CICS and Recovery

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IBM Hursley

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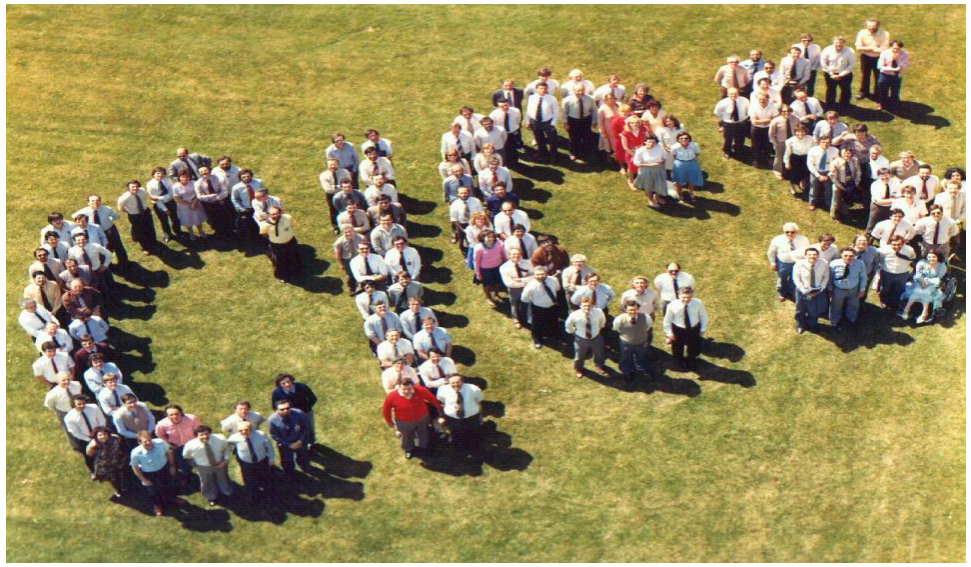
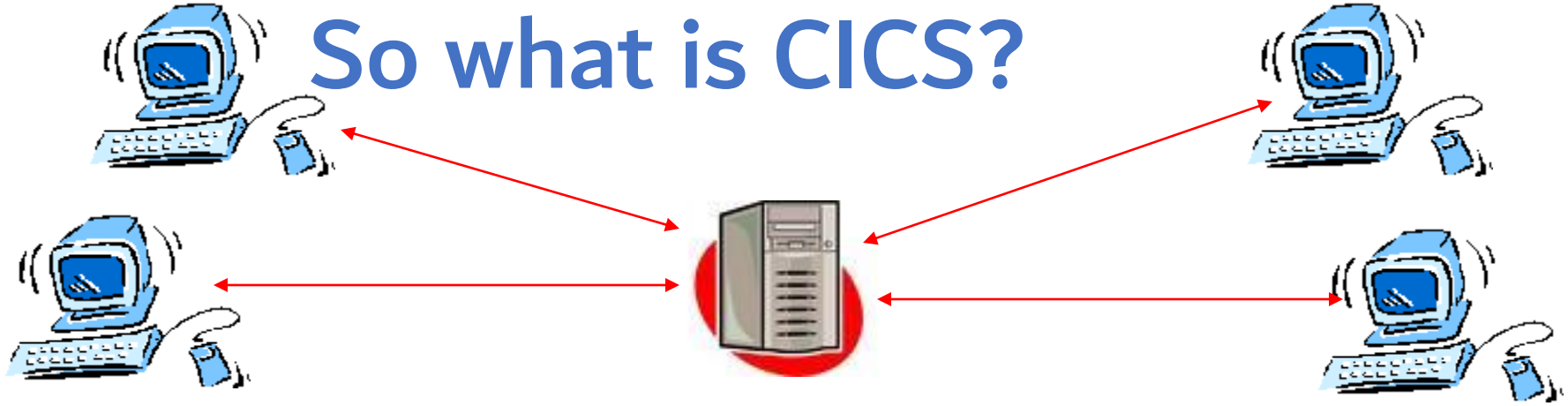
Some background

- I work at IBM Hursley Park
  - near Winchester, Hampshire
  - IBM software development Lab
    - e.g. CICS, WebSphereMQ, etc
  - Hursley House was built in the 1720s
    - used as hospital in WW1
    - used by Vickers in WW2
      - Spitfire development
  - IBM arrived in 1958
    - many new buildings added
  - www.ibm.com/

Some Hursley sights



So what is CICS?

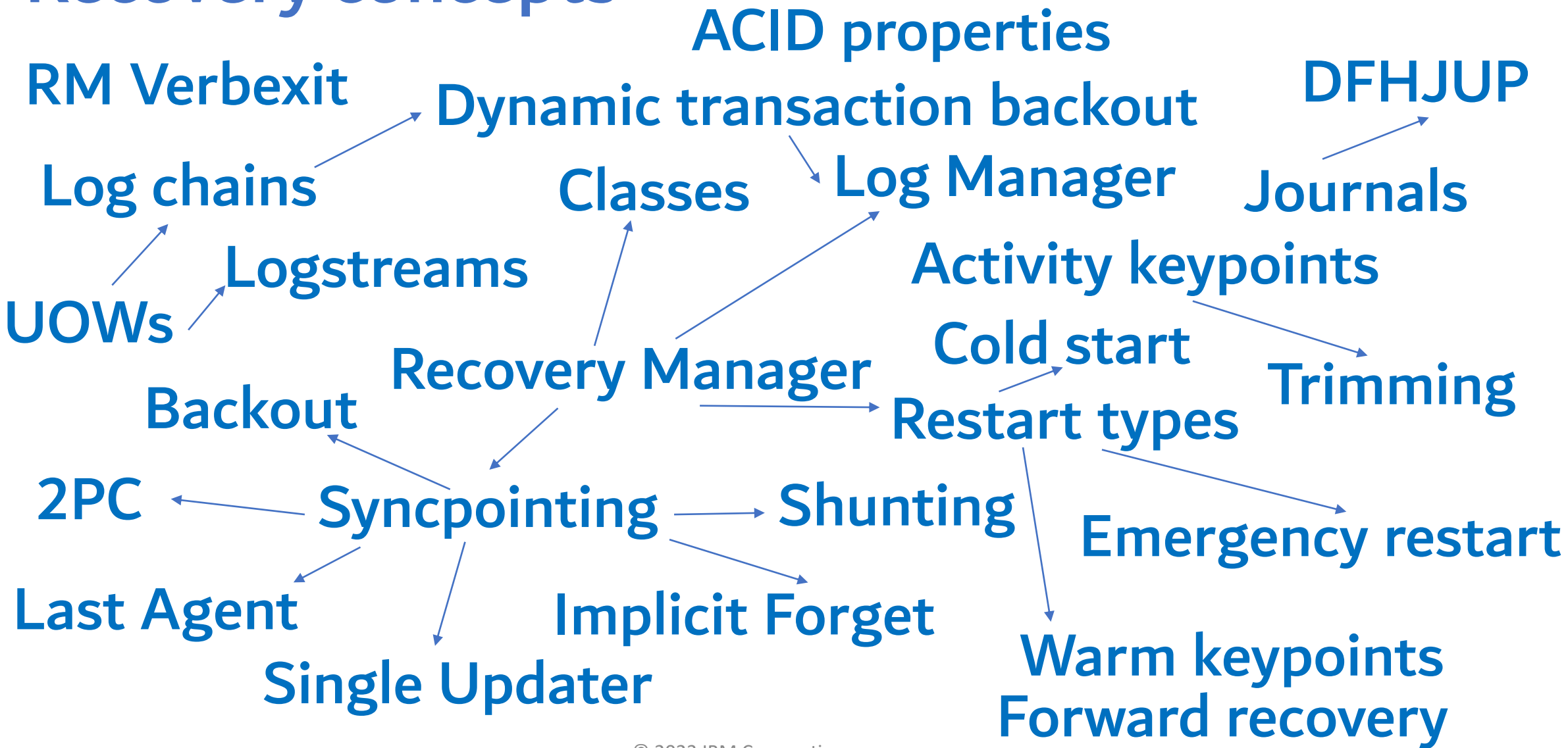


- the world's premier transaction processing software
  - originally developed in 1968
  - many new releases developed over the years
  - acts as middleware between the operating system and its users
  - used by many Fortune 500 companies
    - insurance, stock control, reservations, banking (e.g. ATMs), government, commerce (e.g. market trading), retailing …
  - runs user programs in Java, C, assembler, COBOL, PL1
    - the latest versions support SOAP, Web Services, JSON …

Recovery concepts

Where to start..?

