("create unencrypted blobspace…

  etc…

Quick Start (1)

- **Set DISK_ENCRYPTION in the instance configuration file:**

  DISK_ENCRYPTION keystore=jc_keystore

- **oninit –ivy …..**

Quick start (2) – Message Log File

...
...
Initializing Dictionary Cache and SPL Routine Cache...succeeded Initializing encryption-at-rest if necessary...succeeded Initializing encryption-at-rest structures (part 1)...succeeded Bringing up ADM VP...succeeded
Creating VP classes...succeeded Forking main_loop thread...succeeded Initializing DR structures...succeeded
Forking 1 'ipcshm' listener threads...succeeded Starting tracing...succeeded
Initializing 1 flushers...succeeded
Clearing encrypted root chunk 1 before initialization... 25% done.
50% done.
75% done.
100% done.
Initializing encryption-at-rest structures (part 2)...succeeded
Initializing log/checkpoint information...succeeded
...
...

Quick Start (3) – Instance Results (default)

- **Initially, a new instance with one chunk, encrypted using the default cypher (aes128)**
  - This will be key1 on dbspace1 (rootdbs) for this instance
- **Installation locations, keystore and stash files:**
  - **$INFORMIXDIR/etc/jc_keystore.p12**
  - **$INFORMIXDIR/etc/jc_keystore.sth**
- **Each space in an instance uses a different encryption key**
  - Keys 2-2047 are derived from Key 1 at run-time and never stored anywhere on disk

What's in the Key Store File and Stash Files?

- **The Key Store file ($INFORMIXDIR/etc/<keystore name>.p12) contains a single encryption key, which is used only for ROOTDBS (Dbspace 1).**
  - Key Store file is encrypted
  - To decrypt the Key Store file, the server needs the Master Key

- **The Master Key is stored in a stash file**
  - (**$INFORMIXDIR/etc/<keystore name>.sth**)
  - The stash file is encrypted.
  - The server knows how to read it only because IBM **GSKit** knows how to read it.
    - **gskit** is installed with Informix initially
    - See Appendix E for more details

- **Best practice is to store encrypted chunks on a separate disk from $INFORMIXDIR**

- **Users are expected to back up $INFORMIXDIR with some regularity**

What's in memory

- Pages in the buffer pool are not encrypted
- Decryption happens during the read from disk, at a low level in the I/O code
- Encryption happens at the same low level during a write
- onstat -g dmp will display decrypted data
- Shared memory dump files will contain decrypted data, but not encryption keys

Encryption and Replication

- **Encryption on a secondary is entirely independent of encryption on a primary**
- **A primary may be encrypted while a secondary is not, and vice-versa**
- **A different set of spaces may be encrypted in a primary vs. a secondary**
- **An SDS secondary must use exactly the same encryption keys as used on the primary:**
  - When a shared-disk secondary is first created for an encrypted primary, the primary's keystore file is automatically copied to the secondary's **$INFORMIXDIR/etc** directory
  - File is then encrypted with a master key stored in the stash file

ontape/onbar – Changing Encryption During Restores

- **If storage space encryption is enabled, storage spaces are restored with the same encryption state as during the back up, by default**
  - Can specify to restore storage spaces as encrypted or unencrypted

- **The encryption state of storage spaces on disk does not affect the encryption state of backups**
  - Storage spaces that are encrypted on disk are unencrypted during a backup
    - To encrypt backed up storage spaces, set the **BACKUP_FILTER** configuration parameter to the name of an encryption utility
    - When you restore a storage space that was encrypted on disk before its backup, the storage space is encrypted during the restore, unless you specify to restore the space as unencrypted
    - Similarly, you can restore a storage space that was not encrypted on disk by specifying to encrypt the space during the restore

ontape/onbar – Changing Encryption During Restores

- **The following shows ways you can encrypt and decrypt storage spaces during a physical restore with the ON-Bar or ontape utilities when storage space encryption is enabled:**

Task – Encrypt or Decrypt …..	Method
All existing storage spaces	Full restore with the **-encrypt** or **-decrypt** option. Set/unset **DISK_ENCRYPTION**
Critical storage spaces	Cold restore with the **-encrypt** or **-decrypt** option and specify the spaces with the **-D** option.
Some non-critical storage spaces	Warm restore with the **-encrypt** or **-decrypt** option and specify the spaces with the **-D** option.
All storage spaces for a tenant database	Tenant restore with the **onbar -T** command and include the **-encrypt** or **-decrypt** option.
Storage spaces created by a roll-forward of logical logs	Include **rollfwd_create_dbs=encrypt** or **rollfwd_create_dbs=decrypt** option on the **DISK_ENCRYPTION** parameter value.

ontape/onbar – Changing Encryption During Restores

- **The -encrypt or -decrypt arguments to onbar or ontape apply to a physical restore only:**
  - The server can't use them for the logical restore

- **Decrypt an entire instance but still enable encryption at rest by setting DISK_ENCRYPTION and perform a cold restore using the -decrypt argument:**

  ontape -r -decrypt

  onbar -r -decrypt
- **During a rollforward, spaces may be re-created**
  - Assuming Encryption at Rest is enabled, by default they will be created with the same encryption status they were given originally

- **This default can be overridden by adding rollfwd_create_dbs to the DISK_ENCRYPTION setting, as in:**

  DISK_ENCRYPTION keystore=jc_keystore,rollfwd_create_dbs=encrypt

  DISK_ENCRYPTION

  keystore=jc_keystore,rollfwd_create_dbs=decrypt

Encryption and Restores

- **During an external restore, storage spaces are restored to the same encryption state as during the backup**
  - Encryption state of storage spaces cannot change during an external restore

- **When storage space encryption is not enabled, you see the following:**
  - Encrypting storage spaces during a restore with the **-encrypt** option, restore fails
  - Restoring encrypted storage spaces, storage spaces are restored as unencrypted

- **Encrypt all existing storage spaces during a whole-system restore:**
  onbar -r -encrypt -w
- **Encrypt two storage spaces during a physical restore:**
  ontape -p -encrypt -D dbspace1 dbspace2
- **Decrypt all storage spaces that belong to a tenant database:**
  onbar -T tenant1 -decrypt -t "08-08-2016 00:00:00"

How Can I Tell Whether Encryption at Rest Is Enabled?

- **oncheck**
  - **oncheck -pr | head -15**
  - **oncheck –pr | grep rest**
- **select from sysmaster:sysshmhdr**
  - **select value from sysshmhdr where name = "sh_disk_encryption";**
- **Look for the message "Encryption-at-rest is enabled using cipher" in the message log file**
- **onstat -g dmp**
  - **onstat -g dmp <rhead addr> rhead_t | grep sh_disk_encryption**

Overwriting the Key Store and Stash Files

- **Each instance has its own key store and stash file.**
- **Instances cannot share these files, but stored in a directory that may be shared**
  - Instances that share an **$INFORMIXDIR** must use different key store names in their **DISK_ENCRYPTION** settings.
- **We attempt to prevent clobbering of these files by insisting that FULL_DISK_INIT is set before they can be overwritten.**
- **With encryption enabled, the key store and stash files will be overwritten under the following conditions:**
  - **oninit -i**
  - Cold restore
  - Clone creation via **ifxclone**.

Change the Storage Space Encryption Key

- **master_key reset argument: (SQL administration API)**

- **Use the master_key reset argument with the admin() or task() function to change the master key for storage space encryption**
  - When encryption is first established, a key is automatically generated and stored encrypted in the stash file.
  - User supplied master key of **32** bytes maximum encrypts the keystore for storage space encryption.
    - Users informix or root only may change at any time
    - Stores the new encrypted key in the stash file
    - Accepts no argument, in which case a **random** master key is generated.
      - **Make sure you write it down ……..**
      - **Do you know *random* ?**

execute function task("master key reset","new master key, hopefully not");

Caveats

- **You have to find somewhere to store your keys ……**
  - Future Release
- **Presently, backup data is not encrypted, use BACKUP_FILTER and RESTORE_FILTER**
  - Future Release
- **Don’t forget your keys ……..**
  - Fortunately, since backups are not encrypted yet, you can restore the storage spaces unencrypted.
- **Use of ifxclone on an existing instance**

Questions?

List Enterprise Replication Definition Commands

- **Customers can print a list of successful commands run to define a replication server, replicates, replicate sets, templates, or grids with the new cdr list catalog command.**
- **Use this list of commands to easily duplicate a system for troubleshooting or moving a test system into production.**
- **cdr list catalog**
  - Lists the commands that created the specified replication objects
  - Options:

Long Form	Short Form	Meaning
--all	**-a**	Lists all definition commands. **Default.**
--grids	**-g**	Lists **cdr create grid** commands.
--quiet	**-q**	Lists the commands without headings.
--realizetemplates	**-z**	Lists **cdr realize template** commands.
--replicates	**-r**	Lists **cdr define replicate** commands.
--replicatesets	**-e**	Lists **cdr define replicateset** commands.
--servers	**-s**	Lists **cdr define server** commands.
--templates	**-t**	Lists **cdr define template** commands.

cdr list catalog

- **List the define server commands**

```
$ cdr list cat -s

#
# cdr define server commands.
#

cdr define server --init g_cat_cdr1

cdr define server --connect=g_cat_cdr2 --sync=g_cat_cdr1 --init g_cat_cdr2

cdr define server --connect=g_cat_cdr3 --ats=/usr/informix/ats
       --ris=/usr/informix/ris --sync=g_cat_cdr1 --init g_cat_cdr3

cdr define server --connect=g_cat_cdr4 --sync=g_cat_cdr1
       --init g_cat_cdr4
```

- **Template realization**

```
$ cdr list cat -t

#
# cdr define template commands.
#

cdr define template temp1 --conflict=ignore  --master=g_cat_cdr1
         --database=catdb informix.tab1 informix.tab2 informix.tab4

cdr define template temp2 --conflict=always  --master=g_cat_cdr1
         --database=catdb informix.tab1 informix.tab2 informix.tab4

cdr define template temp3 --conflict=timestamp  --master=g_cat_cdr1
         --database=catdb informix.tab1 informix.tab2 informix.tab4

cdr define template temp4 --conflict=timestamp --floatieee --ats --ris
        --alwaysRepLOBs=y --UTF8=y --master=g_cat_cdr1 --database=catdb
        informix.tab1 informix.tab2 informix.tab4
```

Regular Expression SQL Searches (regex)

Complex Text Search with Regular Expressions (regex)

- **For SQL commands:**
  - Search for and replace text strings with regular expressions in SQL statements.
  - Regular expressions combine literal characters and metacharacters to define the search and replace criteria.

- **Run the functions from the new Informix regex extension to find matches to strings, replace strings, and split strings into substrings.**
  - Specify case-sensitive or case-insensitive searching.
  - Search single-byte character sets or **UTF-8** character sets.

- **For MongoDB commands:**
  - The JSON wire listener now supports searching with regular expressions with the **$regex** operator in MongoDB commands.

Complex Text Search with Regular Expressions (regex)

- **Requirements and Restrictions:**
  - Use basic or extended regular expressions, with case sensitivity or case insensitivity
    - Neither expression type allows searching for a null character
  - Extended regular expressions support more search and replace options than basic regular expressions
  - Database server requirement
    - The Scheduler must be running
      - When you run regex functions, a message that the function is not found is returned if the scheduler is not running.
    - Default sbspace required to return a **CLOB** value when you replace strings and to replace text in a **CLOB** value with the **regex_replace** function
  - Database requirements
    - A non-ANSI logging database
      - If you attempt to use a **regex** function in an unlogged or ANSI database, the message "DataBlade registration failed" is printed in the database server message log
  - Data type support
    - To use **regex** pattern matching, you must provide the text data as a **CHAR, LVARCHAR, NCHAR, NVARCHAR, VARCHAR,** or **CLOB** data type.

Complex Text Search with Regular Expressions (regex)

- **Requirements and Restrictions (cont'd):**
  - Locales and languages support
    - Regex queries can use single-byte character locales and **UTF-8** based locales.
    - If **UTF-8** character encoding is used, including the Chinese **GB18030-2000** code set, you must set the **GL_USEGLU** environment variable before you create the database.
  - Query restrictions
    - **Regex functions do not inherently use any database indexes**.
      - If there is something else that can use an index in the statement …….

- **Metacharacters:**
  - A character that has a special meaning during pattern processing.
  - Use in regular expressions to define search criteria and any text manipulations.
  - Search string metacharacters are different from replacement string metacharacters.

Regex – Search String Metacharacters

- **Basic regular expressions do not support all metacharacters**
  - The function of the backslash character is reversed
  - A backslash character must be included before all metacharacters

- **Metacharacters for extended regular expression searches:**

Metacharacters for **regex** Searches

Metacharacter	Action
^	Beginning of line
$	End of line
|	OrNot applicable to basic regular expressions.
[abc]	Match any character enclosed in the brackets
[^abc]	Match any character not enclosed in the brackets
[a-z]	Match the range of characters specified by the hyphen
[:*cclass*:]	Use the character list specified by ***cclass*:alnum** = Uppercase and lowercase alphabetic characters and numbers: [**A-Za-z0-9**] •**alpha** = Uppercase and lowercase alphabetic characters: [**A-Za-z**] •**blank** = Whitespace and tab characters •**cntrl** = Control characters •**digit** = Numbers: [**0-9**] •**graph** = Visible characters (the alnum class plus the punct class) •**lower** = Lowercase alphabetic characters: [**a-z**] •**print** = Printable characters (the graph class plus whitespace) •**punct** = Punctuation marks: **!"#$%&'()*+,-./:;<=>?@[\\]^_`{|}~** •**space** = Whitespace: **tab**, **newline**, **carriage-return**, **form-feed**, & **vertical-tab** •**upper** = Uppercase alphabetic characters: [**A-Z**] •**xdigit** = Hexadecimal characters: [**0-9a-fA-F**] These classes are valid for single-byte character sets.

Metacharacters for **regex** Searches (cont'd)

Metacharacter	Action
[=*cname*=]	Substitute the character name that is specified by ***cname*** with the corresponding character code. For a list of character names, see Appendix C.
.	Match any single character.
( )	Group the regular expression within the parentheses.
?	Match zero or one of the preceding expression. Not applicable to basic regular expressions.
*****	Match zero, one, or many of the preceding expression.
+	Match one or many of the preceding expression. Not applicable to basic regular expressions.
****	Use the literal meaning of the metacharacter. For basic regular expressions, treat the next character as a metacharacter.

Regex - Replacement String Metacharacters Table

- **Basic regular expressions do not support all metacharacters**
  - The function of the backslash character is reversed.
  - A backslash character must be included before all metacharacters
- **A list of metacharacters for extended regular expression searches:**

Metacharacter	Action
&	Reference the entire matched text for string substitution. For example, the statement **execute function regex_replace('abcdefg', '[af]', '.&.')** replaces '**a**' with '**.a.**' and '**f**' with '**.f.**' to return: '**.a.bcde.f.g**'.
\n	Reference the subgroup ***n*** within the matched text, where ***n*** is an integer **0-9**. **\0** and **&** have identical actions. \1 - \9 substitute the corresponding subgroup. For example, the statement **execute function regex_replace('abcdefg', '[af]', '.\0.')** replaces '**a**' with '**.a.**' and '**f**' with '**.f.**' to return: '**.a.bcde.f.g**'. For example, the statement **execute function regex_replace('abcdefg', '([af])([bg])', '.p1-\1.p2-\2.')** replaces '**ab**' with '**.p1-a.p2-b**' and '**fg**' with '**.p1-f.p2-g.**' to return: '**.p1-a.p2-b.cde.p1-f.p2-g.**'. Not applicable to basic regular expressions.
****	Use the literal meaning of the metacharacter, for example, **\&** escapes the **ampersand** symbol and **** escapes the **backslash**. For basic regular expressions, treat the next character as a metacharacter.

Regex Character Names

- **Search for character codes by specifying the character name in a regex search**
- **Use the syntax [=*cname*=], where *cname* is a character name**
- **The character code is determined in the following order:**
  - If the character name
    - Exists in the current locale, the corresponding character code is used
    - Is one byte, the name is used as the code
    - Is listed in the following table, the corresponding character code is used
    - Otherwise, the character name was not found, and an error is returned
  - A list of codes as used by the ASCII character set is in Appendix A

Questions?

Suspend Validation Of Check Constraints

- **Disable check constraints temporarily with the NOVALIDATE keyword**
  - When a check constraint is enabled or created, you can speed up the statement execution by including the **NOVALIDATE** keyword to skip the checking of existing rows for violations
  - The check constraint is enabled when the statement completes

```
ALTER TABLE item ADD CONSTRAINT (CHECK (unit_price < total_price)
NOVALIDATE);
ALTER TABLE checktab ADD CONSTRAINT (CHECK (c2 in (97, 98, 99))
NOVALIDATE);
```

NOVALIDATE Session Environment Variable

- **NOVALIDATE environment option specifies whether a foreign-key or check constraint created by the ALTER TABLE ADD CONSTRAINT statement; or a table that has its constraint mode reset by the SET CONSTRAINTS statement, are in NOVALIDATE mode by default.**
  - Has no effect on **ADD CONSTRAINT** or **SET CONSTRAINT** operations specifying **DISABLED** mode.

- **If enabled, prevents referential-integrity checking of:**
  - Foreign-key constraints
  - Checking the condition of the check constraints

- **Possible values are:**
  - **'1'** *or* **ON**
    - Don't need to explicitly include the **NOVALIDATE** keyword to bypass **ENABLED** or **FILTERING** constraint validations while the associated DDL statements are running.
  - **'0'** *or* **OFF**
    - Restores the default behavior of those DDL statements; database server automatically checks the table for constraint violations during the **ALTER TABLE** or **SET CONSTRAINTS** operation that created or enabled the constraint.

NOVALIDATE Session Environment Variable – In depth

- **During these subsequent SQL statements:**
  - **ALTER TABLE ADD CONSTRAINT**
  - **SET CONSTRAINTS ENABLED**
  - **SET CONSTRAINTS FILTERING**

  - Validation is bypassed during these DDL operations to improve the database server performance in contexts where there is no reason to expect integrity or check condition violations, or postponement of constraint validation until table relocation to another database.
    - Such as a whole instance move of an entire database(s) from one O/S to a different O/S or code page changes requiring the same movement, where all of the data to be moved is already there and not changing (system is down).
    - This will save large amounts of migration time by not having to perform validations of check constraints on very large tables for example.
      - Hours …….

Questions?

Time Series Analytics

New Time Series Analytics

- **Advanced analytics functions to analyze time series data for patterns or abnormalities**
  - Quantify similarity, distance, and correlation between two time series sequences using the following methods
    - Lp-norm
    - Dynamic Time Warping
    - Longest Common Subsequence
  - Search based on specific measures like similarity, distance, and correlation
  - Find the portions of a sequence which are related to a given pattern
  - Anomaly detection within time series data
    - Given a long time series sequence, provides the ability to tell which part of the time series is dramatically different from the portion of data nearby in time order

New Time Series Analytics

- **These functions have practical usage in**
  - Voice-recognition
  - Signal
  - Handwriting
  - Data mining
  - Motion capture
  - Video capture analysis
  - Financial analysis
    - With applications to the prediction of interest rates, foreign currency risk, stock market volatility, and medical transitions of behavior over time.

- **Much of the technical explanations of what these do is bound up in higher level math such as Calculus.**

New Time Series Analytics functions

- **Scan_Abnormal and Scan_Abnormal_Default**
  - Return time series data that differ from nearby sequences
- **Scan_DTW_Itakura_Parallelogram_Constraint**
  - Returns time series data that matches a pattern using dynamic time warping (DTW) distance with the Itakura parallelogram constraint
- **Scan_DTW_NonConstraint**
  - Returns matching time series sequences using DTW without constraints
- **Scan_DTW_Sakoe_Chiba_Constraint**
  - Returns time series data that matches a pattern using DTW distance with the Sakoe-Chiba constraint
- **Scan_Normal_LCSS and Scan_LCSS**
  - Match the search pattern to the time series using the longest common subsequence (**LCSS**) formula
- **Scan_RangeQuery_LPNorm**
  - Uses the **Lp-norm** function to calculate how close the search pattern matches fragments of the time series

New Time Series Analytics functions

- **Scan_RangeQuery_Pearson_Correlation**
  - Returns time series data that matches a pattern using a Pearson correlation
- **TSAFuncsTraceFile**
  - Sets the file name and path of the trace file for advanced analytics functions
- **TSAFuncsTraceLevel**
  - Enables tracing on advanced analytics functions
- **TSAFuncsRelease**
  - Returns the version number and build date for the TimeSeries advanced analytics extension
- **TSCompute_Itakura_Parallelogram_Constraint_Dist**
  - Calculates a similarity score for two time series sequences with the Itakura Parallelogram constraint applied to the distance calculation of time warping
- **TSCompute_LCSS_Dist and TSCompute_Normalized_LCSS_Dist**
  - Calculates the longest common subsequence distance between two time series sequences

New Time Series Analytics functions

- **TSCompute_LP_Dist**
  - Uses the **Lp-norm** function to calculate how close two time series sequences match
- **TSCompute_NonConstraint_Dist**
  - Calculates the DTW distance between two time series sequences without constraints
- **TSCompute_Sakoe_Chiba_Constraint_Dist**
  - Calculates a similarity score for two time series sequences with the Sakoe Chiba constraint
- **TSGetValueList**
  - Converts a string into a list of values that you can use as input to an advanced analytics function
- **TSPearson_Correlation_Score**
  - Generates a Pearson correlation score for two time series sequences.

New Time Series Analytics functions

- **ValueAsCollection**
  - Returns a search pattern usable as input to an advanced analytics function
    - A search pattern is the list of values from the specified column in the TimeSeries data type for the specified time range

- **Appendix D has a breakdown of all of these functions**

Questions?

