Db2 12 for z/OS and Asynchronous Lock Structure Duplexing: Update

- **Tridex**
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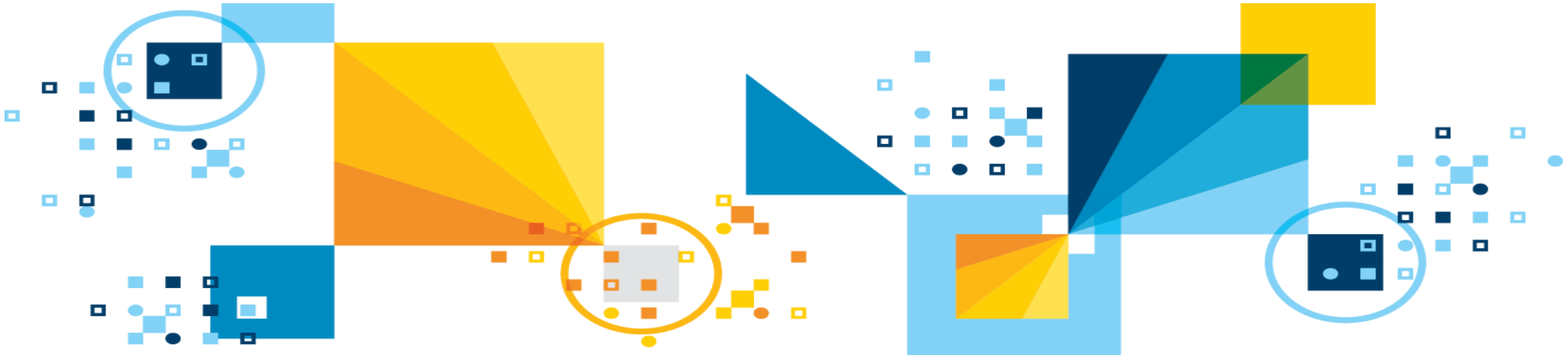
- IBM Washington Systems Center
- *September 19, 2019*



Session Objectives

- Review CF structure duplexing
- System managed duplexing of Db2 lock structure (LOCK1)
- Asynchronous system managed duplexing of LOCK1
- Customer experiences
- Summary and request...

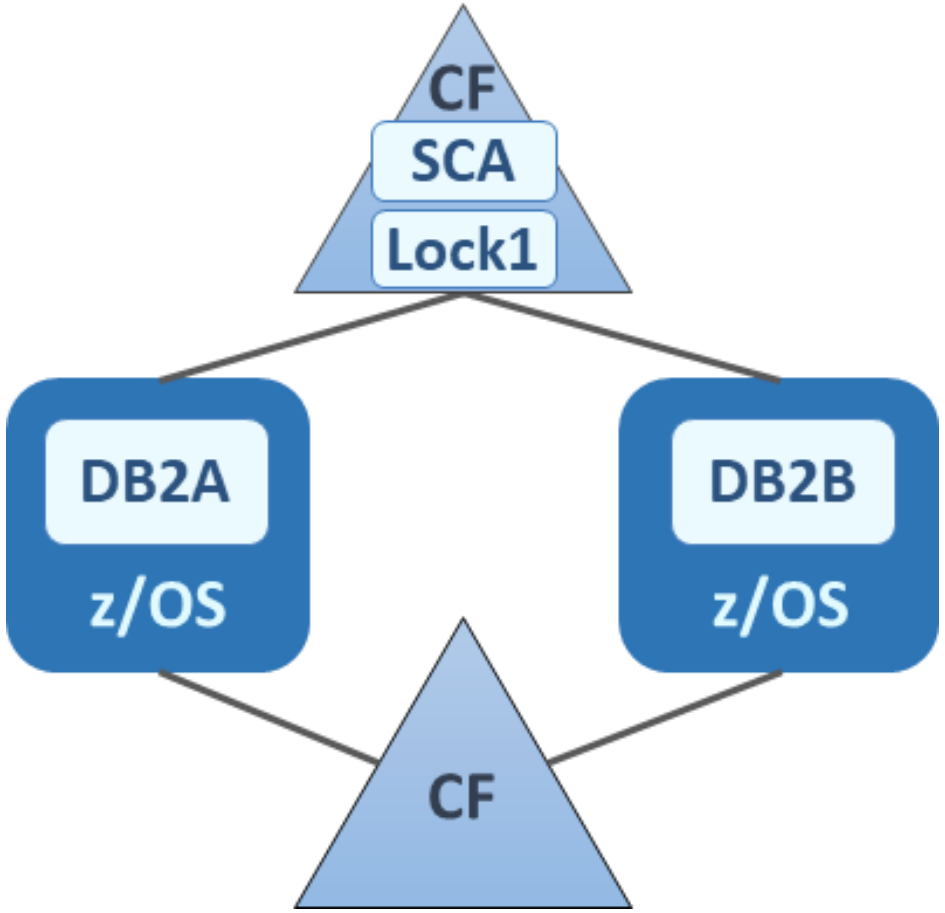
Parallel Sysplex basics for Db2 for z/OS

- Multiple Db2 members in a Db2 data sharing group
- Coupling facility (CF) structures used for high speed sharing of information about locks, status, data (tables, indexes)
- *ssnm*IRLM allocates lock structure: *dsngrpnm*_LOCK1 (LOCK1)
- *ssnm*MSTR allocates shared communication area: *dsngrpnm*_SCA (SCA)
- *ssnm*DBM1 allocates group buffer pool for each local BP with shared data
  - *dsngrmnm*_GBPn (GBP0, GBP1, GBP2, ...GBP8K0, ..GBP16K0, ...GBP32K)

- LOCK1 and SCA are required structures
  - If Db2 cannot allocate them, Db2 fails

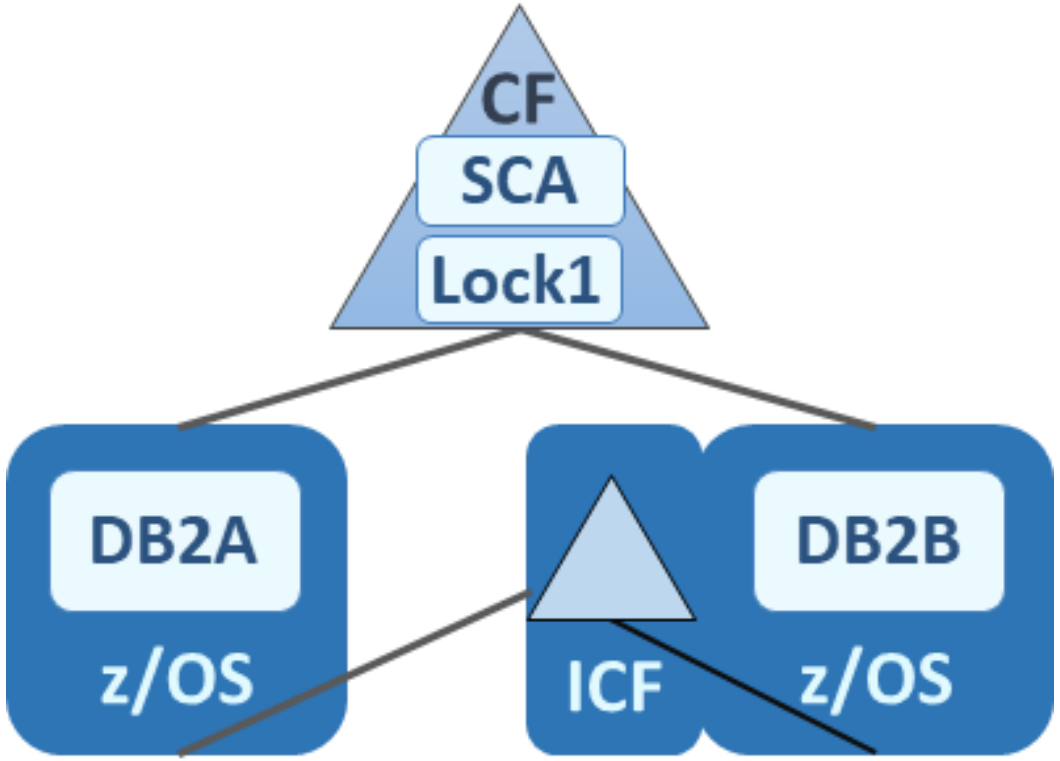
‘Original’ Parallel Sysplex configuration

