

Systems and Networking I

Applied Computer Science and Artificial Intelligence
2023-2024



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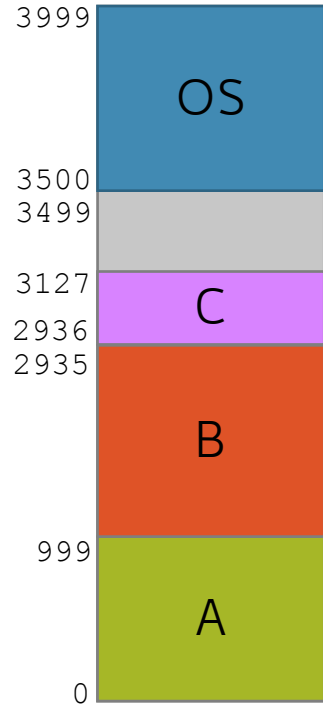
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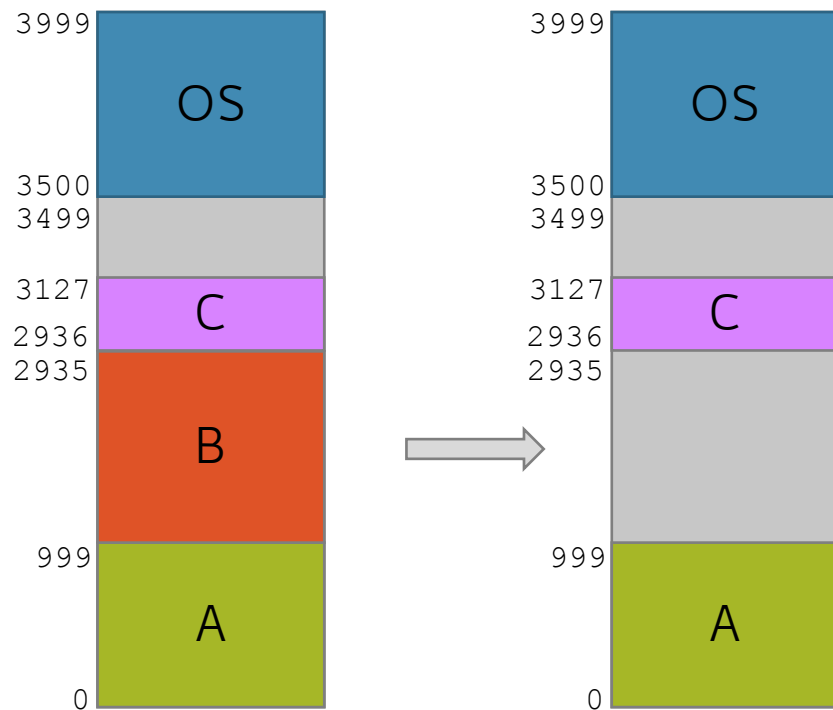
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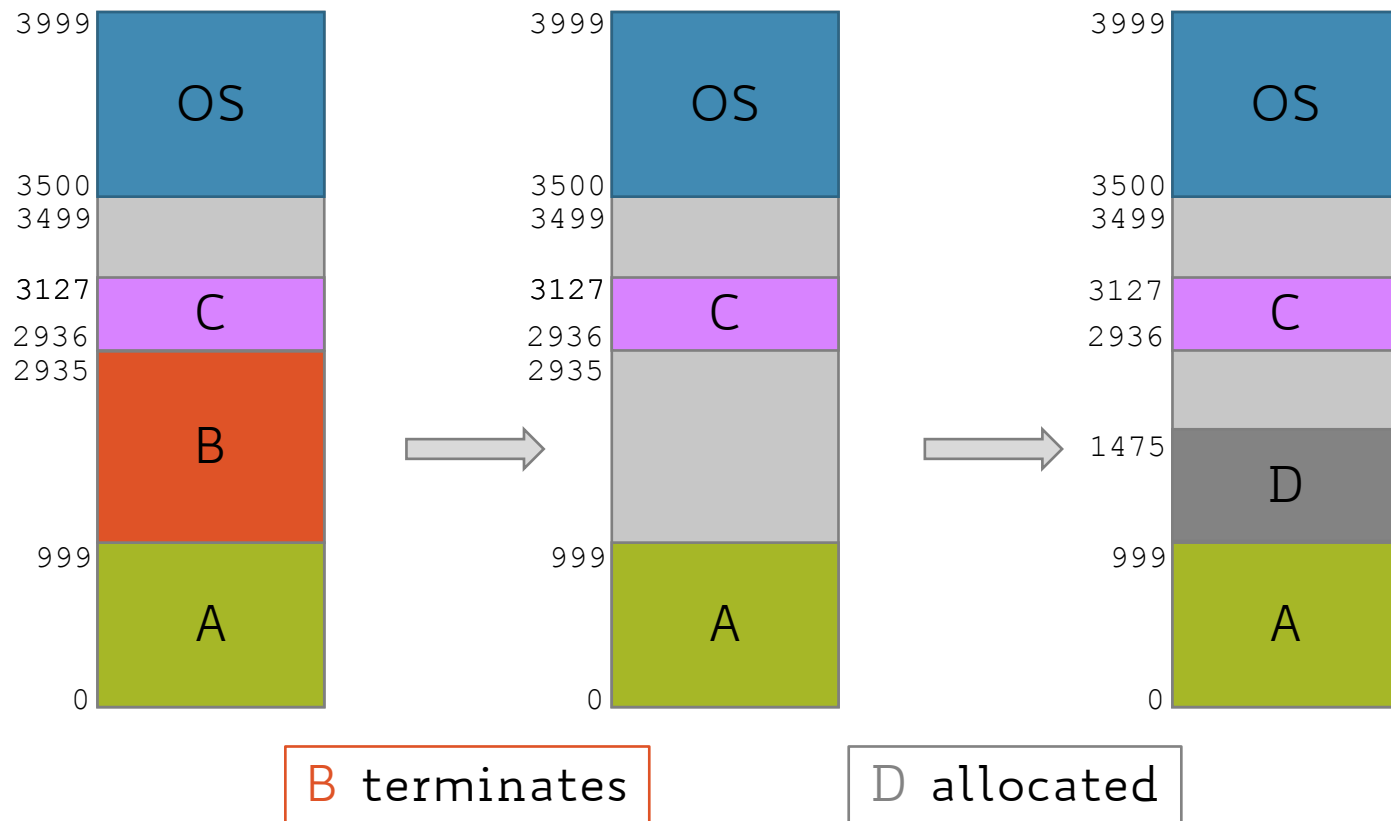