Informix 12.10.xC7 – New Features

Scott Pickett
WW Informix Technical Sales
For questions about this presentation contact: spickett@us.ibm.com

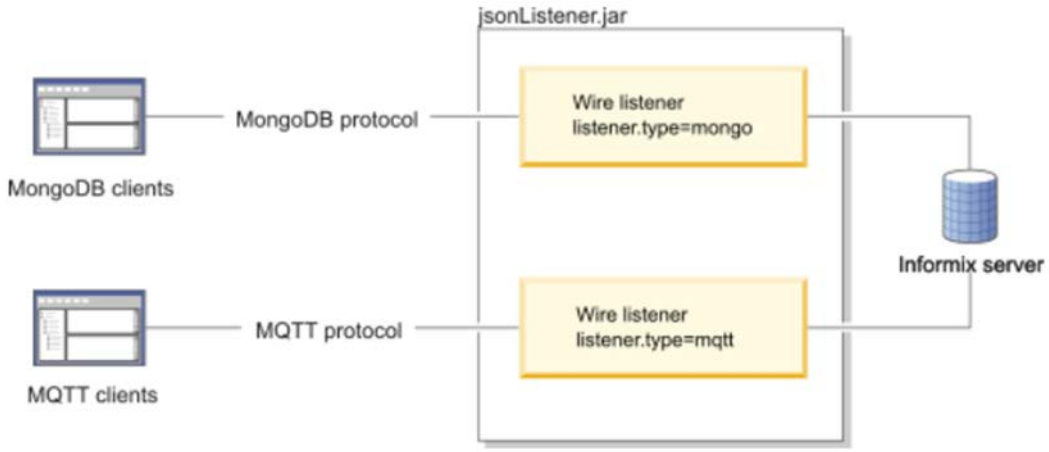
Agenda

- MQTT Protocol Support
- Informix Warehouse Accelerator & POWER 8 Linux in little Endian
- Consistent hashing for shard servers
- TimeSeries Spatiotemporal search improvements
- TimeSeries loader with auto spatiotemporal indexing
- Improved TimeSeries search pattern matching
- Enhancements for TimeSeries hertz data
- Convert spatial data to GeoJSON format

MQTT & JSON – Internet of Things (IoT) (1)

- **Load JSON documents with the MQTT protocol by defining a wire listener of type MQTT.**

- **The MQTT protocol is a light-weight messaging protocol that you can use to load data from devices or sensors:**
  - Use the MQTT protocol with Informix to publish data from sensors into a time series that contains a BSON column.



MQTT & JSON – Internet of Things (IoT) (2)

- **Informix supports the following operations for MQTT:**
  - **CONNECT**
  - **PUBLISH** (equivalent to insert)
  - **DISCONNECT**

- **Configure an MQTT wire listener by setting the listener.type=mqtt parameter in the wire listener configuration file.**
  - From an MQTT client, you send **PUBLISH** packets to insert data.
  - You can authenticate MQTT client users through the wire listener.
  - Network Connections via TCP/IP or TLS and WebSocket; **not UDP** [1]
    - The MQTT protocol requires an underlying transport that provides an ordered, lossless, stream of bytes from the Client to Server and Server to Client.
      - The transport protocol used to carry MQTT 3.1 & 3.1.1 is TCP/IP
      - TCP ports 8883 (TLS) and 1883 (non TLS) communications respectively are used

MQTT & JSON – Connect & Publish

- **Connect (*database_name.user_name)***
  - Include a **Connect** packet to identify the client user.
  - If authentication is enabled in the MQTT wire listener with the **authentication.enable=true** setting, specify a user name and password.
    - User name includes the database name in the following format: ***database_name.user_name***.
    - Example: connect to the database **mydb** as user **joe** with the password **pass4joe**:
      - **CONNECT(mydb.joe. pass4joe)**

- **Publish *(topicName, { message }***
  - The **Publish** packet maps to the MongoDB **insert** or **create** command.
  - The ***topicName*** field must identify the target database and table in the following format: ***database_name/table_name***,
  - The ***message*** field must be in JSON format.
    - If you are inserting data into a relational table, the field names in the JSON documents must correspond to column names in the target table.
  - The following example inserts a JSON document into the sensordata table in the mydb database:
    - **PUBLISH(mydb/sensordata, { "id": "sensor1234", "reading": 87.5})**

MQTT & JSON – Internet of Things (IoT)

- **Prerequisites:**
  - Create a JSON time series with the REST API, the MongoDB API, or SQL statements
  - TimeSeries row type consists of a time stamp and BSON columns

- **Example: In SQL, with row type, accompanying table, and storage container with record insert for the data:**

```
CREATE ROW TYPE ts_data_j2( tstamp datetime year to fraction(5), reading
BSON);
CREATE TABLE IF NOT EXISTS tstable_j2( id INT NOT NULL PRIMARY KEY, ts
timeseries(ts_data_j2) ) LOCK MODE ROW;
EXECUTE PROCEDURE TSContainerCreate('container_j', 'dbspace1', 'ts_data_j2',
512, 512);
INSERT INTO tstable_j2 VALUES(1, 'origin(2014-01-01 00:00:00.00000),
calendar(ts_15min), container(container_j), regular, threshold(0), []');
```

  - Create a virtual table with a JSON time series

```
EXECUTE PROCEDURE TSCreateVirtualTab("sensordata", "tstable_j2");
```

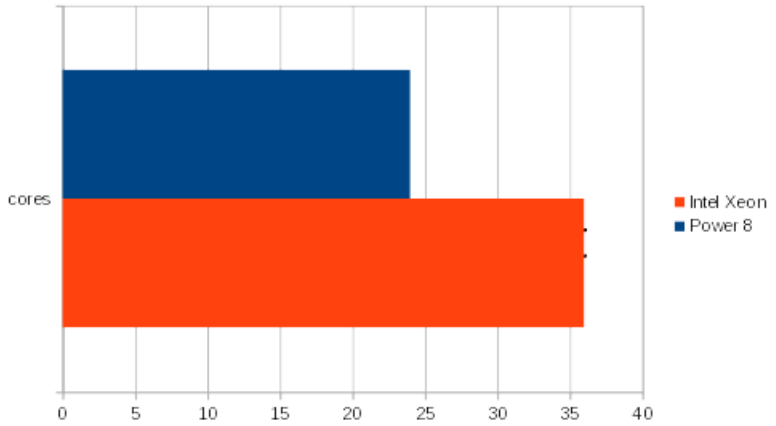
Informix Warehouse Accelerator on Power8 Linux on Little Endian

- **Certified**
  - Not just limited to X86/64 servers …..
  - Reported 26% faster

Comparing : 2 724 951 558 rows

```
select    min(f1.v1) as min_gage,    max(f1.v1) as max_gage,
   min(f1.v2) as min_discharge,    max(f1.v2) as max_discharge  from    v_tstable_j f1   order by max_gage
```

Runtime 18 Seconds on both machines



Intel Xeon E7-8890 V3
HW: 144 CPU in Linux
Thread(s) per core: 2
Core(s) per socket: 18
Socket(s): 4

POWER8E 3026MHz
HW: 192 CPU in Linux
Thread(s) per core: 8
Core(s) per socket: 12
Socket(s): 2

IWA on Power8 Linux on Little Endian

Intel Xeon E7-8890 V3
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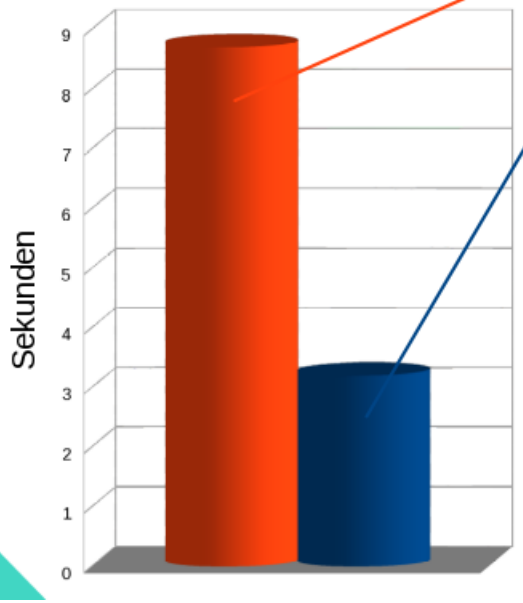
Core(s) per socket: 18
Socket(s): 4

POWER8E 3026MHz
HW: 192 CPU in Linux
Thread(s) per core: 8
Core(s) per socket: 12
Socket(s): 2

This is a nice chart which compares performance of the latest Intel E7-9990 V4 with Power8

Vergleich POWER8 – Intel E7-8890 v4

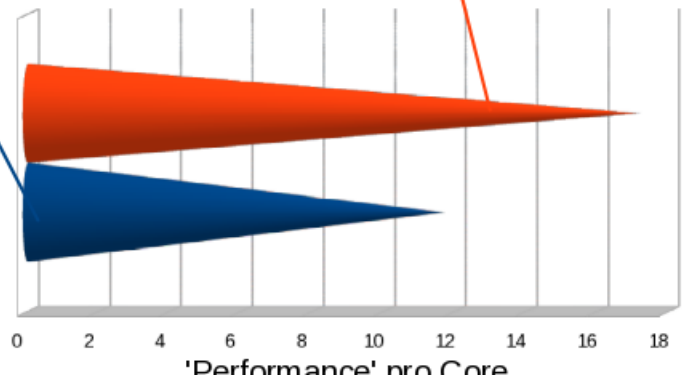
Laufzeit einer Abfrage:



POWER8 System: 2 Sockets = **24 Cores**
POWER8E 12-Core CPU @ 3.02 GHz
(Informix Lizenzierung: PVU 70)

Intel System: 4 Sockets = **96 Cores**
Xeon(R) CPU E7-8890 v4 @ 2.20GHz
(Informix Lizenzierung: PVU 100)

Abfragen pro Stunde pro Core:



Open Source Contributions

- **Informix Node.js driver update**
  - I want to use a native **node.js** driver for Informix database server and be able to download/install it through the **Node.js** package ecosystem (**npm**).
    - In addition, I want to be able to use all the supported APIs from latest stable
    - Version of node.js (v4.4.5 LTS) within my application.
    - **https://www.npmjs.com/package/ifx_db**

- **Informix to Spark streaming prototype:**
  - Performs distributed stream processing and advanced analytics on transactional data to gain real time insight for my business.
  - Instead of batch processing:
    - I need to stream the transactional data to a stream processing engine without disrupting or adding complexity to my transactional data which drives my business.
    - I need a way for my operational (relational/NoSQL) database to stream the transactional data to an external distributed stream processing engine through a well-known/universally supported protocol like MQTT.

Quickly Add or Remove Shard Servers With Consistent Hashing

- Quickly add or remove a shard server by using the new consistent hashing distribution strategy to shard data.
- With consistent hash-based sharding, the data is automatically distributed between shard servers in a way that minimizes the data movement when you add or remove shard servers.
- The original hashing algorithm redistributes all the data when you add or remove a shard server.
- You can specify the consistent hashing strategy when you run the cdr define shardCollection command.

Consistent Hash-based Sharding

- **When a consistent hash-based sharding definition is created, Informix uses a hash value of a specific defined column or field to distribute data to servers of a shard cluster in a consistent pattern.**

- **If a shard server is added or removed, the consistent hashing algorithm redistributes a fraction of the data.**

- **Specify how many hashing partitions to create on each shard server:**
  - The default is **3**.

- **If more than the default number of hashing partitions are created, the more evenly the data is distributed among shard servers.**
  - If more than **10** hashing partitions are specified, the resulting SQL statement to create the sharded table might fail because it exceeds the SQL statement maximum character limit.

cdr define shardCollection

- Below is a sharding definition that is named collection_1. Rows that are inserted on any of the shard servers are distributed, based on a consistent hash algorithm, to the appropriate shard server.

- The b column in the customers table that is owned by user john is the shard key. Each shard server has three hashing partitions.

```
cdr define shardCollection collection_1 db_1:john.customers --type=delete
--key=b --strategy=chash --partitions=3 --versionCol=column_3
g_shard_server_1 g_shard_server_2 g_shard_server_3
```

- ER verifies a replicated row or document was not updated before the row or document can be deleted on the source server.

- Each shard server has a partition range calculated on the server group name and data distributed according to the following sharding definition which is very data dependent: (over)

Consistent Hashing Index Example

- **Change dynamically the number of hashing partitions per shard server by running the cdr change shardCollection command.**

  cdr change shardCollection collection1 - –partitions=4

- **To create three partitions on each shard server:**

  cdr define shardCollection collection_1 db_1:informix.customers --type=delete --key=b --strategy=chash --partitions=3 --versionCol=column_3 g_shard_server_1 g_shard_server_2 g_shard_server_3

- **Output looks like this (over)**

cdr define shardCollection output (in part)

```
g_shard_server_1 (mod(abs(ifx_checksum(b::LVARCHAR, 0)), 10000) between 4019 and 5469) or
                 (mod(abs(ifx_checksum(b::LVARCHAR, 0)), 10000) between 5719 and 6123) or
                 (mod(abs(ifx_checksum(b::LVARCHAR, 0)), 10000) between 2113 and 2652)
g_shard_server_2 (mod(abs(ifx_checksum(b::LVARCHAR, 0)), 10000) between 6124 and 7415) or
                 (mod(abs(ifx_checksum(b::LVARCHAR, 0)), 10000) between 5470 and 5718) or
                 (mod(abs(ifx_checksum(b::LVARCHAR, 0)), 10000) between 7416 and 7873)
g_shard_server_3 (mod(abs(ifx_checksum(b::LVARCHAR, 0)), 10000) between 2653 and 3950) or
                  mod(abs(ifx_checksum(b::LVARCHAR, 0)), 10000) >= 7874 or
                  mod(abs(ifx_checksum(b::LVARCHAR, 0)), 10000) < 2113 or
                 (mod(abs(ifx_checksum(b::LVARCHAR, 0)), 10000) between 3951 and 40
```

Improved TimeSeries Pattern Match Searching

- **Create a pattern match index or run a pattern match search on a field in a BSON document.**
- **The BSON document must be in a BSON column the TimeSeries subtype and the field must hold numeric data.**
- **Execute the TSCreatePatternIndex function or the TSPatternMatch function and specify the BSON column and field name.**
- **With the TSCreatePatternIndex function with new beginning or ending times you extend the time range of an existing pattern match index to incrementally update the index.**
  - Extend the index time range in either direction, or both directions, but the existing and new time ranges must overlap.

Improved Spatiotemporal Searching via GPS input

- **Track at-rest objects and objects temporarily suffering signal-loss**
- **Speed indexing of new data via parallelized multiple Scheduler tasks**
  - Alternatively, you can configure time series loader functions to trigger spatiotemporal indexing as time series data is saved to disk
- **Set storage space, extent sizes for spatiotemporal data and indexes**
- **No limits on time series table configuration or the number of rows:**
  - Index spatiotemporal data in any standard or tenant database
  - Location data can be in a BSON column within the TimeSeries subtype
  - Time series data can be compressed or have a hertz frequency
  - Distance measurements use a spherical calculation based on longitude and latitude coordinates

Prerequisites

- **Before indexing spatiotemporal data, decide how to configure the data and where to store the spatiotemporal tables and indexes.**

- **When starting the spatiotemporal indexing process, a subtrack table is created for the time series column in the time series base table:**
  - Subtrack table contains trajectories that track where objects move, but also store information about when objects are stationary or do not have a signal.
  - Subtrack table is indexed and the spatiotemporal search system tables are populated with information about the subtrack table and the time series.

- **Set the definitions for spatiotemporal data, storage spaces, and extent sizes in the BSON parameters document when the STS_SubtrackCreate function is run.**

- **Set default parameters for the database by running the STS_SetDefaultParameters function.**

Prerequisites

- **Configure the data in the subtrack table by setting the following definitions**
  - Trajectories for moving objects:
    - Regulate the size of a trajectory by setting how often to generate readings for a trajectory, the maximum duration of a trajectory, and the maximum area of the bounding box around the trajectory
  - Stationary objects:
    - Set the minimum length of time and the maximum distance that an object can move and still be considered stationary
  - No data conditions:
    - Set the minimum length of time for a no data condition

Prerequisites

- **Storage space**
  - Adequate storage space before you start indexing spatiotemporal data
  - Specify storage spaces and extent sizes for each subtrack objects:
    - The subtrack table, which contains a row for each trajectory, stationary period, and period without a signal for an object
    - The geometry column from the subtrack table, which contains the trajectories, can require large amounts of space:
      - The geometry column can be fragmented among multiple storage spaces
  - Index on the primary keys of the subtrack table
  - Index on the end time of the trajectories in the subtrack table
  - R-tree index on the trajectories in the geometry column
  - Optional functional index on the instance ID of the time series
    - This index can speed processing during spatiotemporal search queries

Starting Spatiotemporal Indexing (1)

- **Run the STS_SubtrackCreate function for the time series column:**
  - TimeSeries, Spatial, and R-tree index extensions pre-registered in the database.
  - A time series table must exist.
- **To start spatiotemporal indexing:**
  - Prepare storage spaces for the spatiotemporal data.
- **Optional:**
  - With multiple CPU virtual processors available,
    - Set the **PRELOAD_DLL_FILE onconfig** parameter to the path for the spatiotemporal shared library file in the **onconfig** file
    - Restart the database server:

    PRELOAD_DLL_FILE $INFORMIXDIR/extend/sts.*version*/sts.bld
    - The ***version*** is the version number of the spatiotemporal search extension.
- **Optional:**
  - Set default parameters for configuring spatiotemporal data and storage by running the **STS_SetDefaultParameters** function.
- **Run the STS_SubtrackCreate function for the time series.**
  - A subtrack table and spatiotemporal search system tables are created.
  - If Scheduler tasks are configured, the subtrack table is populated and indexed.

Starting Spatiotemporal Indexing (2)

- If you did not configure a Scheduler task with the STS_SubtrackCreate function, run the STS_SubtrackBuild function to populate the subtrack table and index the initial set of data.

- The tables used for Spatiotemporal indexing and data are defined in Appendix B.

Hertz Data Enhancement for TimeSeries

- **Enter whole-second blocks of hertz records into a time series out of chronological order**
  - If a time series is missing data for an entire second at sometime in the past, you can enter the data
    - However, you must enter sub-second elements within a second in chronological order
- **Hertz data can now be stored in rolling window containers**
- **Hertz data is sub-second data**
  - Limit of 255 elements per second presently …..

JSON Spatial Data Improvements

- **Display spatial data in JSON-based applications by converting a geometry to a BSON document in GeoJSON format.**
  - Execute the **SE_AsBSON** function on a geometry to return a **BSON** document.

- **Use SE_AsBSON() to retrieve spatial data from the server and send it to a client that displays data in GeoJSON format:**
  - **SELECT SE_AsBSON(geomcol) FROM mytable**

- **Function takes an ST_Point, ST_LineString, ST_Polygon, ST_MultiPoint, ST_MultiLineString, or ST_MultiPolygon geometry and returns a BSON document in GeoJSON format.**
  - If the geometry value is empty, this function returns **NULL**.

- **Example**
  - The point with the definition of **'4326 point(-123.434 43.872)'** is converted into the following BSON document in GeoJSON format:

    { "type": "Point", "coordinates": [-123.434,43.872] }

Questions?

Informix 12.10.xC6 – New Features

Scott Pickett
WW Informix Technical Sales
For questions about this presentation contact: spickett@us.ibm.com

Agenda

- Parallel Instance Restore
- Limit Tenant Database Shared Memory
- Limit Tenant Database Connections
- Parallelized Sharded Queries
- Increase Throughput for Cluster Communications
- Faster index transfer to secondary servers
- Easier cloning of database servers - ifxclone
- Guardium V10 Support
- IWA Enhancement
- New Platforms

Instance Restore Parallelism – BAR_MAX_RESTORE

- **Set the number of parallel processes to run during a restore independently from the number of processes for a backup with the new BAR_MAX_RESTORE configuration parameter**
- **Previously, the BAR_MAX_BACKUP configuration parameter controlled the number of processes for both backups and restores**
- **Backups and Restores can occur concurrently with ON-Bar …..**

Instance Restore Parallelism – BAR_MAX_RESTORE

- **The Unix and Windows On-Bar BAR_MAX_RESTORE onconfig parameter specifies a max number of parallel restore processes allowed in a restore operation**
- **onconfig.std value 0**
- **If the value is not present, the value of BAR_MAX_BACKUP is used**
- **The value is the number of ON-Bar processes:**
  - **0** = Maximum number of restore processes allowed on system
  - **1** = Serial restore
  - ***n*** = Specified number of restore processes created
- **Takes effect:**
  - When ON-Bar starts
  - Dynamically in your **onconfig** file via **onmode -wf** or equivalent SQL administration API command

Instance Restore Parallelism – BAR_MAX_RESTORE

- **Specify serial restores**
  - Including a serial whole system restore, set **BAR_MAX_RESTORE** to **1**.

- **Specify parallel restores**
  - Including parallel whole system restores, set **BAR_MAX_RESTORE** > **1**.
    - If **BAR_MAX_RESTORE** = **5** and you start a restore, the maximum number of restore processes that ON-Bar creates concurrently is 5.
    - Configure **BAR_MAX_RESTORE** to any number up to the maximum number of storage devices or the maximum number of streams available for physical restores.
    - ON-Bar groups the dbspaces by size for efficient use of parallel resources.

- **If BAR_MAX_RESTORE = 0, the system creates as many ON-Bar restore processes as needed:**
  - This number is limited only by the number of storage spaces or the amount of memory available to the database server, whichever is less.

Parallelized Sharded Queries

- **Run SELECT statements in sharded queries in parallel instead of serially on each shard**
  - Parallel sharded queries return results faster
  - Reduced memory consumption:
    - Table consistency is enforced on the shard servers, which eliminates the processing of data dictionary information among the shard servers
  - Reduced network traffic:
    - Client connections are multiplexed over a common pipe instead of being created individual connections between each client and every shard server
    - Client connections are authenticated on only one shard server instead of on every shard server
    - Network traffic to check table consistency is eliminated

Parallelized Sharded Queries

- **To enable parallel sharded queries, set the new SHARD_ID configuration parameter in the onconfig file to a unique value on each shard server in the shard cluster**
  - If upgrading your existing older 12.1 shard cluster, upgrade and set **SHARD_ID** on all the shard servers to enable parallel sharded queries
  - Run **cdr define shardCollection**
- **Set the new sharding.parallel.query.enable=true and sharding.enable=true parameters in the wire listener configuration file for each shard server**
- **Customize shared memory allocation for parallel sharded queries on each shard server by setting the new SHARD_MEM configuration parameter**
- **Reduce latency between shard servers by increasing the number of pipes for SMX connections with the new SMX_NUMPIPES configuration parameter**

SHARD_ID

- **Sets the unique ID for a shard server in a shard cluster**

- **onconfig.std value 0**
  - Range of values **0** = Default.
    - The database server cannot run parallel sharded queries.
  - **1 - 65535**
    - The unique ID of the shard server.
  - Takes effect After you edit your **onconfig** file and restart the database server
    - If the value is **0** or not set, the value is dynamic via the **onmode -wf** command
    - If the value is set > 0, you must edit the parameter and restart the database server

- **Must be a unique number for each shard server in a shard cluster**

- **If the value is unset or set to 0 on all shard servers in the shard cluster, the shard cluster performs poorly**

- **If the values of the SHARD_ID configuration parameter are not unique on all shard servers in a shard cluster, shard queries fail**

New Wire Listener Configuration File Parameters

- **Set sharding.parallel.query.enable=true and sharding.enable=true for each shard server.**

- **sharding.parallel.query.enable**
  - Indicates whether to enable parallel sharded queries usage.
  - Parallel sharded queries require that the **SHARD_ID** onconfig parameter be set to unique IDs on all shard servers.
  - **sharding.enable** in the wire listener configuration file must also be set to true.

```
                                                  .-false--.
>>-sharding.parallel.query.enable=--+-true--+-----------------><
```

- **sharding.enable**
  - Enable/disable the use of commands and queries on sharded data.

```
                                  .-false-.
>>-sharding.enable=--+-true--+-------------------------------><
```

  - **false** – Default. Disable the use of commands and queries on sharded data.
  - **true** - Enable the use of commands and queries on sharded data.