- 2 external Coupling Facilities (CFs)
- SCA and LOCK1 isolated from MSTR and IRLM
- GBPs spread across CFs
- Failure of any single CEC tolerated
  - Structures rebuilt to other CF by connectors
  - Db2 members restarted on other LPAR to release retained locks



Second PSX configuration

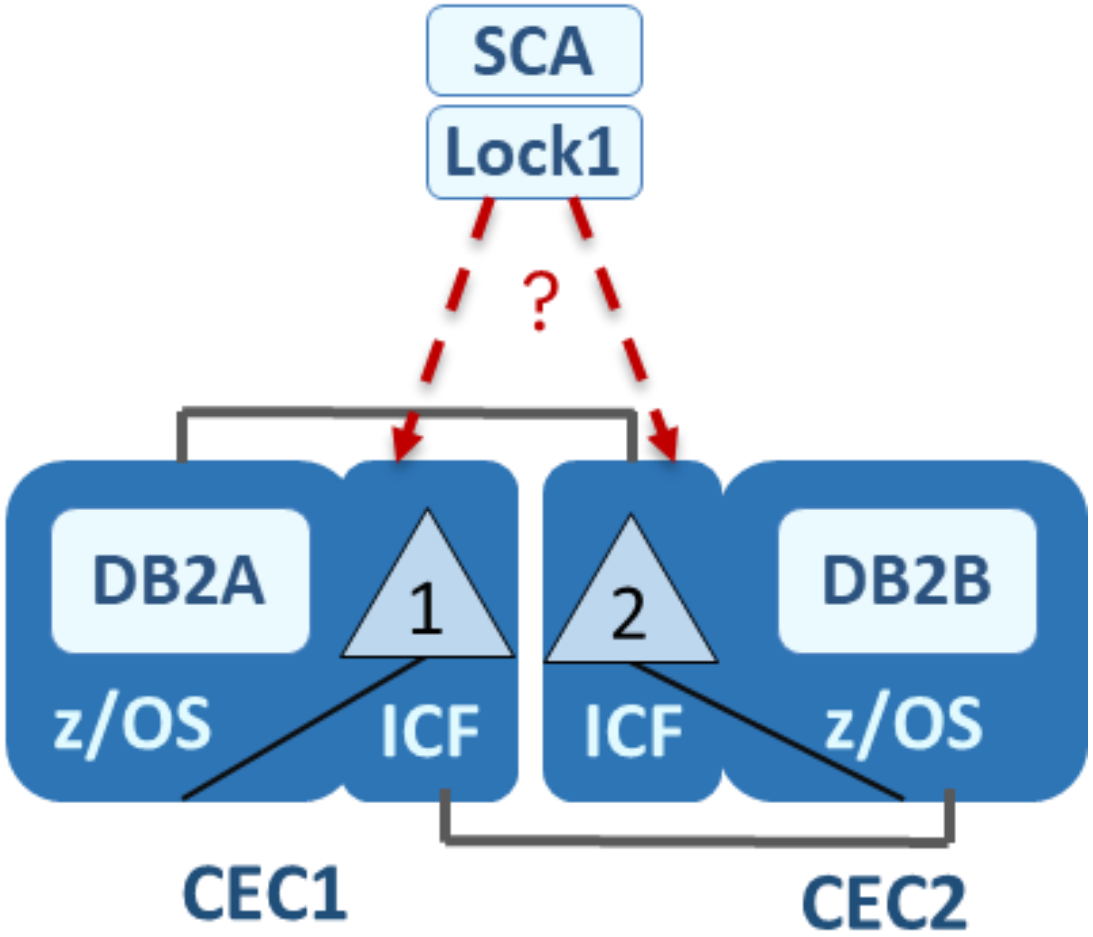
- 1 external CF
- 1 integrated CF (ICF)
- 3 CECs
- SCA and LOCK1 isolated from MSTR and IRLM
- GBPs spread across CFs
  - Duplexed GBPs
  - Primary GBPs spread across CFs
    - Secondary GBP on other CF



Third PSX configuration

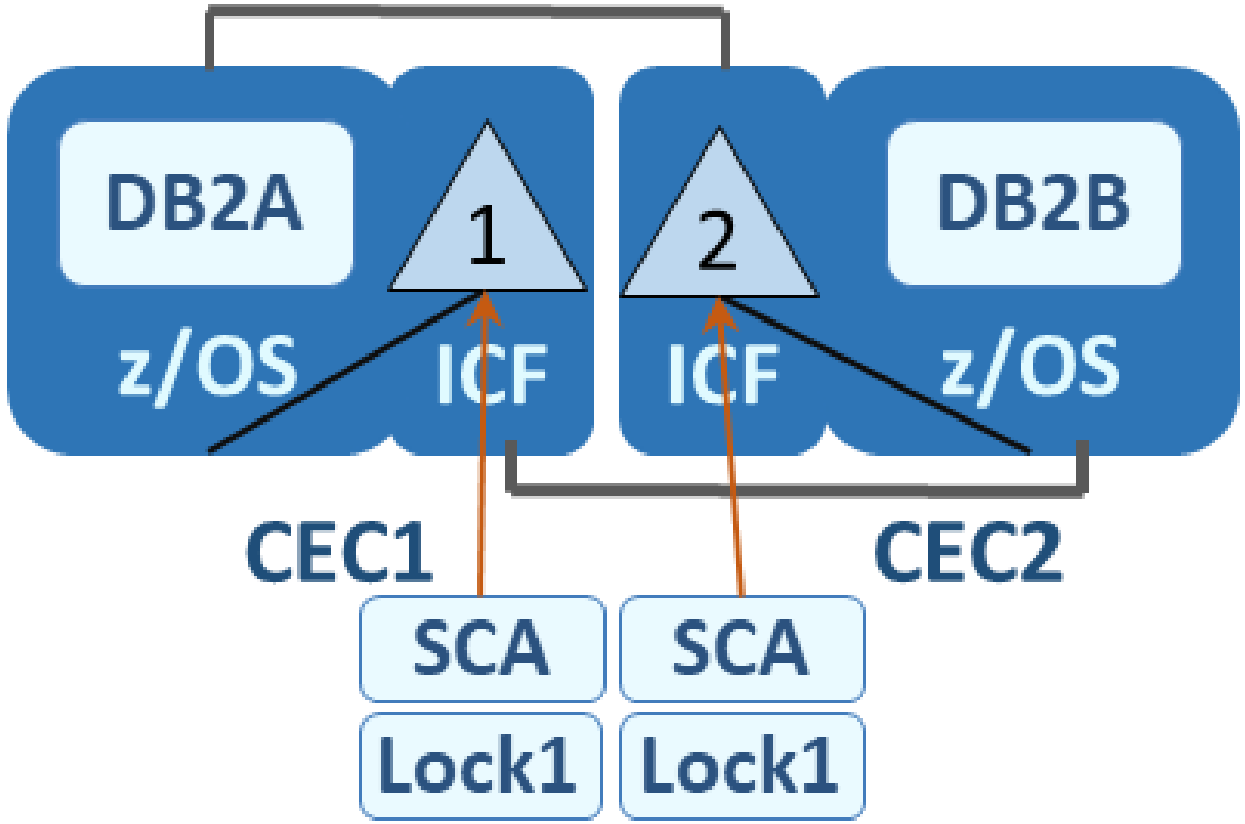
- 2 integrated CFs, 2 CECs
- SCA and LOCK1 not isolated from MSTR and IRLM
- Duplexed GBPs spread across CFs

