Exercise Sheet 4- Persistence

In the following regard an abstract game with its information stored server sided. Assume the following data to be saved by the server in objects $O_1, \dots, O_3$. In the beginning every object O_i has the value o_i.

Beginning at time t_{10} game information should be stored persistently on the hard disk every 10 ticks to avoid data loss by the server in case of a system error.

Assume that writing an object onto the hard disk takes two ticks.

The server thereby performs the following changes of the database:

Time	Object	New Value
t_6	O_1	o_1'
t_9	O_2	o_2'
t_{12}	O_3	o_3'
t_{15}	O_1	o_1''
t_{16}	O_3	o_3''
t_{22}	O_2	o_2''
t_{22}	O_3	o_3'''

Outline how the following logging algorithms proceed:

(a) Naive Snapshot, (b) Copy-on-Update
(c) Wait-Free Zigzag, (d) Wait-Free Ping-Pong
(e) Discuss advantages and disadvantages of these methods.

Check-Point Recovery Method for Games

- **Check-Point**: consistent image of the game state
- **Check-Point Phase:** time needed to create a check-point.
- **Goal**: Saving the game state with a minimal overhead in the game loop
  => minimal influence on latency
- **Idea**: information is not saved directly, instead all information is copied to a shadow copy
  - data in shadow copy is not affected by actions
  - game loop does not need to wait for the I/O-system
    (uses an asynchronous write-thread)
  - writing may take several ticks, persistence layer lags slightly behind
- **Classification of strategies based on** :
  - bulk-copies vs. selectively copying
  - locking single objects
  - resetting dirty-bits
  - memory usage

Naive-Snapshot

- If write-thread is finished with the last check-point, copy the whole game state into shadow memory
- After finishing copying and at the start of the next tick, the write-thread writes the copied game state from shadow memory

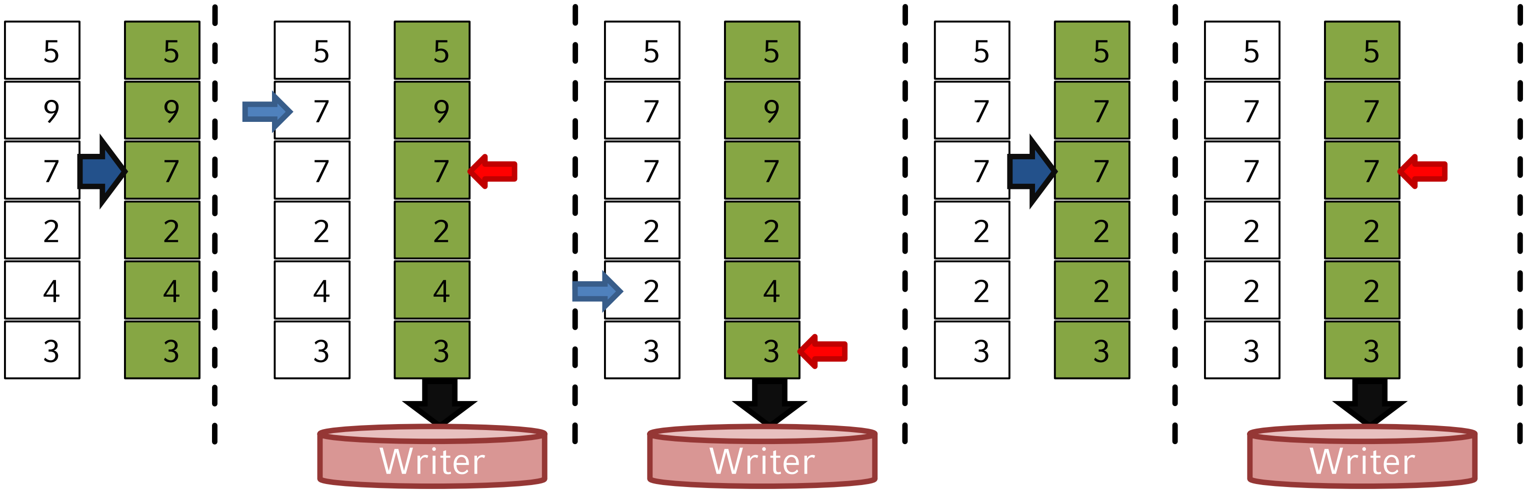
Advantages:

- no overhead from locking or bit-resets
- efficient for large numbers of changes