Recovery concepts



Atomic properties of transactions

- ***Bernstein, Hadzilacos, Goodman***
- "The goal of concurrency control and recovery is to ensure that transactions execute atomically, meaning that
  - each transaction accesses shared data without interfering with other transactions, and
  - if a transaction terminates normally, then all of its effects are made permanent; otherwise it has no effect at all." *

- * P.A. Bernstein, V. Hadzilacos, N. Goodman - Concurrency Control and Recovery in Database Systems, 1987

ACID properties

- **Atomic**
  - All changes to data are performed as if they are a single operation. That is, all the changes are performed, or none of them are.
- **Consistent**
  - Data is in a consistent state when a transaction starts and when it ends.
- **Isolated**
  - The intermediate state of a transaction is invisible to other transactions.
- **Durable**
  - After a transaction successfully completes, changes to data persist and are not undone, even in the event of a system failure.

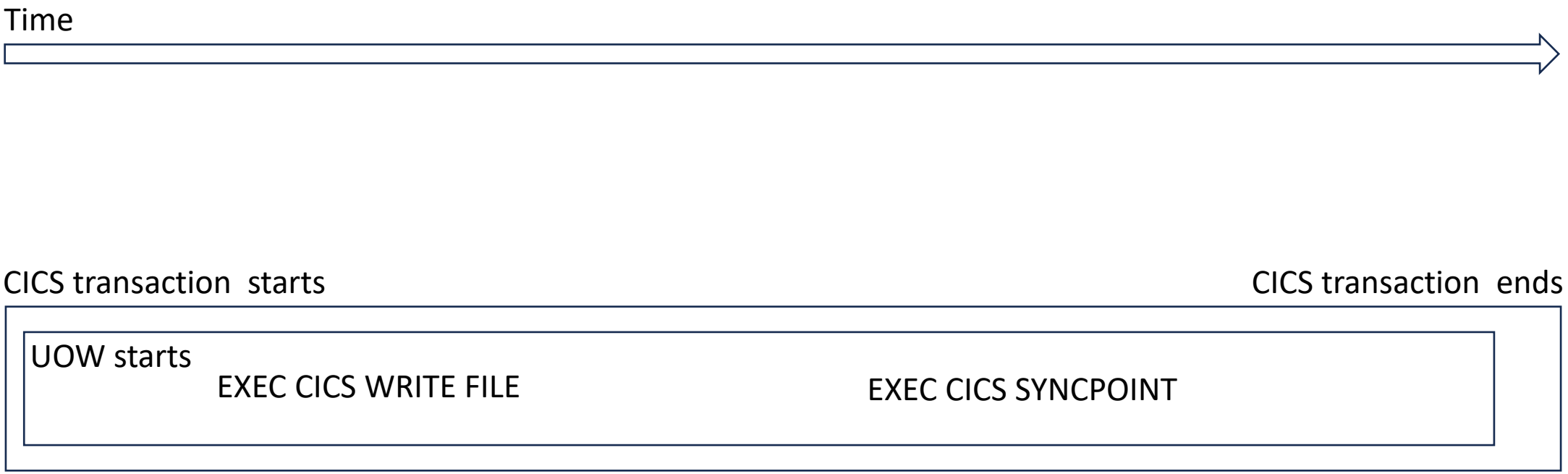
But just what *is* a transaction??

- A complete set of recoverable operations performed by a transaction processor such as CICS
- Adherence to ACID properties, so work is committed or all backed out, etc
- Such indivisible sets of operations are known as *transactions* in the industry
- In CICS they are referred to as *Units of Work (UOWs)*
  - *Other terms include Units of Recovery (UORs)*
- A CICS "transaction" is the environment for an application performing work
  - It can contain one or multiple UOWs
- A CICS transaction is **not** the same as a Unit of Work!
  - CICS Transaction Manager handles transactions
  - CICS Recovery Manager handles Units of Work
- You often hear CICS transactions called tasks – the terms get interchanged

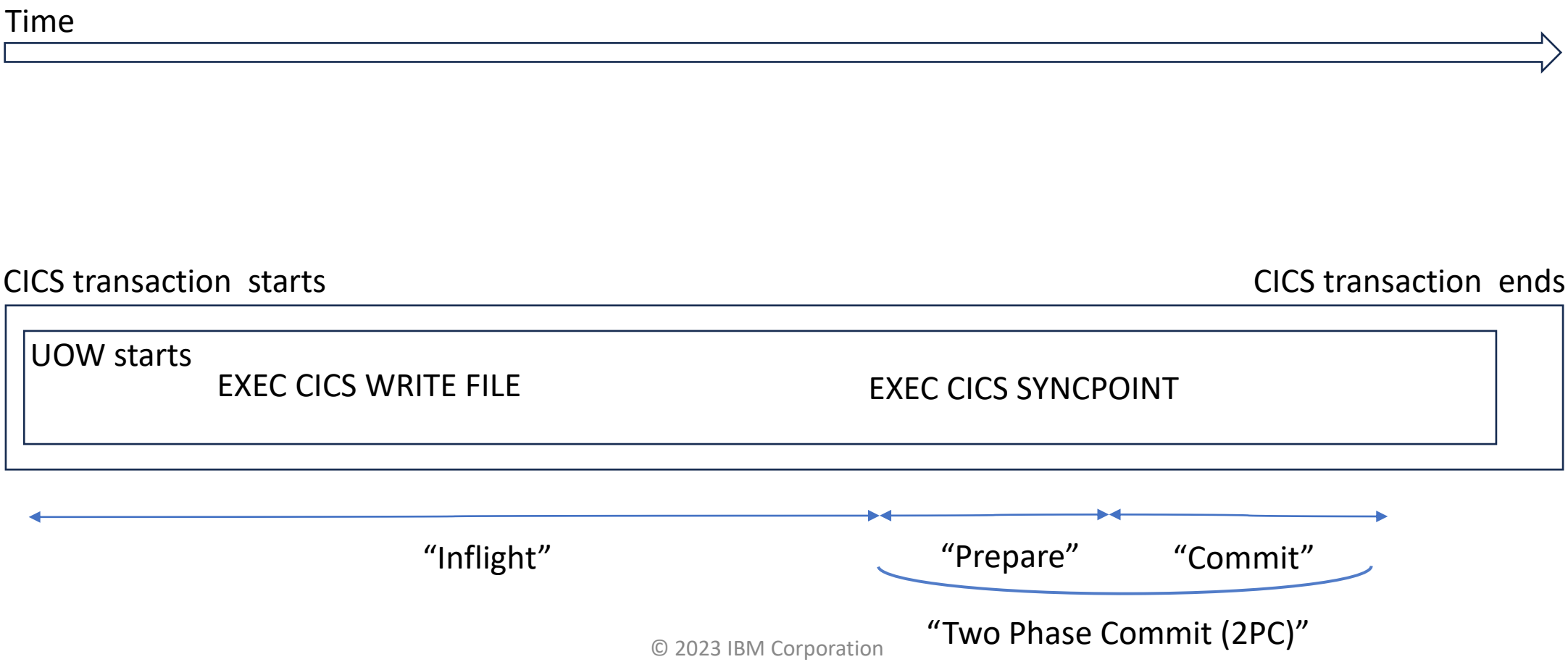
Units of Work and syncpoints

- A Unit of Work includes all the recoverable operations that a task wants to perform in CICS as one logical set of work
  - Updates to files
  - Changes to data bases
  - Reads and writes to queues of data
  - etc
- When the task wants to commit these it can either end (a final EXEC CICS RETURN) or commit them (EXEC CICS SYNCPOINT)
  - The end of task EXEC CICS RETURN drives an implicit syncpoint
  - The EXEC CICS SYNCPOINT ends this UOW and begins another

A stroll through a Unit of Work



A stroll through a Unit of Work



A comparison with a wedding...

