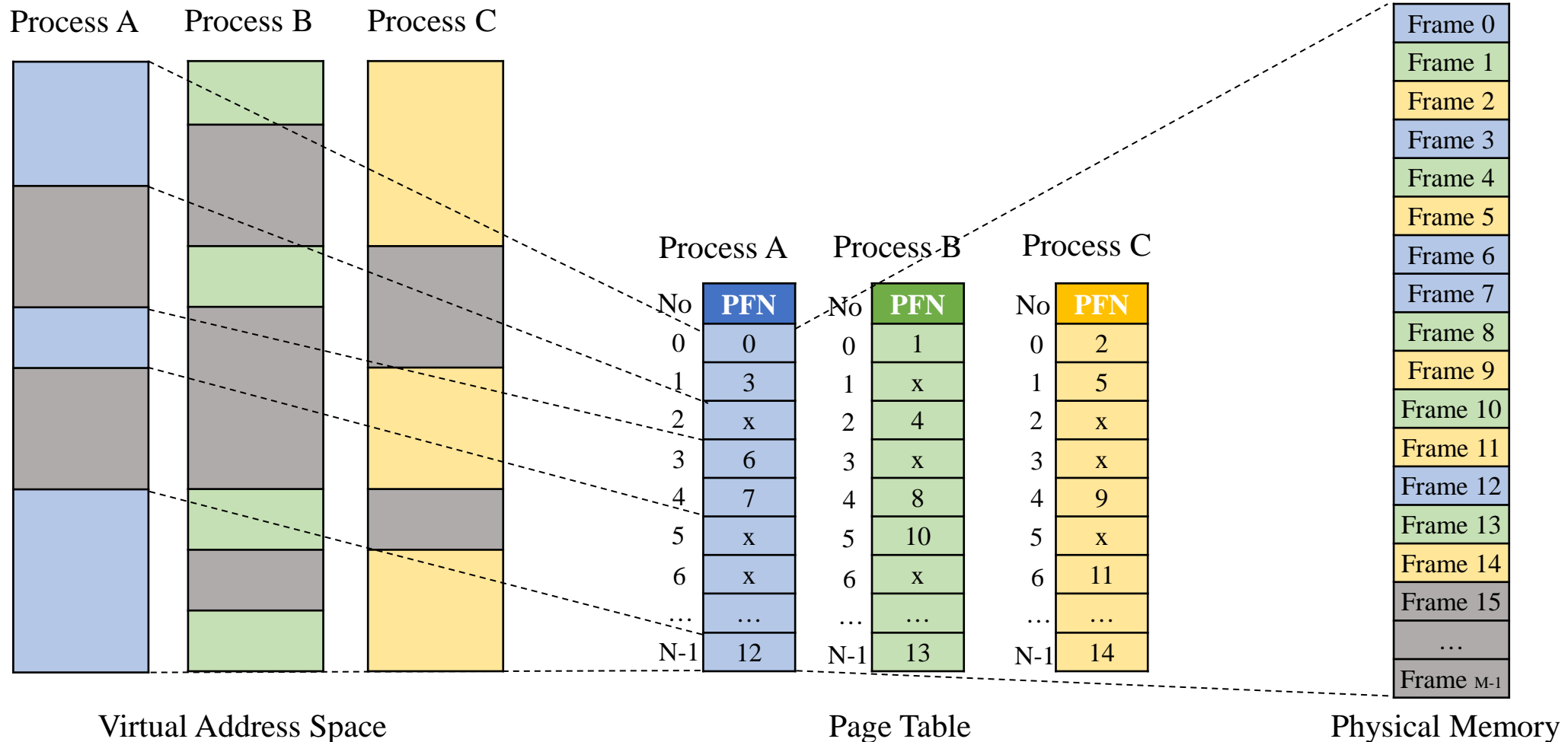

OS 2021 Homework 4

(Due day 2022/1/10 23:59:59)
(Last Submission: 2022/1/15 23:59:59)