- What if one CEC is lost?
- It depends…
- Could be loss if 1 Db2 member
- Could be loss of whole Db2 data sharing group
  - Because loss of SCA or LOCK1 ***and*** Db2 means the SCA or LOCK1 cannot be rebuilt



Third PSX configuration: recommended

- System Managed Duplexing
  - 2 integrated CFs, 2 CECs
  - SCA and LOCK1 duplexed (synchronous)
- User Managed Duplexing
  - Duplexed GBPs spread across CFs
- If either CEC fails
  - Db2 on other CEC available
  - Restart failed Db2 on other LPAR
    - Release retained locks
- Increased cost of lock requests
  - Performance and CPU costs
  - ***New with Db2 12: Async CF duplexing mitigates cost and performance***
    - Focus of the rest of this material

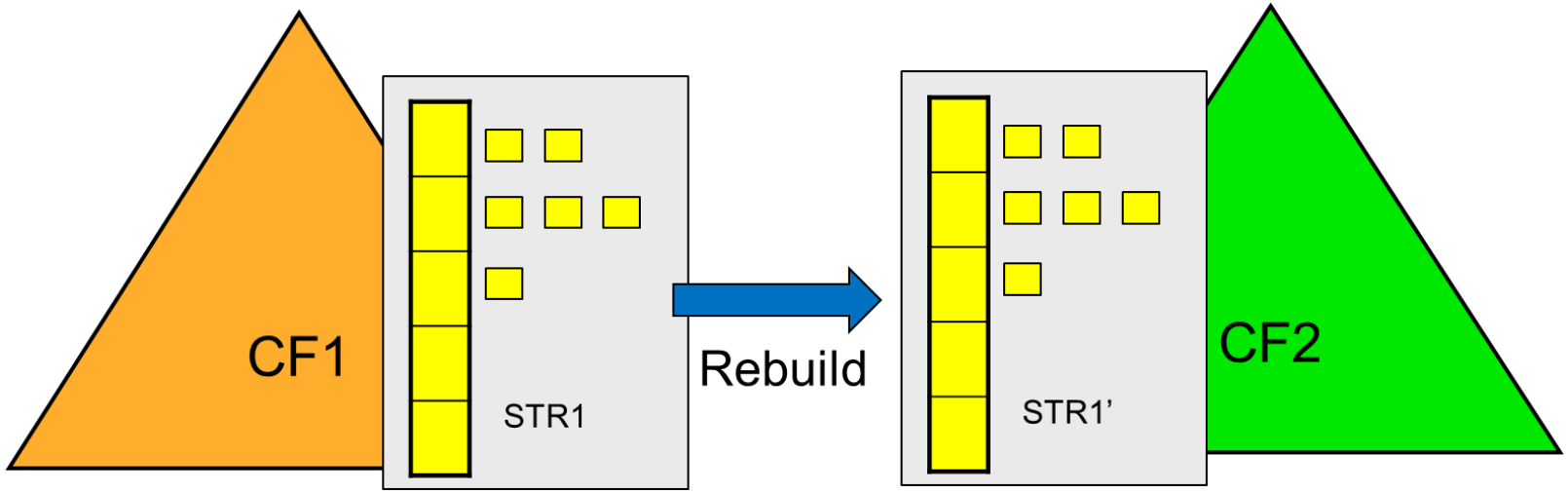


CF structure rebuild

— **Rebuild**
  - Process by which sysplex allocates new instance of CF structure, populates the structure with data, and proceeds to use the new structure instance

— Simplex rebuild
  - Discards the old instance, uses the new

— Duplex rebuild
  - Uses both instances, synchronizing updates so the structure contents remain the same



Two ways to accomplish the rebuild

User-managed

- Can be tailored to application
- Significant programming effort
  - Exploiter must coordinate process and propagate data
- Must be at least one active connector to do the work
- Variety of ways to propagate data to new structure
  - Copy from old structure
  - Reconstruct from in-storage data
  - Reconstruct from DASD and logs
  - Start fresh with empty structure

System-managed

- General purpose
- Virtually no development cost
  - System coordinates process and propagates data
- System does the work; can rebuild even if no connectors
- To propagate data to new structure, the system must have access to the old structure instance

Structure rebuild use cases

User-managed rebuild

- Planned reconfiguration
- Failure recovery

System-managed rebuild

- Planned reconfiguration
- *Limited/no use for failure recovery (must copy old structure)*

User-managed duplex

- Only for cache structures
  - DB2 group buffer pools
- Improved availability

System-managed duplex

- Robust failure recovery

Cost factor estimates for synchronous System Managed duplexing

- Percentage of requests that get duplexed
  - Cache 20% is typical (ranges 1% to 100%)
  - List 100% (or close to it)
  - Lock 100%