- A Unit of Work and its syncpoint can be loosely compared with a wedding...
- The couple meet
  - *(The task starts, its UOW starts)*
- They spend time together
  - *(The UOW carries out recoverable operations)*
- They decide to get married
  - *(The task issues EXEC CICS SYNCPOINT and the UOW enters syncpoint processing)*
- People can object to the wedding or not)
  - *(The UOW prepares itself – Phase 1)*
- The wedding goes ahead
  - *(The UOW logs the fact it is committing, then does the commit work – Phase 2)*
- **Or...** the wedding is stopped because someone objected...
  - *(The UOW logs the fact it is backing out, then does the backout work)*

Stretching the comparison…

- The person conducting the wedding = CICS Recovery Manager
- The paperwork and wedding certificate = CICS Log Manager

- Recovery Manager:
  - Maintains the status and progress of the Units of Work (UOWs)
  - Coordinates recoverable changes made by local resource managers
  - Coordinates recoverable conversations with other remotely connected systems
  - Uses system log information to reconstruct UOWs over restarts

- Log Manager
  - Writes log data to the CICS system logs DFHLOG and DFHSHUNT
  - Writes user data to user logs
  - Maps log definitions to z/OS logstreams

Logs, Logstreams and Journals

- CICS system log data written to DFHLOG (primary logstream)
  - DFHSHUNT (secondary logstream) also provided, for “long duration” data
- Logs maps to a logstream
  - Owned by the z/OS Logger subsystem
  - Reside on CF or DASD
- Other journals are for “general logs”
  - Autojournalling of files
  - Forward recovery
  - Replication logging
  - Terminal I/O logging
  - Security audit logs

Backwards and forwards recovery

- CICS uses the system log for backward recovery
  - “Before images” of resources being changed
  - Used to restore recoverable resources to a previously committed state
- CICSVR (for example) provides forward recovery
  - Using “After images” of VSAM records that were changed
  - Used to restore data sets to the state they were in before being damaged
- General logs may not used for recovery purposes at all

Restart types

- INITIAL
  - A completely fresh run of CICS
- COLD
  - Local resources are reinstated from the CSD; remote obligations are preserved
- AUTO
  - WARM
    - The system is restored to its previous state from before a controlled shutdown
  - EMERGENCY
    - The system is restored to its previous state from before an uncontrolled shutdown
- The restart types make use of the system log in different ways

Log chains

- CICS writes out blocks of records to the system log
- Each block contains records for 1 to many log chains
- Each log chain is associated with a UOW
- The log can be read sequentially
  - Backwards one record at a time
- A log chain can be read individually
  - Backwards one record on the chain at a time

Log chains

Block n-1

The past

"Now"

Time

Log chains

Block n-1

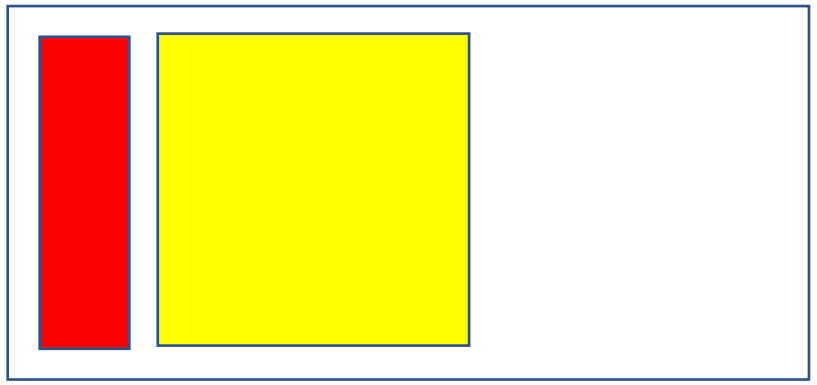
The past

"Now"

Time

Log chains

Block n-1



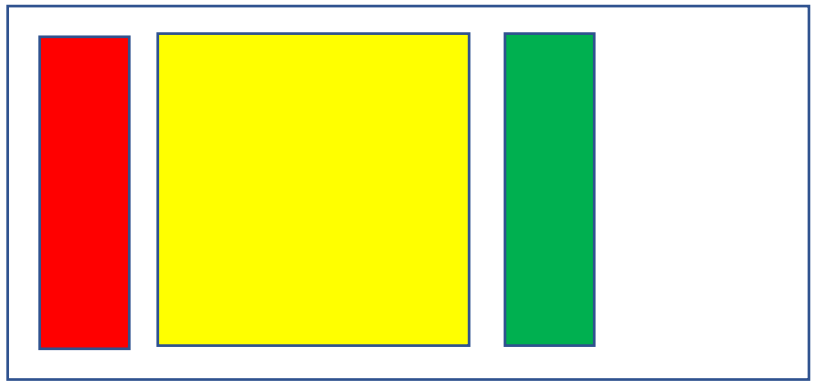
The past

"Now"

Time

Log chains

Block n-1



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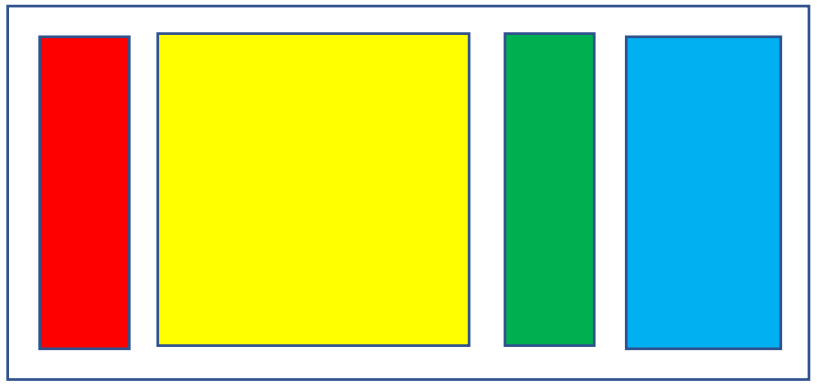

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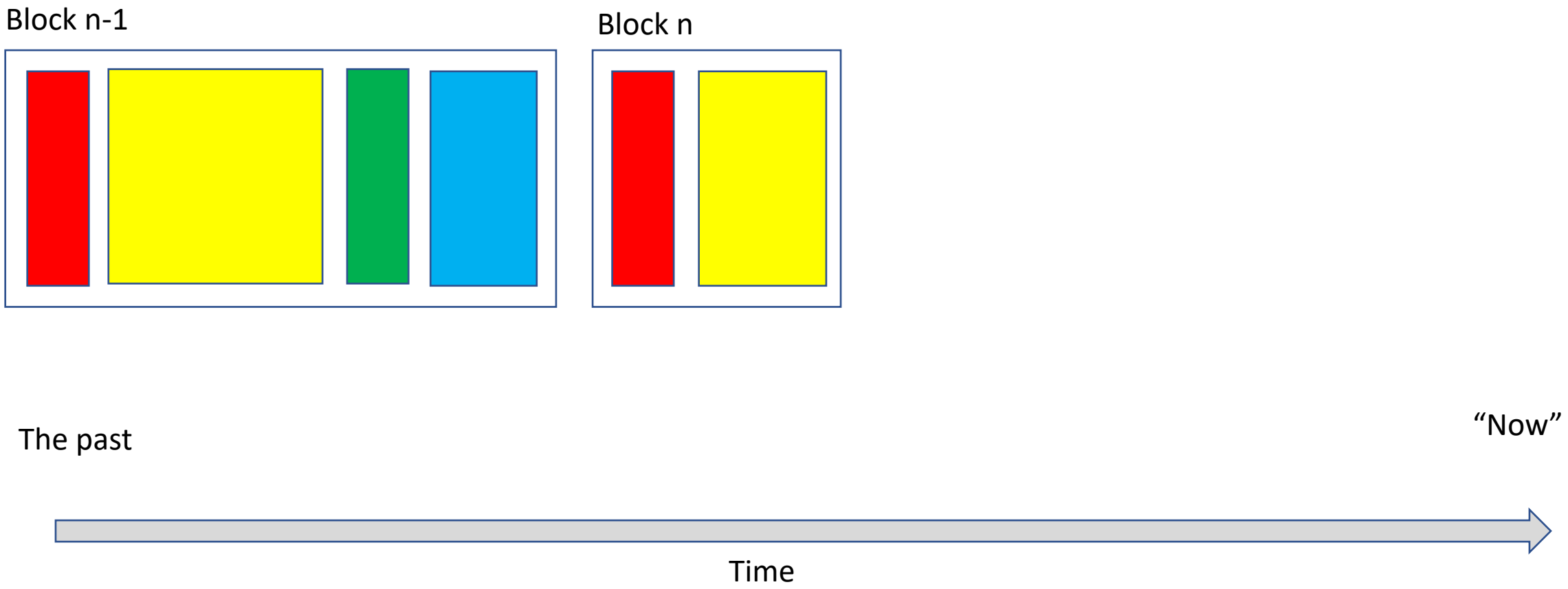