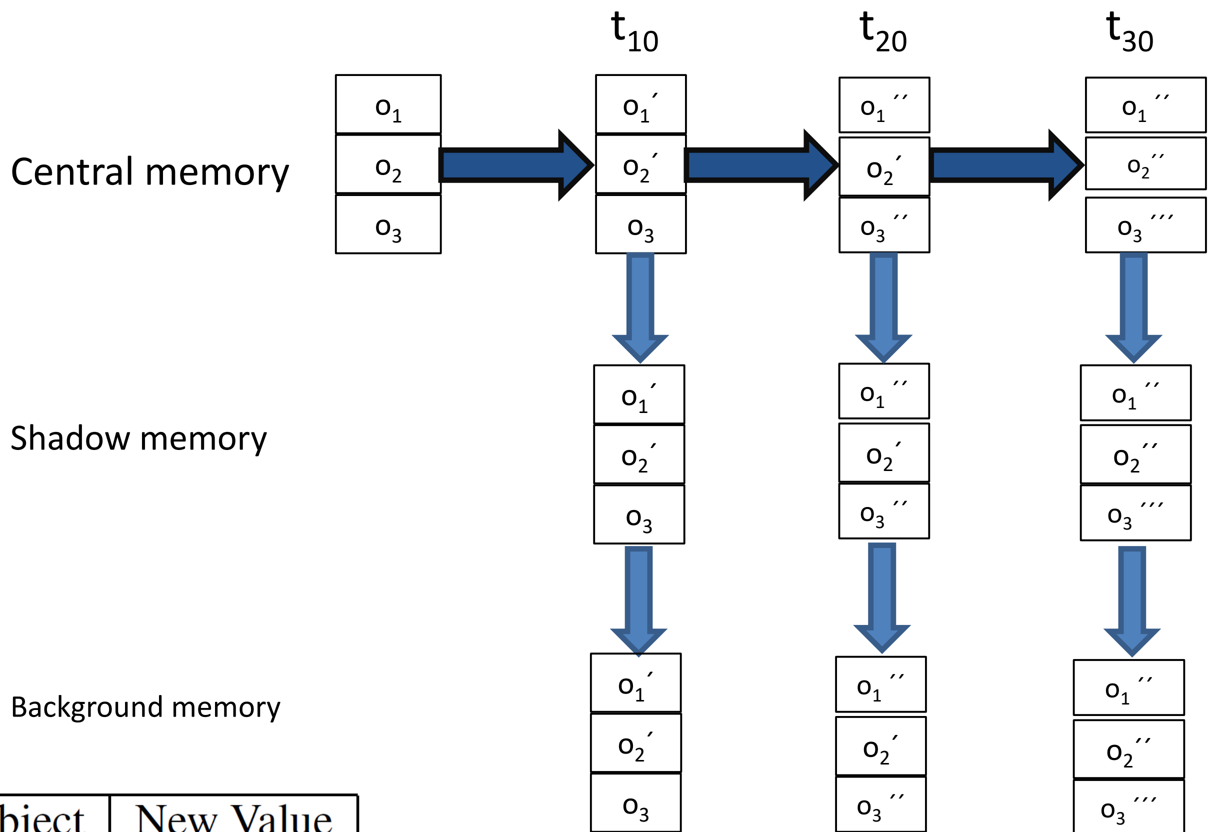
Disadvantages:

- for limited numbers of changes large overhead for copying and writing
- periodically expensive for ticks during where the game state is copied

Naive-Snapshot



Naive-Snapshot



Time	Object	New Value
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t_{12}	O_3	o_3'
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t_{16}	O_3	o_3''
t_{22}	O_2	o_2''
t_{22}	O_3	o_3'''

Writer needs *3*2s = 6* seconds to transfer the complete game state from the shadow memory to the background memory (secondary storage)

Writer starts writing out every 10 seconds => Since *6s<10s* he is finished with writing before the next game state is copied to the shadow memory

Copy-On-Update

- on change, objects are copied to shadow memory and marked (dirty-bits)
- objects are copied only once per period
- after a check-point has been written markers are reset