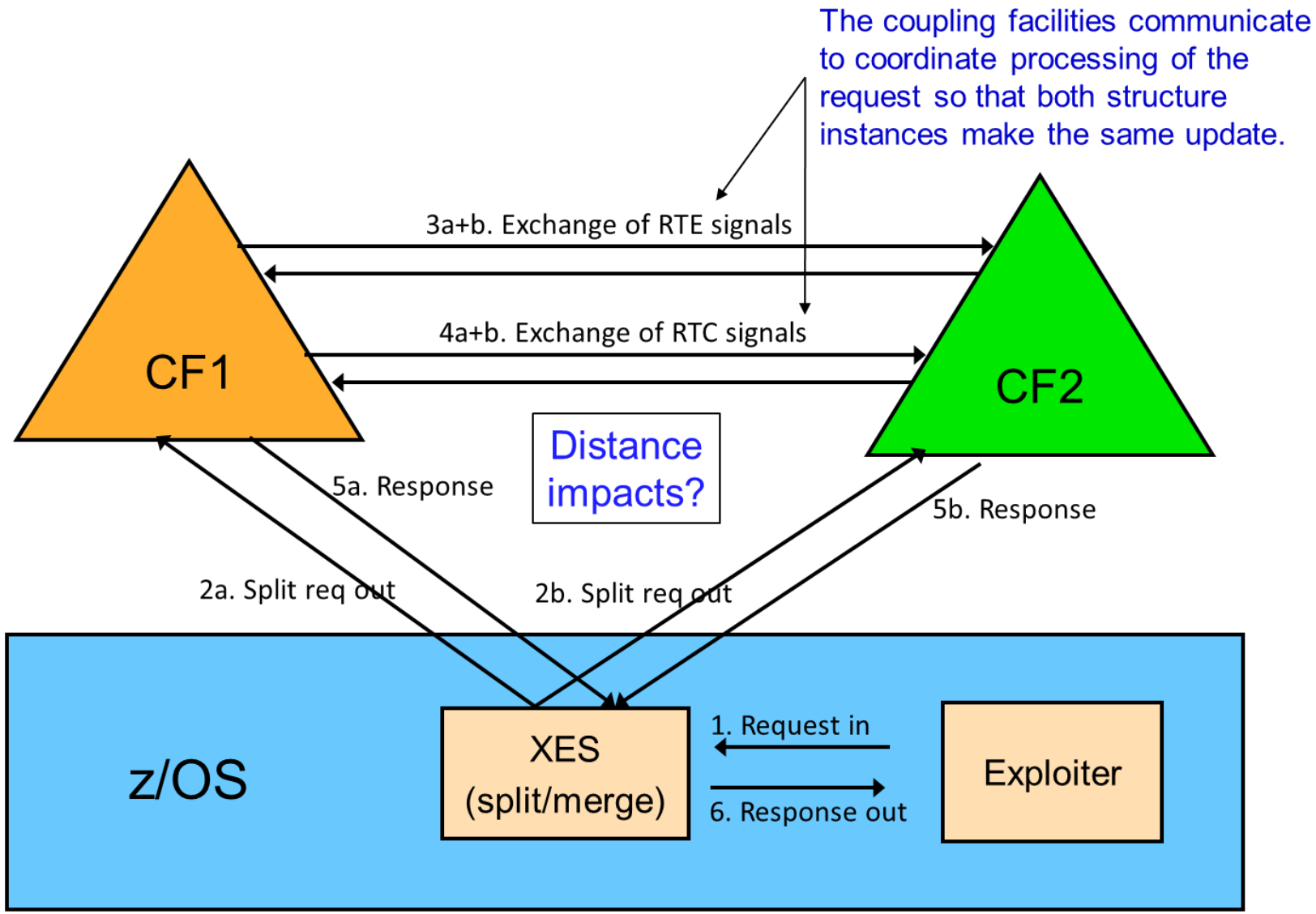
Examples:
[not Db2 GBPs]
Db2 SCA
Db2 LOCK1

- Cost of duplexed request vs. simplex request
  - z/OS CPU = 3x to 4x
  - CF CPU = 4x to 5x
  - CF Link = 6x to 8x

Highly visible

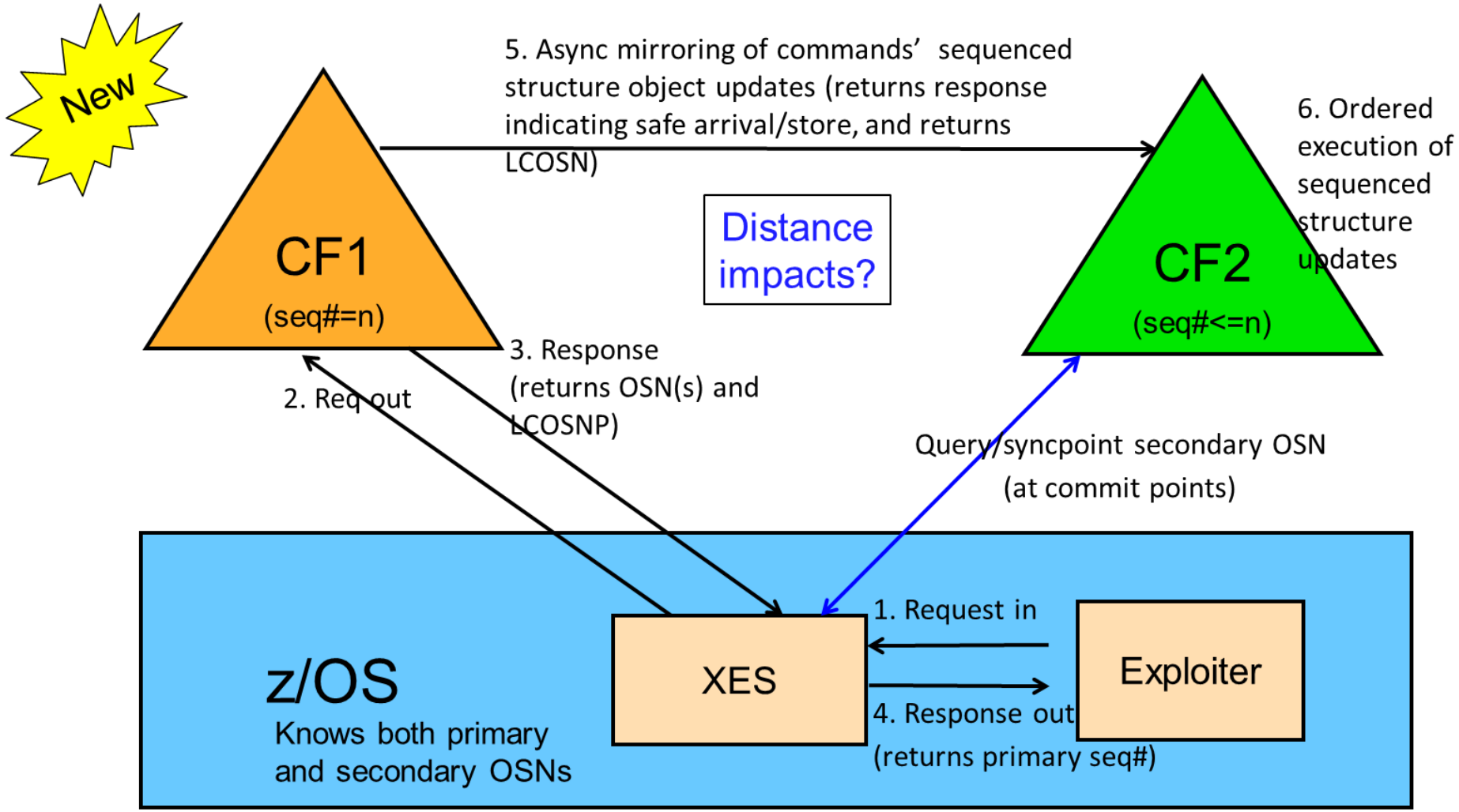
- Total impact to system would depend on particular structures, request frequency, read/write ratios
- Typically significant increase in request response time relative to simplex (further magnified by distance)
  - 2nd order effects on workload difficult to predict
    - Queuing
    - Contention
    - Timeouts

Synchronous System Managed CF structure duplexing



RTE – ready to execute
RTC – ready to complete

Asynchronous System Managed CF structure duplexing



Values known to each system are likely different.