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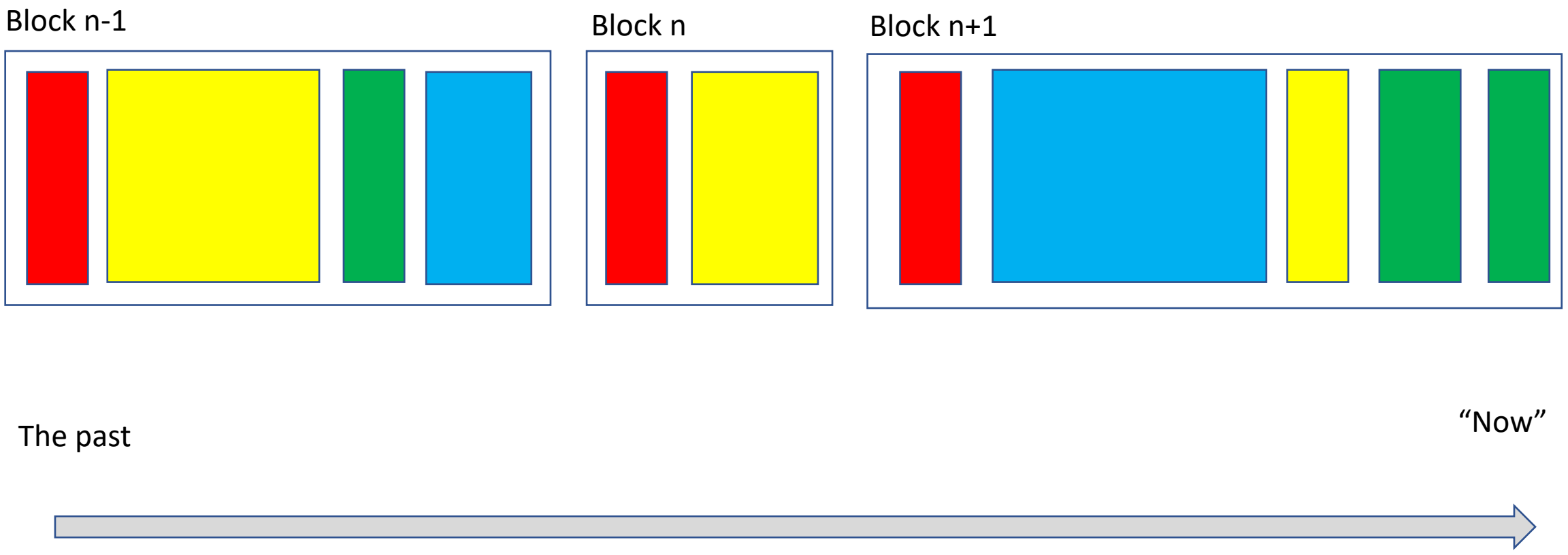

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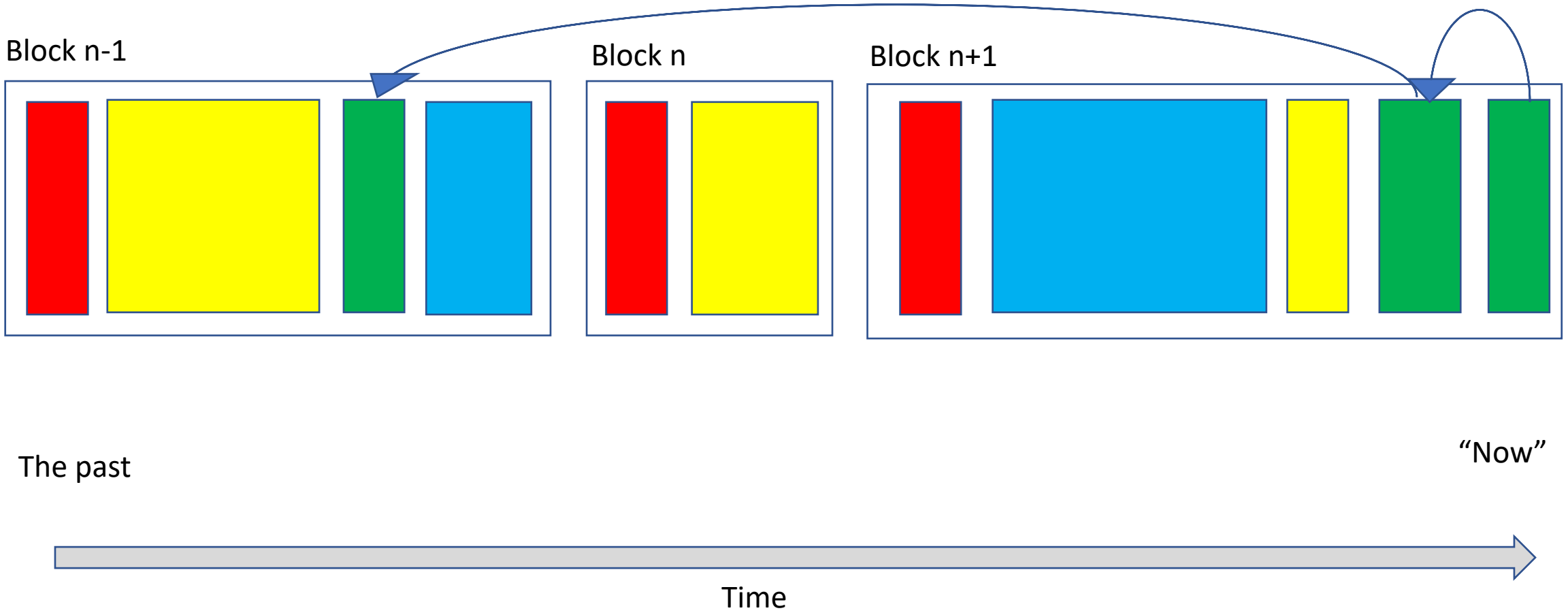