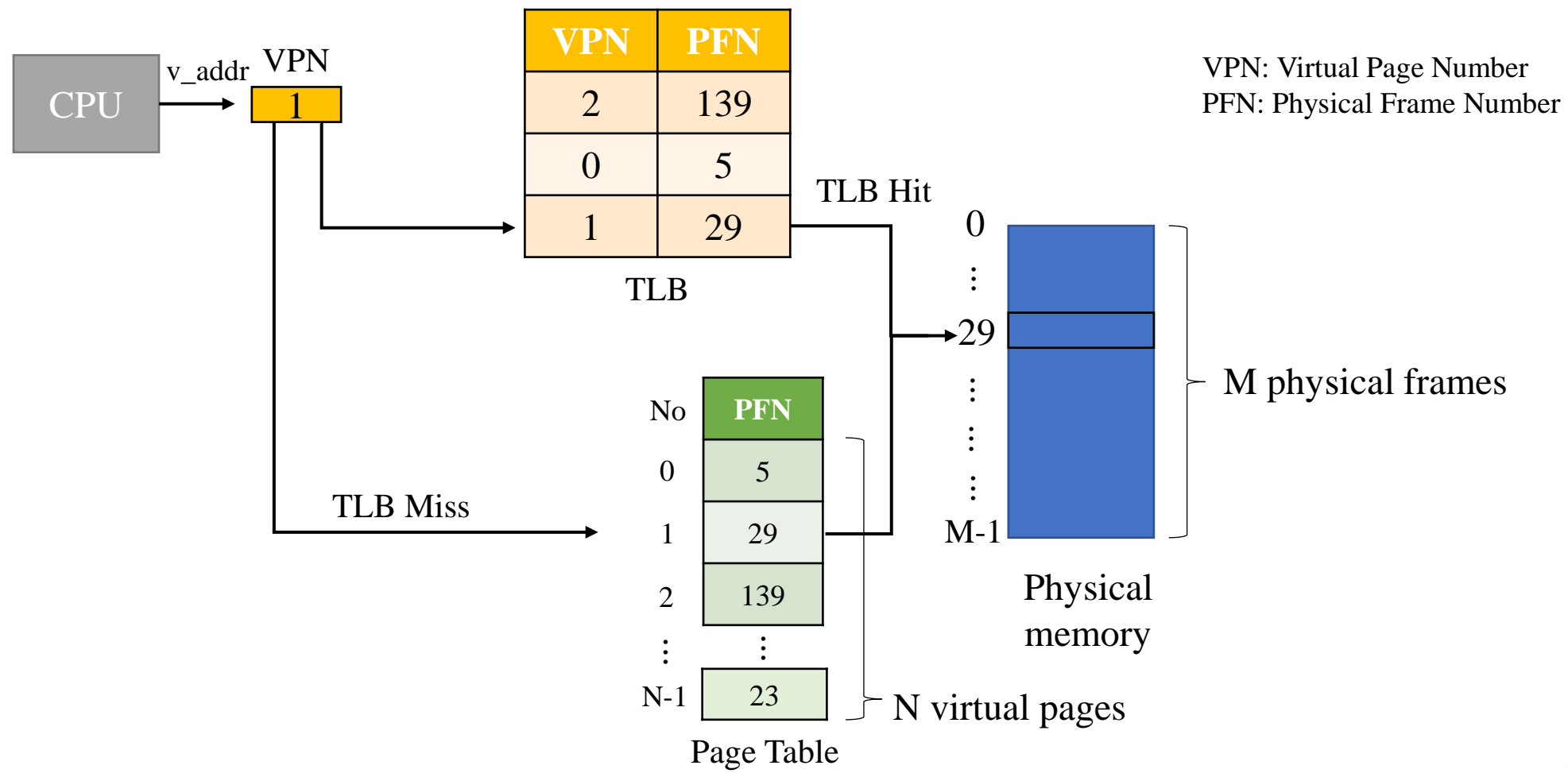
Memory Manager

[GitHub Classroom](#)