OSN = Operation Sequence Number
LCOSN = Last OSN completed by secondary
LCOSNP = LCOSN known to primary

Asynchronously duplexed structure may require “sync up” since secondary instance normally lags the primary

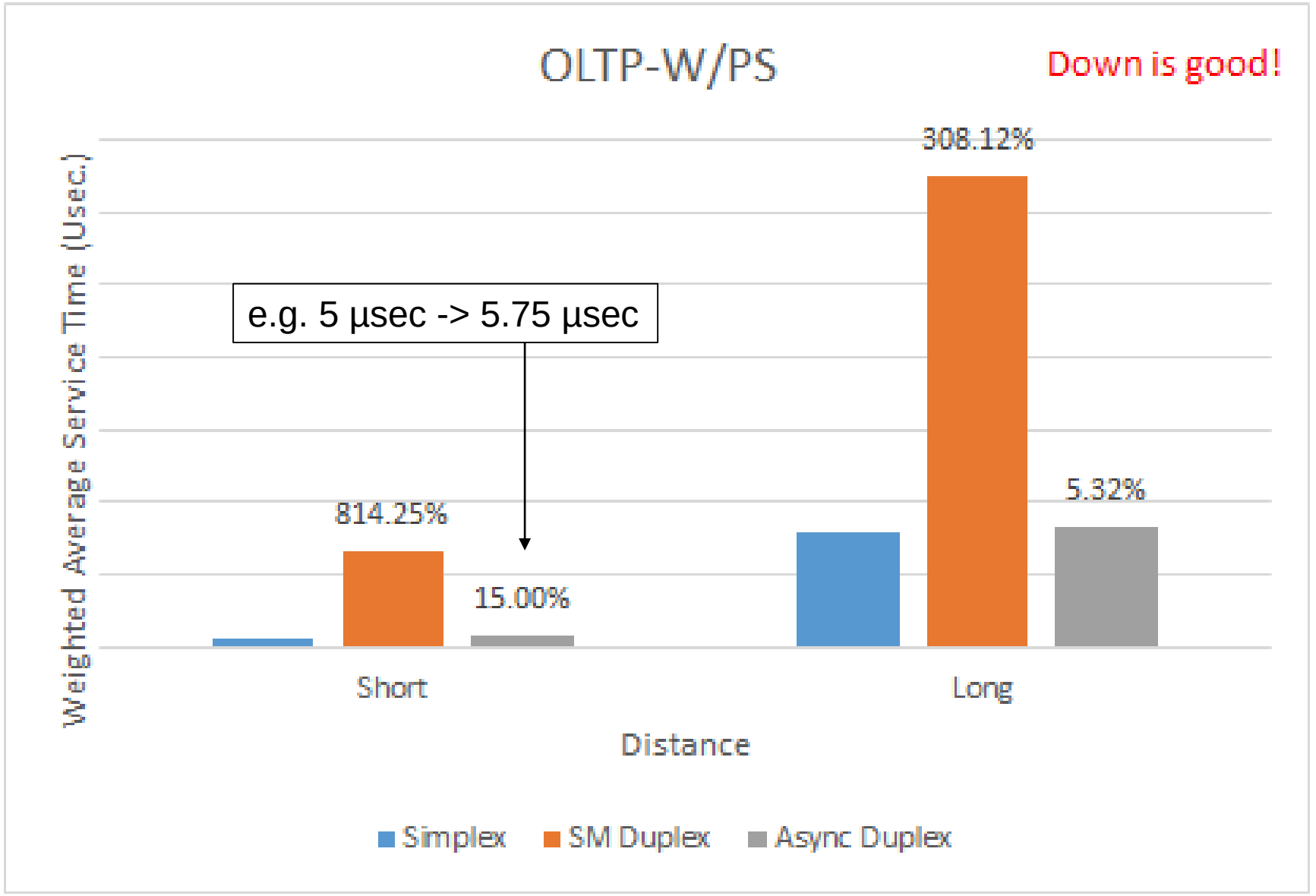
- z/OS may need to make sure the secondary instance gets caught up before it can allow traditional failure processing to proceed.
- So each system maintains a Secondary Update Recovery Table (SURT) to log local in-flight updates not yet known to have been hardened in the secondary structure instance.
- If sync up is needed, a sysplex wide coordinator is nominated to:
  - Gather the logs (SURTs) and use them to…
  - Reconstruct the final result of uncommitted in-flight requests, and
  - Update secondary instance to match the reconstructed results
- Connectors:
  - Might have requests held/delayed until sync up is completed
  - Might need to back out uncommitted transactions related to requests with ADupReqSeqNum values higher than the highest hardened request

Failover for async duplex might be a little slower than for sync duplex.