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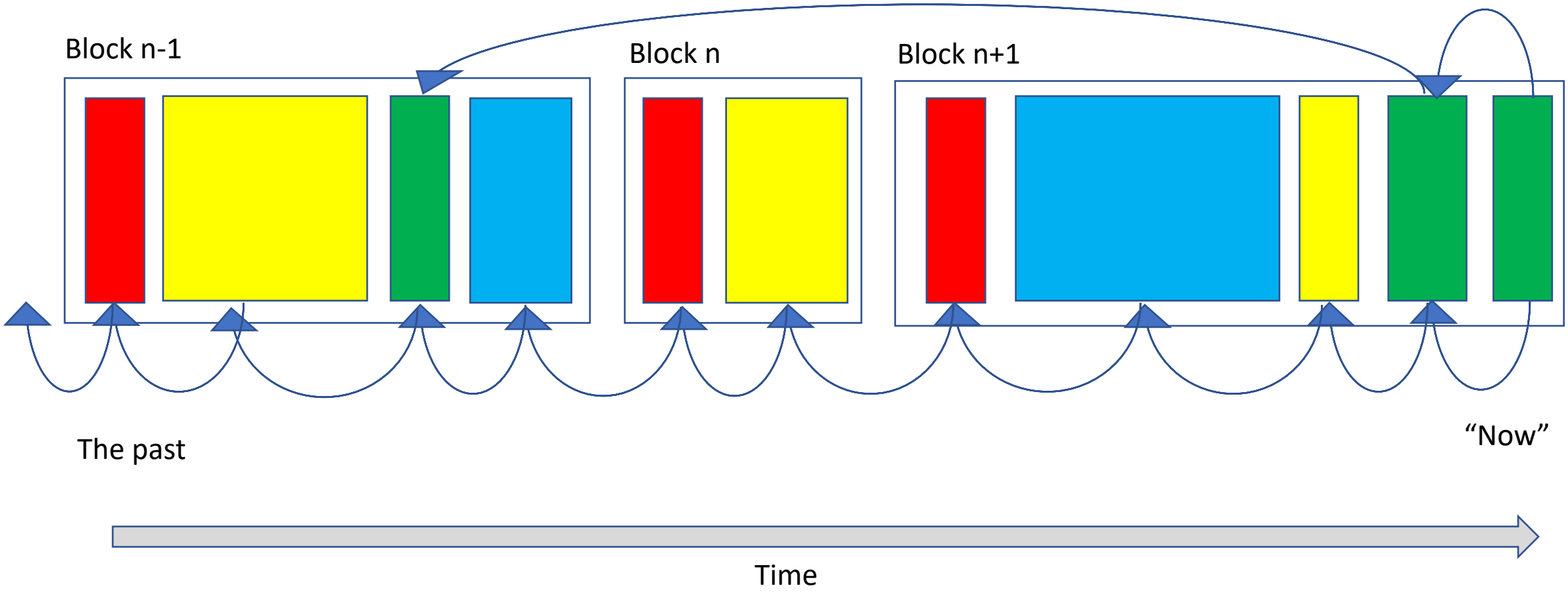
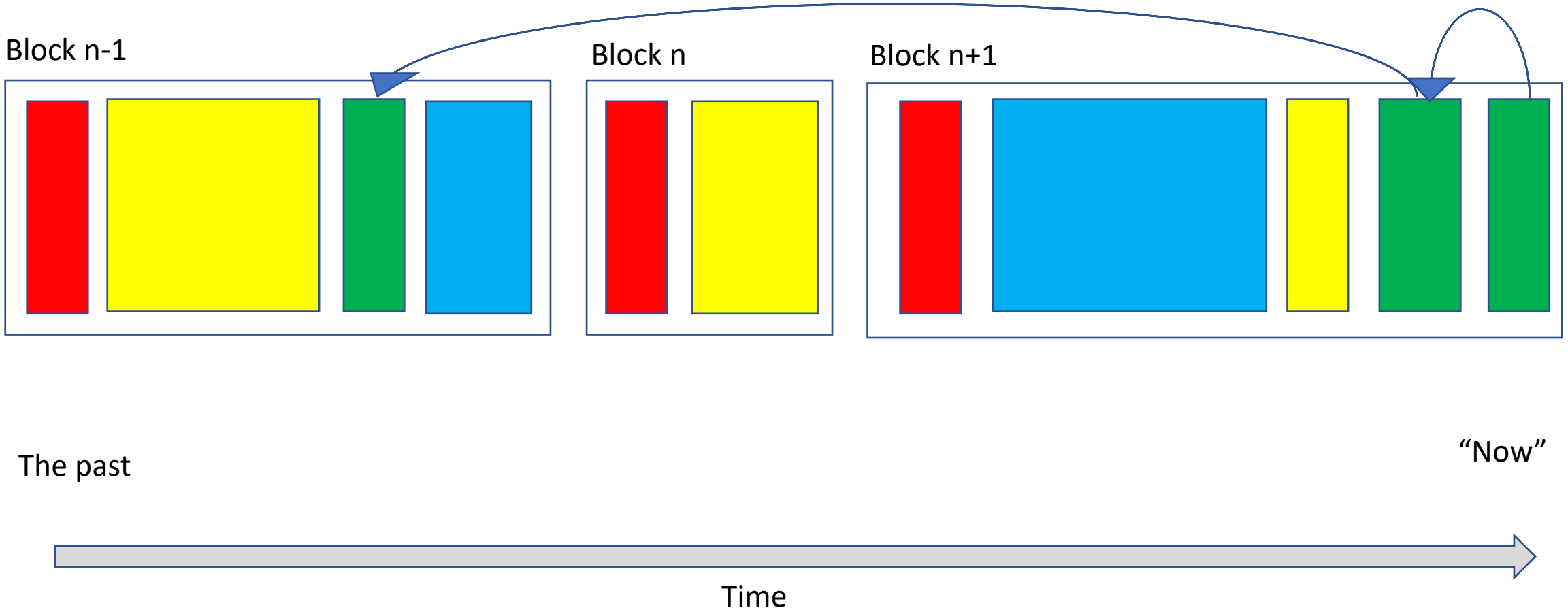


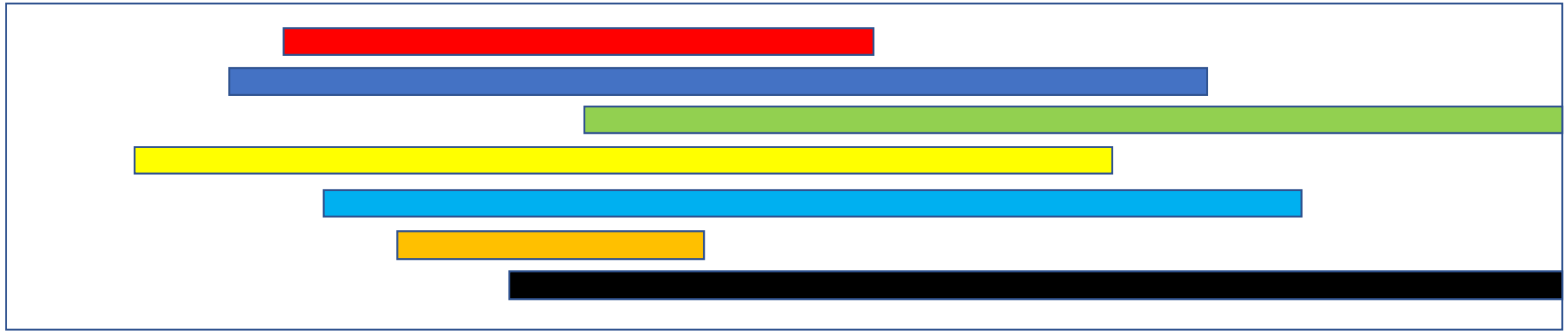
DTB – reading one log chain

- Driven as the result of
  - An abend
  - An EXEC CICS SYNCPOINT ROLLBACK
- Recovery Manager calls Log Manager to read back the UOW log chain
- Records are presented to the appropriate client to back out changes