SHARD_MEM – configuration parameter (1)

- **Allocation of shared memory for sharded queries on a shard server.**
- **onconfig.std value SHARD_MEM 0**
- **range of values**
  - **0**:
    - Memory allocation for sharded queries comes from a single memory pool.
  - **1**:
    - Memory allocation pools are associated with specific CPU VP's.
    - Enterprise Replication allocates memory to the CPU VP's based on which CPU VP the parallel shard query thread is running on.
  - **2**:
    - Memory allocation pools are associated with specific block sizes, so that all pool allocations are the same size, and the first free block that is found can be used.
- **takes effect:**
  - After you edit your **onconfig** file and restart the database server.
  - When you reset the value dynamically in your **onconfig** file by running the **onmode -wf** command.
  - When you reset the value in memory by running the **onmode -wm** command.

SHARD_MEM – configuration parameter (2)

- **Usage**
  - **SHARD_MEM 0**
    - Is the traditional method of memory-allocation.
    - Use this setting when resource allocation is more important than performance.
  - **SHARD_MEM 1**
    - Prevents multiple threads from simultaneously accessing a memory pool.
    - The performance of large-scale sharding environments can improve because memory allocation is done by multiple threads that are working in parallel.
  - **SHARD_MEM 2**
    - Improves performance at the cost of increased memory usage.
    - Memory allocation requests are increased to the closest fixed-block size, so that free memory blocks can be found faster.
    - Memory pools are not associated with specific CPU VP's, so memory can be freed directly to the memory pool.

SMX_NUMPIPES Configuration Parameter

- **Sets the number of pipes for server multiplexer group (SMX) connections.**

- **Usage**
  - High-availability clusters and parallel sharded queries use SMX connections.
    - If the lag time between servers is too long, increase the number of SMX pipes.
    - Provides more network connectivity resources between servers

- **onconfig.std value SMX_NUMPIPES 1**
  - values **1 – 32767**
    - The number of network pipes for SMX connections.

- **takes effect**
  - After you edit your **onconfig** file and restart the database server.
  - When you reset the value dynamically in your **onconfig** file by running the **onmode -wf** command.
  - When you reset the value in memory by running the **onmode -wm** command.

Other Enhancements

- **Faster index transfer to secondary servers**
  - When the **LOG_INDEX_BUILD** configuration parameter is enabled, the transfer of newly-created detached indexes to HDR or remote stand-alone secondary servers use light scans when possible, which leads to faster transfer rates.

- **Easier cloning of database servers**
  - **ifxclone** can create cooked chunks and mirror chunks on the target server
  - When a replication or high-availability server is cloned, the new **--createchunkfile (-k)** option can be included to automatically create the cooked chunks and mirror chunks on the target server that exist on the source server.

    ifxclone -T -L -S Boston -I 192.168.60.78 -P 543 -t Raleigh
    -i 192.168.4.92 -p 765 -d RSS –k

  - **(-k)** - **ifxclone** now has short and long form names for each of its options.
  - If source chunk is raw, **ifxclone** will create a cooked chunk on the target server.

Automatic Update Statistics Database Prioritization

- **Assign a priority to each database in the Auto Update Statistics (AUS) maintenance system**
  - Default all databases have a medium priority
- **Assign specific databases a high or a low priority to ensure that statistics for your most important databases are updated first**
- **Statistics for low priority databases are updated after high and medium priority databases, if time and resources permit**
  - If a system with a production and a test database exists, the production database can be assigned a high and the test database a low priority
  - Can also disable AUS for a database
- **Set AUS priorities in the IBM OpenAdmin Tool (OAT) for Informix or by adding rows to the ph_threshold table in the sysadmin database**

Informix V12 and Guardium V10

- **Enhanced auditing of Informix databases with IBM Guardium**
- **Increased capabilities when you audit the user actions for an Informix database server with Guardium, version 10.0.**
- **Guardium can now mask sensitive data and audit, and if necessary, close, any Informix connection, regardless of connection protocol.**
  - Previously, Guardium audited and closed only TCP connections.
- **After you set up the Guardium server, you start the ifxguard utility to monitor connections to your Informix databases.**
- **You can customize the behavior of the ifxguard utility by editing the ifxguard configuration file and by setting the IFXGUARD configuration parameter in the onconfig file.**
- **Guardium can audit all forms of file system access as well …..**

New Platforms – Informix 12

- **IBM POWER8® for ppc64le with Red Hat Enterprise Linux 7.1,**
- **SUSE Linux Enterprise Server 12**
- **Ubuntu 14.04 LTS.**

- **The spatial data feature is now available on the following platforms:**
  - IBM Power Series® 64-bit with
    - Red Hat Enterprise Linux ES releases 5.3, 6, and 7
    - SUSE SLES 11
  - IBM zSeries 64-bit
    - Red Hat Enterprise Linux ES releases 5.3 and 6,
    - SUSE SLES 11

Questions?

Informix 12.10.xC5

Agenda

- Migration
- Installation
- Administration
- Time Series
- Spatiotemporal
- Warehouse Accelerator
- Devices
- Miscellaneous

Agenda - Migration

- **HA Cluster OnLine Rolling Upgrade**

HA Cluster OnLine Rolling Upgrade

- **Rolling upgrades for high-availability clusters**
  - Parts of the cluster will always be up to receive data
  - Limited to PID to next PID
    - For example, from 12.10.xC4 to 12.10.xC5 **NOT** 11.7 to 12.1
      - Major release changes/migrations (V 11.x to V 12.x, for example) usually involve disk and memory changes to **sysmaster** and system catalogs.
  - Do not use this
    - If you must perform a conversion
      - Release notes …
    - Coming from a special build, for example, 12.10.xC4W1 to 12.10.xC5
      - Unless blessed by Technical Support.
  - You will minimally need 500 MB spare disk space on all servers involved for the install and more if it is Advanced Enterprise/Growth Edition.

- **This is a feature customers using HA Clusters have been requesting for sometime now; the ability to take parts but not all of the cluster down to upgrade it while maintaining business operations.**

HA Cluster OnLine Rolling Upgrade – Prerequisites (1)

- **Install the new software on all the servers in the cluster**
- **Copy the appropriate configuration files**
- **Back up the primary server.**
- **Configure client redirection to minimize interruption of service.**
  - Set up redirection and connectivity for clients by using the method that works best for your environment.
- **If Connection Manager controls the connection redirection in the cluster:**
  - Ensure that every Service Level Agreement (SLA) definition in the Connection Manager configuration file can redirect to at least one server other than the one you are about to update.
  - If you have an SLA with only one secondary:
    - Before you upgrade the secondary server in that SLA, update the SLA to include the cluster primary (PRI).
- **Primary server has an enough disk space for logical log records created during the entire upgrade process.**
  - Space required depends on your environment.
  - If a log wrap occurs during the rolling upgrade procedure, you must apply the fix pack or PID while the cluster is offline.

HA Cluster OnLine Rolling Upgrade - Prerequisites (2)

- **The online log can provide an estimate of your data activity during normal operations.**
  - Ensure, minimally, that you have enough space for data activity for a day.
  - Plan the rolling upgrade for a period of low traffic.

- **Prepare the secondary server that will become the primary when you upgrade the original primary server:**
  - You must use an SD secondary or a fully synchronous HDR secondary server that has transactional consistency with the original primary server.
    - If the cluster contains an SD secondary server, you don't need to do any additional preparation to that server.
    - If the cluster contains an HDR secondary server, make sure that it runs in fully synchronous (SYNC) mode.
    - If the cluster contains only RS secondary servers in addition to the primary server, you must change one of the RS secondary servers to an HDR secondary server in SYNC mode.

Environment Variable Settings

- **Set the environment to use the fix pack or PID version that you installed on the server.**
- **Set INFORMIXDIR to the full path name for the new target installation.**
- **Update all variables that depend on INFORMIXDIR**
  - **PATH**
  - **DBLANG,**
  - **INFORMIXSQLHOSTS**
  - And any platform-specific library path environment variables, such as **LD_LIBRARY_PATH**

Server Upgrades in Order of Upgrade

- **Remote standalone (RS) secondary server**
- **HDR secondary server**
- **Shared disk (SD) secondary server**
- **Primary server**

- **Upgrade the primary server only after *all* the secondary servers are upgraded and tested.**
  - After you upgrade the primary server, if you want to revert to your original environment you must take the cluster offline.

Upgrade Steps Per Server (roughly)

- **onmode -c - to force a checkpoint for each server.**
- **If a wire listener is running on the server that you want to upgrade, stop that wire listener:**
  - **execute function task("stop json listener");**
- **Stop the server that you want to upgrade.**
  - If you wait for connections to exit gracefully, **onmode -kuy**
  - Otherwise, **onmode –ky t**o stop the server.
- **When you stop a secondary server:**
  - If redirection is configured for the cluster, the client application automatically connects to another active server in the cluster.
- **When you stop the primary server:**
  - If failover is configured for the cluster, a secondary server is promoted automatically to primary. Otherwise:
    - **onmode -d make primary** - to do the promotion
    - If the primary is offline before the failover - **onmode -d make primary force**

Rolling Upgrades - Steps to Start

- **Start the upgraded server.**
  - To start an upgraded secondary server: **oninit**
  - To start an upgraded original primary server:
    - Start the original primary server as a secondary server.
    - For convenience, start it as the server type that was promoted to primary during the rolling upgrade.
    - For example, if you promoted an HDR server to primary for the rolling upgrade, start the original primary as an HDR secondary server.
    - To start the upgraded server as an SD secondary server, **oninit -SDS**
  - To start the upgraded server as an HDR secondary server, **oninit -PHY** and then run the following command:
    - **onmode -d secondary *primary_server secondary_server***

- **After the server starts, it runs the new version of the software and automatically reconnects to the cluster.**

Return The Upgraded Cluster To Its Original Config

- **If you want the cluster to operate as before the rolling upgrade:**
  - Manually promote the secondary server that was the original primary to be the primary server again.
    - **onmode -c** - to force a checkpoint.
    - **onmode -d make primary** - to promote the secondary server to primary.
  - Undo changes that you made when you prepared the servers for a rolling upgrade. Some of these optional steps might not apply to you:
    - Adjust the amount of disk space that is allocated for logical log records.
    - Convert the HDR secondary server back to an RS secondary server.
    - Change the HDR secondary server back to **ASYNC** mode from **SYNC** mode.
    - Change the Connection Manager SLA definitions.

Rolling Upgrades – Verification

- **On both the server you upgraded and on the primary server, verify that the upgraded secondary server is active in the cluster:**
  - **onstat -g cluster**

- **If you stopped the wire listener to upgrade this server, restart the wire listener.**

Questions

Agenda - Installation

- **Java 7 Support**
- **New operating system platforms**

Support for Informix Dynamic Server

- **A copy of IBM Runtime Environment, Java Technology Edition Version 7, is now installed on most platforms by default.**
  - Version is used to run Java user-defined routines that are created in the server.

- **Henceforth, IBM Informix 12.10.xC5+ software supports Java™ Platform Standard Edition (Java SE), Version 7.**

- **Mac OS X 10.8, 10.9**
- **Ubuntu 32-bit for ARM v8 (32-bit)**
- **Ubuntu 64-bit for ARM v8 (64-bit)**

Agenda - Administration

- **Multi-tenancy**
  - Control tenant resources
- **Sessions**
  - Limit session resources
- **Backup and restore**
  - Larger maximum tape size for backups

Multi Tenancy – Defined

- **Tenancy refers to the ability of an Informix server to support a set of users in a client organization needing to access the same data and system resources while denying non-administrative users on the same server from accessing those same resources without permission.**

- **Multi tenancy is multiple organizations supported on the same server needing to access only their own segregated data and resources while denying other users access to their data and resources.**

- **In tenancy, a dedicated database is created and assigned storage and processing resources for that database based on defined service-level agreements with the client organization.**
  - It is possible to have services for multiple companies (tenants) that run efficiently within a single Informix instance.

Multi Tenancy - Session Level Resource Limitations

- **Session Level Resource Control Limits**
  - To improve performance and restrict the tenant database size.
  - Prevents any session owned by non-administrative users from using so many resources that other sessions cannot continue processing transactions.
  - To prevent performance issues.

- **Tenant properties in the tenant definition created when you run the admin() or task() SQL administration command with the tenant create or tenant update arguments.**
  - Tenant properties have precedence over related configuration parameters.

Multi Tenancy – Limit Server Resources

- **Memory size threshold:**
  - Set the **session_limit_memory** to terminate sessions exceeding a specified maximum amount of session shared memory .
- **Temp space use size threshold:**
  - Set the **session_limit_tempspace** to the maximum amount of session usable temporary storage.
- **Transaction log space size threshold:**
  - Set the **session_limit_logsize** to the maximum size of a session transaction.
  - Transaction is rolled back if the log size threshold is reached.
- **Transaction time property:**
  - Set the **session_limit_txn_time** to the maximum number of seconds that a transaction can run.
- **You can limit the total amount of permanent storage space for a tenant database by setting the tenant_limit_space property.**

User Session Resources Limited (1) (non-tenant)

- **At a session level, resources can be limited that are owned by non-administrative users to prevent performance issues. This ability can:**
  - Prevent any session from using so many resources that other sessions cannot continue processing transactions.
  - Be useful in embedded environments.

- **DBA can specify limiting sessions exceeding a specified amount of shared memory or temporary storage space by setting the following configuration parameters:**
  - **SESSION_LIMIT_MEMORY** to a maximum amount of session shared memory.
  - **SESSION_LIMIT_TEMPSPACE** to a maximum amount of session temporary storage space.

User Session Resources Limited (2) (non-tenant)

- **DBA can specify rolling back transactions that are too large or take too long by setting the following configuration parameters:**
  - **SESSION_LIMIT_LOGSIZE** to the maximum amount of log space that a transaction can fill.
  - **SESSION_LIMIT_TXN_TIME** to the maximum number of seconds that a transaction can run.

Backup and Restore – Zetabytes Size Enhancement

- **Maximum value of the ontape TAPEDEV and LTAPEDEV configuration parameters is now 9,223,372,036,854,775,807 KB, or 9 ZB.**
- **Lack of resources prevented testing this number …….. Volunteers anyone? ☺**
- **Setting applies to ontape only.**
- **onmode –wm/wf work here.**

Agenda – Time Series

- **Loading data**
  - Load pure JSON documents into time series
  - Faster loading of time series data files
  - Improved logging for the time series loader
  - Create new time series while loading data
- **Displaying information about time series**
  - Display time series storage space usage
  - View active time series loader sessions
- **Querying data**
  - Analyze time series data for matches to patterns
  - Clip selected columns of time series data

JSON compatibility

- **Load JSON based document data directly into time series.**
- **Previously possible, except that an extra step was involved where primary key values and timestamps has to be provided in plain text format.**
- **Run the new TSL_PutJson() function to load pure JSON documents, either from a file or from a named pipe.**
- **Functionality can be used to load JSON documents generated by wireless sensor devices without preprocessing the data.**

TSL_PutJson function

- **TSL_PutJson loads JSON documents as time series data.**

```
TSL_PutJson(
        handle      LVARCHAR,
        pathname    LVARCHAR )
returns integer
```

handle

- A table/column name combination returned by **TSL_Attach()** or **TSL_Init()**.

pathname

- The fully qualified path and name of a file, which is preceded by the **DISK:** keyword, or a pipe, which is preceded by the **PIPE:** keyword.
- Both keywords must be uppercase.

TSL_PutJson – Usage

- **Use TSL_PutJson() to load time series data that is in JSON documents as part of a loader program:**
  - Within the context of a loader session initialized by **TSL_Init()**
  - Can be run multiple times in the same session.
  - Data stored in the database server until **TSL_Flush()** runs to write the data to disk.

- **Primary key value and the time stamp are extracted from the JSON documents and inserted into the corresponding columns in the TimeSeries data type.**
  - They also remain in the original JSON documents stored in the BSON column of the TimeSeries data type.

- **Reject records are listed in the reject file, reject_file.log, that is specified by the TSL_init(), and the reject_file.log.ext file that is in the same directory as the reject log.**

Faster Time Series Data Loads – TSL_Put Function

- **Load files directly into the database by specifying a file path as the second argument to TSL_Put().**
  - Values can be **JSON** Documents or in **BSON** format.

- **Previously, the TSL_Put() accepted data as only LVARCHAR or CLOB data types, which required intermediate steps to process the data:**
  - If you included the data as a string, the client processes the string into an **LVARCHAR** data type.
  - Now, if you include the data file as a **CLOB**, the server loads the contents of the file into a **CLOB** data type and then reads the data from that **CLOB** data type.

- **The time series data that you load with TSL_Put() can now contain JSON or BSON documents as values for columns other than the primary key and timestamp columns.**

```
EXECUTE FUNCTION TSL_Put('tsdata|pkcol','file:/mydata/loadfile.unl');
```

Improved Time Series Loader Logging

- **If you write a loader program to load time series data, you can choose to retrieve loader messages from a queue instead of logging the messages in a message log file.**
- **Retrieving messages from a queue results in less locking contention than logging messages in a file.**
- **Retrieve queued messages as formatted message text in English by running the new TSL_GetFmtMessage() function.**
  - Alternatively, run the **TSL_GetLogMessage()** function to return message numbers
  - Run the **TSL_MessageSet()** function to return the corresponding message text.
- **This method is useful if you want to provide your own message text or if you want to retrieve message text on the client.**

Create New Time Series While Loading Data

- **Create a new time series instance while loading data with a time series loader program**
  - Previously, you had to insert primary key values and create time series instances before you loaded data with a loader program.
- **For a loader program, you can specify the definition of a time series instance by running the new TSL_SetNewTS() function.**
- **Specify if the time series definition applies to the current loader session or to all loader sessions.**
- **When you load data with TSL_Put() for a new primary key value, a new row is added to the table and a new time series instance is created based on the definition.**
- **For a virtual table, you can create a new time series instance while quickly inserting elements into containers.**

Create New Time Series While Loading Data

- In the TSCreateVirtualTab() procedure, set the NewTimeSeries parameter and the elem_insert flag of the TSVTMode parameter.
- Set the origin automatically of any new time series instance to the day that the time series is created by including formatting directives for the year, month, and day.
- Formatting directives for the origin in the time series input string can be included within an INSERT statement or in the NewTimeSeries parameter in the TSL_SetNewTS() function and the TSCreateVirtualTab() procedure.

Examples

- **Set a global new time series creation definition:**

```
EXECUTE FUNCTION TSL_SetNewTS('iot_device_data|ts_data',
                'origin(2014-01-01 00:00:00.00000), calendar(ts_1min),
                 container(iot_cn2), threshold(0), irregular', 0);
```

- **Set a new time series definition for a session:**

```
EXECUTE FUNCTION TSL_SetNewTS('iot_device_data|ts_data',
                'origin(%Y-%M-%D 00:00:00.00000), calendar(ts_1min),
                 container(iot_cn2), threshold(0), irregular', 1);
```

- **The origin is set to the day on which the time series is created by inserting data.**

Displaying Information About Time Series - Monitoring

- **Active time series loader sessions:**

- **When you run a time series loader program, you open a loader session for each table and TimeSeries column combination into which you load data.**

- **You can view a list of handles for active loader sessions by running the TSL_ActiveHandles() function:**
  - The **handle** consists of the table name and the TimeSeries column name.

```
execute function TSL_ActiveHandles() returns SET(LVARCHAR NOT NULL)

SELECT * FROM TABLE(tsl_activehandles()) AS t(al)

al      iot_device_table|ts_data
al      meter_data|readings
```

Display Time Series Storage Space Usage - TSInfo

- **Find the amount of storage space used by a time series by running the new TSInfo() function.**

- **Customize the level of detail of the information:**
  - Details about **element page usage**, such as the
    - Number of pages
    - Number of bytes
    - Amount of free space
    - Number of null pages

- **Return information about other time series properties:**
  - The origin
  - The type of values
  - The containers.

Time Series Data Queries

- **Analyze time series data for matches to patterns**

- **Search time series data for matches to a specific pattern of values:**
  - If you identify a sequence of four values that indicate a problem, search for other sequences of four values that are similar to the original sequence of values
  - The function **TSPatternMatch()** find pattern matches in time series data
  - Specify the margin of error and whether to search through consecutive sequences of values or through every possible subsequence of values

- **Create a pattern matching index to improve query performance by running the function TSCreatePatternIndex()**

Time Series Pattern Matching Searches (1)

- **Search time series data for matches to a user supplied particular pattern of values related to a business situation**
- **For example, after a data pattern of abnormal electricity usage indicating an outage is identified, you can search for matches to that pattern to find other outages.**
- **A pattern is a sequence of numeric values in a field within the TimeSeries subtype. A search pattern can be specified as a time range in a specific time series or as a list of numeric values:**
  - A match is a sequence of values from a target time series that conform to the search criteria.
  - A matching pattern has the same number of values as the search pattern.
  - A match is returned as a primary key value, a time range, and a similarity score.

Time Series Pattern Matching Searches (2)

- **Search for pattern matches via TSPatternMatch() function, specifying:**
  - Target time series instance
  - The search time interval
  - How closely the data must match the specified pattern

- **It is possible to create a pattern matching search index on a time series instance to improve query performance via the function TSCreatePatternIndex() for each time series instance that you want to index**
  - Programmers can control how precisely the data is indexed

Time Series Pattern Matching Searches (3)

- **The following TimeSeries data type, table, and data:**

```
CREATE ROW TYPE myrow(tstamp datetime year to fraction(5), value1
real);

CREATE TABLE tsdata(id int primary key, ts1 timeseries(myrow));

INSERT INTO tsdata VALUES(1000,
            "origin(2011-01-01 00:00:00.00000), calendar(ts_1month),
             container(container), threshold(0), regular,
             [(1),(1),(55),(55),(55),(55),(1),(45),(45),(45),(45),(1)]");
```

- **The table on the next slide shows the time series data in the ts1 table:**

Time Series Pattern Matching Searches (4)

tstamp	value1
2011-01-01 00:00:00	1
2011-02-01 00:00:00	1
2011-03-01 00:00:00	55
2011-04-01 00:00:00	55
2011-05-01 00:00:00	55
2011-06-01 00:00:00	55
2011-07-01 00:00:00	1
2011-08-01 00:00:00	45
2011-09-01 00:00:00	45
2011-10-01 00:00:00	45
2011-11-01 00:00:00	45
2011-12-01 00:00:00	1

- You have an interesting data pattern of (55),(55),(55),(55) and want to find matches to it in the value1 column.
- The sequence of values in the time range 2011-03-01 00:00:00 to 2011-06-01 00:00:00 match the pattern exactly.