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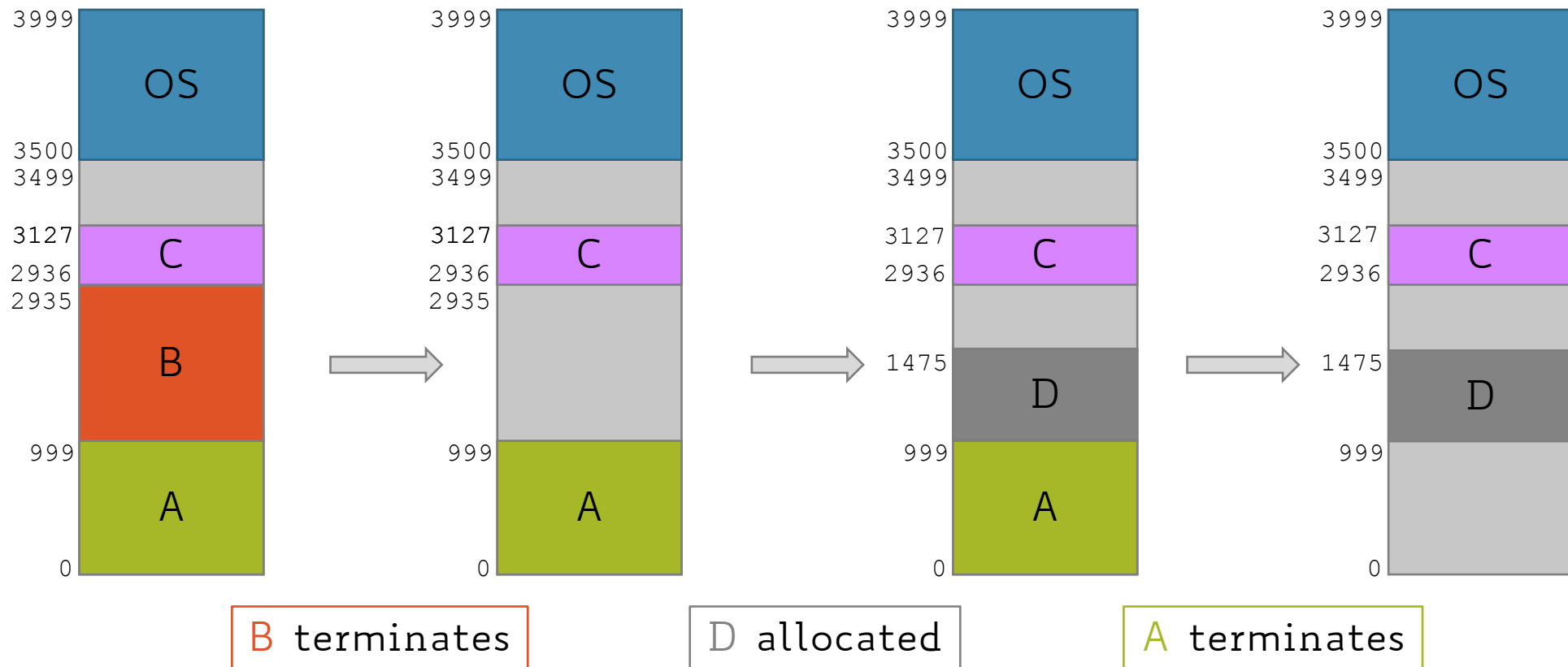
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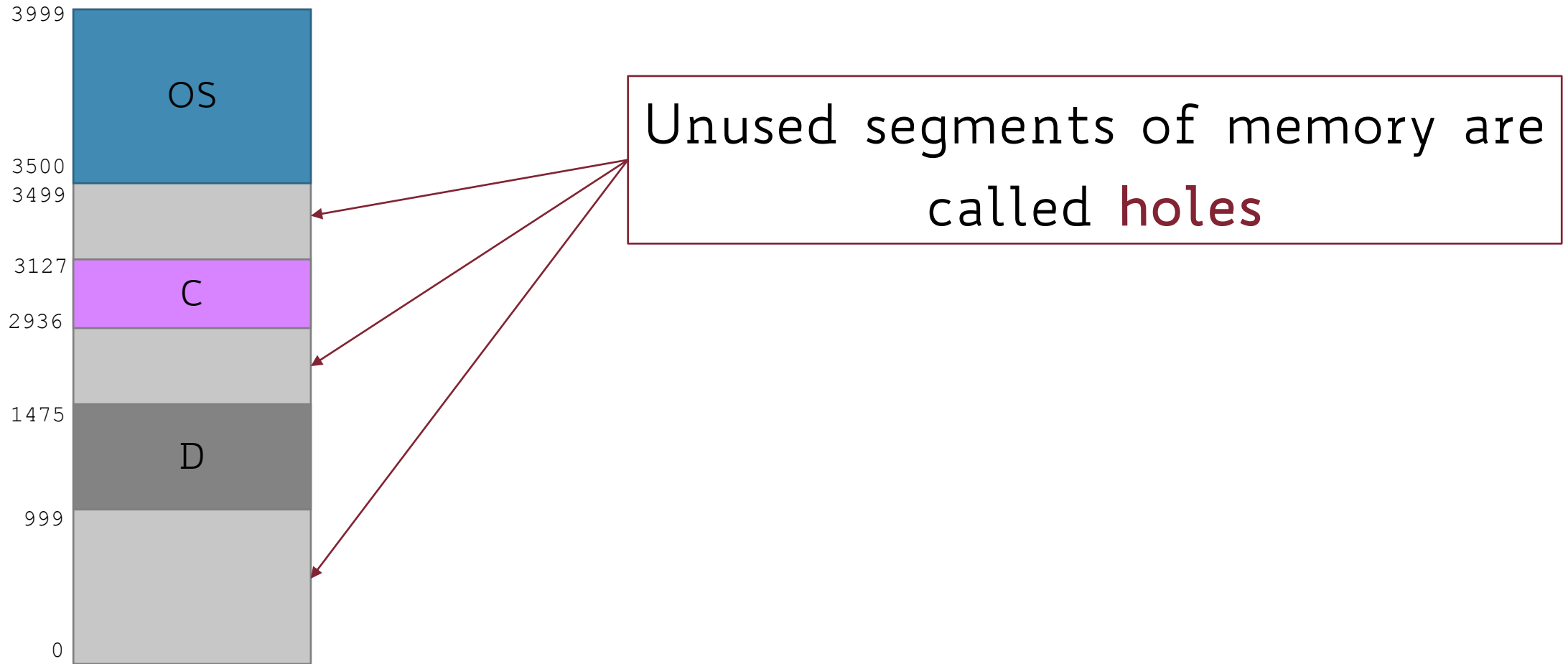