Background-Paging System with Multiple Processes



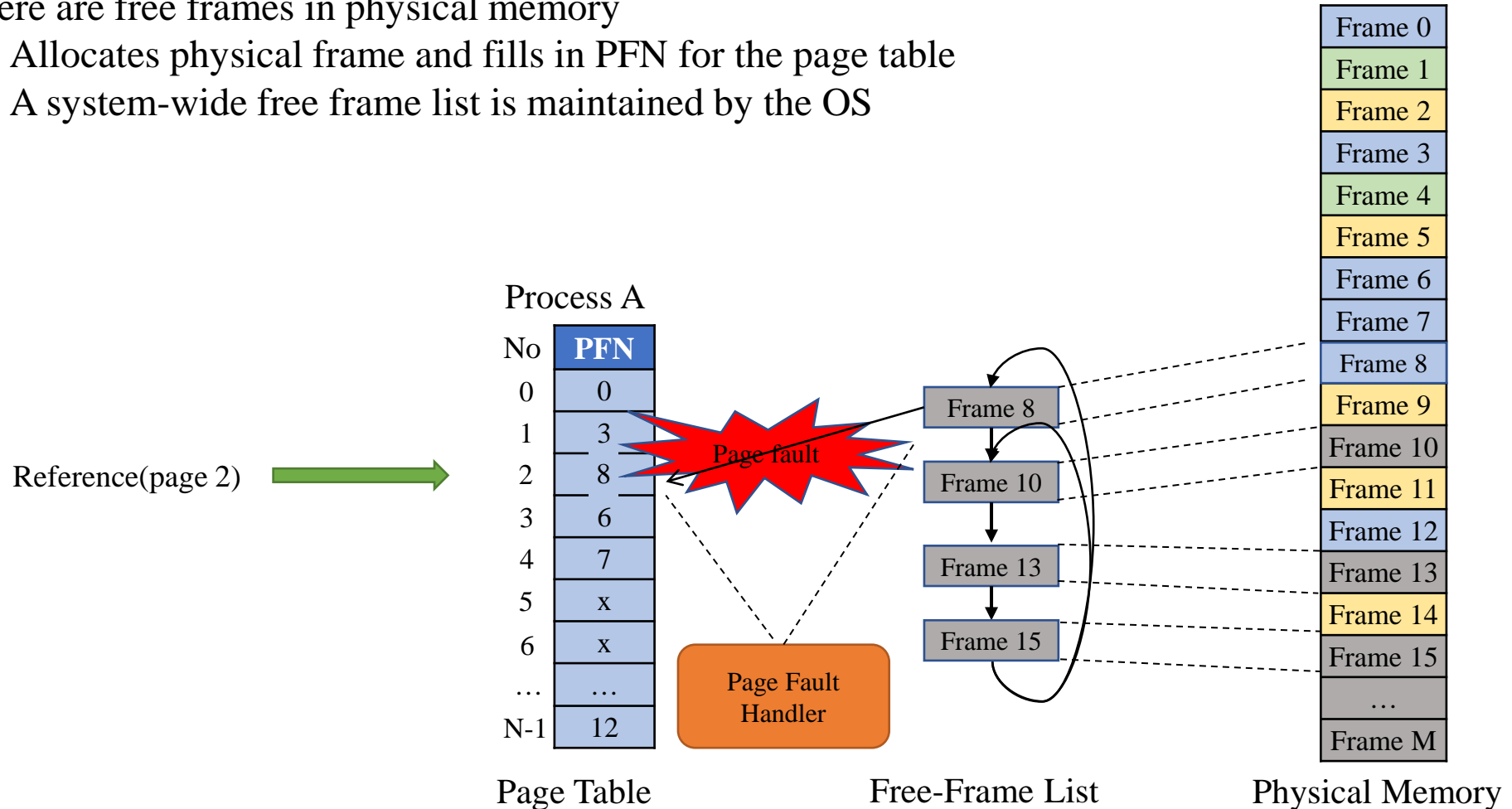
Overview-Address Translation



A paging based memory manager with TLB support

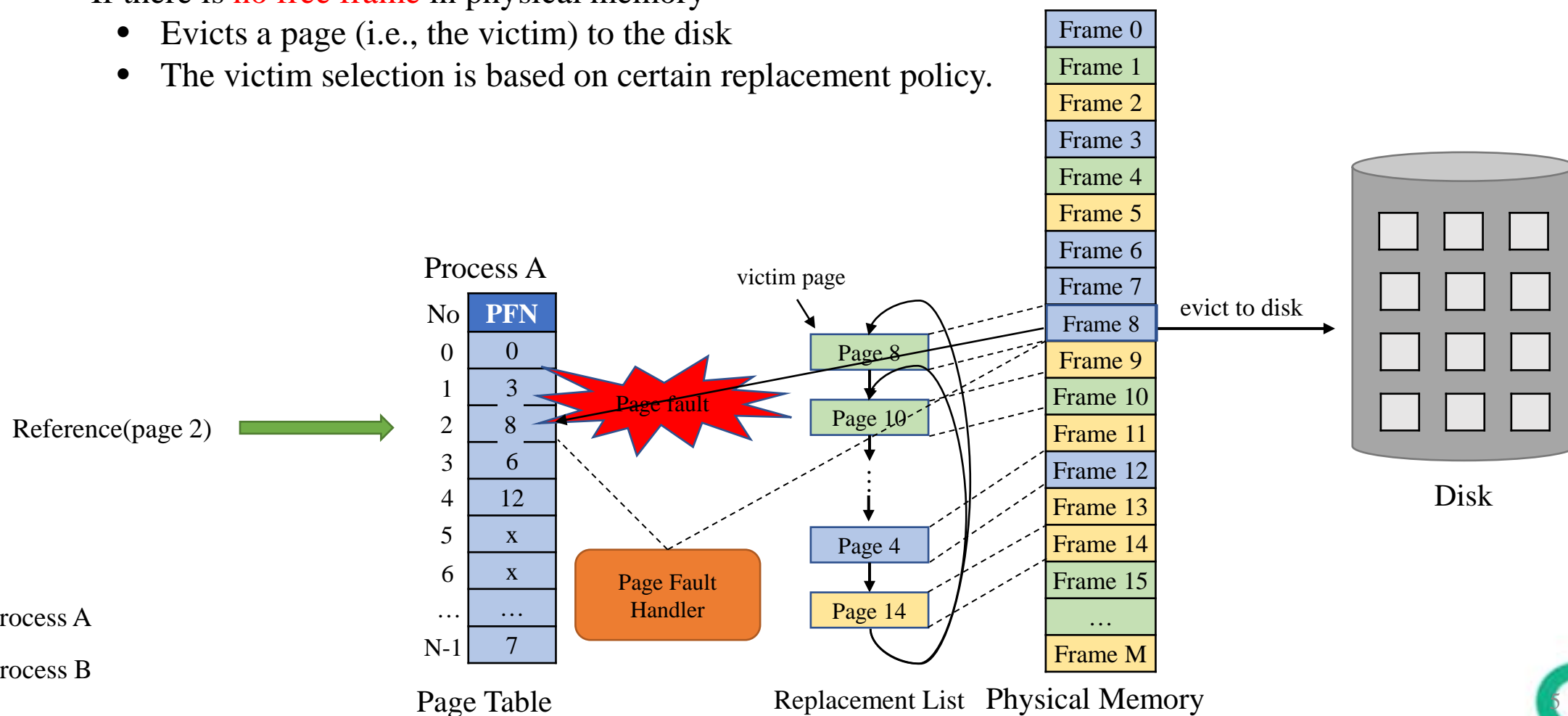
Overview-Page Fault Handler (1/2)

- Once a page fault occurs
 - If there are free frames in physical memory
 - Allocates physical frame and fills in PFN for the page table
 - A system-wide free frame list is maintained by the OS



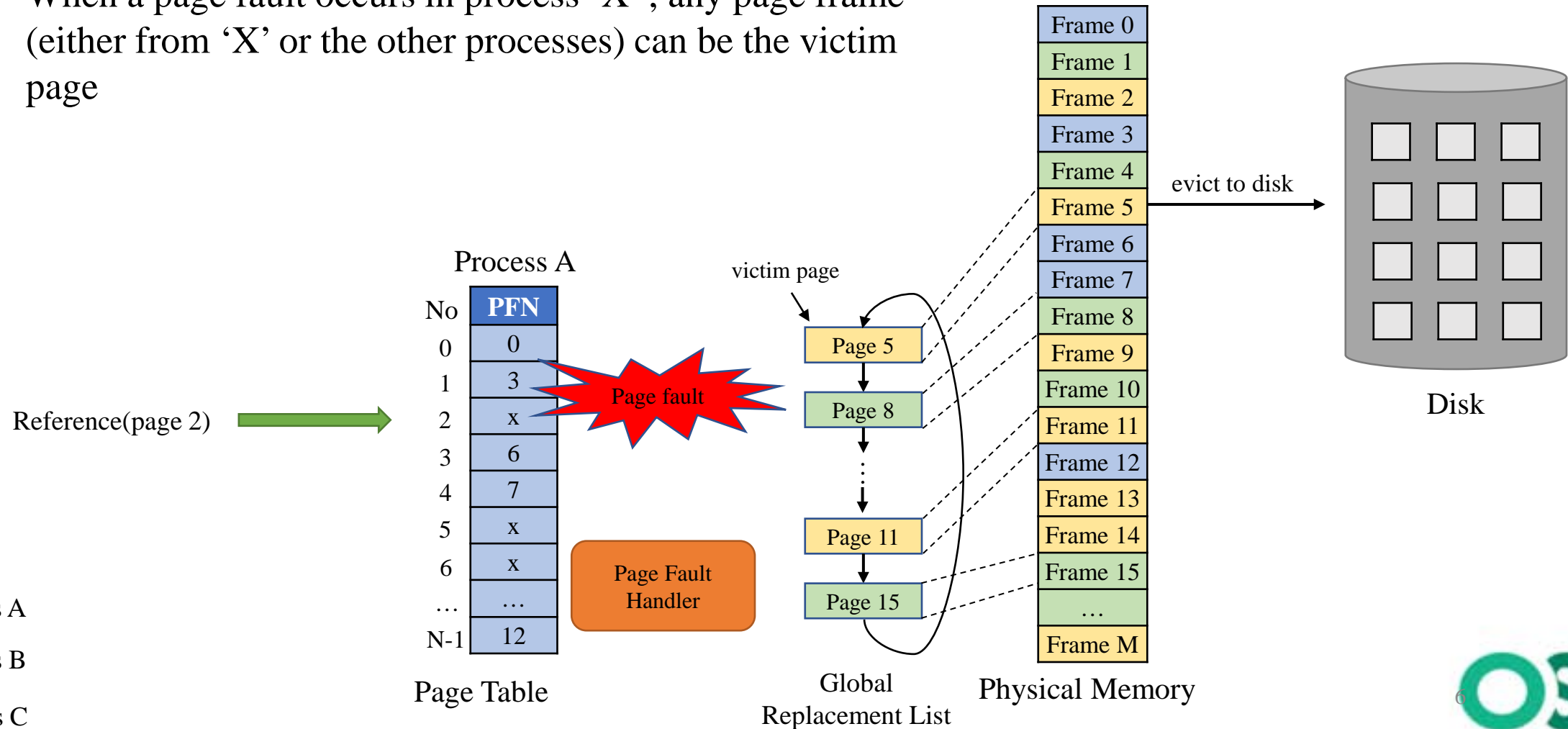
Overview-Page Fault Handler (2/2)

- Once a page fault occurs
 - If there is **no free frame** in physical memory
 - Evicts a page (i.e., the victim) to the disk
 - The victim selection is based on certain replacement policy.