Select (clip) Time Series Data Columns - ProjectedClip

- **You can extract data between two timepoints in a time series and return a new time series that contains only the specified columns of the original time series.**
- **The new ProjectedClip() function will clip time series data from only the columns of the TimeSeries data type that you specify.**
- **The data loaded into your time series might be configured to store a null value when a value does not differ from the previous value.**
- **If you have a low frequency of non-null values, you can replace null values with the previous non-null values in the output time series:**
  - Replace only the first value for a column, if that value is null.
    - Append (**lf**) to the column name in the column list to designate its low frequency.
  - Replace all null values with the corresponding previous non-null values.
    - Append (**nn**) to the column name in the column list to designate a column with no null return values.

Select (clip) Columns – ProjectedClip() (1)

- **Calls and Arguments:**

```
ProjectedClip(
        ts              TimeSeries,
        begin_stamp     DATETIME YEAR TO FRACTION(5),
        end_stamp       DATETIME YEAR TO FRACTION(5),
        flag            INTEGER DEFAULT 0)
returns TimeSeries;

ProjectedClip(
        ts              TimeSeries,
        begin_stamp     DATETIME YEAR TO FRACTION(5),
        end_stamp       DATETIME YEAR TO FRACTION(5),
        flag            INTEGER DEFAULT 0,
        column_list     LVARCHAR)
returns TimeSeries;
```

Select (clip) Columns – ProjectedClip() (2)

- **ts**
  - The time series to clip
- **begin_stamp**
  - The beginning point of the range
    - Can be **NULL**, which indicates the origin of the time series
- **end_stamp**
  - The end point of the range
    - Can be **NULL**, which indicates the last value of the time series
- **flag (optional)**
  - The configuration of the resulting time series
- **column_list (optional)**
  - A list of column names from the input time series to include in the output time series. Separate column names with a comma
  - Append (**lf**) to the column name to designate a low frequency column
  - Append (**nn**) to the column name to designate a column with no null return values

Select (clip) Columns – ProjectedClip() (3)

- **ProjectedClip() returns a column subset in the input time series instead of all the columns**

- **When executed, ProjectedClip() casts the results to an existing output time series**
  - Output time series rules definitions depend on whether a column list is included
  - If a column list is not included:
    - The names and corresponding data types of the columns in the output time series must be the same as in the input time series
    - The output time series can have fewer columns than the input time series
    - Columns from the input time series are mapped by name to the corresponding columns in the output time series
  - If a column list is included, the following rules apply:
    - Column names and corresponding data types in the column list must match the input time series
    - Order and number of columns can differ
    - Number of columns and corresponding data types in the output time series must match the column list
    - Column names can differ

Select (clip) Columns – ProjectedClip() (4)

- Column values from the input time series are written to the output time series in the order that is specified by the column list.
- The data loaded into your time series might be configured to store a null value when a value does not differ from the previous value.
- If no previous non-null value exists for a low frequency or no nulls column, NULL is returned.
- For example, if you have rolling window containers, NULL is returned when the last non-null value is no longer in an active window.
- Also, the last non-null value is not returned if the first returned value is a null element, which does not have a time stamp or values for any columns.

Select (clip) Columns – ProjectedClip() (5) Return Data

- **Returned data is the output time series to which the function is cast**
  - Contains data from only the requested range and columns.
- **The output time series has the same calendar as the input time series, but it can have a different origin and number of entries.**
- **Specific examples in the speaker notes.**

Questions

Agenda - Spatiotemporal

- **Track moving objects**
- **Types of queries that can be issued**
- **Architecture**
- **Requirements**
- **Data types**
- **Functions**
  - Appendix A has the details.

Spatiotemporal

- **With this feature, Informix merges its time series capabilities with its spatial data capabilities to produce storage and query capabilities from the use of standard Global Positioning Systems (GPS).**

- **GPS systems standardly use System Reference ID (SRID) 4326.**

Track Moving Objects - General

- **A moving object, such as a vehicle, can be tracked by capturing location information for the object at regular time intervals via GPS data, for example.**

- **Use the new spatiotemporal search extension to index the data and then query on either time or on location to determine the relationship of one to the other.**
  - Query when an object was at a specified location, or at a specified time.
  - You can also find the trajectory of a moving object over a range of time.

- **The spatiotemporal search extension depends on the TimeSeries and spatial extensions:**
  - Store the spatiotemporal data in a TimeSeries data type with columns for longitude and latitude.
  - Index and query spatiotemporal data with new spatiotemporal search functions.
  - Query spatiotemporal data with time series and spatial routines.

Types of Queries

- **The location of a moving object at a specific time.**
  - Find the location of bus number 3435 at 2014-03-01 15:30.
- **The last known time and location of a specific moving object.**
  - Find the last known location of taxi number 324.
- **When, in a time range, a moving object was in a region around a point of interest.**
  - When was a delivery truck within 100 meters of the Mom and Pop Diner between February 2-4, 2015.
- **When a moving object was at a specific location.**
  - Find when object number 324 was at the Four Seasons Hotel.
- **The trajectories, of a specific moving object for a time range.**
  - Find the trajectories of bus number 1543 between 9:00-17:00 yesterday.
- **The trajectories of moving objects near a point of interest during a time range.**
  - Find which taxi driver witnessed an accident by finding which taxi was nearest to the location of the accident at 9:00.

Solution Architecture at a High Level

- **Informix already contains within it the necessary time series and spatial data types and spatial indexing functionality to store and process this data.**
  - The spatiotemporal solution builds upon the functionality and data types already found in the Informix TimeSeries and Spatial features.

- **New is:**
  - An SQL function to index spatiotemporal data.
  - SQL functions to query spatiotemporal data.
  - SQL functions to remove spatiotemporal indexes.

- **Spatiotemporal searches return location data as spatial data types from the Informix spatial extension.**
  - Customers provide client programs to do visualization, such as ESRI.

Requirements

- **Hardware requirements common to Informix Dynamic Server.**

- **Software requirements:**
  - Time Series feature automatically registered
    - A database table containing a timeseries datatype is present.
  - Spatial feature automatically registered
  - R-Tree feature present
  - The OpenAdmin Tool scheduler is running:
    - The Scheduler automatically registers the Spatiotemporal Search and Spatial extensions and runs the task to index spatiotemporal data.
    - The name of the Spatiotemporal Search extension is **sts.bld** and it is in the **$INFORMIXDIR/extend/sts.version/** directory, where version is the version number of the extension.
    - If you have multiple CPU VP's, set **PRELOAD_DLL_FILE** configuration parameter to the path for the spatiotemporal shared library file:

      - **PRELOAD_DLL_FILE $INFORMIXDIR/extend/sts.version/sts.bld**

      - **version** is the version number of the extension.
      - **Restart** the database server after setting this.

Time Series Requirements

- **Time series table must conform to the following requirements and restrictions:**
  - The first column must be a primary key column that represents an object ID and has a data type of **INTEGER**, **CHAR**, or **VARCHAR**
  - A composite primary key is not allowed
  - The second column must be a TimeSeries subtype column
  - The table can have more columns, however, any additional TimeSeries columns are not indexed
  - Table name must be unique and is used to identify the spatiotemporal search
    - If the table name is > 100 bytes, the first 100 bytes of the name must be unique.

TimeSeries subtype requirements

- **The TimeSeries subtype must have the following structure:**
  - The first field is the time stamp field.
    - This requirement is true of all TimeSeries subtypes.
  - The second and third fields have a **FLOAT** data type to hold longitude and latitude data that are in the Spatial Reference System 4326 (WGS 84 standard).

- **Optional additional fields can have any data type that is supported in a TimeSeries subtype.**

- **Time series definition restrictions.**
  - Although a regular time series is supported, an irregular time series is more appropriate for moving object data.

- **Rolling window containers usage requires a manual rebuild of the spatiotemporal index when you attach or detach rolling window intervals.**

Spatial data types for spatiotemporal searches (1)

- **Spatiotemporal search functions**
  - Either take a spatial data type as an argument or return a spatial data type.
  - Use the following spatial data types:
    - **ST_Point**
      - A location that is specified by longitude (X) and latitude (Y) coordinate values.
      - For functions that take an **ST_Point** argument, supply an X,Y coordinate value.
      - ST_Points are also returned by some functions.
    - **ST_MultiLineString**
      - A set of one or more linestrings that represent a trajectory.
      - ST_MultiLineStrings are returned by functions that find trajectories.
    - **ST_Geometry**
      - An abstract non-instantiable superclass.
      - For functions that take an ST_Geometry, supply an ST_Point, ST_MultiPoint, ST_LineString, ST_MultiLineString, ST_Polygon, or ST_MultiPolygon value.

- **Spatial data types require a spatial reference ID (SRID) that identifies the type of map projection system.**

- **For spatiotemporal search data, the SRID must be 4326, which is the SRID commonly used by global positioning system (GPS) devices.**

Spatial data types for spatiotemporal searches (2)

- **Spatiotemporal search functions that take a distance parameter to define a region of interest take an optional unit of measure parameter:**
  - Default, the unit of measurement for distance is meters.
  - Specify a unit of measure that is listed in the **unit_name** column of the **st_units_of_measure** table.

Prerequisites

- **To prepare for spatiotemporal searching:**
  - Create and load a time series that conforms to the requirements for spatiotemporal search.
  - Run the **STS_Init()** spatiotemporal search indexing process on the time series table, which starts the **autosts** Scheduler task that indexes the data.
    - At task start, the following appears in the database server message log:
      - INFO (STSMessage) Building trajectories for table_name is started.
    - At task end, the following appears in the database server message log:
      - INFO (STSMessage) Building trajectories for table_name is stopped.
- **When the index is complete, you can run spatiotemporal searches.**

Stopping spatiotemporal search indexing

- When you stop spatiotemporal search indexing, you remove the spatiotemporal search internal tables, Scheduler tasks, and indexes.
- To stop spatiotemporal search indexing for a specific time series, run the STS_Cleanup() function and specify the time series table.
- To stop spatiotemporal search indexing for a database, run the STS_Cleanup() function without any parameters while connected to the database.
- To remove all spatiotemporal search software in the database in one step, run the following statement:
  - EXECUTE FUNCTION SYSBldPrepare('sts*', 'drop');

Functions/Routines for Spatiotemporal Searches (1)

- **Start spatiotemporal indexing for a table:**
  STS_Init()
- **Stop spatiotemporal search indexing and drop internal tables:**
  STS_Cleanup()
- **Find the position of an object at a specific time:**
  STS_GetPosition()
- **Find the most recent position of any object in the time series:**
  STS_GetLastPosition()
- **Find the first time in a time range when an object is near a position:**
  STS_GetFirstTimeByPoint()
- **Find the nearest object to a point at a specific time:**
  STS_GetNearestObject()
- **Find the exact trajectory for a time range:**
  STS_GetTrajectory()
- **Find the compressed trajectory for a time range:**
  STS_GetCompactTrajectory()

Functions/Routines for Spatiotemporal Searches (2)

- **The set of objects whose trajectories intersected a region during the time range:**
  STS_GetIntersectSet()
- **The set of objects that were within a region at a specific time:**
  STS_GetLocWithinSet()
- **The shortest distance between a point and the trajectory of an object during a time range:**
  STS_TrajectoryDistance()
- **Whether the trajectory remained within the boundary of the region for the time range:**
  STS_TrajectoryWithin()
- **Whether the trajectory crossed the boundary of the region in the time range:**
  STS_TrajectoryCross()
- **Whether the trajectory either crossed the boundary of the region or remained within the boundary of the region for the time range:**
  STS_TrajectoryIntersect()

Functions/Routines for Spatiotemporal Searches (3)

- **Return release information**
  - **STS_Release()**
- **Enable tracing**
  - **STS_Set_Trace() procedure**

- **Specifics for these functions are shown in Appendix A.**

Questions

Agenda – JSON

- Manipulate JSON & BSON data via SQL
- High Availability for MongoDB and REST clients
- Wire Listener configuration enhancements
- Wire Listener query support
- Enhanced user account management through the wire listener

High Availability for MongoDB and REST clients

- **To provide high availability to client applications:**
  - REST clients use a reverse proxy for multiple wire listeners.
  - MongoDB clients use a HA cluster configuration for Informix database servers.

- **Each database server in the cluster has a directly connected wire listener on the same computer as the database server that the wire listener is connected to and all wire listeners run on port 27017.**
  - **http://docs.mongodb.org/meta-driver/latest/legacy/connect-driver-to-replica-set/**

- **To provide high availability between the wire listener and the Informix database server, use one of the following methods:**
  - Route the connection via the Connection Manager between the wire listener and the database server.
    - Known methods
  - Configure the **url** parameter in the wire listener configuration file to use one of the Informix JDBC Driver methods of connecting to a high-availability cluster, via a dynamic reading of the **sqlhosts** file.
    - Has been enhanced in 12.10.xC5

Wire Listener Configuration File Enhancements

- **The wire listener configuration file can be any name, and there can be many of them created in a HA cluster, as long as each file is created in $INFORMIXDIR/etc and has a required .properties file name suffix.**
  - Use **$INFORMIXDIR/etc/jsonListener-example.properties** as a template.
    - Copy it first; DON'T edit it directly.

- **To include parameters in the wire listener, you must uncomment the row and customize parameters with the default values in the copy of the original template file.**

- **The url parameter is required. All other parameters are optional.**
  - Review the defaults for the following parameters and verify that they are appropriate for your environment:
    - **authentication.enable ## please make sure to enable this**
    - **listener.type**
    - **listener.port**
    - **listener.hostName**

Wire Listener Configuration File – url Parameter

- **Specifies the host name, database server, user ID, and password that are used in connections to the database server.**

- **You must specify the sysmaster database in the url parameter; the wire listener uses sysmaster for administrative purposes.**

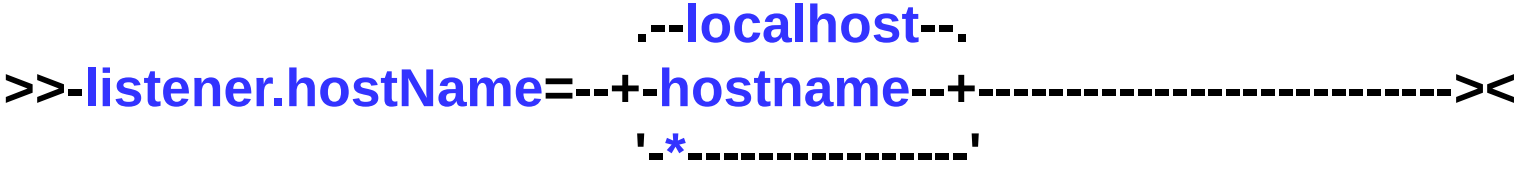
  >>-url=--jdbc:informix-sqli://*hostname*:*portnum*--/sysmaster:-----> >--
  +-------------------------------+---------------------->< '-USER=*userid*;--
  PASSWORD=*password*-'

- **You can now include additional JDBC properties, each semi-colon ';' separated with a semi-colon in the url parameter such as:**
  - **INFORMIXCONTIME**
  - **INFORMIXCONRETRY**
  - **LOGINTIMEOUT**
  - **IFX_SOC_TIMEOUT**

listener.hostName Wire Listener Parameter

- **Specifies the host name of the wire listener. The host name determines the network adapter or interface that the wire listener binds the server socket to.**

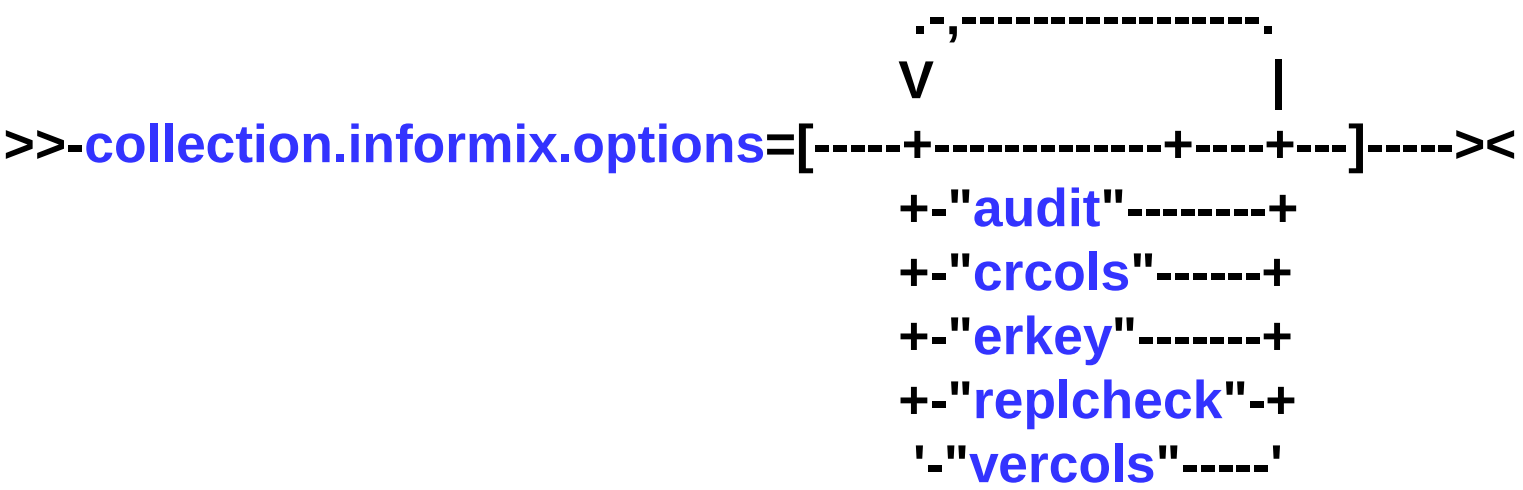
- **To enable the wire listener to be accessed by clients on remote hosts, turn on authentication by using the authentication.enable parameter.**



- **localhost**
  - Bind the wire listener to the **localhost** address. The wire listener is not accessible from clients on remote machines. Default value.
- **hostname**
  - The host name or IP address of host machine where the wire listener binds to.
- ***
  - The wire listener can bind to all interfaces or addresses.

collection.informix.options Wire Listener Parameter (1)

- **Specifies table options for shadow columns or auditing to use when creating a JSON collection.**



collection.informix.options Wire Listener Parameter (2)

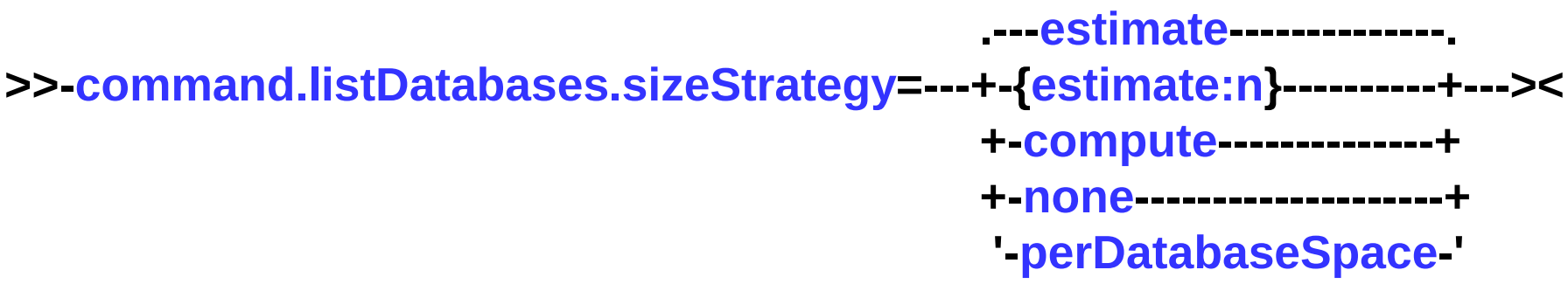
- **audit**
  - Uses *the* ***CREATE*** **TABLE** statement **AUDIT** option to create a table to be included in the set of tables that are audited at the row level if selective row-level is enabled.
- **crcols**
  - Uses the **CREATE TABLE** statement **CRCOLS** option to create the two shadow columns that Enterprise Replication uses for conflict resolution.
- **erkey**
  - Uses the **CREATE TABLE** statement **ERKEY** option to create the **ERKEY** shadow columns that Enterprise Replication uses for a replication key.
- **replcheck**
  - Uses the **CREATE TABLE** statement **REPLCHECK** option to create the **ifx_replcheck** shadow column that Enterprise Replication uses for consistency checking.
- **vercols**
  - Uses the **CREATE TABLE** statement **VERCOLS** option to create two shadow columns that Informix uses to support update operations on secondary servers.

command.listDatabases.sizeStrategy (1)

- **Wire listener parameter specifying a strategy to calculate the size of your database when the MongoDB listDatabases command is run.**

- **The listDatabases command estimates the size of all collections and collection indexes for each database:**
  - Relational tables and indexes are excluded from this size calculation.