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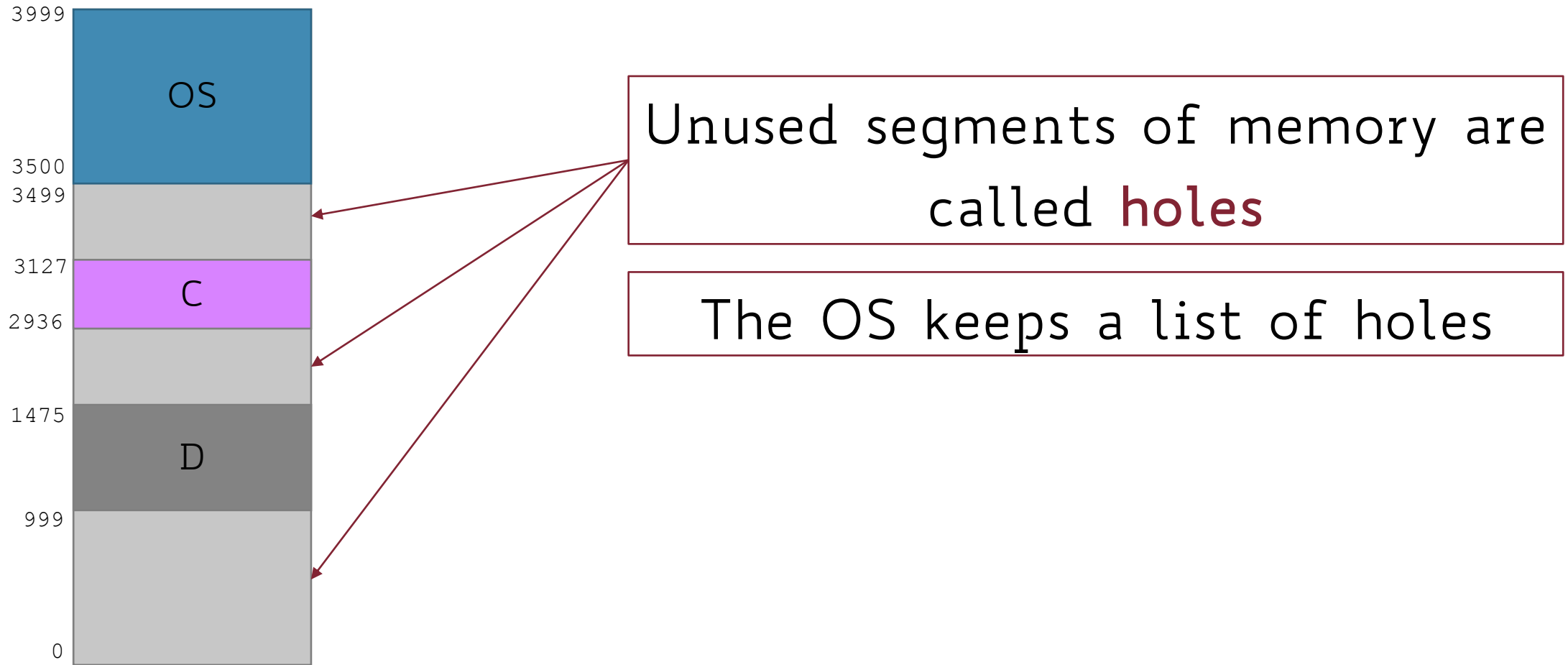
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