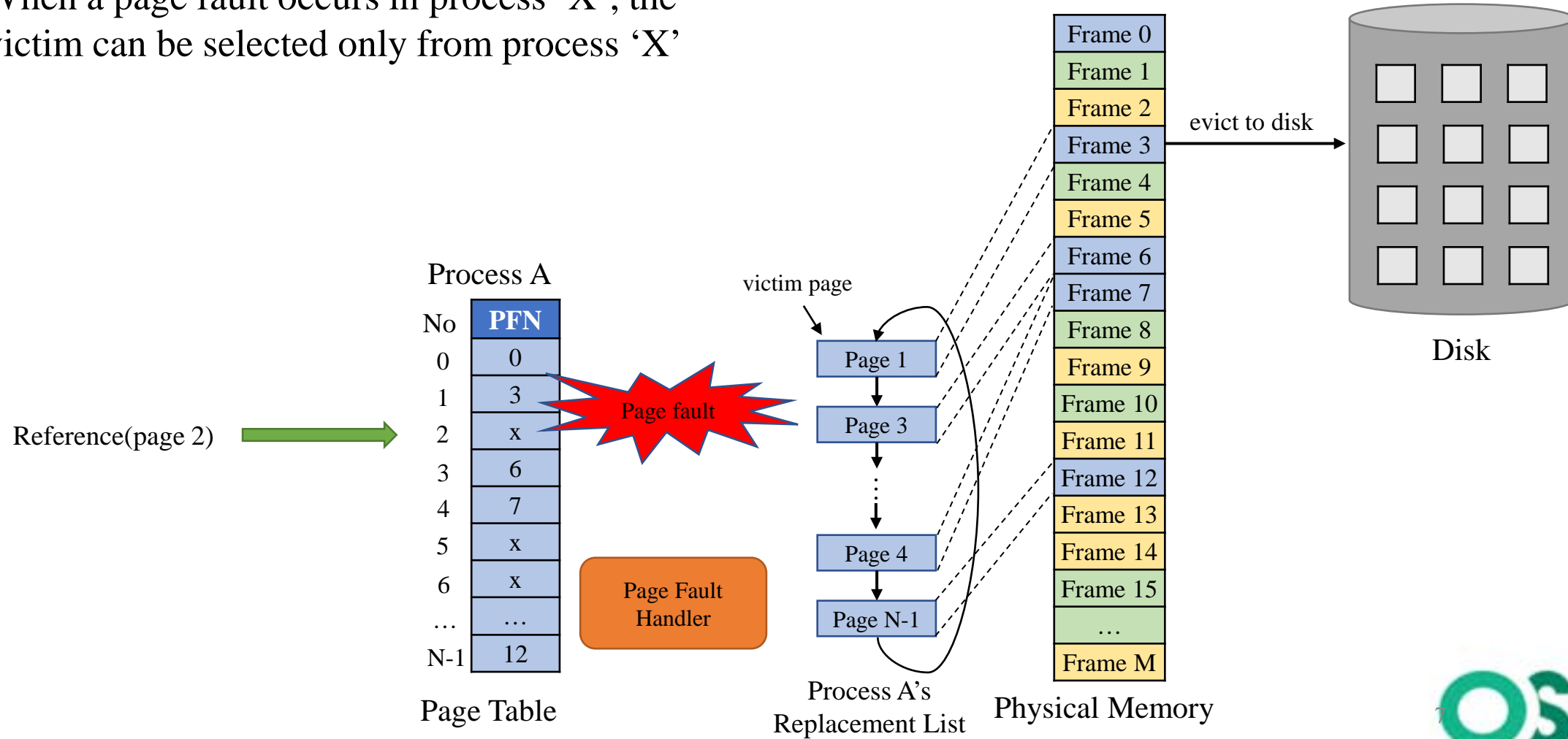
Overview-Allocation Policy (1/2)

- Global
 - When a page fault occurs in process 'X', any page frame (either from 'X' or the other processes) can be the victim page