Applies when “lose” SURT for some connector

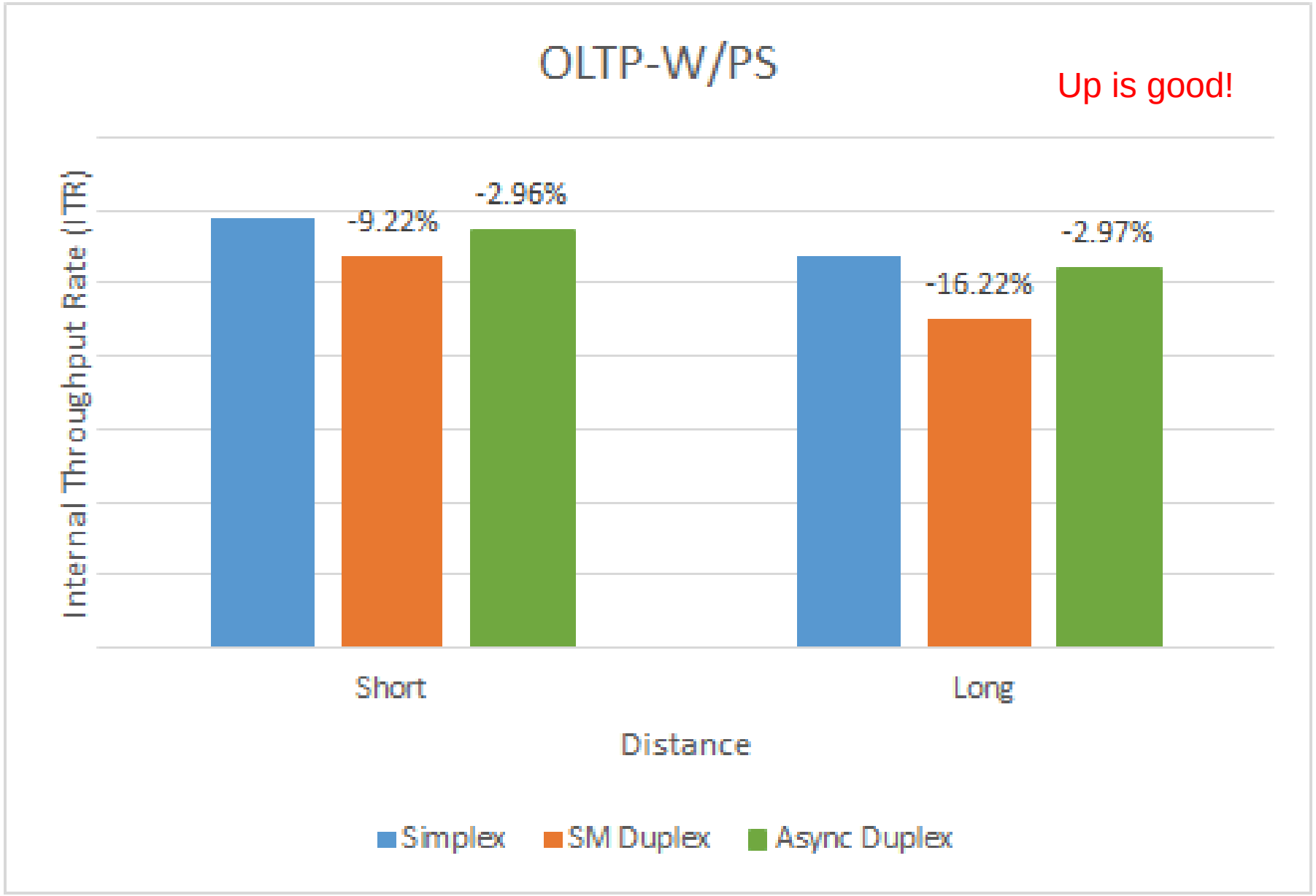
Is it really worth all this effort? …

Near simplex service times!



Short = 150m Long=10km

With less overhead!



Short = 150m Long=10km

Lock structure duplexing is now practical in more situations

- Performance is very similar to simplex operation
  - Even at distance !

- With all the benefits of robust duplex failure recovery
  - Though failover is a bit more work since secondary is not identical copy
  - And so recovery process is not necessarily transparent to exploiter

- Exploiter participation?
  - Not needed for lock structures without record data if connectors support system managed processes (XES can do it all)
  - Is needed for structures with record data
    - Exploiter must be prepared to roll back a transaction initiated by a failed connector that could not be committed because updates are missing in the surviving secondary
    - Db2 LOCK1 has record data

Requirements for Asynchronous Duplexing of CF lock structures

- At least two peer connected coupling facilities
  - CFLEVEL=21 minimum service level 02.16, or CFLEVEL=22 or higher
  - z13 GA2+, z13s, z14, z14 ZR1

- z/OS V2.2 with APARs:
  - OA47796, OA49148, OA51945, OA52015, OA52618
- z/OS V2.3 with APARs:
  - OA52618

- Db2® 12 with enabling APAR PI66689
- IRLM 2.3 with APAR PI68378

- All systems in the sysplex must be capable of doing async duplex protocols

  - Note: additional APARs may be required

RMF: CF Usage Summary

C O U P L I N G   F A C I L I T Y   A C T I V I T Y

PAGE 1

z/OS V2R2

SYSPLEX THEPLEX
RPT VERSION V2R2 RMF

START 01/05/2017-10.29.00
END 01/05/2017-11.29.00

INTERVAL 001.00.00
CYCLE 01.000 SECONDS

COUPLING FACILITY NAME = CFN7
TOTAL SAMPLES(AVG) = 1800 (MAX) = 1800 (MIN) = 1800

COUPLING FACILITY USAGE SUMMARY

GENERAL STRUCTURE SUMMARY

TYPE	STRUCTURE NAME	STATUS CHG	ALLOC SIZE	% OF CF STOR	# REQ	% OF ALL REQ	% OF CF UTIL	AVG REQ/ SEC	LST/DIR ENTRIES TOT/CUR	DATA ELEMENTS TOT/CUR	LOCK ENTRIES TOT/CUR	DIR REC/ DIR REC XI'S
LOCK	EXAMPLE_LOCK1	ACTIVE SEC A	250M	1.3	5555K	100	100	1543.0	531K 620	0 0	34M 1024	N/A N/A
	STRUCTURE TOTALS		250M	1.3	5555K	100	100	1543.0				

STATUS – Appending ‘A’ indicates that the structure is async duplexed (for this case, secondary structure instance)

RMF: Report of Coupling Facility Structure Activity

```
STRUCTURE NAME = EXAMPLE_LOCK1      TYPE = LOCK    STATUS = ACTIVE  PRIMARY ASYNC
          # REQ     -------------- REQUESTS --------------   -------------- DELAYED REQUESTS -------------
SYSTEM    TOTAL                #     % OF  -SERV TIME(MIC)-    REASON     #    % OF  ---- AVG TIME(MIC) -----  EXTERNAL REQUEST
NAME      AVG/SEC              REQ    ALL     AVG   STD_DEV              REQ    REQ   /DEL     STD_DEV   /ALL   CONTENTIONS

SYS1        300M   SYNC     294M    52.6     4.6     4.5     NO SCH     1     0.0  140.0        0.0     0.0   REQ TOTAL       395M
          83299    ASYNC   5649K     1.0    64.6    21.8                                                       REQ DEFERRED   2054K
                   CHNGD       0     0.0  INCLUDED IN ASYNC                                                    -CONT          1897K
                                                                                                               -FALSE CONT     267K

SYS2        259M   SYNC     254M    45.5     4.6     4.1     NO SCH     1     0.0  146.0        0.0     0.0   REQ TOTAL       345M
          72049    ASYNC   5134K     0.9    64.8    21.8                                                       REQ DEFERRED   2003K
                   CHNGD       0     0.0  INCLUDED IN ASYNC                                                    -CONT          1922K
                                                                                                               -FALSE CONT     233K

-------------------------------------------------------------------------------------------------------------------------------
TOTAL       559M   SYNC     548M    98.1     4.6     4.3     NO SCH     2     0.0  143.0        4.2     0.0   REQ TOTAL       740M
          155.3K   ASYNC     11M     1.9    64.7    21.8                                                       REQ DEFERRED   4057K
                   CHNGD       0     0.0                                                                      -CONT          3819K
                                                                                                               -FALSE CONT     500K
```

```
STRUCTURE NAME = EXAMPLE_LOCK1      TYPE = LOCK    STATUS = ACTIVE  SECONDARY ASYNC
          # REQ     -------------- REQUESTS --------------   -------------- DELAYED REQUESTS -------------
SYSTEM    TOTAL                #     % OF  -SERV TIME(MIC)-    REASON     #    % OF  ---- AVG TIME(MIC) -----  EXTERNAL REQUEST
NAME      AVG/SEC              REQ    ALL     AVG   STD_DEV              REQ    REQ   /DEL     STD_DEV   /ALL   CONTENTIONS

SYS1       2797K   SYNC    2797K    50.4    17.0     3.5     NO SCH     0     0.0    0.0        0.0     0.0   REQ TOTAL       395M
          777.1    ASYNC       0     0.0     0.0     0.0                                                       REQ DEFERRED   2054K
                   CHNGD       0     0.0  INCLUDED IN ASYNC                                                    -CONT          1897K
                                                                                                               -FALSE CONT     267K

SYS2       2757K   SYNC    2757K    49.6    15.6     3.6     NO SCH     0     0.0    0.0        0.0     0.0   REQ TOTAL       345M
          766.0    ASYNC       0     0.0     0.0     0.0                                                       REQ DEFERRED   2003K
                   CHNGD       0     0.0  INCLUDED IN ASYNC                                                    -CONT          1922K
                                                                                                               -FALSE CONT     233K

-------------------------------------------------------------------------------------------------------------------------------
TOTAL      5555K   SYNC    5555K     100    16.3     3.6     NO SCH     0     0.0    0.0        0.0     0.0   REQ TOTAL       740M
          1543     ASYNC       0     0.0     0.0     0.0                                                       REQ DEFERRED   4057K
                   CHNGD       0     0.0                                                                      -CONT          3819K
                                                                                                               -FALSE CONT     500K
```