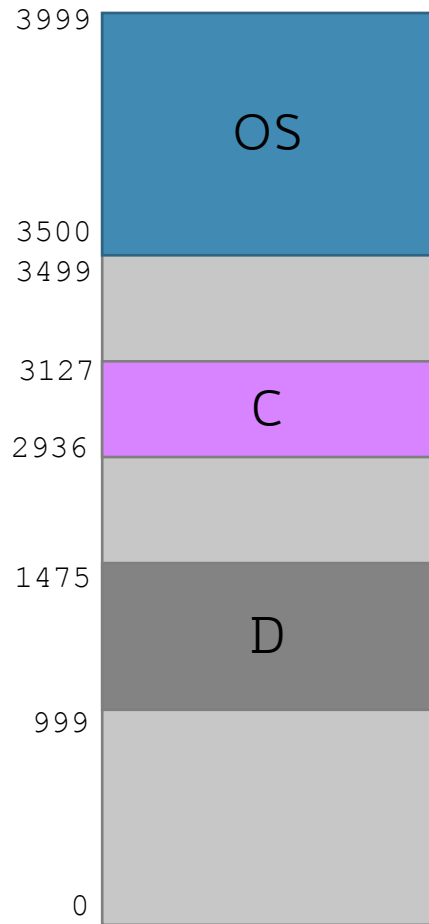
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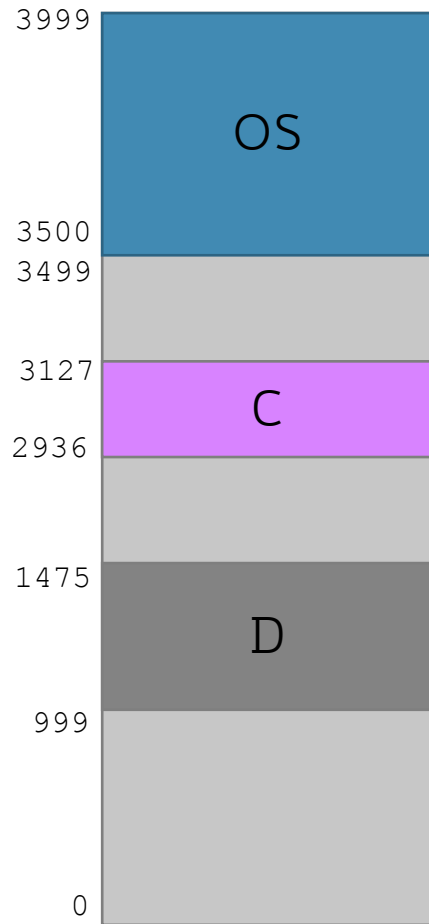