DTB – reading one log chain



Chain and Stream history points

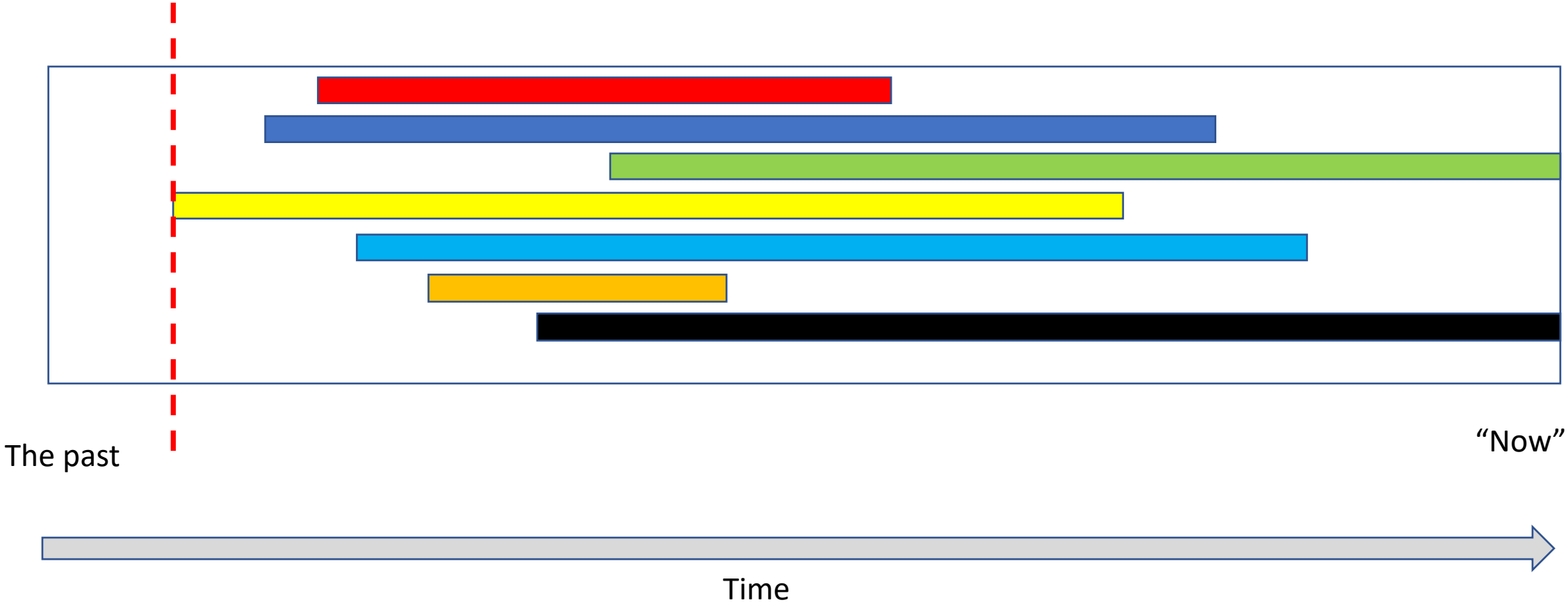


The past

"Now"

Time

Chain and Stream history points



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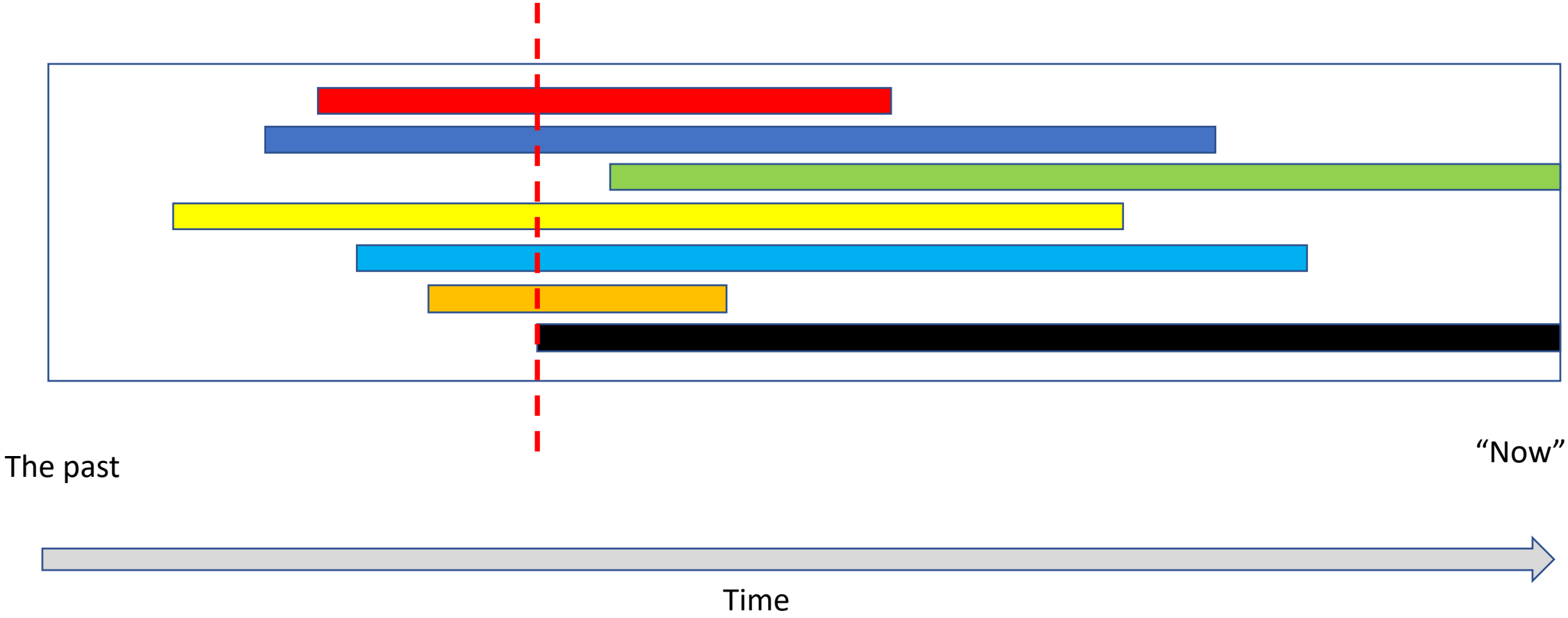


Two phase commit sequence

- Driven by EXEC CICS SYNCPOINT, EXEC DLI TERM, etc
- Recovery Manager drives 2PC processing for remote coordination
- Phase 1 is **Prepare**
  - The local resources are polled to vote
  - The remote systems are polled to vote
  - If clients vote yes they must be prepared to commit forwards if told to later
    - Remote systems enter an **Indoubt** phase until told which way to commit
- CICS logs the fact the UOW is committing forwards
- Phase 2 is **Commit**
  - The remote systems are called to commit
  - The local resources are called to commit