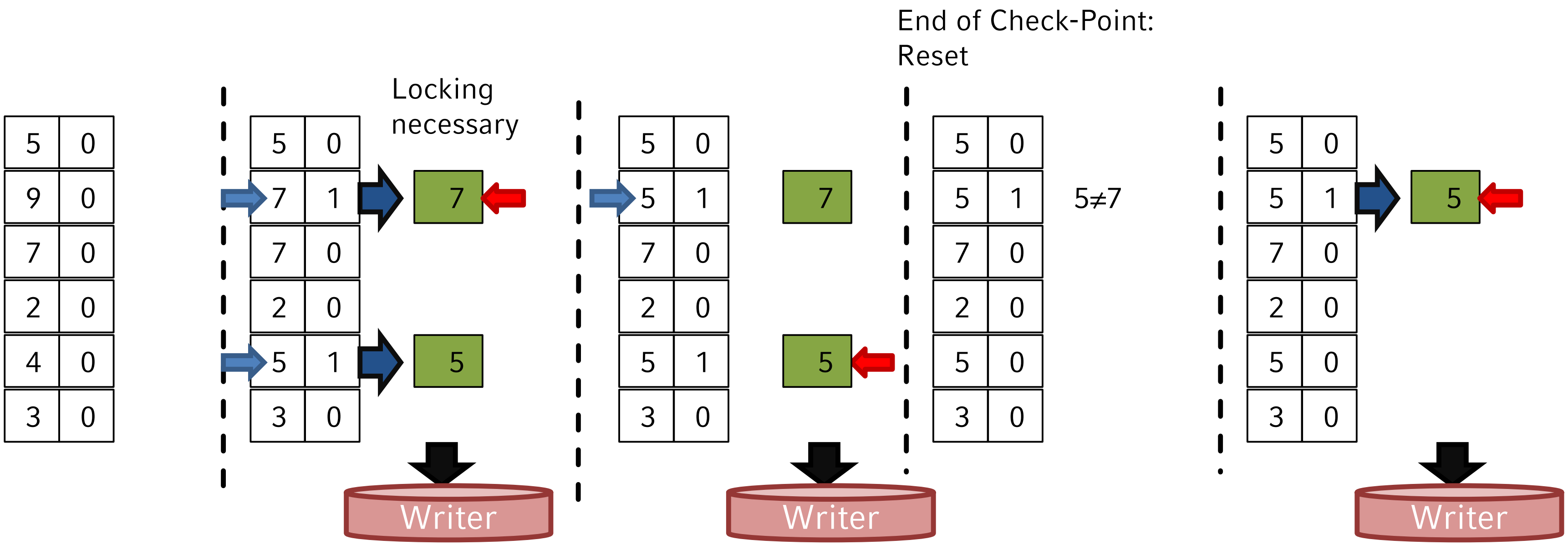
Advantages:

- smaller change volume
- better distribution of copies over multiple ticks

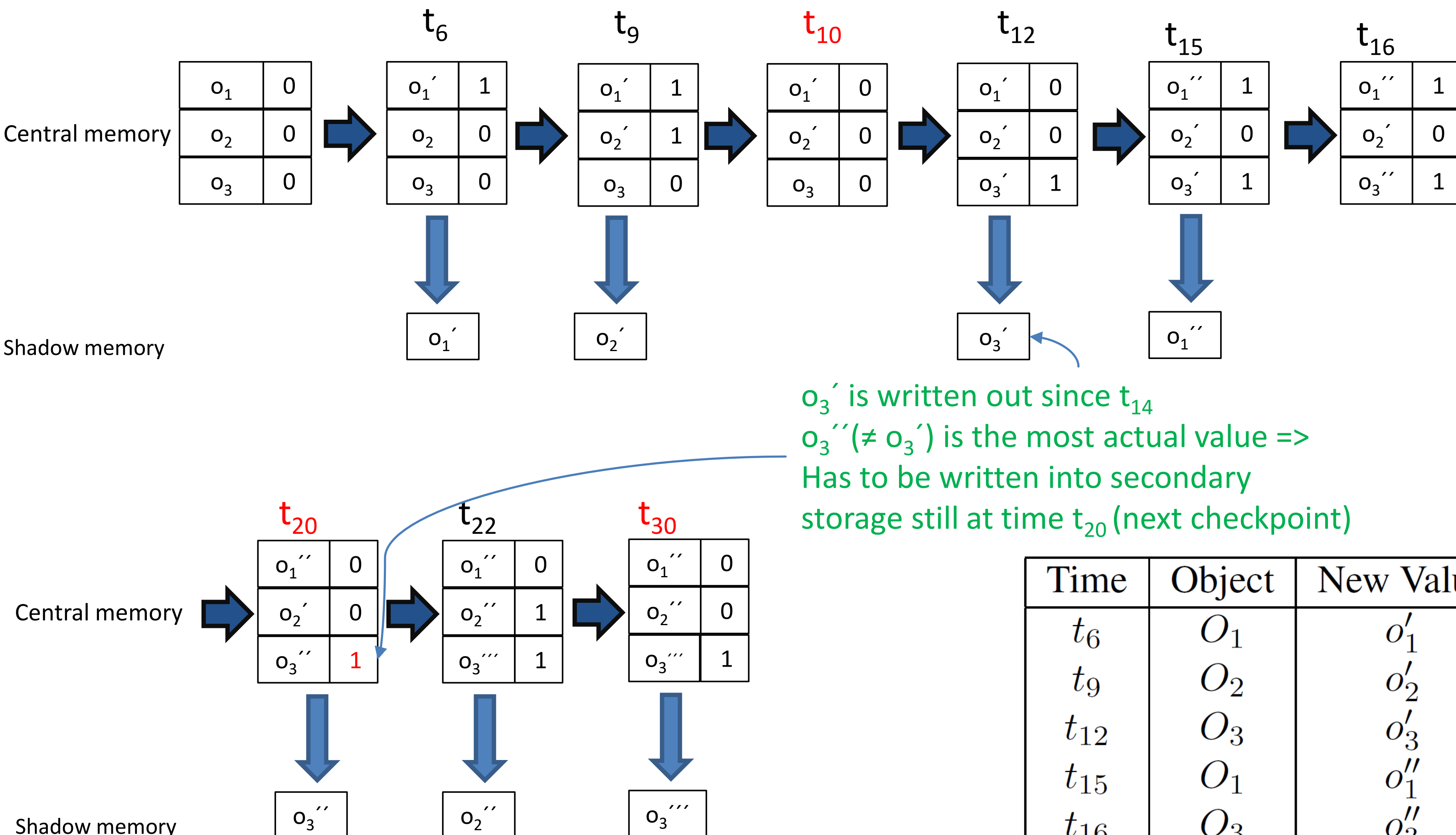
Disadvantages:

- requires locking to avoid simultaneous change and copy operations
- overhead for bit-reset

Copy-On-Update



Copy-On-Update



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Wait-Free Zigzag

- every object contains two flags referring to a game state (GS): MW (Write-State) and MR (Read-State) for handling actions
- entries in GS[MW] are not changed during this period
- for changes MR is set to MW
- writer-thread reads the element from GS[-MW_i] for object i

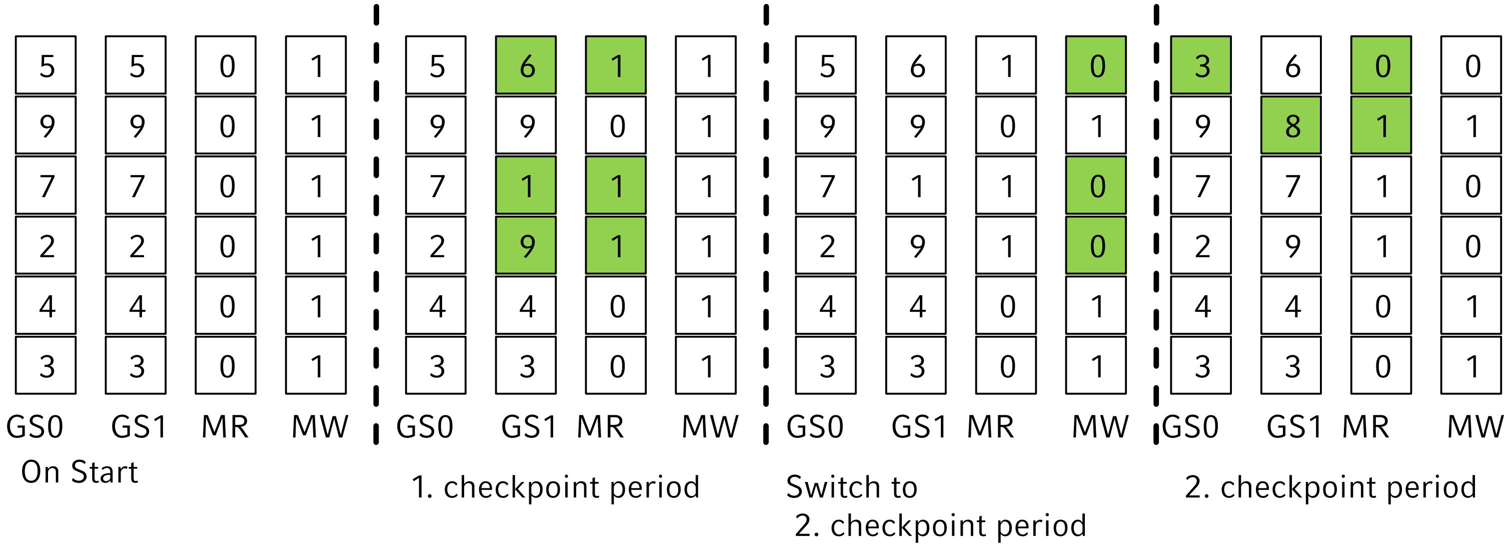
Advantages:

- no locking necessary
- changes can be written over time

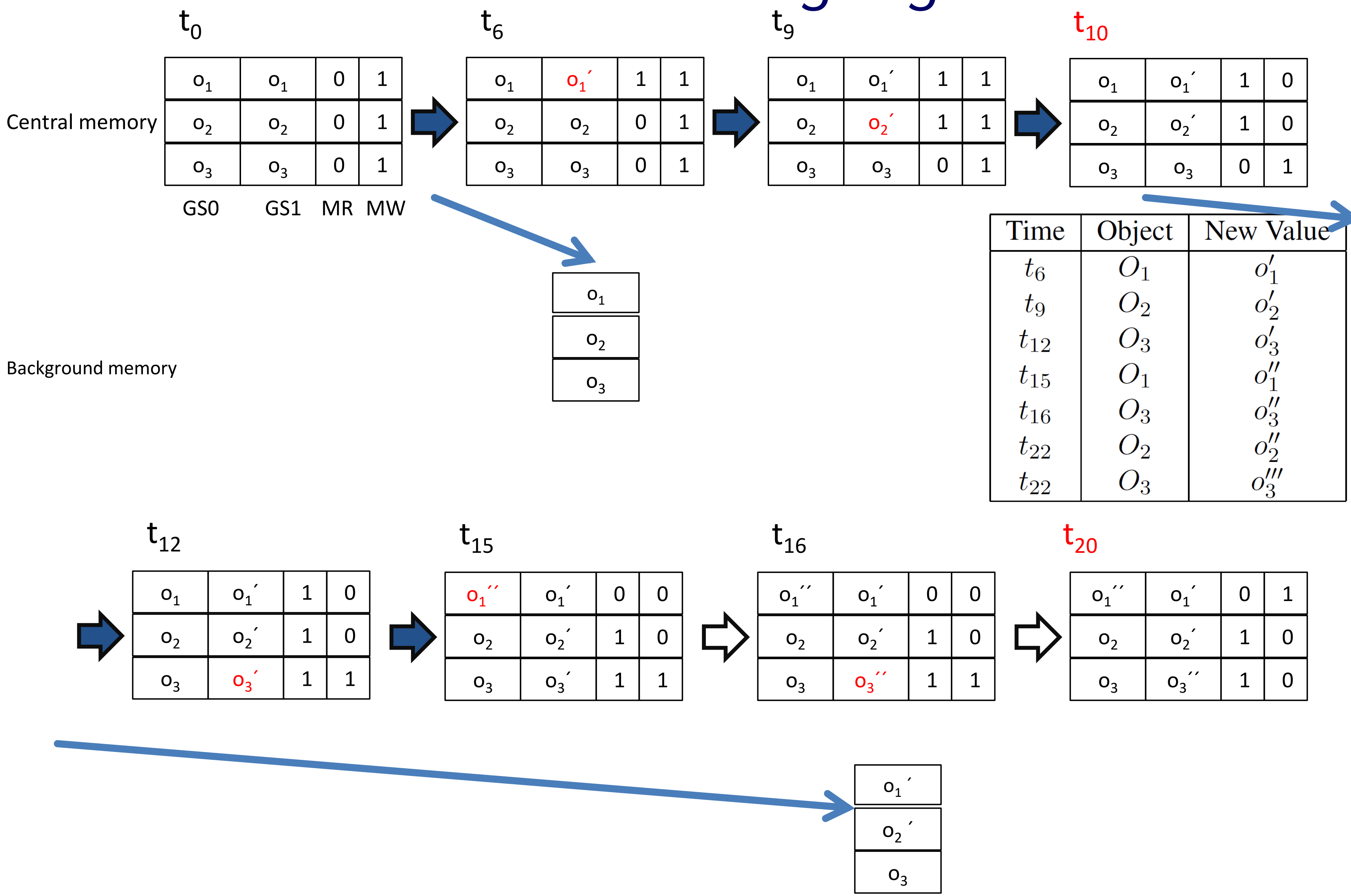
Disadvantage:

- still requires bit-reset at the end of each period

Wait-Free Zigzag

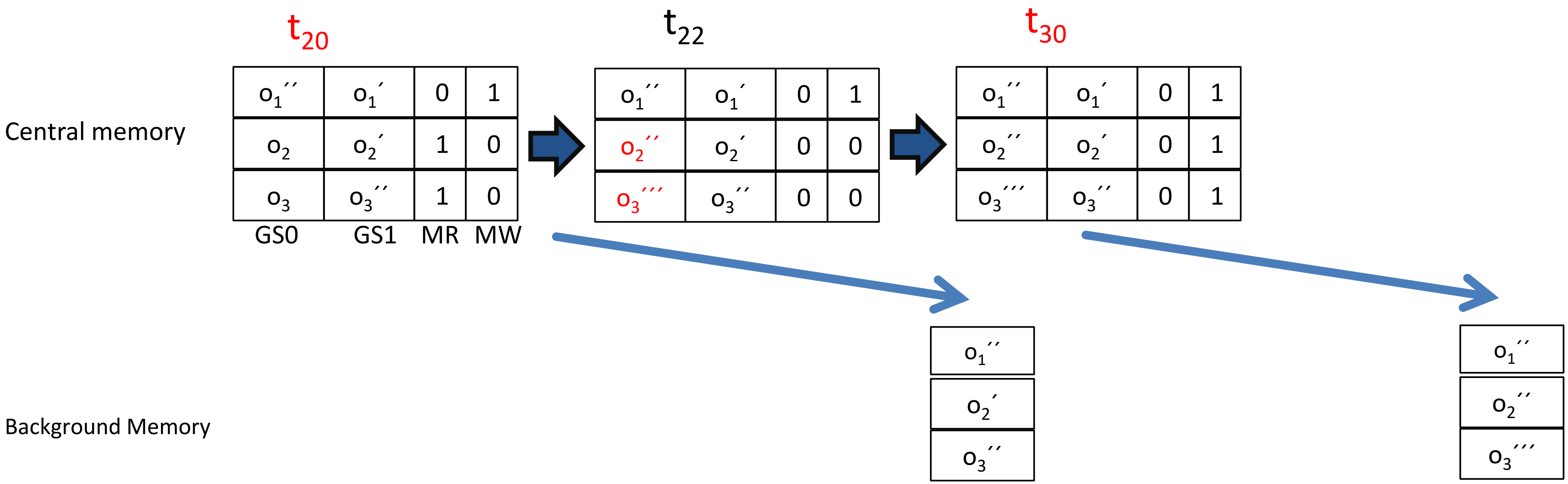


Wait-Free Zigzag



Time	Object	New Value
t_6	O_1	o'_1
t_9	O_2	o'_2
t_{12}	O_3	o'_3
t_{15}	O_1	o''_1
t_{16}	O_3	o''_3
t_{22}	O_2	o''_2
t_{22}	O_3	o'''_3

Wait-Free Zigzag (2)



Time	Object	New Value
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t_9	O_2	o'_2
t_{12}	O_3	o'_3
t_{15}	O_1	o''_1
t_{16}	O_3	o''_3
t_{22}	O_2	o''_2
t_{22}	O_3	o'''_3

Wait-Free Ping-Pong

- uses 3 game states:
  action handling (GS), persistence-system (read), persistence-system (write)
  (odd or even)
- updates always take place in GS and persistence-system (write)
- writer-thread reads persistence-system (read)
- for a new period swap persistence-system(write) and persistence-system(read)

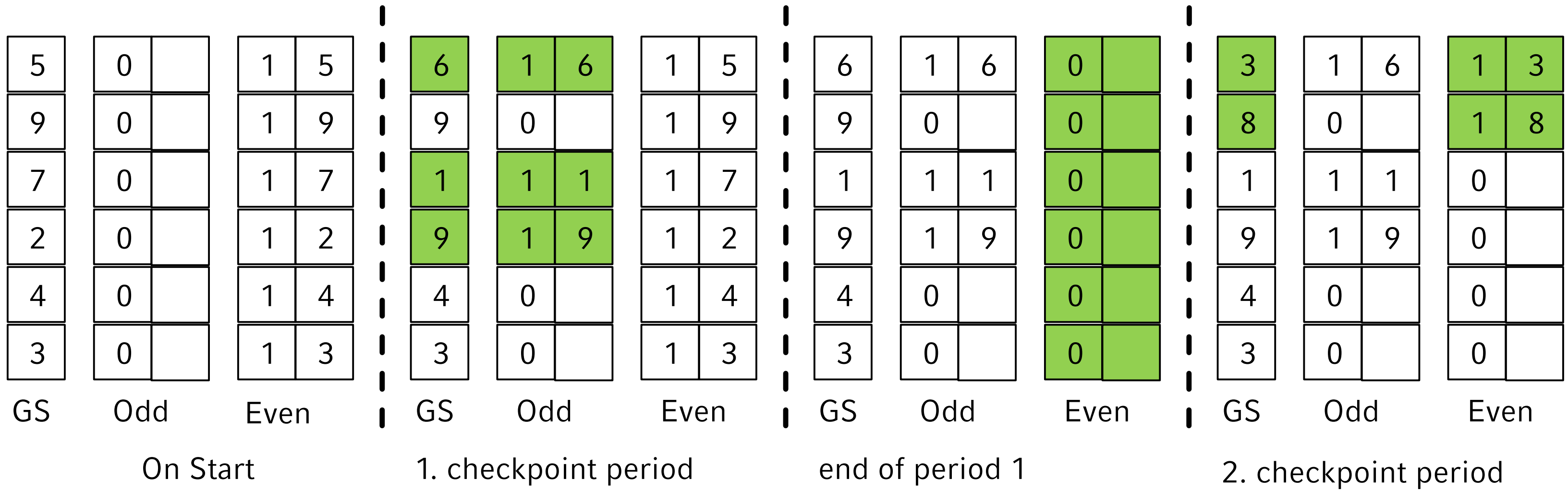
Advantage:

- neither locking nor bit-reset at the end of a period

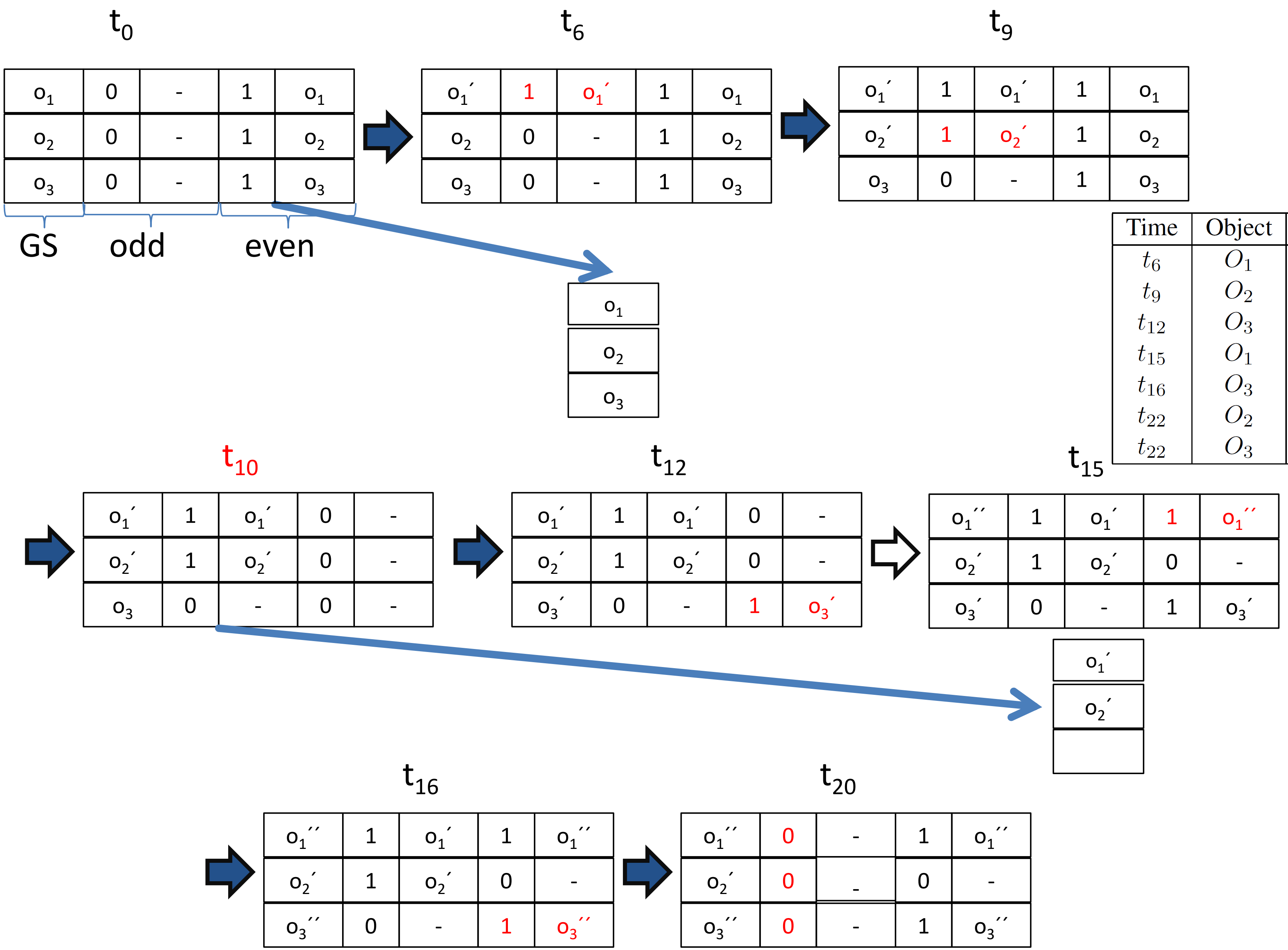
Disadvantage:

- triple memory requirements instead of double

Wait-Free Ping-Pong



Wait-Free Ping-Pong



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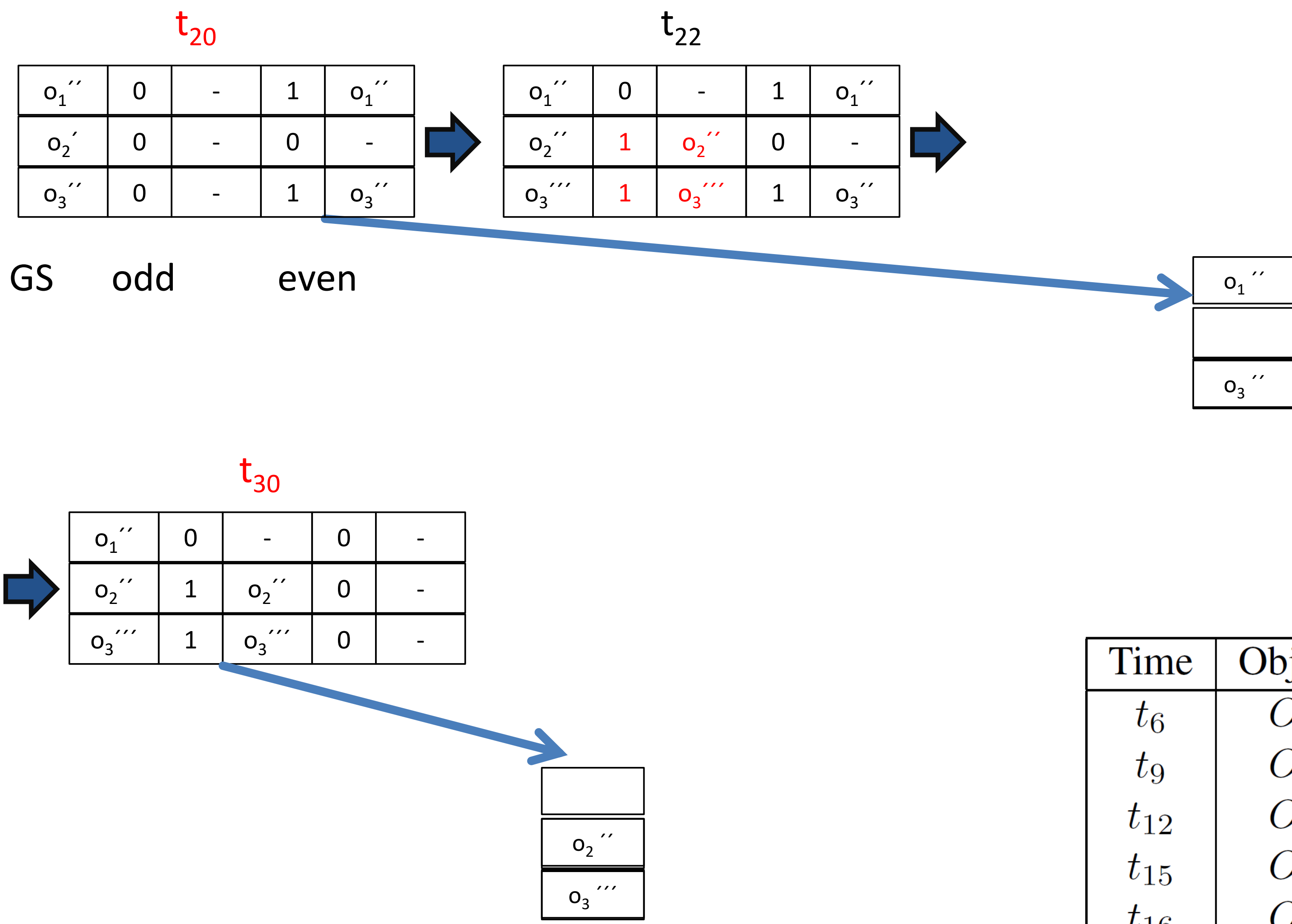
Wait-Free Ping-Pong (2)



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Discussion

- Naive-Snapshot is easiest to implement for very volatile systems with several changes
- the less changes happen, the more advantageous the other methods become
- Wait-Free Ping-Pong and Wait-Free Zig-Zag prevent locking the game entity by the persistence-system
- Wait-Free Ping-Pong also reduces overhead for phase-shifts, but uses a great deal of memory