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How?

Memory Allocation Policies: First-Fit

- Linearly scan the list of holes until one is found that is big enough to satisfy the request

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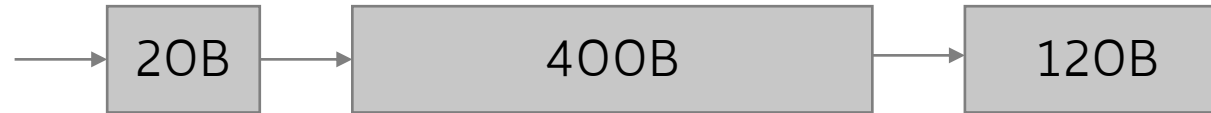
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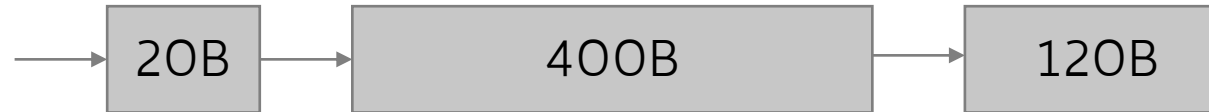
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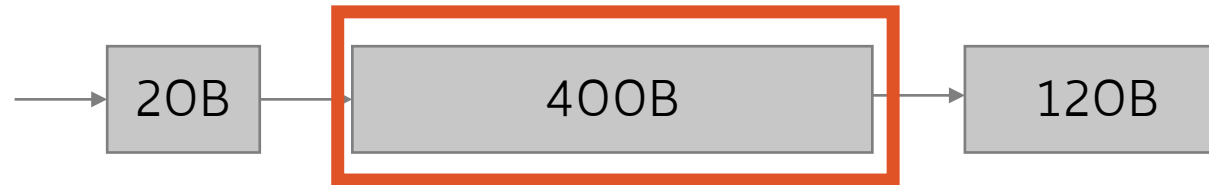
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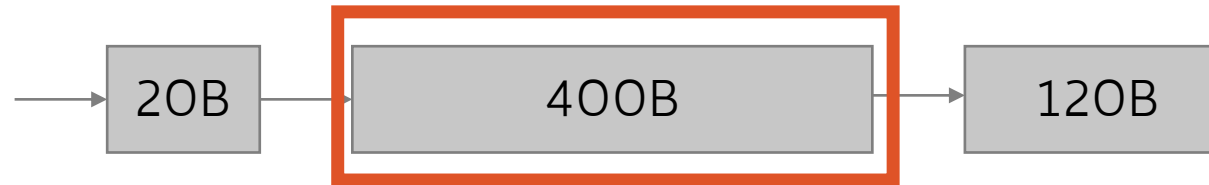
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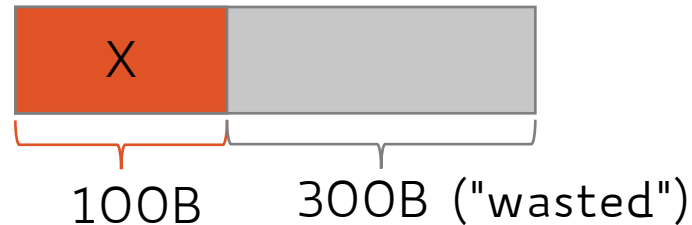
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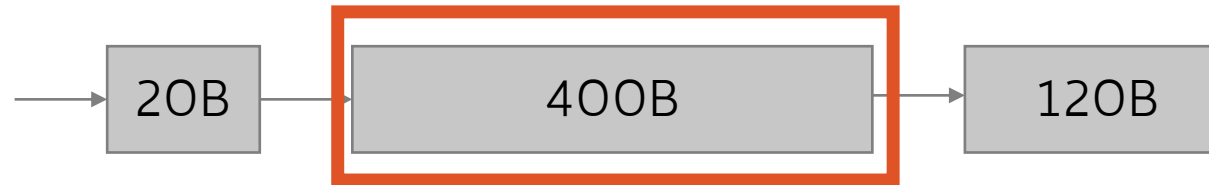