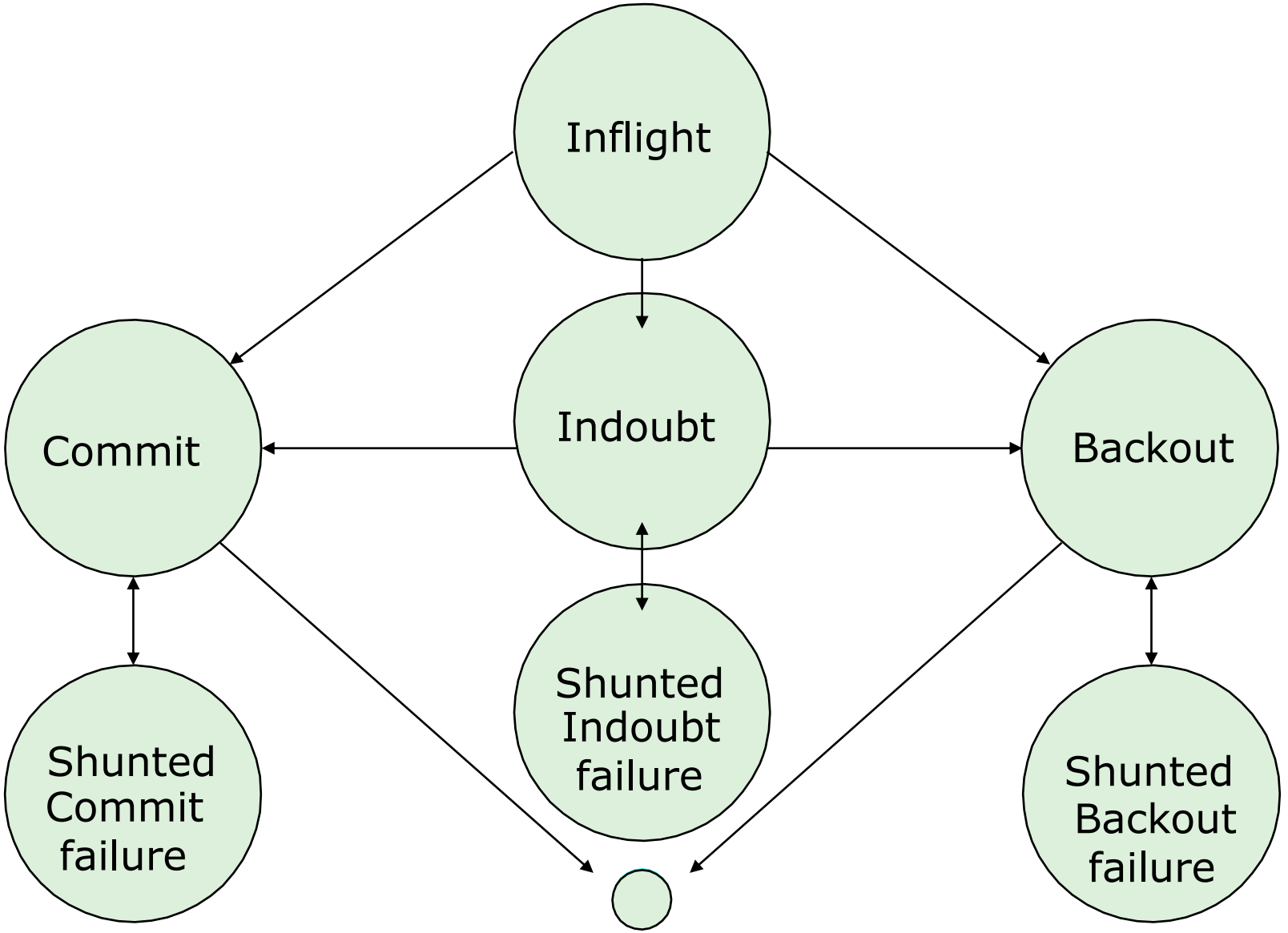
Backout (commit backwards) sequence

- Driven by EXEC CICS SYNCPOINT ROLLBACK, an ABEND, etc
- Backout is a single phase process to commit backwards
  - The remote systems are called to commit backwards
  - The local resources are called to commit backwards
- Resource managers do not need to prepare to backout
  - Note - “Any resource manager worth its salt should default to backout”
- CICS logs the fact the UOW has committed backwards

Shunting and unshunting

- CICS can shunt UOWs that fail at key moments during a syncpoint
- A shunted UOW awaits resolution of an indoubt failure, a commit failure or a backout failure
  - Recovery manager attempts to complete a shunted UOW when the failure that caused it to be shunted has been resolved
- Shunting releases resources such as terminals, user programs, working storage, etc, normally by abending the transaction
  - CICS retains locks on recoverable data until it can attempt an unshunt
- Shunted UOW log data tends to persist for longer durations, so is moved from DFHLOG to DFHSHUNT
  - **Note** - DFHSHUNT is not just for shunted UOW's log records

Shunted Unit of Work state



Last Agent

- Recovery Manager invokes every participating system to prepare
- The final one can be called **directly** to commit
- CICS passes the coordination role to this system
  - **Note** – the old coordinating system is now Indoubt
- The new coordinator will then either commit forwards or backwards (backout)
- This response is returned to the old coordinator which does the same
- It then instructs its own participants to do likewise
- **Note** – Last Agents may be daisy-chained

Single Updater

- An optimized form of Last Agent
- When the coordinator passes the role to a Last Agent, and no local logging has occurred up to this point
- This means the old coordinator is not indoubt
  - It doesn't care which way it commits

Implicit Forget

- The coordinator could wait for a response to each commit
  - This would delay processing
- Implicit Forget avoids this
- Recovery Manager retains the UOW and its state information
  - Decouples from the communication layer object (e.g. session)
  - The session can be reused by another task
  - When data is sent down the session, the code notifies CICS of this
  - CICS can now forget the remote system (and potentially the old UOW)

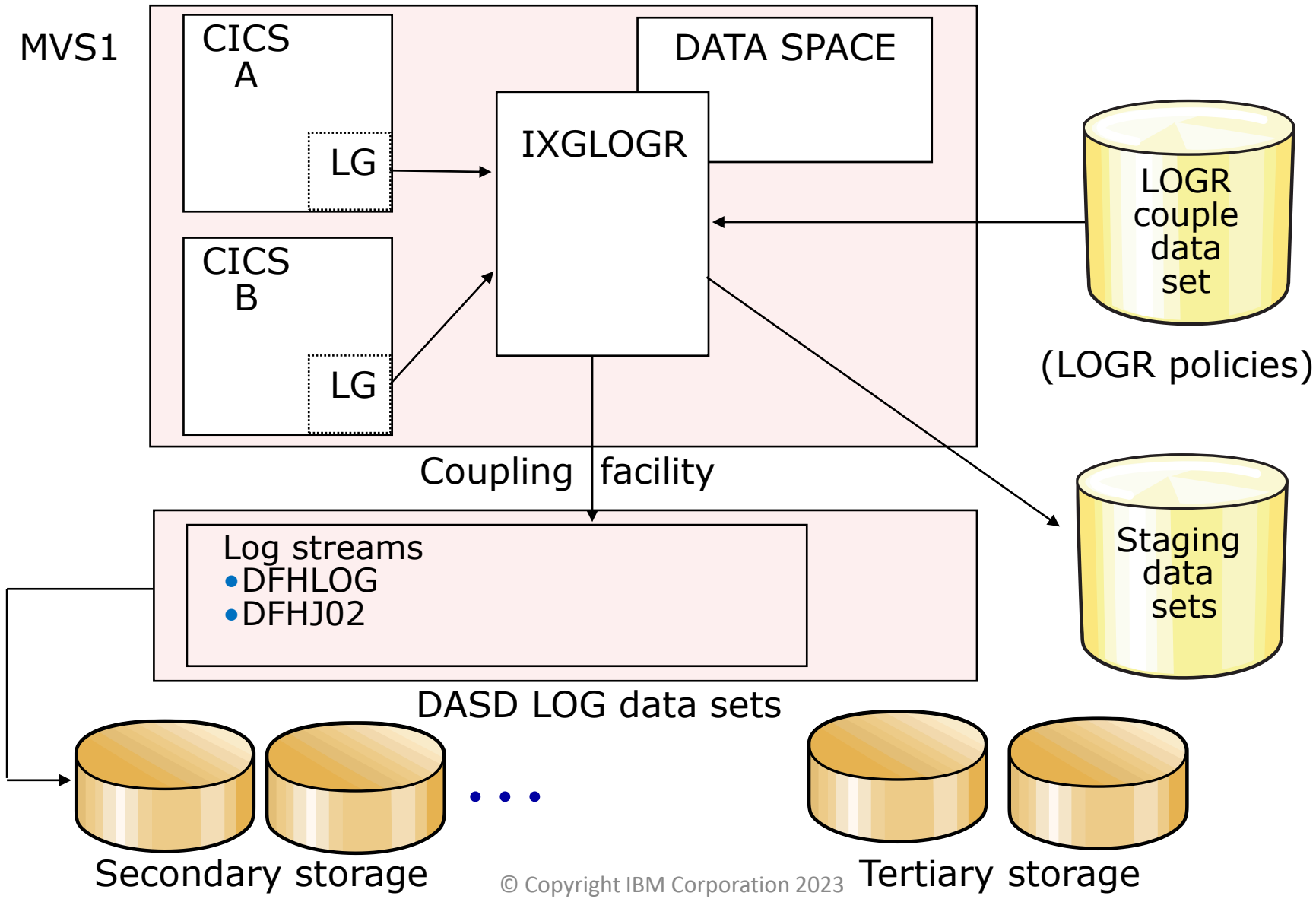
Keypointing

- Driven by AKPFREQ being reached
- Causes a CSKP system transaction to be attached
  - Note - You cannot attach CSKP by entering it at a terminal
- Keypointing will write state data to DFHLOG
- It also will trim DFHLOG and DFHSHUNT
- Important messages:
  - **DFHRM0205** *date time applid* **An activity keypoint has been successfully taken.**
  - **DFHLG0743** *date time applid* **Tail of log stream** *lsn* **deleted at block id** *X'blockid'*.
  - **DFHLG0760** *date time applid* **Log stream** *lsn* **not trimmed by keypoint processing. Number of keypoints since last trim occurred:** *trimnum*. **History point held by transaction:** *transid*, **task number:** *trannum*.