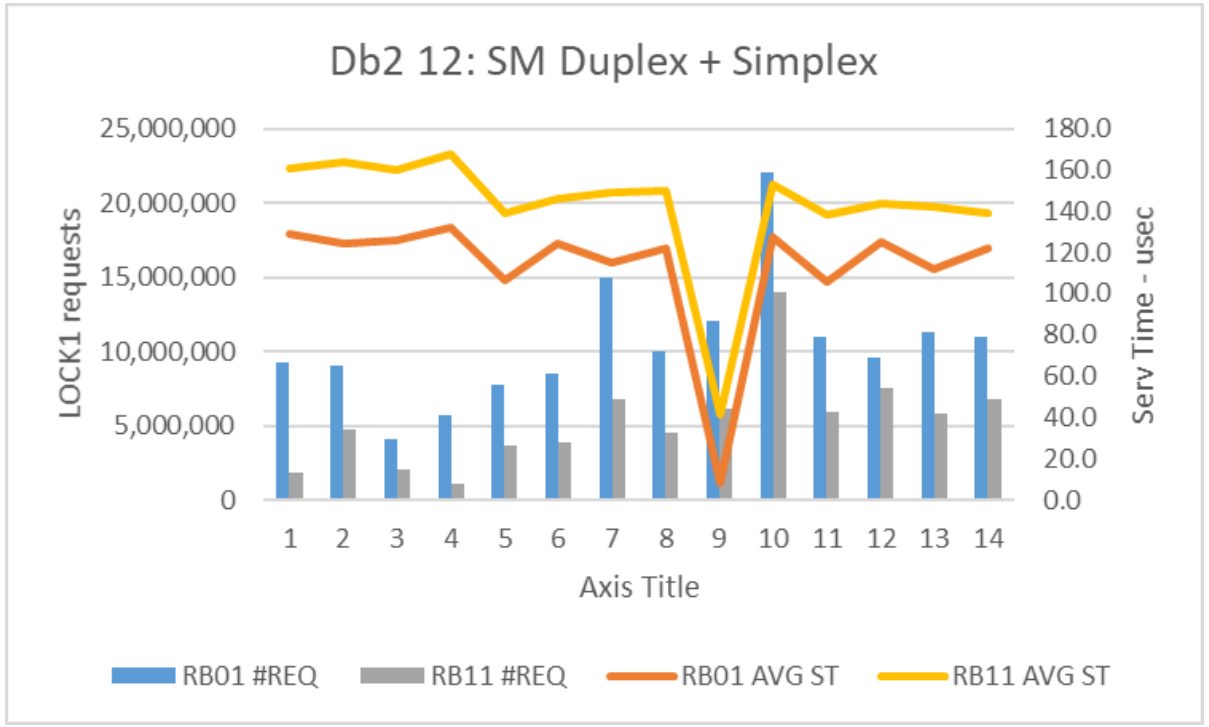
RMF: Report of Coupling Facility Structure Activity (continued)

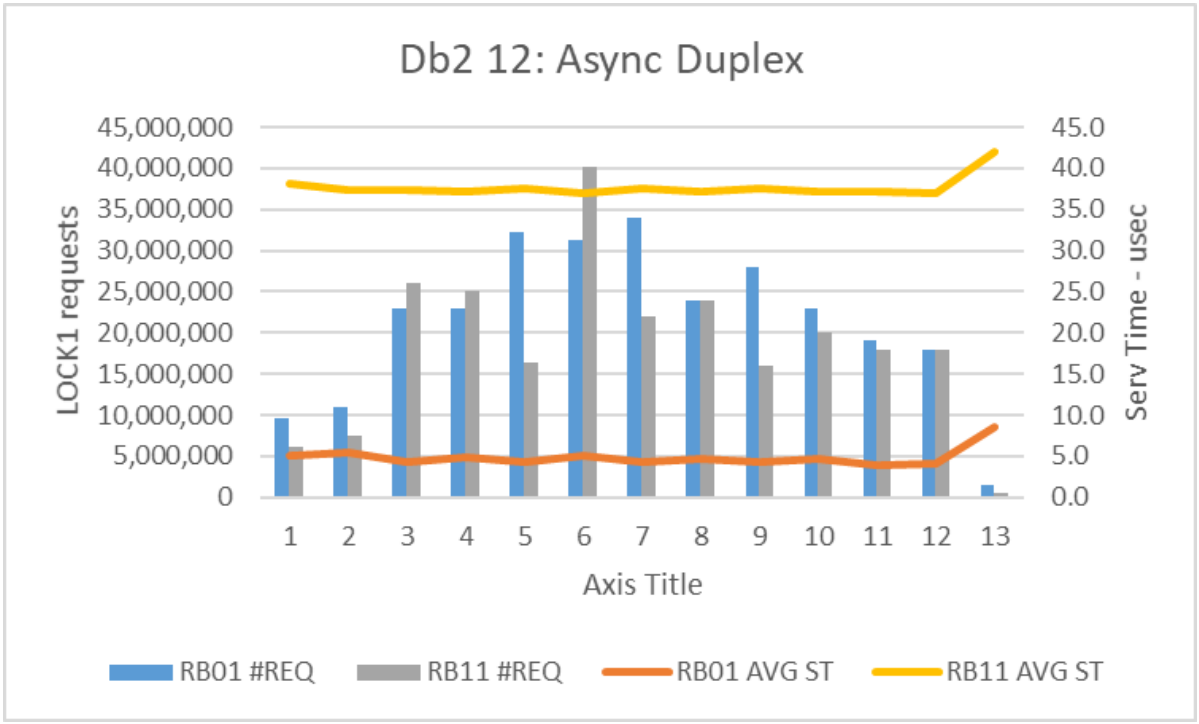
Things to note in the reports (prior slide):

- Big difference in number of requests to each lock structure instance
  - Primary instance is target for the actual lock requests
  - Secondary is target for “inquiries” as to progress
- Response times are different
  - Locks vs “inquiries”
  - The requests have very different natures

Customer experience

— European bank
- 2 sites, 2-3 km apart
- Had deployed System Managed duplexing except on first workday of each month
  - Too expensive then
- Now use async CF duplexing on all days of the month