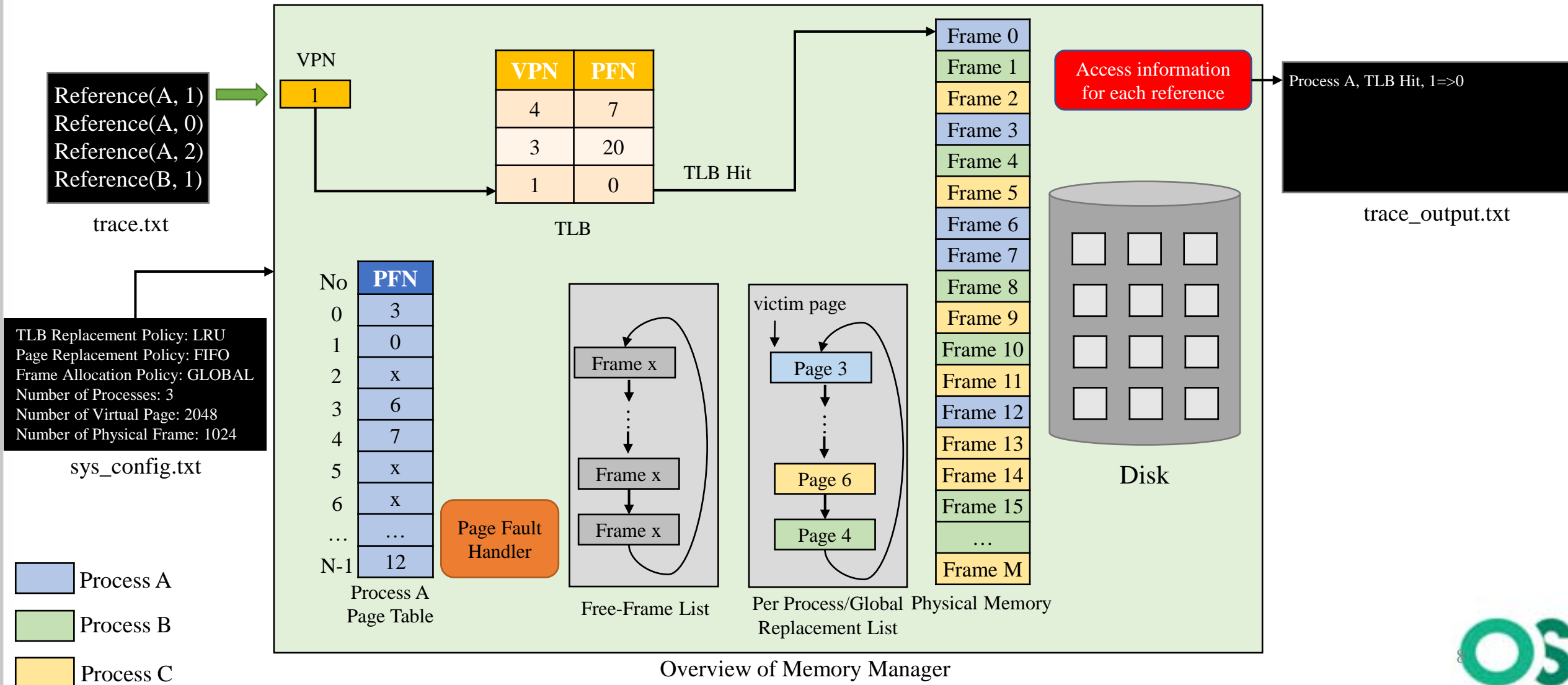


Overview-Allocation Policy (2/2)

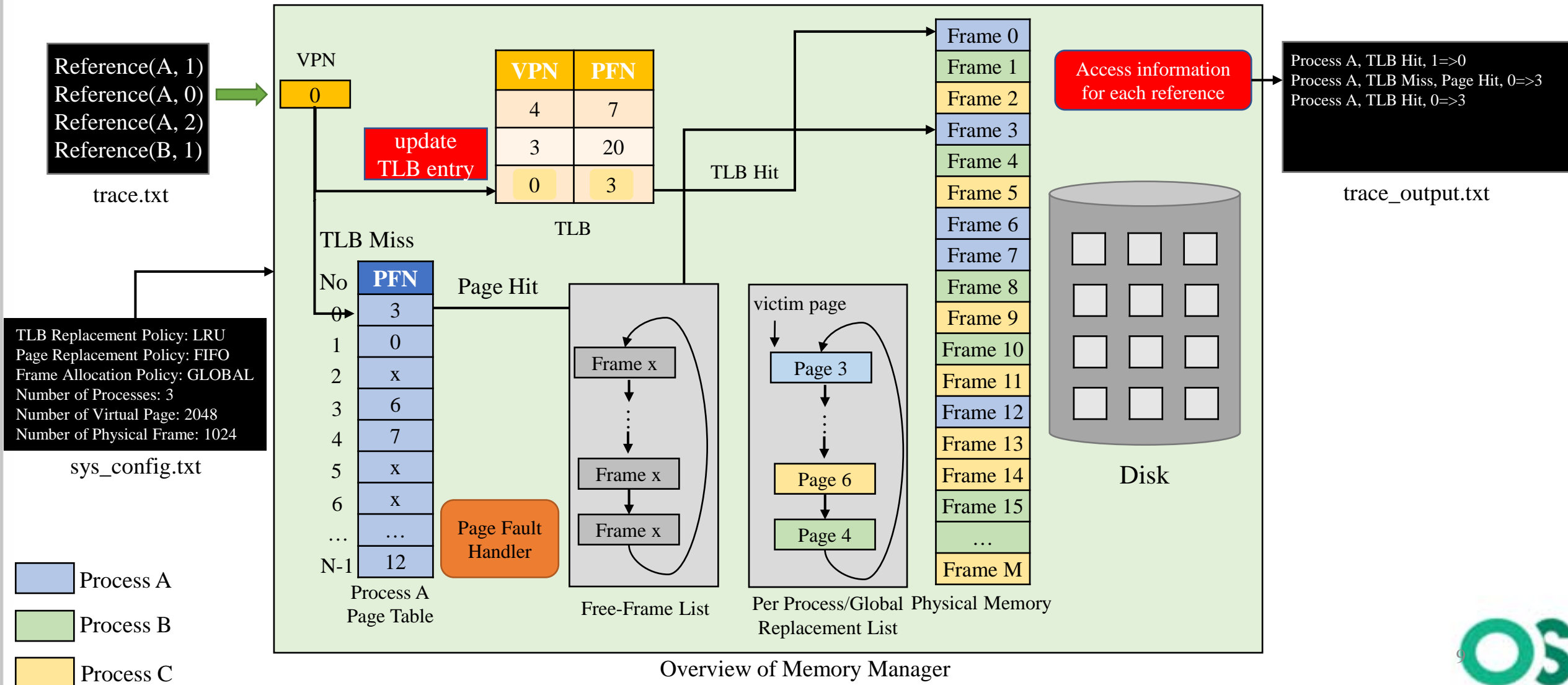
- Local
 - When a page fault occurs in process 'X', the victim can be selected only from process 'X'



Overview-Memory Manager (1/5)



Overview-Memory Manager (2/5)