- **Performs expensive and CPU-intensive computations on the size of each database in the database server instance.**
  - You can decrease the expense by using the **new** in 12.10.xC5 **command.listDatabases.sizeStrategy** parameter.



command.listDatabases.sizeStrategy (2)

- **estimate**
  - Estimate the database size by sampling documents in every collection; this is the default value.
  - This strategy is the equivalent of {estimate: 1000}, which takes a sample size of 0.1% of the documents in every collection; this is the default value.

command.listDatabases.sizeStrategy=estimate

- **estimate: n**
  - Estimate the database size by sampling one document for every **n** documents in every collection. The following example estimates the collection size by using sample size of 0.5% or 1/200th of the documents:

command.listDatabases.sizeStrategy={estimate:200}

command.listDatabases.sizeStrategy (3)

- **compute**
  - Compute the exact size of the database.

  command.listDatabases.sizeStrategy=compute

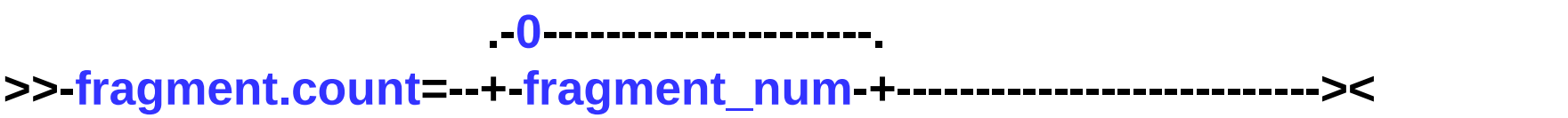
- **none**
  - List the databases but do not compute the size.
  - The database size is listed as 0.

  command.listDatabases.sizeStrategy=none

- **perDatabaseSpace**
  - Calculates the size of a tenant database created by multi-tenancy feature by adding the sizes for all dbspaces, sbspaces, and blobspaces that are assigned to the tenant database.

fragment.count Wire Listener Parameter

- **Specifies the number of fragments to use when creating a collection.**
  - **0**
    - The database server determines the number of collection fragments to create. Default.
  - ***fragment_num*** > 0,
    - Number of collection fragments created at collection creation.



jdbc.afterNewConnectionCreation

- **Wire listener parameter specifies one or more SQL commands to run after a new connection to the database is created.**

- **For example, to accelerate queries run through the wire listener by using the Informix Warehouse Accelerator:**

```
jdbc.afterNewConnectionCreation=["SET ENVIRONMENT USE_DWA
'ACCELERATE ON'"]
```

authentication.enable Wire Listener Parameter (1)

- **Specifies whether to enable user authentication.**
- **Authentication of MongoDB clients occurs in the wire listener, not in the database server.**
  - Privileges are enforced by the wire listener.
- **All communications that are sent to the database server originate from the user that is specified in the url parameter, regardless of which user was authenticated.**
- **User information and privileges are stored in the system_users collection in each database.**
- **MongoDB authentication is done on a per database level, whereas Informix authenticates to the instance.**

authentication.enable Wire Listener Parameter (2)

```
                                    .-false-.
>>-authentication.enable=--+-true--+-----------------------><
```

- **false**
  - Do not authenticate users.
  - This is the default value.
- **true**
  - Authenticate users.
  - Use the **authentication.localhost.bypass.enable** parameter to control the type of authentication.

Wire Listener Logging – Default Logback Mechanism (1)

- **The wire listener can output trace, debug, informational messages, warnings, and error information to a log.**
- **Logback is pre-configured and installed along with the JSON components.**
- **If you start the wire listener from the command line, you can specify the amount of detail, name, and location of your log file by using the -loglevel and -logfile command-line arguments.**
  - If you have customized the **Logback** configuration or specified another logging framework, the settings for **-loglevel** and **-logfile** are ignored.

Wire Listener Logging – Default Logback Mechanism (2)

- **If the wire listener is started automatically after you create a server instance or if you run the task() or admin() function with the start json listener argument, errors are sent to a log file:**
  - UNIX:
    - The log file is in **$INFORMIXDIR/jsonListener.log**.
  - Windows:
    - The log file is named ***servername*_jsonListener.log** and is in your home directory. **C:\Users\ifxjson\ol_informix1210_5_jsonListener.log.**

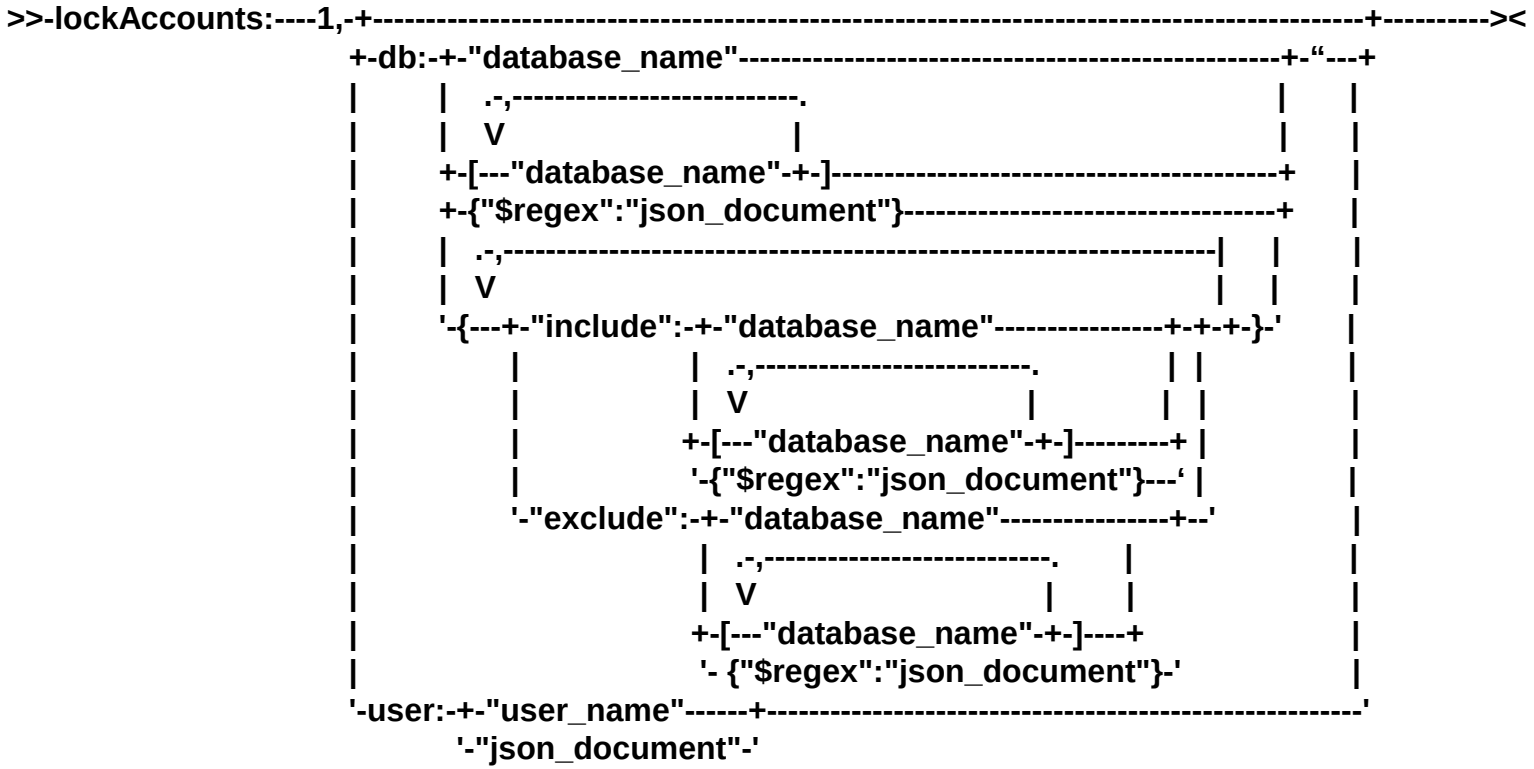
Enhanced Account Management Via the Wire Listener

- **Control user authorization to Informix databases through the wire listener by locking and unlocking user accounts or individual databases via the new Informix JSON lockAccount and unlockAccounts commands.**

JSON – lockAccounts – Lock a Database/User Account

- If you specify the lockAccounts:1 command without specifying a db or user argument, all accounts in all databases are locked.
- Run this command as instance administrator.

- Syntax:



JSON – lockAccounts – Lock a Database/User Account

- **lockAccounts:1**
  - Required parameter locks a database or user account.

- **db**
  - Optional parameter specifies the database name of an account to lock.
  - For example, to lock all accounts in database that is named **foo**:

    db.runCommand({lockAccounts:1,db:"foo"})

- **exclude**
  - Optional parameter specifies the databases to exclude.
  - For example, to lock all accounts on the system except those in the databases named **alpha** and **beta**:

    db.runCommand({lockAccounts:1,db:{"exclude":["alpha","beta"]})

JSON – lockAccounts – Lock a Database/User Account

- **include**
  - Optional parameter specifies the databases to include.
  - To lock all accounts in the databases named **delta** and **gamma**:

```
db.runCommand({lockAccounts:1,db:{"include":["delta","gamma"]})
```

- **$regex**
  - Optional evaluation query operator selects values from a specified JSON document.
  - To lock accounts for databases that begin with the character **a.** and end in **e**:

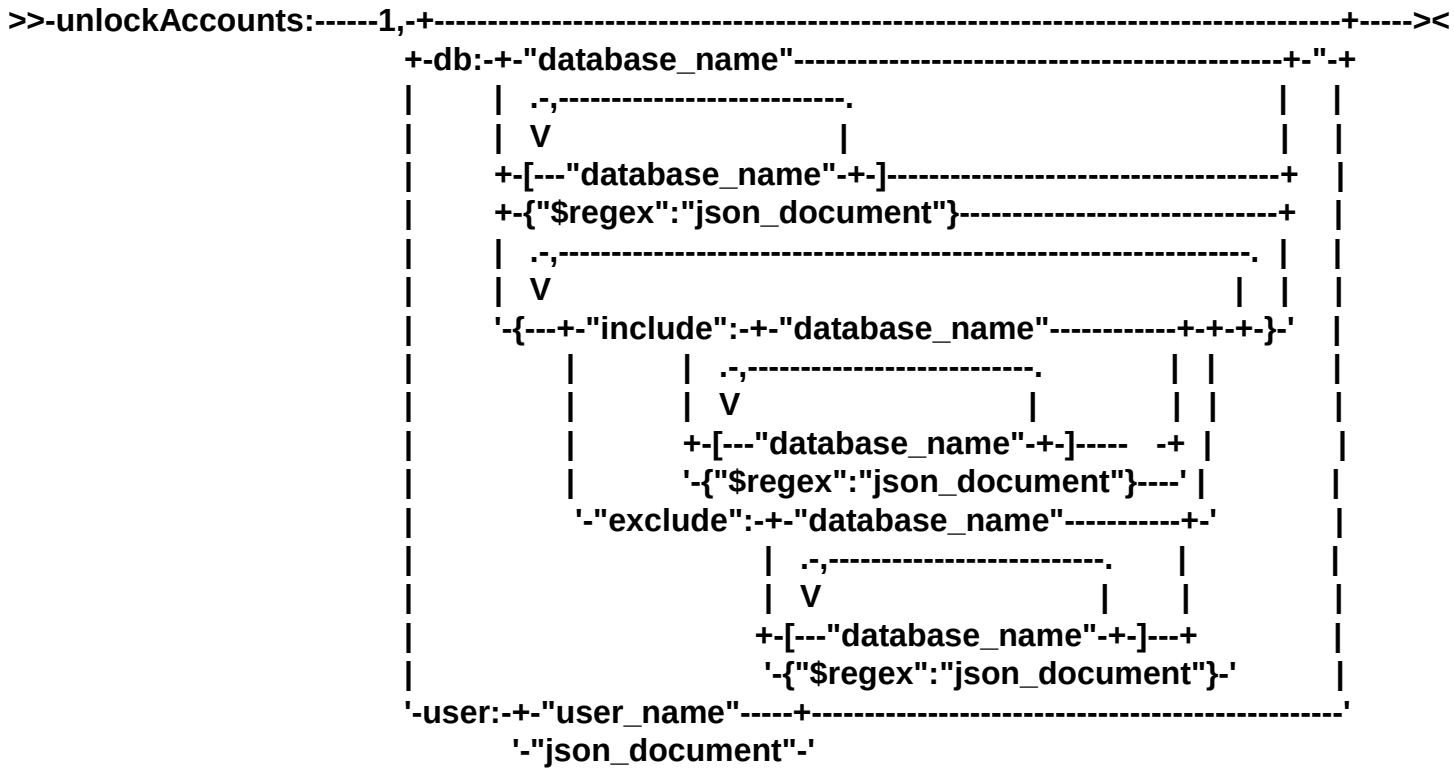
```
db.runCommand({lockAccounts:1,db:{"$regex":"a.*e"})
```

- **user**
  - Optional parameter specifies the user accounts to lock.
  - For example, to lock the account of all users that are not named **alice**:

```
db.runCommand({lockAccounts:1,user:{$ne:"alice"}});
```

JSON – unlockAccounts – Unlock a Database/User Account

- If you specify the unlockAccounts:1 without specifying a db or user argument, all accounts in all databases are unlocked.
- Run this command as instance administrator.



JSON – unlockAccounts – Unlock a Database/User Account

- **unlockaccounts:1**
  - Required parameter unlocks a database or user account.

- **db**
  - Optional parameter specifies the database name of an account to unlock.
  - To unlock all accounts in database that is named **foo:**

    db.runCommand({unlockAccounts:1,db:"foo"})

- **exclude**
  - Optional parameter specifies the databases to exclude.
  - To unlock all accounts on the system except those in the databases named **alpha** and **beta:**

    db.runCommand({unlockAccounts:1,db:{"exclude":["alpha","beta"]})

JSON – unlockAccounts – Unlock a Database/User Account

- **include**
  - Optional parameter specifies the databases to include.
  - To unlock all accounts in the databases named **delta** and **gamma**:

```
db.runCommand({unlockAccounts:1,db:{"include":["delta","gamma"]})
```

- **$regex**
  - Optional evaluation query operator selects values from a specified JSON document.
  - To unlock accounts for databases that begin with the character **a.** and end in **e:**

```
db.runCommand({unlockAccounts:1,db:{"$regex":"a.*e"})
```

- **user**
  - This optional parameter specifies the user accounts to unlock.
  - For example, to unlock the account of all users that are not named **alice**:

```
db.runCommand({unlockAccounts:1,user:{$ne:"alice"}});
```

Manipulation of JSON & BSON Data Types with SQL

- **JSON and BSON data types, allowed in local and distributed queries, are Informix built-in data types accessible and alterable with SQL statements.**
- **By calling BSON value functions within SQL statements it is possible to retrieve specific key values from JSON or BSON data columns.**
- **It is possible to define indexes on key values within a JSON or BSON column.**

High Availability for MongoDB and REST Clients

- **MongoDB and REST clients can be provided High Availability functionality via running a wire listener on each server in an Informix high-availability cluster**

- **Provide high availability between the wire listener and the Informix database server:**
  - Connect the wire listener to the database server thru the Connection Manager
  - Specify an **sqlhosts** file via the **url** parameter in the wire listener properties file

Wire Listener Configuration Enhancements

- **These new or updated parameters can be set in the wire listener properties file:**
  - **url** parameter can include JDBC environment variables
  - **listener.hostName** parameter can specify the listener host name to control the network adapter or interface to which the wire listener connects
  - **collection.informix.options** parameter specifies table options to automatically add shadow columns or enable auditing during JSON collection creation
  - **command.listDatabases.sizeStrategy** parameter can specify a strategy for computing the database size when **listDatabases** is executed
  - **fragment.count** parameter can specify the number of fragments to create for a collection
  - **jdbc.afterNewConnectionCreation** parameter can specify SQL statements, such as **SET ENVIRONMENT**, to run after connecting to the database server

Wire Listener Query Support

- **The wire listener now supports these types of queries:**
  - Join queries on:
    - JSON data
    - Relational data
    - Both JSON and relational data
  - Array queries on JSON data with the **$elemMatch** query operator:
    - Ratings, for example, must be an arrayed column in the inventory collection

      db.inventory.find({ ratings: { $elemMatch: { $gt: 25, $lt: 90 } } })
  - **$first** and **$last** group operators

Wire Listener Query Support (1)

- **Join query support is an important part of the hybrid SQL/NoSQL value proposition of Informix.**

- **The JSON listener now supports the following running joins by querying against a new pseudo system.join table:**
  - Collection-to-collection
  - Relational-to-relational
  - Collection-to-relational

- **Join queries are done by running a "find" query against the new pseudo system table called system.join.**

- **For, example, in the Mongo shell, you'd run a query like this:**

  > db.system.join.find({ *join query document* })

Wire Listener Query Support (2)

- **Join Query Document:**

```
{ $collections :
      {
            "tabName1" :  { join_table_specification },
            "tabName2" :  { join_table_specification },
            ...
      },
  "$condition" : { join_condition_specification }
}
```

- **Required:**
  - **$collections** and **$condition** fields to run a find query against **system.join**
  - The **$collections** field must map to a document that includes two or more collections or relational tables to be joined
  - The **$condition** specifies how to join the collections/tables.
  - No other query operators are supported in the top level of the join query document (over)

Wire Listener Query Support (3)

- **The join_table_specification for each collection/table must include the required $project field; can have an optional $where query document:**

  {"**$project**" : { … }, "$where": { … }}

  - The **$project** field follows the same projection syntax as regular Mongo queries
  - The optional **$where** field and uses the same query syntax as regular Mongo queries

- **The join_condition_specification is a document of key-value pairs that define how all of the tables specified are joined together. These conditions can be specified in two ways:**
  - A key-string value pair to map a single table's column to another table's column:

    "tabName1.column1": "tabName2.column2"

  - As a key-array pair to map a table's column to multiple other table columns

    "tabName1.column1":
    ["tabName2.column2", "tabName3.column3", ….]

Wire Listener Query Support – Implementation Details

- **Join queries work:**
  - With the **sort, limit, skip, and explain** options that can be set on a Mongo cursor
  - With listener cursoring

- **Collection-to-Collection joins:**
  - The listener will look up if there are matching typed BSON indexes on the join fields for each collection.
    - If so, it will use that **bson_value_*** function in the join condition to take advantage of the index.

  - If the join was on **customer.customer_num** and **orders.customers_num** and there were **bson_value_int** indexes on both **customer.customer_num** and **orders.customer_num**, then the listener SQL join condition would be:

    bson_value_int(customer.data, "customer_num") =
    bson_value_int(orders.data, "customer_num")

Wire Listener Query Support – Implementation Details

- If there are no matching indexes using the same **bson_value_*** function, then the listener defaults to the **bson_get** function for the join condition:

  bson_get(customer.data, “customer_num”) =
  bson_get(orders.data, “customer_num”)

- **Collection-to-Relational joins:**
  - For collection-to-relational joins, the data type of the relational column determines the **bson_value_*** function that is used:
    - If joining a collection field to a **character relational** column, the **bson_value_lvarchar** function is used.
    - If joining a collection field to a **numeric relational** column, the **bson_value_double** function is used, etc.

- **Relational-to-Relational joins:**
  - No type conversions in the SQL query itself are necessary.
  - The SQL condition is as expected:

    tab1.col1 = tab2.col2

Wire Listener Query Support Examples (1)

- For all these examples, the tables can be collections, relational tables, or a combination of both; the syntax is the same.

- Example 1: Get the customers orders that totaled more than $100. Join the customers and orders collections/tables on the customer_num field/column where the order total > 100.

```
{ “$collections” :
      {
            “customers” :
{ “$project”: { customer_num: 1, name: 1, phone: 1 } },
            “orders” :
{ “$project”: { order_num: 1, nitems: 1, total: 1, _id: 0 },
  “$where” : { total : { “$gt”: 100 } } }
      },
  “$condition” :
{ “customers.customer_num” : “orders.customer_num” }
}
```

Wire Listener Query Support Examples (2)

- **Get the IBM locations in California and Oregon.**
- **Join the companies, sites, and zipcodes collections/tables where company name is "IBM" and state is "CA" or "OR".**

```
{ $collections :
      {
            "companies" :
{ "$project": { name: 1, _id: 0 }
  "$where" : { "name" : "IBM" } },
            "sites" :
{ "$project": { site_name: 1, size: 1, zipcode: 1, _id:0 } },
            "zipcodes" :
{ "$project": { state: 1, city: 1, _id:0 }
  "$where" : { "state": { "$in", ["CA", "OR"] } } }
      },
  "$condition" :
{ "companies._id" : "sites.company_id",
  "sites.zipcode" : "zipcodes.zipcode" }
}
```

Wire Listener Query Support Examples (3)

- Use array syntax in the condition.
- Get the order info, shipment info, and payment info for order number 1093.

```
{ $collections :
      {
            “orders” :
{ “$project”: { order_num: 1, nitems: 1, total: 1, _id: 0 },
  “$where” : { order_num : 1093 } },
            “shipments” :
{ “$project”: { shipment_date: 1, arrival_date: 1 } },
            “payments” :
{ “$project”: { payment_method: 1, payment_date: 1 } }
      },
  “$condition” :
{ “orders.order_num” :
[ “shipments.order_num”, “payments.order_num” ] }
```

Questions

Agenda – Informix Warehouse Accelerator (IWA)

- **Load data marts faster by adding a second virtual processor for IWA.**

Multiple VP's for IWA Loading Performance

- When initialized, IWA automatically creates a single Virtual Processor (VP) dedicated to its operations when the first IWA related activity occurs and there is no IWA VP definition in the configuration file.
- This IWA VP is known internally by name as a dwavp.
- The dwavp is permanently and explicitly created by the DBA at the time of initialization in the configuration file:
  - VPCLASS dwavp,num=1
- If not explicitly added, a single dwavp virtual processor is allocated dynamically when the first IWA related activity occurs.
- To add a dwavp virtual processor for the database server instance from the command line:
  - onmode -p +1 dwavp

Multiple DWAVP's for Loading Performance

- When loading multiple data marts, you can define two dwavp virtual processors to avoid administrative command delays while loading data marts.

- For example, to add two dwavp virtual processors for the database server instance, in the $ONCONFIG file:
  - VPCLASS dwavp,num=2.