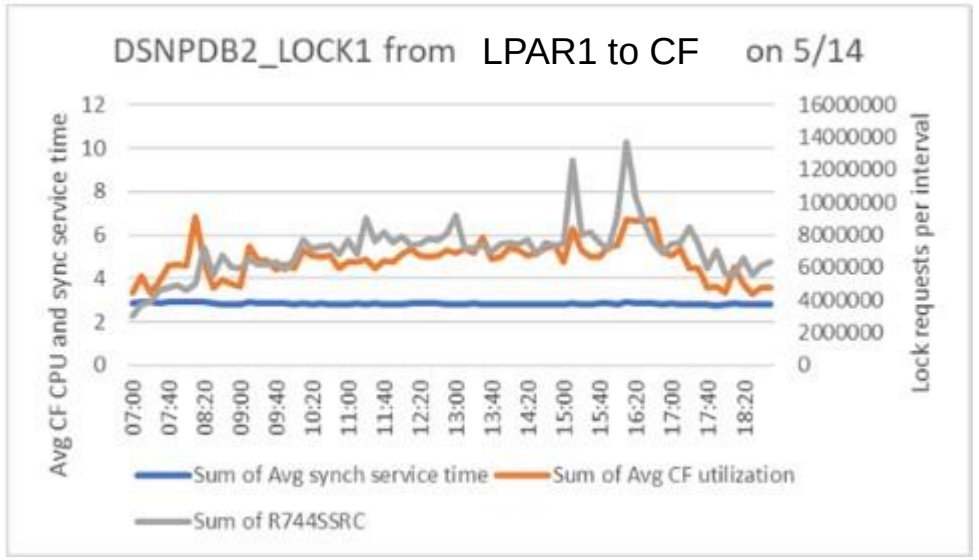


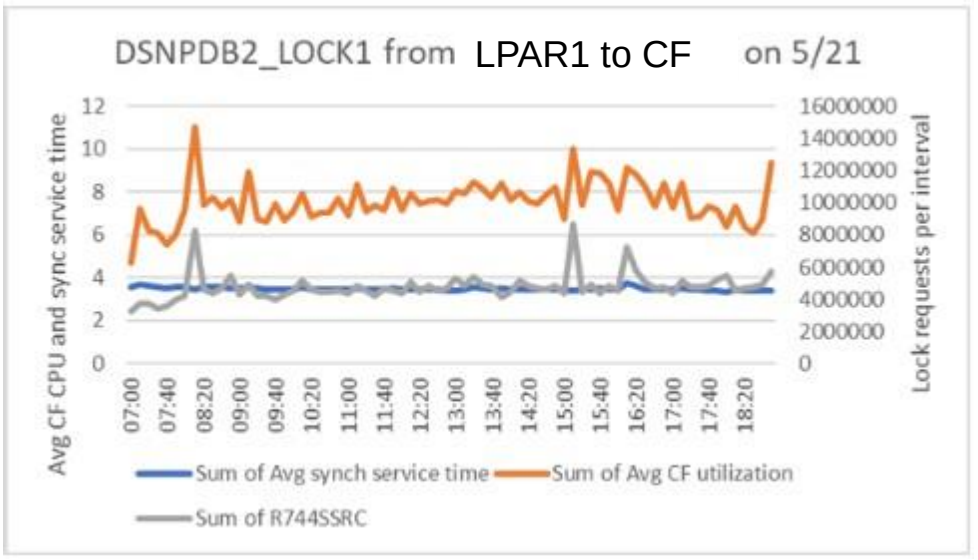


Customer experience

— North American bank (1|2)

- Had 2-CEC and 2-ICF configuration, and was exposed to ‘double failure’ situation; chose not to use synchronous SMD (although did test it)
- Implemented asynchronous SMD earlier this (2019)





Customer experience

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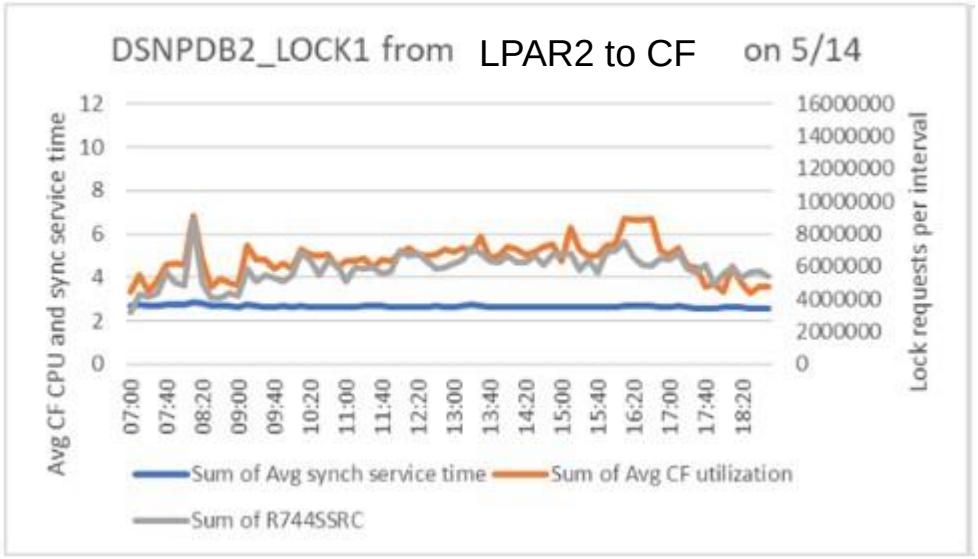

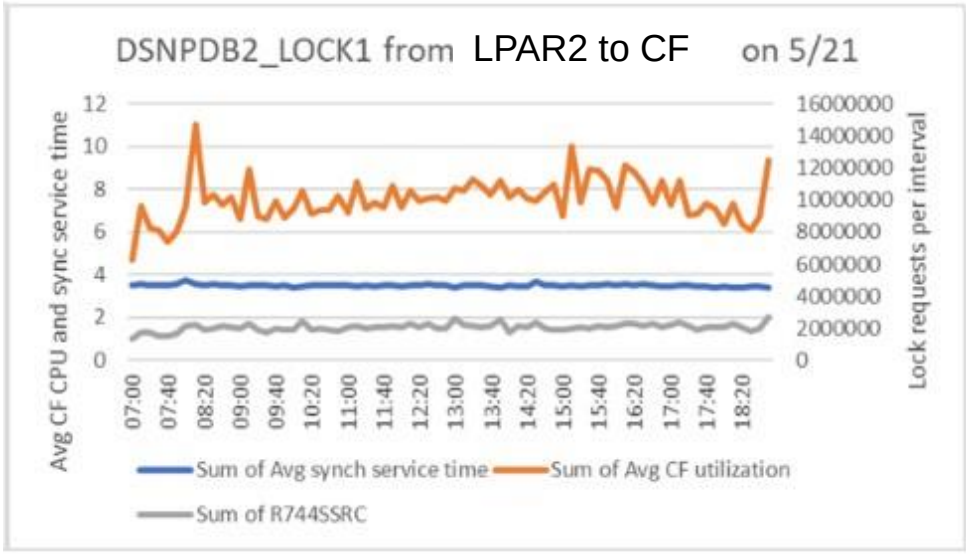

Are you a candidate for async CF duplexing?

— Are you System Managed duplexing your LOCK1 structure?

- Should you be?
- Are you exposed to the availability risk of not duplexing your LOCK1 and SCA?

— If you are a candidate for asynchronous CF duplexing, please let me know.

- This technology can be very helpful, and there are a number of shops that should be doing this.

Questions?

— ? ? ?

Session summary

— Asynchronous CF duplexing for lock structures provides

- Robust failure recovery
- Simplex-like response time
- Even at distance

— Request: are you interested in deploying async systems managed duplexing?

- I am interested in working with you.
- Please consider sharing your data; I will anonymize it…

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