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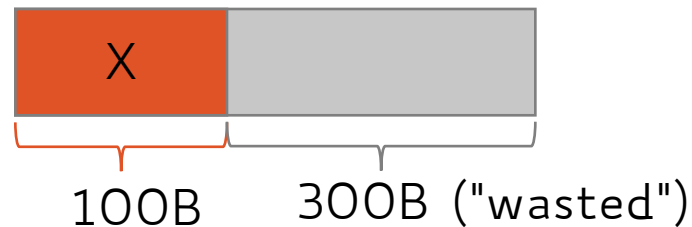


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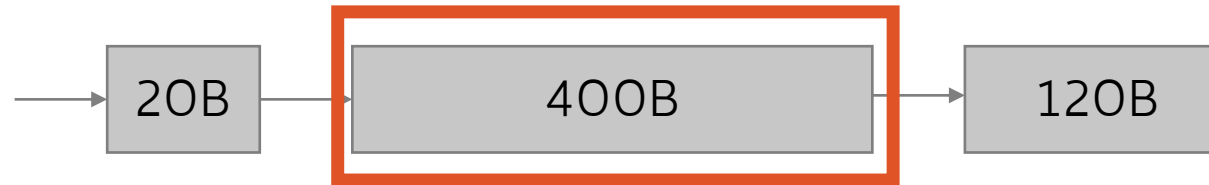
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We will not be able to satisfy this request even if theoretically we could

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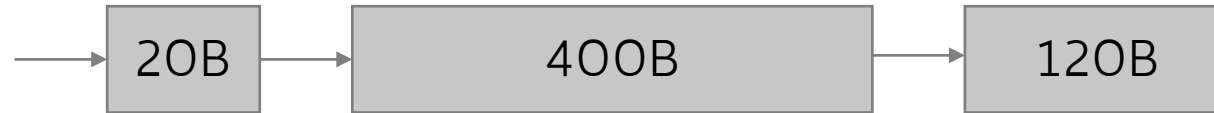
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Binary Search Tree (BST)

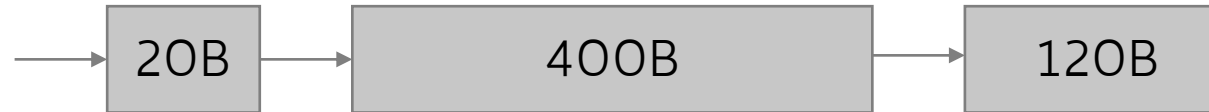
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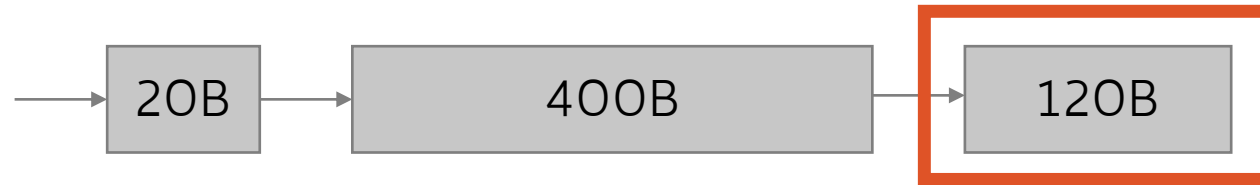
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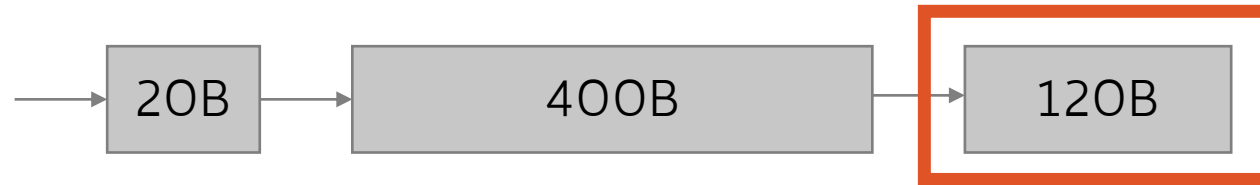
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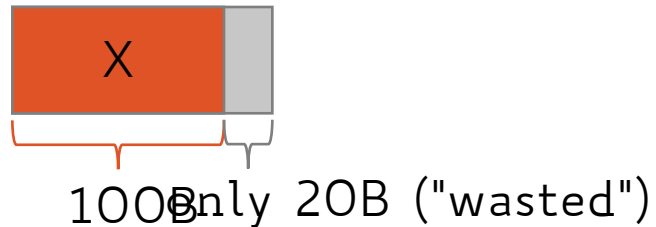
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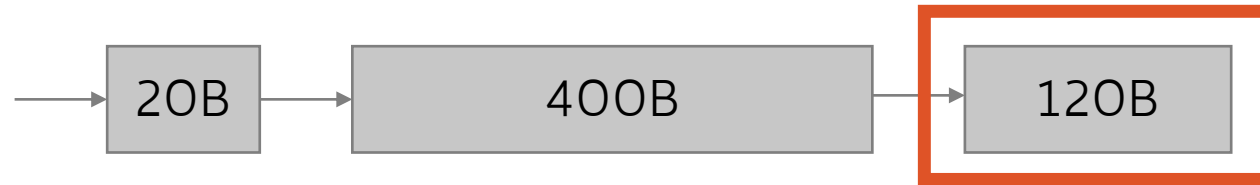