Devices, Platforms & Environments

- **Raspberry PI devices certified for V6 ARM 32 with IDS 12.**
- **IDS Developer Edition 12 for ARM V7 32**
- **INTEL Quark (DK50) 32 bit and IDS 12**
- **Smaller runtime embed footprint using revised onconfig settings for devices.**
- **Mac OS 10.9 client/server support for Mac-based device developers**

- **New 12.10.xC5 Platforms :**
  - Mac OS X 10.8, 10.9
  - ARM v7
  - Quark
  - Raspberry Pi
  - Ubuntu 64-bit for ARM v8 (64-bit)
  - RHEL 7 certification for Linux x86-64 (64-bit)
  - PPC64

Miscellaneous

- **Tivoli Work Manager 9.3 Support for Informix 12.**
- **Clear text passwords no longer passed by onstat –g ses/sql**
- **Simple REST API deployed**
- **CSDK - Improved UTF-8 support in the ODBC Driver.**
- **Advanced Enterprise Edition**
  - Server binaries are now stamped Advanced Enterprise with applicable license.
- **Improved Guardium 10 support for Informix (Q3 2015).**

Questions

Logo

Logo

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Appendix A – Spatiotemporal Functions

Spatiotemporal Functions – STS_Init() (1)

- **The STS_Init () function creates internal tables and starts a Scheduler task that builds the initial spatiotemporal index, and then periodically indexes new spatiotemporal data.**

- **Syntax**

```
STS_Init(ts_tabname        VARCHAR(128)) returns INTEGER

STS_Init(ts_tabname        VARCHAR(128)
        task_frequency      INTERVAL DAY TO SECOND default "0 01:00:00",
        task_starttime      DATETIME HOUR TO SECOND default NULL,
        ts_default_starttime  DATETIME YEAR TO SECOND default "1970-01-01
00:00:00",
        ts_interval_to_process INTERVAL DAY TO SECOND default "0 01:00:00",
        ts_interval_to_avoid  INTERVAL DAY TO SECOND default "1 00:00:00"
)
returns INTEGER
```

Spatiotemporal Functions – STS_Init() (2)

- **ts_tabname**
  - The name of the time series table.
- **task_frequency** **(optional)**
  - How frequently to index new data.
  - Default is every hour.
- **task_starttime** **(Optional)**
  - The first time to start the task.
  - Default is NULL, which means to start the task when the **STS_Init** function is run.
- **ts_default_starttime** **(Optional)**
  - The first time stamp in the time series from which to index.
  - Default is 1970-01-01 00:00:00.
- **ts_interval_to_process** **(Optional)**
  - The time interval in the time series to process each time that the task is run.
  - Default is one hour.
  - Set to a value that takes less time to index than the **task_frequency** parameter.
- **ts_interval_to_avoid** **(Optional)**
  - The indexing lag time.
  - The time interval in the time series before the current time to avoid indexing.
  - Default is one day.

Spatiotemporal Functions – STS_Init() (3)

- **Run STS_Init () to start the indexing process by creating internal spatiotemporal search tables and starting a Scheduler task for the specified table.**
  - The Scheduler task, which has a prefix of **autosts**, starts at the time specified by the **task_starttime** parameter, indexes the initial set of data, and periodically indexes new data.
  - The task prints messages in the database server message log when indexing starts and completes.
  - If spatiotemporal search indexing is already running for the specified table, run the **STS_Init()** to change the Scheduler task properties.

- **The first run of the task processes the data in the time interval that is defined by the value of the ts_default_starttime parameter:**
  - **ts_default_starttime = current_time - ts_interval_to_avoid**

Spatiotemporal Functions – STS_Init() (4)

- **The end time of the processing interval is saved in the internal lasttime table. Subsequent runs of the task start based on the value of the task_frequency parameter and index the data between the last end time that is saved in the lasttime table and the earlier of the following times:**
  - The last end time plus the value of the **ts_interval_to_process** parameter
  - The current time minus the value of the **ts_interval_to_avoid** parameter

- **Any data that you insert with timepoints that are earlier than the last end time that is saved in the lasttime table are not indexed.**

- **If you run the task the first time on an empty time series, the recorded last end time is the current time minus the value of the parameter ts_interval_to_avoid.**
  - Any data that you insert with earlier timepoints are not indexed.
- **Returns 0 or 1 - an integer that indicates the status of the function:**
  - **0** = The Scheduler task for spatiotemporal search indexing started.
  - **1** = An error occurred.

Spatiotemporal Functions – STS_Init() (5)

- **Example**

- **The following statement is run at 2015-02-01 08:00:00 (not shown) to start spatiotemporal search indexing on the T_Vehicle table:**

- **EXECUTE FUNCTION STS_Init('T_Vehicle');**

- **The Scheduler task for T_Vehicle is created with default values**
  - The task runs for the first time at **08:00:00** and processes the time series data with timepoints between **1970-01-01 00:00:00** and **2015-01-31 08:00:00**.
- **The last end time of 2015-01-31 08:00:00 is recorded in the lasttime table. The task takes about 30 minutes to index the data.**
- **The task runs again at 09:00:00 and indexes data with timepoints between 2015-01-31 08:00:00 and 2015-01-31 09:00:00. The last end time of 2015-01-31 09:00:00 is recorded in the lasttime table.**
- **Any data with timepoints earlier than 2015-01-31 08:00:00 that was inserted after the first task was run is not indexed.**

STS_Cleanup() (1)

- **Stop spatiotemporal search indexing and drop internal tables.**
- **Syntax**

  STS_Cleanup(ts_tabname VARCHAR(128)) returns INTEGER
  STS_Cleanup() returns INTEGER

  ts_tabname (Optional) - The name of the time series table.

- **Usage**
  - Run with the **ts_tabname** parameter when you want to stop spatiotemporal indexing and drop the existing spatiotemporal search tables for the specified time series table:
    - When the spatiotemporal search tables becomes large, you can drop them and then restart spatiotemporal search indexing with a more recent start time.
  - Run without a parameter to stop spatiotemporal indexing and drop the existing spatiotemporal search tables for the current database.
- **Returns**
  - An integer that indicates the status of the function:

    0 = Spatiotemporal search indexing was removed.
    1 = An error occurred.

STS_Cleanup() (2)

- **Example:**
  - Stop indexing and drop index tables for a table

- **The following statement stops spatiotemporal search indexing and deletes the internal tables for the time series table T_Vehicle:**

```
EXECUTE FUNCTION STS_Cleanup('T_Vehicle');
```

- **Example:**
  - Stop indexing and drop index tables for a database

- **The following statement stops spatiotemporal search indexing and deletes the internal tables for the current database:**

```
EXECUTE FUNCTION STS_Cleanup();
```

STS_GetPosition() (1)

- **Find the position of an object at a specific time:**

- **Syntax**

```
STS_GetPosition(ts        TimeSeries,
                tstamp    DATETIME YEAR TO FRACTION(5))
returns LVARCHAR
```

ts
The time series.

tstamp
The time stamp to query.

STS_GetPosition() (2)

- **To identify which object to track is defined in the WHERE clause of the query.**

- **Returns**
  - An LVARCHAR string that represents the position of the object.
  - The string includes the spatial reference ID (SRID 4326) and a point that consists of a longitude value and a latitude value.
  - NULL, if nothing found.

- **Example**
  - The following query returns the position of the vehicle 1 at 2014-02-02 13:34:06:

```
SELECT STS_GetPosition(ts_track, '2014-02-02 13:34:06')
  FROM T_Vehicle
 WHERE modid='1';

(expression)  4326 point(116.400610 39.906050)
```

STS_GetLastPosition() (1)

- **Find the most recent position of any object in the time series:**
- **Syntax**

```
STS_GetPosition(ts        TimeSeries,
                tstamp    DATETIME YEAR TO FRACTION(5))
returns LVARCHAR
```

ts
The time series.
tstamp
The time stamp to query.

STS_GetLastPosition() (2)

- **Run STS_GetPosition() to find where a moving object was at a specific time.**
- **To identify which object to track is in the WHERE clause of the query.**
- **Returns:**
  - An **LVARCHAR** string that represents the position of the object.
  - The string includes the spatial reference ID (4326) and a point that consists of a longitude value and a latitude value.
  - Or **NULL**, if nothing found.
- **Example:**
  - The following query returns the position of the vehicle 2 at 2014-02-02 18:38:06:

```
SELECT STS_GetPosition(ts_track, '2014-02-02 18:38:06')
  FROM T_Vehicle
  WHERE modid='2';

(expression)  4326 point(116.400610 39.906050)
```

STS_GetFirstTimeByPoint() (1)

- **Find the first time in a time range when an object is near a position**
- **Syntax**

```
STS_GetFirstTimeByPoint(ts_tabname   LVARCHAR,
                        obj_id       LVARCHAR,
                        ts           TimeSeries,
                        starttime    DATETIME YEAR TO FRACTION(5),
                        endtime      DATETIME YEAR TO FRACTION(5),
                        geometry     LVARCHAR,
                        max_distance REAL)
returns DATETIME

STS_GetFirstTimeByPoint(ts_tabname   LVARCHAR,
                        obj_id       LVARCHAR,
                        ts           TimeSeries,
                        starttime    DATETIME YEAR TO FRACTION(5),
                        endtime      DATETIME YEAR TO FRACTION(5),
                        geometry     LVARCHAR,
                        max_distance REAL,
                        uom          LVARCHAR)
returns DATETIME
```

STS_GetFirstTimeByPoint() (2)

- **Syntax** **(cont'd)**

- **ts_tabname**
  - The name of the time series table.
- **obj_id**
  - The ID of the object.
  - Must be a value from the primary key column of the time series table.
  - Can be the name of the column that stores the object IDs if the WHERE clause specifies a specific object ID.
- **ts**
  - The name of the TimeSeries data type.
- **starttime**
  - The start of the time range.
  - Can be NULL.
- **endtime**
  - The end of the time range.
  - Can be NULL.

STS_GetFirstTimeByPoint() (3)

- **Syntax (cont'd)**

- **geometry**
  - The geometry at the center of the region of interest.
  - Can be an ST_Point, ST_MultiPoint, ST_LineString, ST_MultiLineString, ST_Polygon, or ST_MultiPolygon.
  - Must use the SRID 4326.
- **max_distance**
  - The distance from the geometry that defines the border of the region of interest.
  - The unit of measure is specified by the **uom** parameter.
- **uom (Optional)**
  - The unit of measure for the **max_distance** parameter.
  - Default is meters.
  - Must be the name of a linear unit of measure from the **unit_name** column of the **st_units_of_measure** table.

STS_GetFirstTimeByPoint() (4)

- **Usage**

- **Run STS_GetFirstTimeByPoint () to find when an object first passed within the specified distance of the specified position during the specified time range.**
  - If you do not specify a time range, the function returns the first time that an object passed close enough to the position.
  - If the object was too far away from the position during the time range, the **STS_GetFirstTimeByPoint** function returns **NULL**.

- **Returns**
  - A time stamp
  - **NULL** if the trajectory of the object during the time range was always farther than the maximum distance from the position.

- **Example: Find the first time that the vehicle ever passed the position**

STS_GetFirstTimeByPoint() (5)

- **The following query returns the first time ever that vehicle 1 passed within 100 meters of the point (116.401 39.911):**

```
SELECT STS_GetFirstTimeByPoint('T_Vehicle', modid, ts_track, null,
                null, '4326 point(116.401 39.911)', 100)
  FROM T_Vehicle
WHERE modid = '1';
```

(expression)

- **2014-02-02 13:37:15.00000**
- **1 row(s) retrieved.**
- **Example: Find the first time that the vehicle passed the position in a time range**

STS_GetFirstTimeByPoint() (6)

- **The following query returns the first time that vehicle 1 passed within 100 meters of the point (116.401 39.911) between 2014-02-02 13:39:00 and 2014-02-02 16:30:00:**

```
SELECT STS_GetFirstTimeByPoint
                    ('T_Vehicle', modid, ts_track,
                    '2014-02-02 13:39:00', '2014-02-02 16:30:00',
                    '4326 point(116.40100 39.91100)', 100)
        FROM T_Vehicle
        WHERE modid='1';
```

```
(expression)

2014-02-02 13:40:55.00000

1 row(s) retrieved.
```

STS_GetNearestObject() (1)

- **Find the nearest object to a point at a specific time.**
- **Syntax**

```
STS_GetNearestObject(ts_tabname    LVARCHAR,
                     ts_colname    LVARCHAR,
                     timestamp     DATETIME YEAR TO FRACTION(5),
                     geometry      LVARCHAR,
                     max_distance  REAL)
returns LVARCHAR

STS_GetNearestObject(ts_tabname    LVARCHAR,
                     ts_colname    LVARCHAR,
                     timestamp     DATETIME YEAR TO FRACTION(5),
                     geometry      LVARCHAR,
                     max_distance  REAL,
                     uom           LVARCHAR)
returns LVARCHAR
```

TS_GetNearestObject() (2)

- **ts_tabname**
  - The name of the time series table.
- **ts_colname**
  - The name of the TimeSeries column.
- **timestamp**
  - The time point to query.
- **geometry**
  - The geometry at the center of the region of interest.
  - Can be an ST_Point, ST_MultiPoint, ST_LineString, ST_MultiLineString, ST_Polygon, or ST_MultiPolygon.
  - Must use the SRID 4326.
- **max_distance**
  - The distance from the geometry that defines the border of the region of interest.
  - The unit of measure is specified by the **uom** parameter.
- **uom** **(Optional)**
  - The unit of measure for the **max_distance** parameter.
  - The default is meters.
  - Must be the name of a linear unit of measure from the **unit_name** column of the **st_units_of_measure** table.

TS_GetNearestObject() (3)

- **Usage**
  - Run **STS_GetNearestObject** to find which object was closest to a location but within a specific distance at a specific time.
  - If you specify that 0 meters distance from the point, **STS_GetNearestObject** returns the closest object regardless of the distance.

- **Returns**
  - The object ID.
  - Or **NULL**, if nothing found.

- **Example**
  - The following statement returns the vehicle ID whose location was the closest to the point (10,10), but within 1010 meters, at 2014-02-02 13:36:00:

```
EXECUTE FUNCTION STS_GetNearestObject('T_Vehicle', 'ts_track',
'2014-02-02 13:36:00', '4326 point(116.4 39.9)', 1010);
    (expression)  1
1 row(s) retrieved.
```

STS_GetTrajectory() (1)

- **Find the exact trajectory for a time range**

- **Syntax:**

```
STS_GetTrajectory(ts          TimeSeries,
                  starttime   DATETIME YEAR TO FRACTION(5),
                  endtime     DATETIME YEAR TO FRACTION(5))
returns LVARCHAR
```

- **ts**
  - The time series.
- **starttime**
  - The start of the time range.
- **endtime**
  - The end of the time range.

STS_GetTrajectory() (2)

- **Run STS_GetTrajectory to find where an object went (its path) during a time range, which is based on the data in the time series table.**
- **The location for each time point in the range is extracted from the time series table and converted into one or more linestrings.**
- **Identify which object to track in the WHERE clause of the query.**
- **Returns**
  - An **LVARCHAR** string that represents the trajectory of the object.
    - The string includes the spatial reference ID and a multilinestring that consists of multiple sets of longitude and latitude values.
  - **NULL,** if nothing found.
- **Example: Get the trajectory between specific times**

STS_GetTrajectory() (3)

- **Example:**

- **The following query returns the trajectory of the vehicle 1 between 2014-02-02 13:00:00 and 2014-02-02 16:30:00:**

```
SELECT STS_GetTrajectory
            (ts_track, '2014-02-02 13:00:00', '2014-02-02 16:30:00')
   FROM T_Vehicle
  WHERE modid='1';
```

(expression)

4326 multilinestring((116.400610 39.906050, 116.401210 39.913900, 116.401170 39.911590, 116.392450 39.906350, 116.369990 39.905940, 116.345260 39.905890))

1 row(s) retrieved.

STS_GetTrajectory() (4)

- **Example: Get the trajectory from a specific time until the current time**

- **The following query returns the trajectory of the vehicle 1 between 2014-02-02 13:00:00 and the current time:**

```
SELECT STS_GetTrajectory
            (ts_track, '2014-02-02 13:00:00', current)
   FROM T_Vehicle
 WHERE modid='1';
```

(expression)

4326 multilinestring((116.400610 39.906050, 116.401210 39.913900, 116.401170 39.911590, 116.392450 39.906350, 116.369990 39.905940, 116.345260 39.905890),(116.420000 40.100000, 116.401000 39.907000, 116.402000 39.908000, 116.402010 39.908010))

1 row(s) retrieved.

STS_GetCompactTrajectory() (1)

- **STS_GetCompactTrajectory returns the compressed trajectory of a specified object for the specified time range.**

- **Syntax**

```
STS_GetCompactTrajectory(ts_tabname    LVARCHAR,
                         obj_id        LVARCHAR,
                         ts            TimeSeries,
                         starttime     DATETIME YEAR TO FRACTION(5),
                         endtime       DATETIME YEAR TO FRACTION(5))
returns LVARCHAR
```

STS_GetCompactTrajectory() (2)

- **ts_tabname**
  - The name of the time series table.
- **obj_id**
  - The ID of the object.
  - Must be a value from the primary key column of the time series table.
  - Can be the name of the column that stores the object IDs if the WHERE clause specifies a specific object ID.
- **ts**
  - The name of the TimeSeries column.
- **starttime**
  - The start of the time range.
- **endtime**
  - The end of the time range.

STS_GetCompactTrajectory() (3)

- **Run STS_GetCompactTrajectory to find where an object went during a time range, based on the compressed spatiotemporal search data. The trajectory information is retrieved from the subtack table and returned as one or more linestrings.**

- **Returns**
  - An **LVARCHAR** string that represents the trajectory of the object.
    - The string includes the spatial reference ID and an ST_MultiLinestring.
  - **NULL**, if nothing found.

STS_GetCompactTrajectory() (4)

- **Example**

- **The following query returns the trajectory of the vehicle 1 between 2014-02-02 13:00:00 and 2014-02-02 16:30:00:**

```
SELECT STS_GetCompactTrajectory('T_Vehicle', modid, 'ts_track',
                '2014-02-02 13:00:00', '2014-02-02 16:30:00')
   FROM T_Vehicle
  WHERE modid='1';
```

(expression)

4326 multilinestring((116.40061 39.90605, 116.40121 39.9139, 116.40117 39.91159, 116.39245 39.90635, 116.36999 39.90594, 116.345261 39.905891, 116.345261 39.905891))

1 row(s) retrieved.

STS_GetIntersectSet() (1)

- **The set of objects whose trajectories intersected a region during the time range.**
- **Syntax**

```
STS_GetIntersectSet(ts_tabname   LVARCHAR,
                    ts_colname    LVARCHAR,
                    starttime     DATETIME YEAR TO FRACTION(5),
                    endtime       DATETIME YEAR TO FRACTION(5),
                    geometry      LVARCHAR,
                    max_distance REAL)
returns Set(LVARCHAR)

STS_GetIntersectSet(ts_tabname   LVARCHAR,
                    ts_colname     LVARCHAR,
                    starttime      DATETIME YEAR TO FRACTION(5),
                    endtime        DATETIME YEAR TO FRACTION(5),
                    geometry       LVARCHAR,
                    max_distance   REAL,
                    uom            LVARCHAR)
returns Set(LVARCHAR)
```

STS_GetIntersectSet() (2)

- **Syntax** **(cont'd)**

- **ts_tabname**
  - The name of the time series table.
- **ts_column**
  - The name of the TimeSeries column.
- **starttime**
  - The start of the time range.
- **endtime**
  - The end of the time range.
- **geometry**
  - The geometry at the center of the region of interest.
  - Can be an ST_Point, ST_MultiPoint, ST_LineString, ST_MultiLineString, ST_Polygon, or ST_MultiPolygon.
  - Must use the SRID 4326.
- **max_distance**
  - The distance from the geometry that defines the border of the region of interest.
  - The unit of measure is specified by the **uom** parameter.

STS_GetIntersectSet() (3)

- **Syntax (cont'd)**

- **uom (Optional)**
  - The unit of measure for the **max_distance** parameter.
  - The default is meters.
  - Must be the name of a linear unit of measure from the **unit_name** column of the **st_units_of_measure** table.

- **Usage**

- **Run STS_GetIntersectSet to find which objects intersected a region during a time range.**

- **Returns**
  - A set of object IDs.
  - NULL, if nothing found.

STS_GetIntersectSet() (4)

- **Example**
- **The following statement returns the vehicles IDs that intersected the region within 1000 meters of the point (116.4, 39.91) during the time between 2014-02-02 13:36:00 and 2014-02-02 13:54:00:**

```
EXECUTE FUNCTION STS_GetIntersectSet
('T_Vehicle', 'ts_track', '2014-02-02 13:36:00', '2014-02-02 13:54:00',
'4326 point(116.4 39.91)', 1000);
```

```
(expression)  SET{'1','2'}

1 row(s) retrieved.
```

- **The query returned the IDs 1 and 2.**

STS_GetLocWithinSet() (1)

- **The set of objects that were within a region at a specific time:**

- **Syntax:**

```
STS_GetLocWithinSet(ts_tabname   LVARCHAR,
                    ts_colname       LVARCHAR,
                    timestamp        DATETIME YEAR TO FRACTION(5),
                    geometry         LVARCHAR,
                    max_distance     REAL)
returns Set(LVARCHAR)

STS_GetLocWithinSet(ts_tabname   LVARCHAR,
                    ts_colname     LVARCHAR,
                    timestamp      DATETIME YEAR TO FRACTION(5),
                    geometry       LVARCHAR,
                    max_distance   REAL,
                    uom            LVARCHAR)
returns Set(LVARCHAR)
```

STS_GetLocWithinSet() (2)

- **ts_tabname**
  - The name of the time series table.
- **ts_colname**
  - The name of the TimeSeries column.
- **timestamp**
  - The time point to query.
- **geometry**
  - The geometry at the center of the region of interest.
  - Can be an ST_Point, ST_MultiPoint, ST_LineString, ST_MultiLineString, ST_Polygon, or ST_MultiPolygon.
  - Must use the SRID 4326.
- **max_distance**
  - The distance from the geometry that defines the border of the region of interest. The unit of measure is specified by the **uom** parameter.
- **uom** **(optional)**
  - The unit of measure for the **max_distance** parameter.
  - The default is meters.
  - Must be the name of a linear unit of measure from the **unit_name** column of the **st_units_of_measure** table.

STS_GetLocWithinSet() (3)

- **Run STS_GetLocWithinSet () to find which objects were in a region at a specific time.**

- **Returns**
  - A set of object IDs.
  - **NULL**, if nothing found.

- **Example**

- **The following statement returns the IDs of vehicles that were within 1000 meters of the point (116.4, 39.91) at 2014-02-02 13:36:00:**

```
EXECUTE FUNCTION STS_GetLocWithinSet('T_Vehicle', 'ts_track',
                '2014-02-02 13:36:00', '4326 point(116.4 39.91)', 1000);
```

(expression) SET{'1','2'}

- **The query returns the IDs 1 and 2.**

STS_TrajectoryDistance() (1)

- **The shortest distance between a point and the trajectory of an object during a time range.**
- **Syntax**

```
STS_TrajectoryDistance(ts_tabname    LVARCHAR,
                       obj_id        LVARCHAR,
                       ts_colname    LVARCHAR,
                       starttime     DATETIME YEAR TO FRACTION(5),
                       endtime       DATETIME YEAR TO FRACTION(5),
                       geometry      LVARCHAR)
returns FLOAT
STS_TrajectoryDistance(ts_tabname    LVARCHAR,
                       obj_id        LVARCHAR,
                       ts_colname    LVARCHAR,
                       starttime     DATETIME YEAR TO FRACTION(5),
                       endtime       DATETIME YEAR TO FRACTION(5),
                       geometry      LVARCHAR,
                       uom           LVARCHAR)
returns FLOAT
```

STS_TrajectoryDistance() (2)

- **ts_tabname**
  - The name of the time series table.
- **obj_id**
  - The ID of the object.
  - Must be a value from the primary key column of the time series table.
  - Can be the name of the column that stores the object IDs if the WHERE clause specifies a specific object ID.
- **ts_colname**
  - The name of the TimeSeries column.
- **starttime**
  - The start of the time range.
  - Can be NULL.
- **endtime**
  - The end of the time range.
  - Can be NULL.