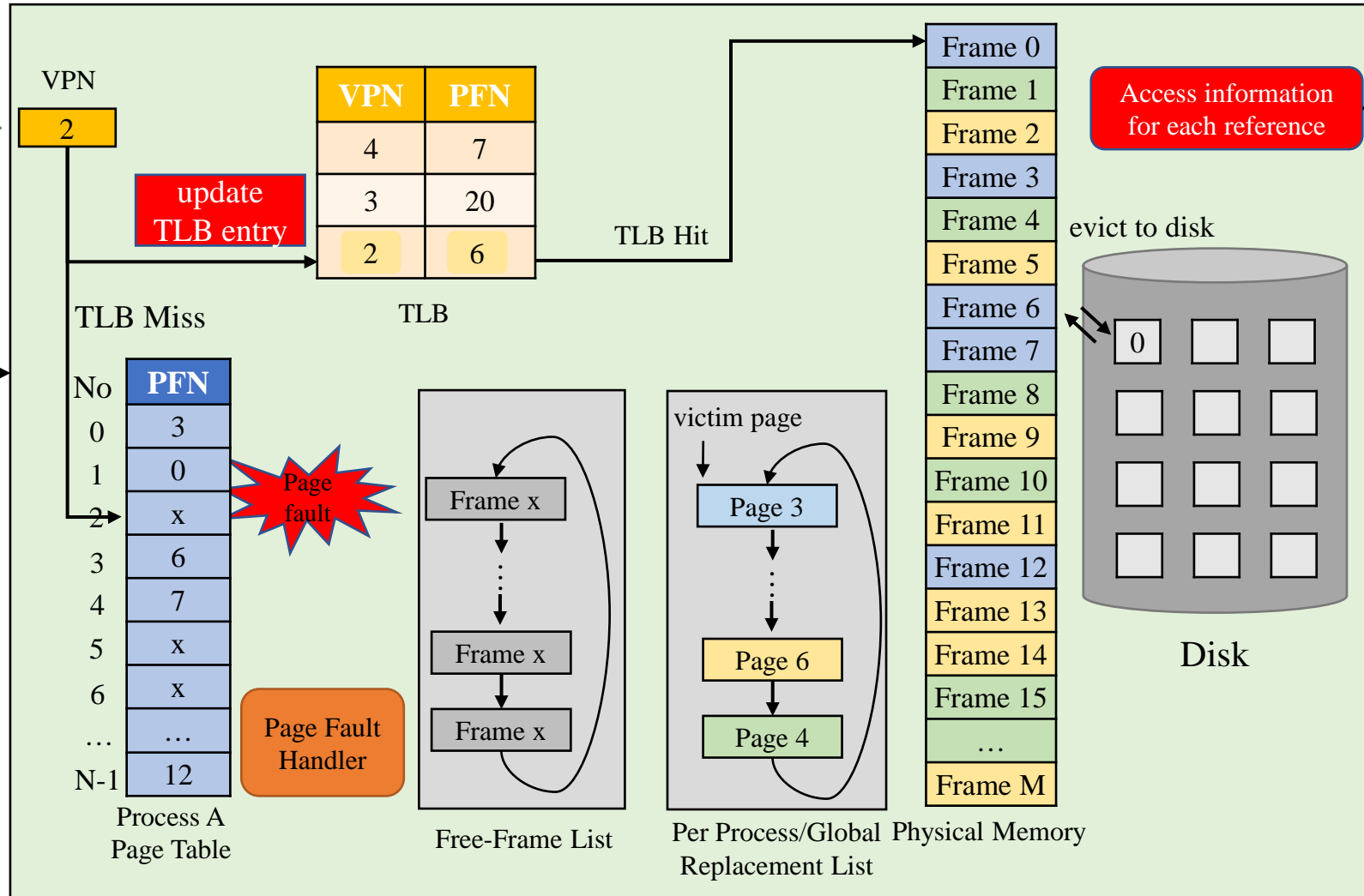
Overview-Memory Manager (3/5)

Reference(A, 1)
Reference(A, 0)
Reference(A, 2)
Reference(B, 1)

trace.txt

TLB Replacement Policy: LRU
Page Replacement Policy: FIFO
Frame Allocation Policy: GLOBAL
Number of Processes: 3
Number of Virtual Page: 2048
Number of Physical Frame: 1024

sys_config.txt



Process A, TLB Hit, 1=>0
Process A, TLB Miss, Page Hit, 0=>3
Process A, TLB Hit, 0=>3
Process A, TLB Miss, Page Fault, 6,
Evict 3 of Process A to 0, 2 <- -1
Process A, TLB Hit, 2=>6

trace_output.txt

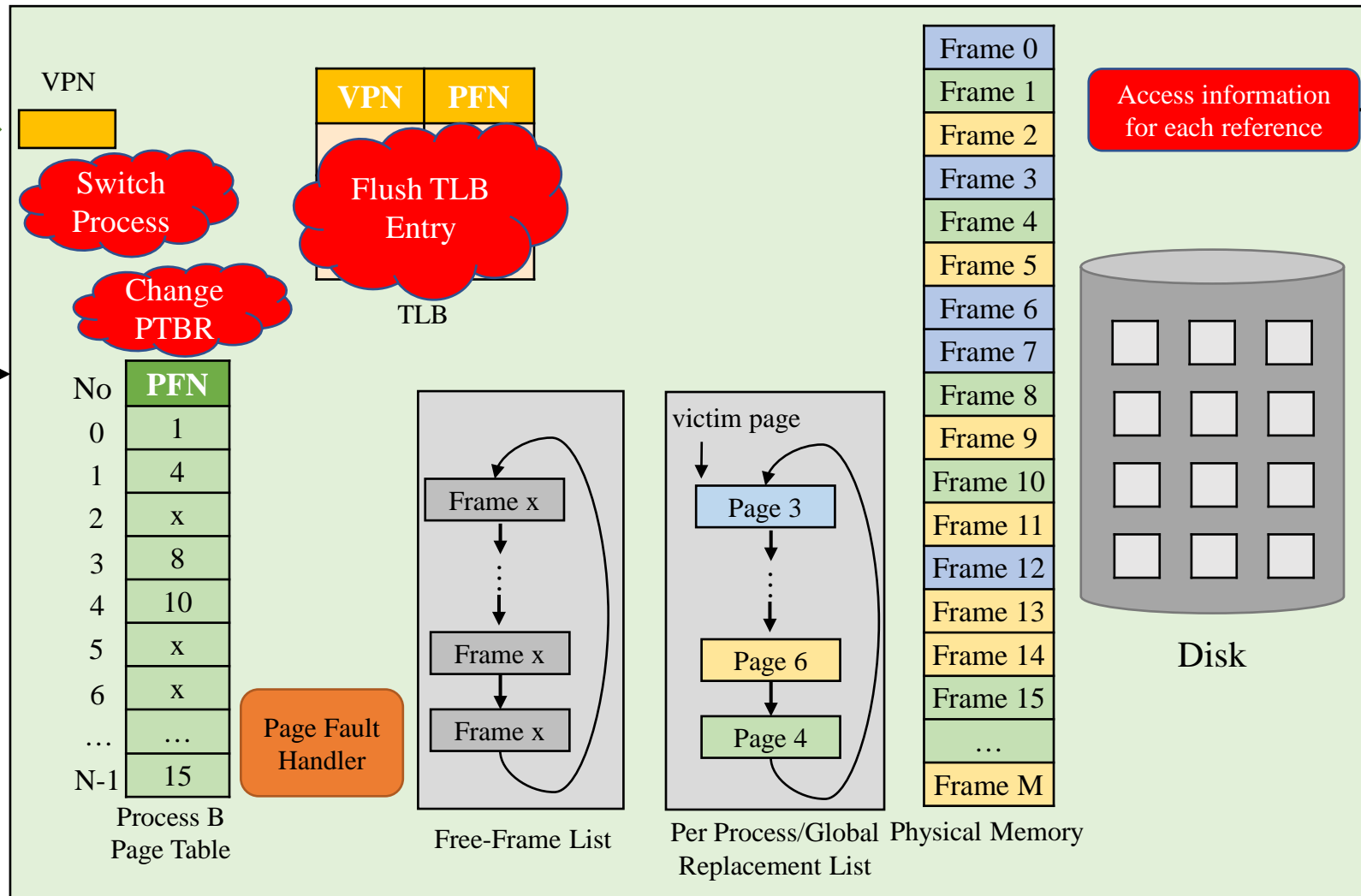
Overview-Memory Manager (4/5)