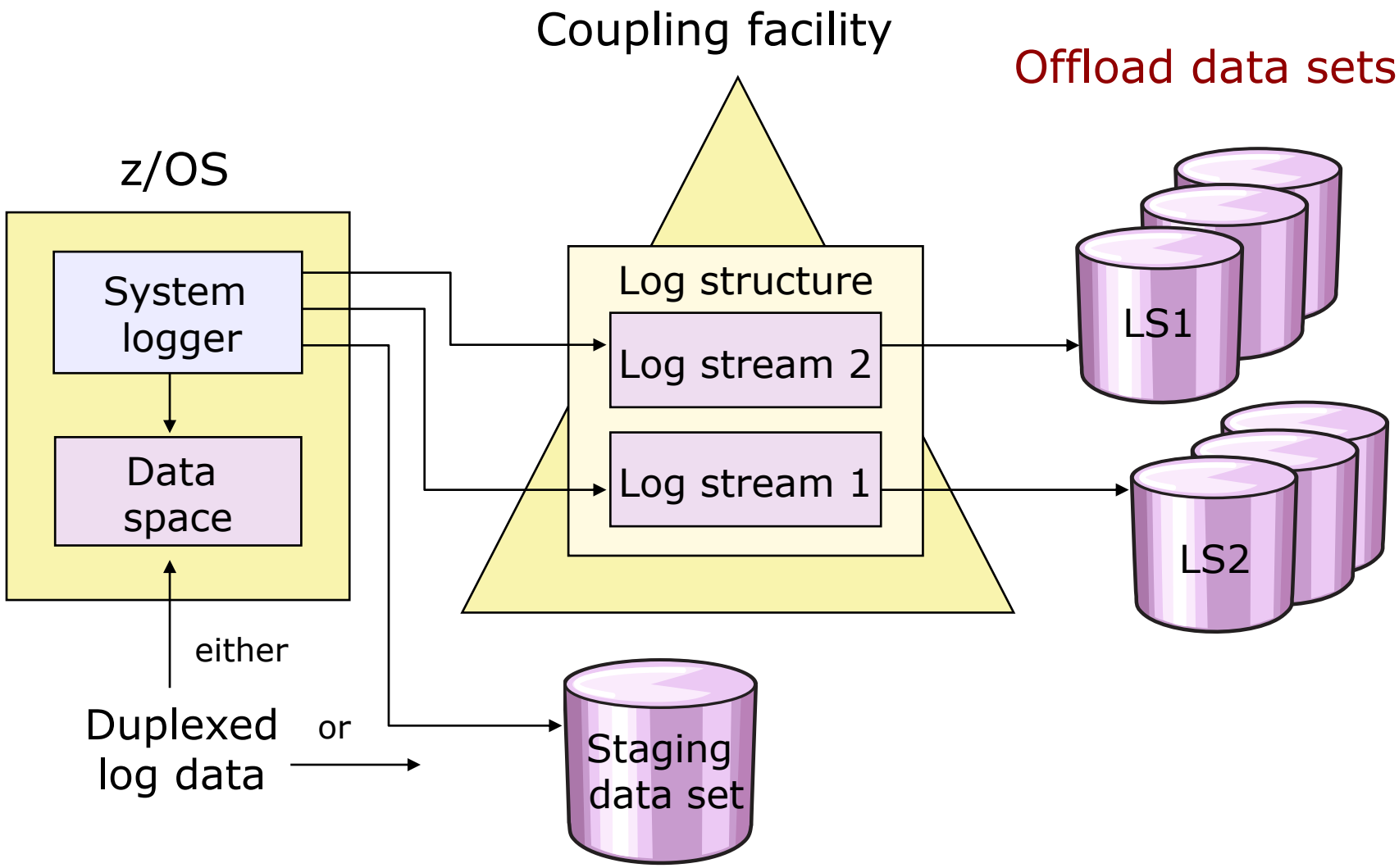
Log trimming

- Keypoints are an opportunity for CICS to delete unwanted log data
- Log Manager issues delete calls to the z/OS Logger
  - These logically delete ranges of the DFHLOG and DFHSHUNT logstreams
- When the logstream reaches its HIGHOFFLOAD percentage, the z/OS Logger will perform offload housekeeping work
  - Logically deleted log blocks are physically deleted
  - If necessary, remaining log data is moved to secondary storage (offload datasets)
- This continues until the LOWOFFLOAD percentage is reached
- Offload housekeeping is a good thing
  - Offload I/O to DASD is not so good
- Note – check for DFHLG0760 messages (or no DFHRM0205 messages)
  - Evidence that log trimming is not taking place

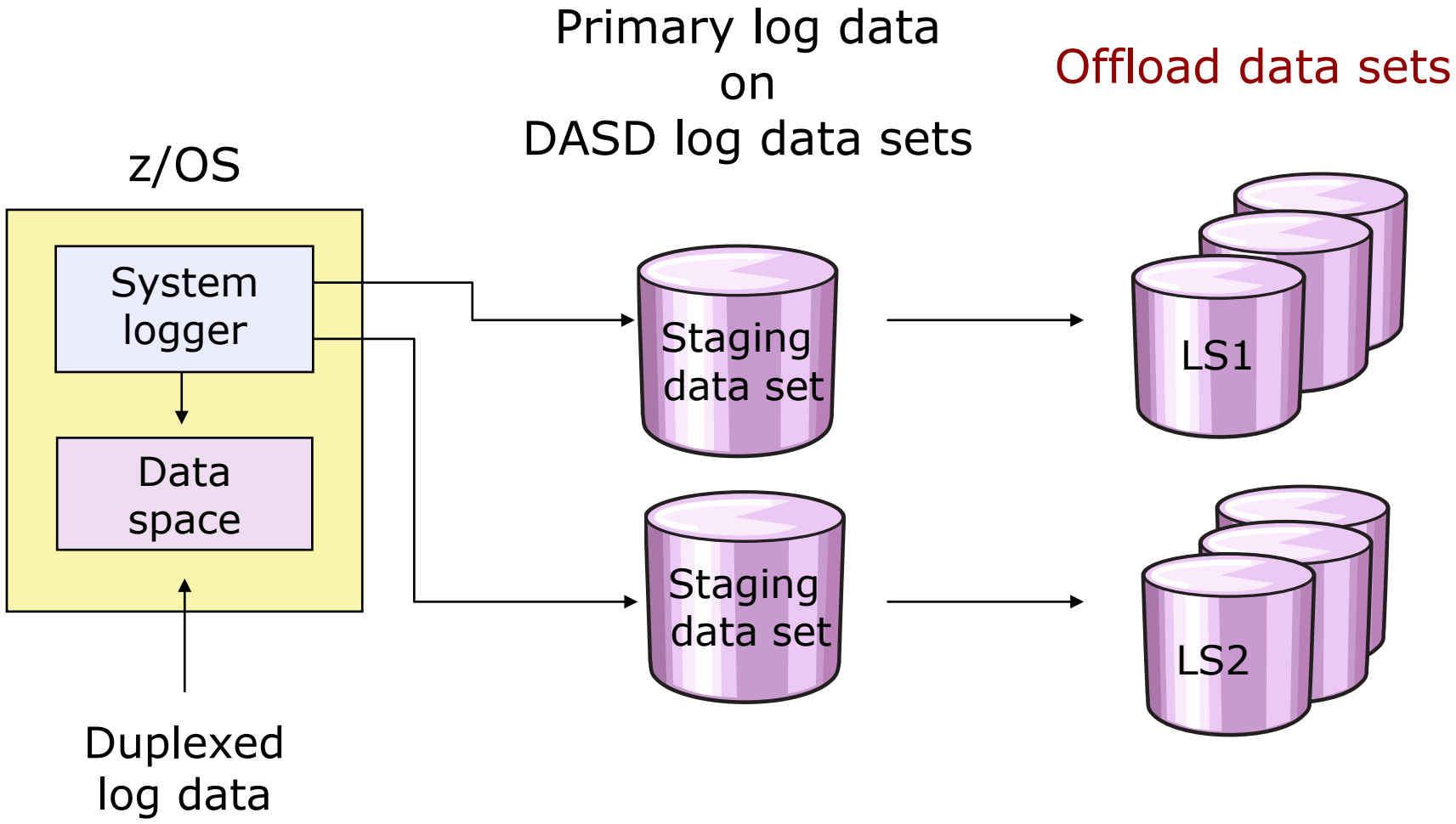
z/OS System Logger overview



Log stream storage for CF logging



Log stream storage for DASD-only logging



Log analysis

- CICS system logs are written to and read back by CICS
- CICS general logs are only written to by CICS
- DFHJUP is provided to read back logstreams for offline purposes
  - You can PRINT or COPY log data
- DFHJUP provides COMPAT41 to return log data in “old-style format”
  - Some batch utilities still exist that work with such old-style CICS log data