STS_TrajectoryDistance() (3)

- **Syntax (cont'd)**
- **geometry**
  - The geometry at the center of the region of interest.
  - Can be an ST_Point, ST_MultiPoint, ST_LineString, ST_MultiLineString, ST_Polygon, or ST_MultiPolygon.
  - Must use the SRID 4326.
- **uom (optional)**
  - The unit of measure for the return value.
  - The default is meters.
  - Must be the name of a linear unit of measure from the **unit_name** column of the **st_units_of_measure** table.

- **Run STS_TrajectoryDistance () to find how close and object came to a specific point during a time range.**

STS_TrajectoryDistance() (4)

- **Returns**
  - A FLOAT value that represents the distance in the specified unit of measure.
  - **NULL**, if nothing found.

- **Example**
- **The following query returns the shortest distance in meters between the trajectory of vehicle 1 and the point (116.4. 39.9) between 2014-02-02 13:35:00 and 2014-02-02 13:54:00:**

```
SELECT STS_TrajectoryDistance
            ('T_Vehicle', modid, 'ts_track', '2014-02-02 13:35:00',
             '2014-02-02 13:54:00', '4326 point(116.4 39.9)')::decimal(10,2)
  FROM T_Vehicle
 WHERE modid='1';

(expression)
      830.36

1 row(s) retrieved.
```

STS_TrajectoryWithin() (1)

- **Indicates whether the trajectory of a specified object stayed within the specified region during the specified time range.**
- **Syntax**

```
STS_TrajectoryWithin(ts_tabname   LVARCHAR,
                     obj_id           LVARCHAR,
                     ts_colname    LVARCHAR,
                     starttime        DATETIME YEAR TO FRACTION(5),
                     endtime          DATETIME YEAR TO FRACTION(5),
                     geometry         LVARCHAR,
                     max_distance REAL)
returns Boolean
STS_TrajectoryWithin(ts_tabname   LVARCHAR,
                     obj_id           LVARCHAR,
                     ts_colname    LVARCHAR,
                     starttime        DATETIME YEAR TO FRACTION(5),
                     endtime          DATETIME YEAR TO FRACTION(5),
                     geometry         LVARCHAR,
                     max_distance  REAL,
                     uom              LVARCHAR)
returns Boolean
```

STS_TrajectoryWithin() (2)

- **ts_tabname**
  - The name of the time series table.
- **obj_id**
  - The ID of the object.
  - Must be a value from the primary key column of the time series table.
  - Can be the name of the column that stores the object IDs if the WHERE clause specifies a specific object ID.
- **ts_colname**
  - The name of the TimeSeries column.
- **starttime**
  - The start of the time range. Can be NULL.
- **endtime**
  - The end of the time range. Can be NULL.
- **geometry**
  - The geometry at the center of the region of interest.
  - Can be an ST_Point, ST_MultiPoint, ST_LineString, ST_MultiLineString, ST_Polygon, or ST_MultiPolygon.
  - Must use the SRID 4326.

STS_TrajectoryWithin() (3)

- **max_distance**
  - The distance from the geometry that defines the border of the region of interest.
  - The unit of measure is specified by the **uom** parameter.
- **uom** **(optional)**
  - The unit of measure for the **max_distance** parameter.
  - The default is meters.
  - Must be the name of a linear unit of measure from the **unit_name** column of the **st_units_of_measure** table.

- **Usage**

- **Run STS_TrajectoryWithin to find out whether an object stayed within a region during the entire time range.**
  - **STS_TrajectoryWithin** returns '**f**' if the object was in the region for only part of the time range or if the object was never in the region during the time range.

STS_TrajectoryWithin() (4)

- **Returns**
  - **t**
    - If the trajectory of the object was within the region during the entire time range.
  - **f**
    - If the trajectory of the object was within the region for only part of the time range.
    - If the trajectory of the object was not within the region during the time range.

- **The following query returns whether vehicle 1 stayed within 1000 meters of the point (116.4, 39.91) between 2014-02-02 13:34:00 and 2014-02-02 13:54:00:**

```
SELECT STS_TrajectoryWithin
        ('T_Vehicle', modid, 'ts_track', '2014-02-02 13:34:00',
         '2014-02-02 13:54:00', '4326 point(116.4 39.91)', 1000)
  FROM T_Vehicle
WHERE modid='1';

(expression)
        f
1 row(s) retrieved.
```

STS_TrajectoryCross() (1)

- **Whether the trajectory crossed the boundary of the region in the time range:**
- **Syntax**

```
STS_TrajectoryCross(ts_tabname   LVARCHAR,
                    obj_id           LVARCHAR,
                    ts_colname       LVARCHAR,
                    starttime        DATETIME YEAR TO FRACTION(5),
                    endtime          DATETIME YEAR TO FRACTION(5),
                    geometry         LVARCHAR,
                    max_distance REAL)
returns Boolean
STS_TrajectoryCross(ts_tabname   LVARCHAR,
                    obj_id           LVARCHAR,
                    ts_colname       LVARCHAR,
                    starttime        DATETIME YEAR TO FRACTION(5),
                    endtime          DATETIME YEAR TO FRACTION(5),
                    geometry         LVARCHAR,
                    max_distance     REAL,
                    uom              LVARCHAR)
returns Boolean
```

STS_TrajectoryCross() (2)

- **ts_tabname**
  - The name of the time series table.
- **obj_id**
  - The ID of the object.
  - Must be a value from the primary key column of the time series table.
  - Can be the name of the column that stores the object IDs if the WHERE clause specifies a specific object ID.
- **ts_colname**
  - The name of the TimeSeries column.
- **starttime**
  - The start of the time range.
- **endtime**
  - The end of the time range.
- **geometry**
  - The geometry at the center of the region of interest.
  - Can be an ST_Point, ST_MultiPoint, ST_LineString, ST_MultiLineString, ST_Polygon, or ST_MultiPolygon.
  - Must use the SRID 4326.

STS_TrajectoryCross() (3)

- **max_distance**
  - The distance from the geometry that defines the border of the region of interest.
  - The unit of measure is specified by the **uom** parameter.
- **uom** **(optional)**
  - The unit of measure for the **max_distance** parameter.
  - The default is meters.
  - Must be the name of a linear unit of measure from the **unit_name** column of the **st_units_of_measure** table.

- **Run STS_TrajectoryCross () to know whether an object crossed the boundary of a specific region during a time range.**

- **STS_TrajectoryCross ()**
  - Returns **t** if the object crossed the boundary of the region one or more times during the time range.
  - Returns **f** if the object remained either outside or inside of the region for the time range (did not cross the boundary).

STS_TrajectoryCross() (4)

- **The following query returns whether vehicle 1 crossed the boundary of the region, which is specified by the point (116.4, 39.91) and the distance of 1000 meters, between 2014-02-02 13:34:00 and 2014-02-02 13:54:00:**

```
SELECT STS_TrajectoryCross
            ('T_Vehicle', modid, 'ts_track', '2014-02-02 13:34:00',
             '2014-02-02 13:54:00', '4326 point(116.4 39.91)', 1000)
  FROM T_Vehicle
 WHERE modid = '1';
```

```
(expression)

          t

1 row(s) retrieved.
```

STS_TrajectoryIntersect()(1)

- **Indicates whether the trajectory either crossed or remained within, the boundary of the region for the time range.**
- **Syntax**

```
STS_TrajectoryIntersect(ts_tabname   LVARCHAR,
                        obj_id       LVARCHAR,
                        ts_colname   LVARCHAR,
                        starttime    DATETIME YEAR TO FRACTION(5),
                        endtime      DATETIME YEAR TO FRACTION(5),
                        geometry     LVARCHAR,
                        max_distance REAL)
returns Boolean
STS_TrajectoryIntersect(ts_tabname   LVARCHAR,
                        obj_id       LVARCHAR,
                        ts_colname   LVARCHAR,
                        starttime    DATETIME YEAR TO FRACTION(5),
                        endtime      DATETIME YEAR TO FRACTION(5),
                        geometry     LVARCHAR,
                        max_distance REAL,
                        uom          LVARCHAR)
returns Boolean
```

STS_TrajectoryIntersect()(2)

- **ts_tabname**
  - The name of the time series table.
- **obj_id**
  - The ID of the object.
  - Must be a value from the primary key column of the time series table.
  - Can be the name of the column that stores the object IDs if the **WHERE** clause specifies a specific object ID.
- **ts_colname**
  - The name of the TimeSeries column.
- **starttime**
  - The start of the time range.
- **endtime**
  - The end of the time range.
- **geometry**
  - The geometry at the center of the region of interest.
  - Can be an ST_Point, ST_MultiPoint, ST_LineString, ST_MultiLineString, ST_Polygon, or ST_MultiPolygon.
  - Must use the SRID 4326.

STS_TrajectoryIntersect()(3)

- **max_distance**
  - The distance from the geometry that defines the border of the region of interest.
  - The unit of measure is specified by the **uom** parameter.
- **uom** **(optional)**
  - The unit of measure for the **max_distance** parameter.
  - The default is meters.
  - Must be the name of a linear unit of measure from the **unit_name** column of the **st_units_of_measure** table.

- **Run STS_TrajectoryIntersect () to find out whether the specified object went through the specified region during the specified time range.**
  - **Intersect**ion means either crossed the boundary of the region or remained within the boundary of the region.

STS_TrajectoryIntersect()(4)

- **Returns**
  - **t**
    - If the trajectory of the object crossed the boundary of the region during the time range.
    - If the trajectory of the object remained within the region during the time range.
  - **f**
    - if the trajectory of the object did not intersect the region during the time range.

STS_TrajectoryIntersect()(5)

- **The following query returns whether vehicle 1 intersected the boundary of the region, which is described by the point (116.4, 39.91) and the distance of 1000 meters, between 2014-02-02 13:34:00 and 2014-02-02 13:54:00:**

```
SELECT STS_TrajectoryIntersect
            ('T_Vehicle', modid, 'ts_track', '2014-02-02 13:34:00',
             '2014-02-02 13:54:00', '4326 point(116.4 39.91)', 1000)
  FROM T_Vehicle
WHERE modid = '1';
```

```
(expression)

          t

1 row(s) retrieved.
```

STS_Release()

- **The STS_Release function returns the internal version number and build date for the spatiotemporal search extension.**
- **Syntax**

  STS_Release()
  Returns LVARCHAR;

- **Returns**
  - A string with the version number and build date.
- **The following statement returns the version number and build date:**
- **EXECUTE FUNCTION STS_Release;**

STS_Set_Trace() procedure (1)

- **STS_Set_Trace enables tracing and sets the tracing file.**
- **Syntax**

STS_Set_Trace(trace_params LVARCHAR, trace_file LVARCHAR);

- **trace_params**
  - The tracing parameters in the following format:
    - **tracing_type tracing_level**:
    - **tracing_type**
      STSQuery: Set tracing on spatiotemporal queries.
      STSBuild: Set tracing on spatiotemporal indexing.
    - **tracing_level**
      0 = Turn off tracing.
      >1 = Any integer greater than 1 = Turn on tracing.
- **trace_file**
  - The full path and name of the tracing file.

STS_Set_Trace() procedure (2)

- **Run STS_Set_Trace with the STSQuery value to enable tracing if you want to view the entry points of spatiotemporal query functions.**

- **Run STS_Set_Trace with the STSBuild value to enable tracing if you want to view the entry points of spatiotemporal indexing functions.**
  - You must specify the full path and name of the tracing file.

STS_Set_Trace() procedure (3)

- **Set query tracing**
- **The following statement starts tracing on spatiotemporal queries and sets the tracing file name and path:**

```
EXECUTE PROCEDURE STS_Set_Trace('STSQuery 2',
'/tms/sts_query.log');
```

- **Stop query tracing**
- **The following statement stops tracing on spatiotemporal queries:**

```
EXECUTE PROCEDURE STS_Set_Trace('STSQuery 0',
'/tms/sts_query.log');
```

Appendix B – Spatiotemporal Catalog Tables

STS_DefaultParameters Table

- Contains the default parameters document for the database and the table is empty until you run the STS_SetDefaultParameters function. If you omit the parameters document from the STS_SubtrackCreate function, the values in this table are used.
- The STS_DefaultParametersTable table contains a *parameters* column, which is of type BSON, and only one row, which contains the default parameters document.
- You can update the default parameters document with the STS_SetDefaultParameters function. The existing default parameters document is replaced.

STS_InstanceTable

- **The table contains the association between a time series instance and a subtrack definition.**
- **Every time series that has subtrack records in a subtrack table has a row in the STS_InstanceTable table.**
- **The following table lists the columns of the STS_InstanceTable table:**

Column	Data Type	Description
instance_id	BIGINT	Time Series instance ID. The primary key
subtrack_id	INTEGER	Unique ID of the subtrack table

- **The time series instance ID is listed in the TSInstanceTable table.**

STS_SubtrackTable

Column name	Data type	Description
subtrack_id	SERIAL	The unique ID of the subtrack table.
subtrack_name	VARCHAR(128)	The name of the subtrack table. The primary key.
base_table_name	VARCHAR(128)	The name of the time series table.
ts_column_name	VARCHAR(128)	The time series column name in the time series table.
flags	INTEGER	Specifies whether a Scheduler task indexes new data: 1 = A Scheduler task is running. 2 = No Scheduler task.
parameters	BSON	A BSON document that contains parameters to build the subtrack.
ts_data_first_timestamp	DATETIME YEAR TO SECOND	First time stamp in the time series to index with the Scheduler task.
ts_data_lag_to_current	INTERVAL DAY TO SECOND	Time interval before current time to avoid indexing with the Scheduler task.
task_nschsessions	INTEGER	Number of Scheduler sessions to start to update the index in parallel.
task_frequency	INTERVAL DAY TO SECOND	How frequently to index new data with the Scheduler task.
task_start_time	DATETIME HOUR TO SECOND	First time to start the Schedule task.
task_data_interval_to_process	INTERVAL DAY TO SECOND	Time interval in the time series to process each time that the Scheduler task is run.

STS_SubtrackTable

- The STS_SubtrackTable table contains the subtrack definitions.
- When you run the STS_SubtrackCreate function, a row is added to the STS_SubtrackTable table.

Subtrack table

- **Contains spatiotemporal data for the associated time series column.**
- **You specify the name of the subtrack table when you run the STS_SubtrackCreate function.**

Column name	Data type	Description
instance_id	BIGINT	The time series instance ID.
begin_time	DATETIME YEAR TO FRACTION(5)	The start time of the entry.
end_time	DATETIME YEAR TO FRACTION(5)	The end time of the entry.
state	SMALLINT	The type of entry: 0 = Moving. The **geometry** column contains a trajectory. 1 = Stationary. The **geometry** column contains a location. 2 = No signal. The object had no signal for the time period between the start time and the end time, and the object is in the same location. 3 = Interrupted signal. The object had no signal for the time period between the start time and the end time, and the object is in a different location.
geometry	ST_Geometry	Depends on the value of the **state** column: 0 = An ST_LineString or ST_MultiLineString that represents the trajectory of the object. 1 = An ST_Point that represents the location of the object. 2 or 3 = NULL

Appendix C – Regex Character Names.

Regex Character Names (1 of 4)

Name	Code	Name	Code
soh	01 = Start of heading	newline	0A (LF) = Line feed
stx	02 = Start of text	vt	0B = Vertical tab
etx	03 = End of text	vertical-tab	0B (VT) = Vertical tab
eot	04 = End of transmission	ff	0C (FF) = Form feed
enq	05 = Enquiry	form-feed	0C (FF) = Form feed
ack	06 = Acknowledgment	cr	0D (CR) = Carriage return
bel	07 = Bell	carriage-return	0D (CR) = Carriage return
alert	07 (BEL) = Bell	so	0E = Shift Out/X-On
bs	08 = Backspace	si	0F = Shift In/X-Off
backspace	08 = Backspace	dle	10 = Data line escape
ht	09 = Horizontal tab	dc1	11 = Device control 1
tab	09 (HT) = Horizontal tab	dc2	12 = Device control 2
lf	0A = Line feed	dc3	13 = Device control 3

Regex Character Names (2 of 4)

Name	Code	Name	Code
syn	16 = Synchronous idle	space	' '
etb	17 = End of transmit block	exclamation-mark	'!'
can	18 = Cancel	quotation-mark	'"'
em	19 = End of medium	number-sign	'#'
sub	1A = Substitute	dollar-sign	'$'
esc	1B = Escape	percent-sign	'%'
is4	1C (FS) = File separator	ampersand	'&'
fs	1C = File separator	apostrophe	'\'
is3	1D (GS) = Group separator	left-parenthesis	'('
gs	1D (GS) = Group separator	right-parenthesis	')'
is2	1E (RS) = Record separator	asterisk	'*'
rs	1E (RS) = Record separator	plus-sign	'+'
is1	1F (US) = Unit separator	comma	,
us	1F (US) = Unit separator	hyphen	'-'

Regex Character Names (3 of 4)

Name	Code	Name	Code
hyphen-minus	-	Colon	:
period	'.'	semicolon	';'
full-stop	'.'	less-than-sign	'<'
Slash	/	equals-sign	'='
solidus	'/'	greater-than-sign	'>'
Zero	0	question-mark	?
one	'1'	commercial-at	@
two	'2'	left-square-bracket	'['
Three	3	backslash	\
four	4	reverse-solidus	\
Five	5	right-square-bracket	]
six	'6'	circumflex	^'
Seven	7	circumflex-accent	^'
Eight	8	underscore	_'
Nine	9	low-line	_'

Regex Character Names (4 of 4)

Name	Code	Name	Code
grave-accent	`		
left-brace	'{'		
left-curly-bracket	'{'		
vertical-line	'|'		
right-brace	'}'		
right-curly-bracket	'}'		
Tilde	~		
del	7F = Delete		

Appendix D – Advanced Time Series Analytic Functions

List of Functions (1)

- Scan_Abnormal
- Scan_Abnormal_Default
- Scan_DTW_Itakura_Parallelogram_Constraint
- Scan_DTW_NonConstraint
- Scan_DTW_Sakoe_Chiba_Constraint
- Scan_Normal_LCSS
- Scan_LCSS
- Scan_RangeQuery_LPNorm
- Scan_RangeQuery_Pearson_Correlation

List of Functions (2)

- TSAFuncsTraceFile
- TSAFuncsTraceLevel
- TSAFuncsRelease
- TSCompute_Itakura_Parallelogram_Constraint_Dist
- TSCompute_LCSS_Dist
- TSCompute_LP_Dist
- TSCompute_NonConstraint_Dist
- TSCompute_Normalized_LCSS_Dist
- TSCompute_Sakoe_Chiba_Constraint_Dist
- TSGetValueList
- TSPearson_Correlation_Score
- ValueAsCollection

Scan_Abnormal function

- Return time series data that differ from nearby sequences.
- Syntax

```
Scan_Abnormal (
    ts              TimeSeries,
    ident           LVARCHAR,
    col_name        LVARCHAR,
    begin_tstamp    DATETIME YEAR TO FRACTION(5),
    end_tstamp      DATETIME YEAR TO FRACTION(5),
    window_length   INTEGER,
    score_threshold DOUBLE PRECISION,
    subseq_length   INTEGER,
    step_size       INTEGER,
    k_value         INTEGER,
    p_value         DOUBLE PRECISION)
RETURNS LIST (SEARCHROW NOT NULL)
```

Scan_Abnormal function

ts
- The time series value for the specified primary key.

ident
- A string identifier that is associated with the time series instance.

col_name
- The column name in the TimeSeries data type from which to retrieve the values.

begin_stamp
- The begin point of the search range.
  - Can be NULL, which represents the first time series element.

end_stamp
- The end point of the search range.
  - Can be NULL, which represents the last time series element.

window_length
- The length of the sequence.

score_threshold
- The abnormal score threshold. Range of values: **0.0 - 1.0.**

Scan_Abnormal function

subseq_length
- The size of the sliding window.

step_size
- How far the sliding window is advanced for each candidate match.

k_value
- Number of nearest neighbor sequences on which to base the abnormality score.

p_value
- The ***p*** value defined in the **Lp-norm** function, used in the distance calculation.

- **Usage**
  - Run to find all subsequences that differ from nearby subsequences.
  - The sliding window of the input time series steps over the target time series.
  - The differences between the time series are a measure of Euclid distance.
  - Use to find outlier data compared to historical data or to generate real-time alerts for current outlier data.

Scan_Abnormal function

- **Returns**
  - A list of matches in a **LIST** data type that contains a **SEARCHROW** data type value for each match.

Scan_Abnormal_Default function

- Return time series data that differ from nearby sequences.
- Syntax

```
Scan_Abnormal_Default (
   ts                TimeSeries,
   ident             LVARCHAR,
   col_name          LVARCHAR,
   begin_tstamp      DATETIME YEAR TO FRACTION(5),
   end_tstamp        DATETIME YEAR TO FRACTION(5),
   window_length     INTEGER,
   score_threshold   DOUBLE PRECISION,
   subseq_length     INTEGER,
   step_size         INTEGER,
   k_value           INTEGER,
   p_value           DOUBLE PRECISION)
RETURNS LIST (SEARCHROW NOT NULL)
```

Scan_Abnormal_Default function

ts
- The time series value for the specified primary key.

ident
- A string identifier that is associated with the time series instance.

col_name
- The column name in the TimeSeries data type from which to retrieve the values.

begin_stamp
- The begin point of the search range.
  - Can be NULL, which represents the first time series element.

end_stamp
- The end point of the search range.
  - Can be NULL, which represents the last time series element.

window_length
- The length of the sequence.

score_threshold
- The abnormal score threshold. Range of values: **0.0 - 1.0.**

Scan_Abnormal_Default function

subseq_length
- The size of the sliding window.

step_size
- How far the sliding window is advanced for each candidate match.

k_value
- The number of nearest neighbor sequences on which to base the abnormality score.

p_value
- The *p* value as defined in the Lp-norm function, which is used in the distance calculation.

- **Usage**
  - Run to find all subsequences that differ from nearby subsequences.
  - The sliding window of the input time series steps over the target time series.
  - The differences between the time series are a measure of Euclid distance.
  - Use to find outlier data compared to historical data or to generate real-time alerts for current outlier data.