Reference(A, 1)
Reference(A, 0)
Reference(A, 2)
Reference(B, 1)

trace.txt

TLB Replacement Policy: LRU
Page Replacement Policy: FIFO
Frame Allocation Policy: GLOBAL
Number of Processes: 3
Number of Virtual Page: 2048
Number of Physical Frame: 1024

sys_config.txt



Process A, TLB Hit, 1=>0
Process A, TLB Miss, Page Hit, 0=>3
Process A, TLB Hit, 0=>3
Process A, TLB Miss, Page Fault, 6,
Evict 3 of Process A to 0, 2 << -1
Process A, TLB Hit, 2=>6

trace_output.txt

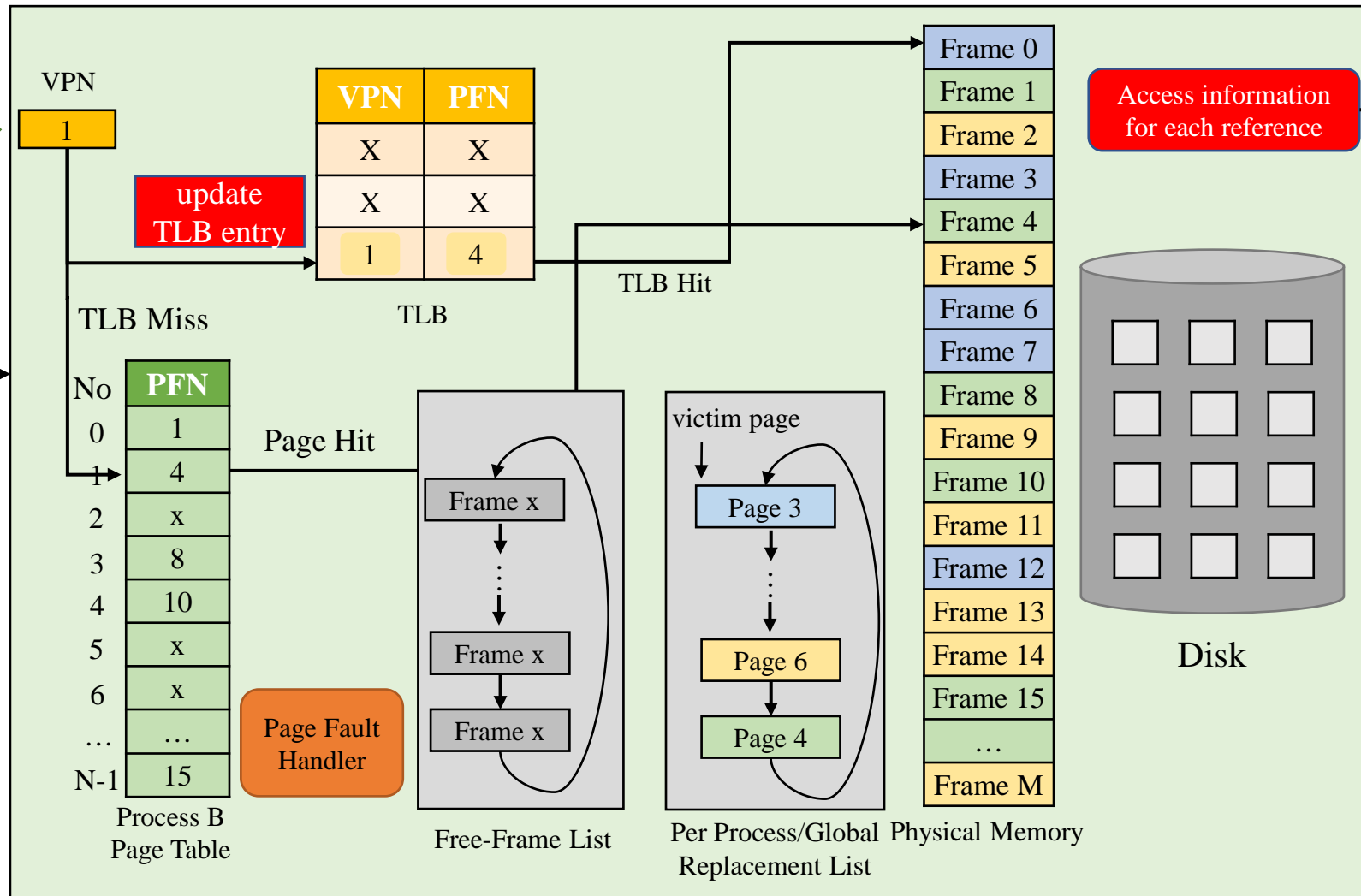
Overview-Memory Manager (5/5)

Reference(A, 1)
Reference(A, 0)
Reference(A, 2)
Reference(B, 1)

trace.txt

TLB Replacement Policy: LRU
Page Replacement Policy: FIFO
Frame Allocation Policy: GLOBAL
Number of Processes: 3
Number of Virtual Page: 2048
Number of Physical Frame: 1024

sys_config.txt



Process A, TLB Hit, 1=>0
Process A, TLB Miss, Page Hit, 0=>3
Process A, TLB Hit, 0=>3
Process A, TLB Miss, Page Fault, 6,
Evict 3 of Process A to 0, 2 << -1
Process A, TLB Hit, 2=>6
Process B, TLB Miss, Page Hit, 1=>4
Process B, TLB Hit, 1=>4

trace_output.txt

Based on the access
information, generate the
analysis for each process

Process A, Effective Access Time = 150
Process B, Effective Access Time = 75
Process A, Page Fault Rate: 0.800
Process B, Page Fault Rate: 0.770

analysis.txt

Overview of Memory Manager

Requirements (1/2)

- Implement a paging based memory manager with TLB support
 - Allocate/manage physical frames for **multiple processes**
 - Use a TLB to speed up address translation by software simulation
 - Use an one-level page table for mapping virtual pages to physical frames
- When the page table has been updated
 - Ensure that TLB/page table are consistent
- When the process has been switched
 - Flush TLB and change PTBR
- TLB Replacement Policy
 - Random
 - LRU
- Page Replacement Policy
 - FIFO
 - Clock
- Frame Allocation Policy
 - Global
 - Local

Requirements (2/2)

- Show the **TLB miss/hit** and related information for each reference in trace file on the output file.
 - If a TLB miss occurs, show the **page hit/page fault** and related information for each reference in trace file on the output file.
- Show the following information for each process under different policies
 - **Effective Access Time**
 - **Page Fault Rate**
- Write a document to show the pros and cons of each policy
 - Please describe your own opinions

Requirement-Page Table

- **Reference Bit**
 - **1**: the page table entry is referenced
 - **0**: the page table entry is not referenced
- **Present Bit**
 - **1**: the page is in physical memory
 - **0**: the page is not in physical memory, it is on disk
- When a page is page-out to disk block **K**, the **PFN** field will be set as **K**

VPN	PFN/DBI	Reference	Present
0	4	1	0
1	0	1	0
2	0	0	0
...			
Z	2	1	1

VPN : virtual page number
PFI : physical frame number
DBI : disk block number

Assumptions

- The number of TLB entries is fixed to 32
 - There is no ASID support in this homework assignment
- There will be **P** processes, **N** virtual pages and **M** physical frames
 - P, N and M will be given in the trace file
 - N is greater than M
 - N and M are both power of 2
- Page fault handler only evicts a page to the disk when there is **no free frame** in physical memory
- An evicted page should be written back to the disk whether it is dirty or not
 - This is not the case in real world, but it simplifies the complexity of this homework
- The disk always has enough space for evicted pages
 - To page-out a page, select an free disk block with the smallest disk block number

Input File Format (1/2)

- Two input files: system configuration file and trace information file
- System configuration file
 - File name: “sys_config.txt”
 - Includes 6 lines
 - Which TLB Replacement Policy?
 - Which Page Replacement Policy?
 - Which Frame Allocation Policy?
 - Number of Process?
 - $20 \geq P \geq 1$
 - Number of Virtual Page N
 - $2048 \geq N \geq 2$
 - Power of 2
 - Number of Physical Frame M
 - $1024 \geq M \geq 1$
 - $N \geq M$
 - Power of 2

```
1 TLB Replacement Policy: LRU | Random
2 Page Replacement Policy: FIFO | CLOCK
3 Frame Allocation Policy: LOCAL | GLOBAL
4 Number of Processes: P (>=1)
5 Number of Virtual Page: N (power of 2)
6 Number of Physical Frame: M (power of 2)
```

sys_config.txt

Input File Format (2/2)

- Trace information file
 - File name: “trace.txt”
 - Includes page reference information of the processes
 - Reference (X, Y): reference virtual page Y of Process X
 - X ranges from ‘A’ ~ ‘T’

```
1 Reference(A, 0)
2 Reference(A, 1)
3 Reference(A, 2)
4 Reference(B, 0)
5 Reference(B, 1)
6 Reference(B, 2)
7 Reference(C, 0)
8 Reference(C, 1)
9 Reference(C, 2)
...
2 Reference(B, 4)
...
Z Reference(C, 8)
```

trace.txt

Output File Format (1/2)

- Show the following information for each reference
 - Format for a **TLB hit**: Process [X], TLB Hit, [VPN]=>[PFN]
 - Format for a **TLB miss**:
 - **Page hit**: Process [X], TLB Miss, Page Hit, [VPN]=>[PFN]
 - **Page fault**: Process [X], TLB Miss, Page Fault, [PFN], Evict [VPN] of Process [X] to [Destination], [VPN]<<[Source]
 - PFN: frame index that is about to be replaced
 - Source: the block number of the page which is page-in from disk
 - Destination: the block number where the evicted page page-out
 - If there is no source/destination (e.g., first reference, no page is page-out) or no evicted VPN, set the value as **-1**
- Store as “trace_output.txt”

```
Process A, TLB Miss, Page Fault, 0, Evict -1 of Process A to -1, 6 << -1
Process A, TLB Hit, 6=>0
...
Process A, TLB Miss, Page Hit, 1=>6
...
Process B, TLB Miss, Page Hit, 2=>10
```

trace_output.txt

Output File Format (2/2)

- Show the **Effective access time** for each process

- $EAT = \alpha(m+t) + (1-\alpha)(2m+t)$

- Assume

- $m = 100\text{ns}$
 - $t = 20\text{ns}$

TLB Lookup time = t time units

Memory cycle time = m time units

Hit ratio = α

- Show the **page fault rate** for each process
- Store as `analysis.txt`

```
Process A, Effective Access Time = 191.428
Process A, Page Fault Rate: 0.800
Process B, Effective Access Time = 160.725
Process B, Page Fault Rate: 0.770
```

analysis.txt

three decimal place accuracy