Scan_Abnormal_Default function

- **Uses the same detection algorithm as the Scan_Abnormal function with the following fixed values:**
  - ***step_size* = 1**
  - ***k_value* = (*window_length* - *subseq_length*|*step_size***
- **Returns**
  - A list of matches in a **LIST** data type that contains a **SEARCHROW** data type value for each match.

Scan_DTW_Itakura_Parallelogram_Constraint function

- Returns time series data that matches a pattern using dynamic time warping distance with the Itakura parallelogram constraint.
- Syntax

```
Scan_DTW_Itakura_Parallelogram_Constraint (
    ts                          TimeSeries,
    ident                       LVARCHAR,
    col_name                    LVARCHAR,
    begin_tstamp                DATETIME YEAR TO FRACTION(5),
    end_tstamp                  DATETIME YEAR TO FRACTION(5),
    pattern                     LIST (ROW (DOUBLE PRECISION) NOT
    NULL),
    enlarge_threshold           DOUBLE PRECISION,
    mconstraint_horizontal      DOUBLE PRECISION,
    mconstraint_vertical        DOUBLE PRECISION,
    dtw_threshold               DOUBLE PRECISION)
RETURNS LIST (SEARCHROW NOT NULL)
```

Scan_DTW_Itakura_Parallelogram_Constraint function

ts
- The time series value for the specified primary key.

ident
- A string identifier that is associated with the time series instance.

col_name
- The column name in the TimeSeries data type from which to retrieve the values.

begin_stamp
- The begin point of the search range.
  - Can be NULL, which represents the first element in the time series.

end_stamp
- The end point of the search range.
  - Can be NULL, which represents the last element in the time series.

pattern
- Search pattern returned by the **ValueAsCollection** or **TSGetValueList** function.

Scan_DTW_Itakura_Parallelogram_Constraint function

enlarge_threshold

- A number that when multiplied by the pattern length specifies the size of the sliding window.

mconstraint_horizontal

- A number that represents the mConstraint horizontal values that define a parallelogram-shaped region to restrict the DTW distance calculation.

mconstraint_vertical

- A number that represents the mConstraint vertical values that define a parallelogram-shaped region to restrict the DTW distance calculation.

dtw_threshold

- A number that represents the upper bound of the DTW score.

- **Usage**
  - Run to find fragments in a time series that are under the threshold, based on the DTW score with an Itakura Parallelogram constraint, with a sliding window.
- **Returns**
  - A list of matches in a **LIST** data type that contains a **SEARCHROW** data type value for each match.

Scan_DTW_NonConstraint function

- Returns matching time series sequences using dynamic time warping without constraints.
- Syntax

```
Scan_DTW_NonConstraint(
    ts                      TimeSeries,
    ident                   LVARCHAR,
    col_name                LVARCHAR,
    begin_tstamp            DATETIME YEAR TO FRACTION(5),
    end_tstamp              DATETIME YEAR TO FRACTION(5),
    pattern LIST            (ROW (DOUBLE PRECISION) NOT NULL),
    enlarge_threshold       DOUBLE PRECISION,
    dtw_threshold           DOUBLE PRECISION)
RETURNS LIST (SEARCHROW NOT NULL)
```

Scan_DTW_NonConstraint function

ts
- The time series value for the specified primary key.

ident
- A string identifier that is associated with the time series instance.

col_name
- The column name in the TimeSeries data type from which to retrieve the values.

begin_stamp
- The begin point of the range to search.
  - Can be NULL, which represents the first element in the time series.

end_stamp
- The end point of the range to search.
  - Can be NULL, which represents the last element in the time series.

pattern
- Search pattern returned by the **ValueAsCollection** or **TSGetValueList** function.

Scan_DTW_NonConstraint function

enlarge_threshold

- A number that when multiplied by the pattern length specifies the size of the sliding window.

dtw_threshold

- A number that represents the upper bound of the DTW score.

- **Usage**
  - Run to find fragments that are under the threshold based on the unconstrained DTW score in a time series using a sliding window.
- **Returns**
  - A list of matches in a **LIST** data type that contains a **SEARCHROW** data type value for each match.

Scan_DTW_Sakoe_Chiba_Constraint function

- Returns time series data that matches a pattern using dynamic time warping distance with the Sakoe-Chiba constraint.
- Syntax

```
Scan_DTW_Sakoe_Chiba_Constraint (
    ts                  TimeSeries,
    ident               LVARCHAR,
    col_name            LVARCHAR,
    begin_tstamp        DATETIME YEAR TO FRACTION(5),
    end_tstamp          DATETIME YEAR TO FRACTION(5),
    pattern             LIST (ROW (DOUBLE PRECISION) NOT
    NULL),
    enlarge_threshold   DOUBLE PRECISION,
    norm_mconstraint    DOUBLE PRECISION,
    dtw_threshold       DOUBLE PRECISION)
RETURNS LIST (SEARCHROW NOT NULL)
```

Scan_DTW_Sakoe_Chiba_Constraint function

ts
- The time series value for the specified primary key.

ident
- A string identifier that is associated with the time series instance.

col_name
- The column name in the TimeSeries data type from which to retrieve the values.

begin_stamp
- The begin point of the range to search.
  - Can be NULL, which represents the first element in the time series.

end_stamp
- The end point of the range to search.
  - Can be NULL, which represents the last element in the time series.

pattern
- Search pattern returned by the **ValueAsCollection** or **TSGetValueList** function.

Scan_DTW_Sakoe_Chiba_Constraint function

enlarge_threshold

- A number that when multiplied by the pattern length specifies the size of the sliding window.

norm_mconstraint

- A number that represents the normalized mConstraint in the Sakoe-Chiba function.

dtw_threshold

- A number that represents the upper bound of the DTW score.

- **Usage**
  - Run to find fragments that are under the threshold based on the DTW score with a Sakoe-Chiba constraint in a time series using a sliding window.
- **Returns**
  - A list of matches in a **LIST** data type that contains a **SEARCHROW** data type value for each match.

Scan_Normal_LCSS function

- Matches the search pattern to the time series using the longest common subsequence formula.
- Syntax

```
Scan_Normal_LCSS(
    ts                  TimeSeries,
    ident               LVARCHAR,
    col_name            LVARCHAR,
    begin_tstamp        DATETIME YEAR TO FRACTION(5),
    end_tstamp          DATETIME YEAR TO FRACTION(5),
    pattern             LIST (ROW (DOUBLE PRECISION) NOT
    NULL),
    enlarge_threshold   DOUBLE PRECISION,
    normalized_delta            DOUBLE PRECISION,
    epsilon             DOUBLE PRECISION,
    norm_lcss_threshold DOUBLE PRECISION)
RETURNS LIST (SEARCHROW NOT NULL)
```

Scan_Normal_LCSS function

ts
- The time series value for the specified primary key.

ident
- A string identifier that is associated with the time series instance.

col_name
- The column name in the TimeSeries data type from which to retrieve the values.

begin_stamp
- The begin point of the search range.
  - Can be NULL, which represents the first element in the time series.

end_stamp
- The end point of the search range.
  - Can be NULL, which represents the last element in the time series.

pattern
- Search pattern returned by the **ValueAsCollection** or **TSGetValueList** function.

Scan_Normal_LCSS function

enlarge_threshold
- A number that when multiplied by the pattern length specifies the size of the sliding window.

normalized_delta
- The limit of the delta distance.

epsilon
- The value of ϵ in the longest common subsequence formula.

norm_lcss_threshold
- The high bound of the distance.

lcss_threshold
- The high bound of the distance.

- **Usage**
  - This function measures the longest common subsequence (LCSS) similarity between the subsequences of a time series and a pattern using a sliding window, where the length of the two subsequences is not necessarily the same.

Scan_Normal_LCSS function

- **Returns**
  - A list of matches in a **LIST** data type that contains a **SEARCHROW** data type value for each match.

Scan_LCSS function

- Matches the search pattern to the time series using the longest common subsequence formula.
- Syntax

```
Scan_LCSS(
    ts                      TimeSeries,
    ident                   LVARCHAR,
    col_name                LVARCHAR,
    begin_tstamp            DATETIME YEAR TO FRACTION(5),
    end_tstamp              DATETIME YEAR TO FRACTION(5),
    pattern                 LIST (ROW (DOUBLE PRECISION) NOT
    NULL),
    enlarge_threshold       DOUBLE PRECISION,
    normalized_delta                DOUBLE PRECISION,
    epsilon                 DOUBLE PRECISION,
    norm_lcss_threshold     DOUBLE PRECISION)
RETURNS LIST (SEARCHROW NOT NULL)
```

Scan_LCSS function

ts
- The time series value for the specified primary key.

ident
- A string identifier that is associated with the time series instance.

col_name
- The column name in the TimeSeries data type from which to retrieve the values.

begin_stamp
- The begin point of the search range.
  - Can be NULL, which represents the first element in the time series.

end_stamp
- The end point of the search range.
  - Can be NULL, which represents the last element in the time series.

pattern
- Search pattern returned by the **ValueAsCollection** or **TSGetValueList** function.

Scan_LCSS function

enlarge_threshold
- A number that when multiplied by the pattern length specifies the size of the sliding window.

normalized_delta
- The limit of the delta distance.

epsilon
- The value of ϵ in the longest common subsequence formula.

norm_lcss_threshold
- The high bound of the distance.

lcss_threshold
- The high bound of the distance.

- **Usage**
  - This function measures the longest common subsequence (LCSS) similarity between the subsequences of a time series and a pattern using a sliding window, where the length of the two subsequences is not necessarily the same.

Scan_LCSS function

- **Returns**
  - A list of matches in a **LIST** data type that contains a **SEARCHROW** data type value for each match.

Scan_RangeQuery_LPNorm function

- Uses the Lp-norm function to calculate how close the search pattern matches fragments of the time series.
- Syntax

```
Scan_RangeQuery_LPNorm(
    ts              TimeSeries,
    ident           LVARCHAR
    col_name        LVARCHAR
    begin_tstamp    DATETIME YEAR TO FRACTION(5),
    end_tstamp      DATETIME YEAR TO FRACTION(5),
    pattern         LIST (ROW (DOUBLE PRECISION) NOT NULL),
    p_value                 DOUBLE PRECISION,
    dist_hb         DOUBLE PRECISION
)
RETURNS LIST (SEARCHROW NOT NULL)
```

Scan_RangeQuery_LPNorm function

ts
- The time series value for the specified primary key.

ident
- A string identifier that is associated with the time series instance.

col_name
- The column name in the TimeSeries data type from which to retrieve the values.

begin_stamp
- The begin point of the search range.
  - Can be NULL, which represents the first element in the time series.

end_stamp
- The end point of the search range.
  - Can be NULL, which represents the last element in the time series.

pattern
- Search pattern returned by the **ValueAsCollection** or **TSGetValueList** function.

Scan_RangeQuery_LPNorm function

p_value

- The ***p*** value as defined in the **Lp-norm** function.
- Must be **> 0**.

dist_hb

- The high bound of the threshold of the **Lp-norm** distance.

- **Usage**
  - Run to find fragments in the specified time series for the specified time range that are under the threshold of the constraint, which is based on the **Lp-norm** distance that is computed with the specified pattern.
  - The length of the fragments must be the same.
- **Returns**
  - A list of matches in a **LIST** data type that contains a **SEARCHROW** data type value for each match.

Scan_RangeQuery_Pearson_Correlation function

- **Returns time series data that matches a pattern using a Pearson correlation.**
- **Syntax**

```
Scan_RangeQuery_Pearson_Correlation (
    ts              TimeSeries,
    ident           LVARCHAR,
    col_name        LVARCHAR,
    begin_tstamp    DATETIME YEAR TO FRACTION(5),
    end_tstamp      DATETIME YEAR TO FRACTION(5),
    pattern         LIST (ROW (DOUBLE PRECISION) NOT NULL),
    lower_bound     DOUBLE PRECISION)
RETURNS LIST (SEARCHROW NOT NULL)
```

Scan_RangeQuery_Pearson_Correlation function

ts
- The time series value for the specified primary key.

ident
- A string identifier that is associated with the time series instance.

col_name
- The column name in the TimeSeries data type from which to retrieve the values.

begin_stamp
- The begin point of the search range.
  - Can be NULL, which represents the first element in the time series.

end_stamp
- The end point of the search range.
  - Can be NULL, which represents the last element in the time series.

pattern
- Search pattern returned by the **ValueAsCollection** or **TSGetValueList** function.

Scan_RangeQuery_Pearson_Correlation function

lower_bound

- A number that represents the lower bound of similarity as calculated by the Pearson Correlation function.
- Range of values is **0.0 - 1.0**.

- **Usage**
  - Run to find fragments in a sliding windows that match the search pattern using a Pearson Correlation function to calculate the lower bound.
- **Returns**
  - A list of matches in a **LIST** data type that contains a **SEARCHROW** data type value for each match.

TSAFuncsTraceFile function

- **Sets the trace file name and path for advanced analytics functions.**
- **Syntax**

  TSAFuncsTraceFile (*trace_file* LVARCHAR) returns INTEGER *trace_file*
  - The path and name of the trace file.
- **Usage**
  - Run the **TSAFuncsTraceFile** function to give the trace file for advanced analytics functions a different name and location from the default of **/tmp/*sessionID*.trc**, where ***sessionID*** is the session ID.
  - You enable tracing with the **TSAFuncsTraceLevel** function.
- **Returns**
  - **0** = The trace file name and path are set.
  - An error.
- **Example**
  - The following statement sets the file name and path of the trace file:

    EXECUTE FUNCTION TSAFuncsTraceFile(/usr/mytrace/timeseries.trc);

TSAFuncsTraceLevel function

- **Enables tracing on advanced analytics functions.**
- **Syntax**

  TSAFuncsTraceLevel('TSAF_DEBUG 1') returns INTEGER
- **Usage**
  - Run the **TSAFuncsTraceLevel** function to enable tracing if you want to view the entry points of advanced analytics functions.
  - Tracing file is named ***/tmp/sessionID*.trc**, where ***sessionID*** is the session ID.
  - You can change the location and name of the tracing file with the **TSAFuncsTraceFile** function.
- **Returns**
  - **0** = Tracing is enabled.
  - An error.
- **Example**
  - The following statement enables tracing:

    EXECUTE FUNCTION TSAFuncsTraceLevel('TSAF_DEBUG 1');

TSAFuncsRelease function

- **Returns the version number and build date for the TimeSeries advanced analytics extension.**
- **Syntax**

  TSAFuncsRelease() returns LVARCHAR;
- **Returns**
  - A string with the version number and build date.
- **Example**
  - The following statement returns the version number and build date:

    EXECUTE FUNCTION TSAFuncsRelease();

TSCompute_Itakura_Parallelogram_Constraint_Dist function

- **Calculates a similarity score for two time series sequences with the Itakura Parallelogram constraint applied to the distance calculation.**
- **Syntax**

```
TSCompute_Itakura_Parallelogram_Constraint_Dist (
    sequence1                 list,
    sequence2                 list,
    mconstraint_horizontal    DOUBLE PRECISION,
    mconstraint_vertical      DOUBLE PRECISION)
RETURNS DOUBLE PRECISION
```

sequence1 and ***sequence2***

- A list of values returned by the **ValueAsCollection** or **TSGetValueList** function.

mconstraint_horizontal

- A number that represents the mConstraint horizontal values that define a parallelogram-shaped region to restrict the DTW distance calculation.

– ***mconstraint_vertical***

- A number that represents the mConstraint vertical values that define a parallelogram-shaped region to restrict the DTW distance calculation.

TSCompute_Itakura_Parallelogram_Constraint_Dist function

- **Usage**
  - Run the **TSCompute_Itakura_Parallelogram_Constraint_Dist** function to calculate the distance between two time series sequences with the Itakura Parallelogram constraint.
  - The length of the sequences must be the same.
- **Returns**
  - A number that represents the similarity distance between two sequences.

TSCompute_LCSS_Dist function

- **Calculates the longest common subsequence distance between two time series sequences.**
- **Syntax**

```
TSCompute_LCSS_Dist (
    sequence1          list,
    sequence2          list,
    normalize_delta    DOUBLE PRECISION,
    epsilon            DOUBLE PRECISION)
RETURNS DOUBLE PRECISION
```

sequence1

- A list of values returned by the **ValueAsCollection** or **TSGetValueList** function.

sequence2

- A list of values returned by the **ValueAsCollection** or **TSGetValueList** function.

normalized_delta

- The limit of the delta distance.

epsilon

- The value of ϵ in the longest common subsequence formula.

TSCompute_LCSS_Dist function

- **Usage**
  - The **TSCompute_LCSS_Dist** function returns the actual distance.
- **Returns**
  - A number that represents the difference between two sequences.

TSCompute_Normalized_LCSS_Dist function

- **Calculates the longest common subsequence distance between two time series sequences.**
- **Syntax**

```
TSCompute_Normalized_LCSS_Dist (
    sequence1          list,
    sequence2          list,
    normalize_delta    DOUBLE PRECISION,
    epsilon            DOUBLE PRECISION)
RETURNS DOUBLE PRECISION
```

sequence1

- A list of values returned by the **ValueAsCollection** or **TSGetValueList** function.

sequence2

- A list of values returned by the **ValueAsCollection** or **TSGetValueList** function.

normalized_delta

- The limit of the delta distance.

epsilon

- The value of ϵ in the longest common subsequence formula.

TSCompute_Normalized_LCSS_Dist function

- **Usage**
  - Run to use the longest common subsequence algorithm to calculate the distance between two time series sequences.
  - Returns the distance as a value **0.0 - 1.0.**
- **Returns**
  - A number that represents the difference between two sequences.

TSCompute_LP_Dist function

- **Uses the Lp-norm function to calculate how closely the two time series sequences match.**
- **Syntax**

  TSCompute_LP_Dist (*sequence1* list, *sequence2* list, *p_value* DOUBLE PRECISION)
  RETURNS DOUBLE PRECISION

  sequence1
  - A list of values returned by the **ValueAsCollection** or **TSGetValueList** function.

  sequence2
  - A list of values returned by the **ValueAsCollection** or **TSGetValueList** function.

  p_value
  - The ***p*** value as defined in the **Lp-norm** function.
  - Must be greater than 0.

TSCompute_LP_Dist function

- **Usage**
  - Run to calculate the distance between two time series sequences with the Lp-norm function.
  - The length of the sequences must be the same.
- **Returns**
  - A number that represents the difference between two sequences.

TSCompute_NonConstraint_Dist function

- **Calculates the DTW distance between two time series sequences without constraints.**
- **Syntax**

  TSCompute_NonConstraint_Dist (*sequence1* list, *sequence2* list)
  RETURNS DOUBLE PRECISION

  sequence1
  - A list of values returned by the **ValueAsCollection** or **TSGetValueList** function.

  sequence2
  - A list of values returned by the **ValueAsCollection** or **TSGetValueList** function.
- **Usage**
  - Run to calculate the distance between two time series sequences without constraints.
  - The length of the sequences must be the same.
- **Returns**
  - A number that represents the distance between two sequences.

TSCompute_Sakoe_Chiba_Constraint_Dist function

- **Calculates a similarity score for two time series sequences with the Sakoe Chiba constraint.**
- **Syntax**

```
TSCompute_Sakoe_Chiba_Constraint_Dist
(
sequence1          list,
sequence2          list,
norm_mconstraint   DOUBLE PRECISION
)
RETURNS DOUBLE PRECISION
```

  - ***sequence1***
    - A list of values that is returned by the **ValueAsCollection** or **TSGetValueList** function.
  - ***sequence2***
    - A list of values that is returned by the **ValueAsCollection** or **TSGetValueList** function.
  - ***norm_mconstraint***
    - A number that represents the normalized mConstraint in the Sakoe-Chiba function.

TSCompute_Sakoe_Chiba_Constraint_Dist function

- **Usage**
  - Run the **TSPearson_Correlation_Score** function to calculate the similarity distance between two time series sequences, restricted by the Sakoe-Chiba constraint.
  - The length of the sequences must be the same.
- **Returns**
  - A number that represents the distance between the two time series sequences.

TSGetValueList function

- **Converts a string into a list of values useful as input to an advanced analytics function.**
- **Syntax**

  TSGetValueList (*value_string* LVARCHAR)
  RETURNS LIST (ROW (value DOUBLE PRECISION) NOT NULL)
  TSGetValueList (*value_string* LVARCHAR, *num_elements* INTEGER)
  RETURNS LIST (ROW (value DOUBLE PRECISION) NOT NULL)

  value_string
  - A character string that represents a list of data values.

  num_elements
  - A positive integer representing the number of input values to use from the start of the input string.
- **Usage**
  - Run this to return a search pattern usable as input to an advanced analytics function.
  - You can run the **TSGetValueList** function within an advanced analytics function as the **pattern** argument.

TSGetValueList function

- **Returns**
  - A list of row types that have a **DOUBLE PRECISION** field.

TSPearson_Correlation_Score function

- **Generates a Pearson correlation score for two time series sequences.**
- **Syntax**

  TSPearson_Correlation_Score (*sequence1* list, *sequence2* list)
  RETURNS DOUBLE PRECISION

  sequence1
  - A list of values that is returned by the **ValueAsCollection** or **TSGetValueList** function.

  sequence2
  - A list of values that is returned by the **ValueAsCollection** or **TSGetValueList** function.
- **Usage**
  - Run to calculate the Pearson correlation coefficient between two time series sequences.
  - The length of the sequences must be the same.
- **Returns**
  - Number, between **0.0 - 1.0**, representing the Pearson correlation coefficient.

ValueAsCollection function

- Returns a search pattern useful as input to an advanced analytics function
- Syntax

```
ValueAsCollection (
    ts              TimeSeries,
    begin_tstamp    DATETIME YEAR TO FRACTION(5),
    end_tstamp      DATETIME YEAR TO FRACTION(5),
    col_name        LVARCHAR
)
RETURNS LIST (ROW (value DOUBLE PRECISION) NOT NULL)
ValueAsCollection (
     ts             TimeSeries,
     begin_tstamp   DATETIME YEAR TO FRACTION(5),
     end_tstamp     DATETIME YEAR TO FRACTION(5),
     col_num        INTEGER
) RETURNS LIST (ROW (value DOUBLE PRECISION) NOT NULL
```

ValueAsCollection function

- **Usage**
  - Returns a search pattern that you can use as input to an advanced analytics function
    - A search pattern is the list of values from the specified column in the TimeSeries data type for the specified time range.
  - You can run this function within the analytics function as the **pattern** argument.
- **Returns**
  - A list of row types that have a **DOUBLE PRECISION** field.

Appendix E – GSKit Installation

GSKit

- **Normally installed with Informix Dynamic Server as part of the installation process and enabled by default for both Linux/Unix and Windows.**

- **Separate install instructions for:**
  - **AIX**
  - **LINUX**
  - **Solaris**
  - **Windows**