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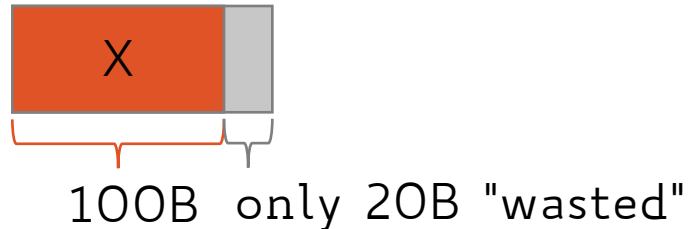


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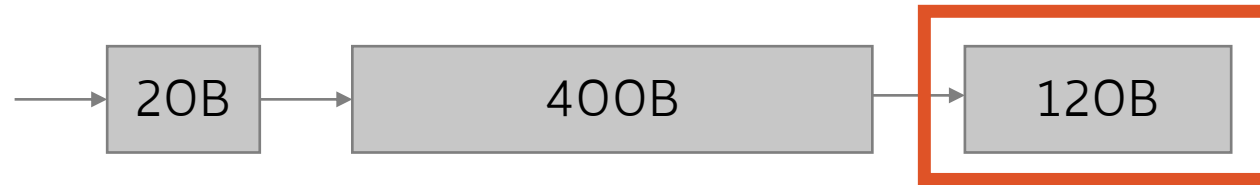
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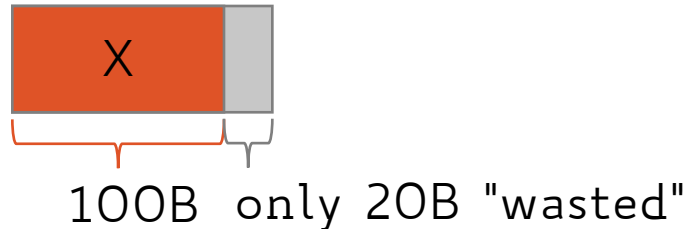
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We can now assign it the second available hole segment (400B)

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- First-Fit is also generally faster than Best-Fit

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Problem

Individual holes may be too small to serve a process request but they can be large enough if combined together

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```
graph TD; Problem[Problem] --> External[External Fragmentation]; Problem --> Internal[Internal Fragmentation];
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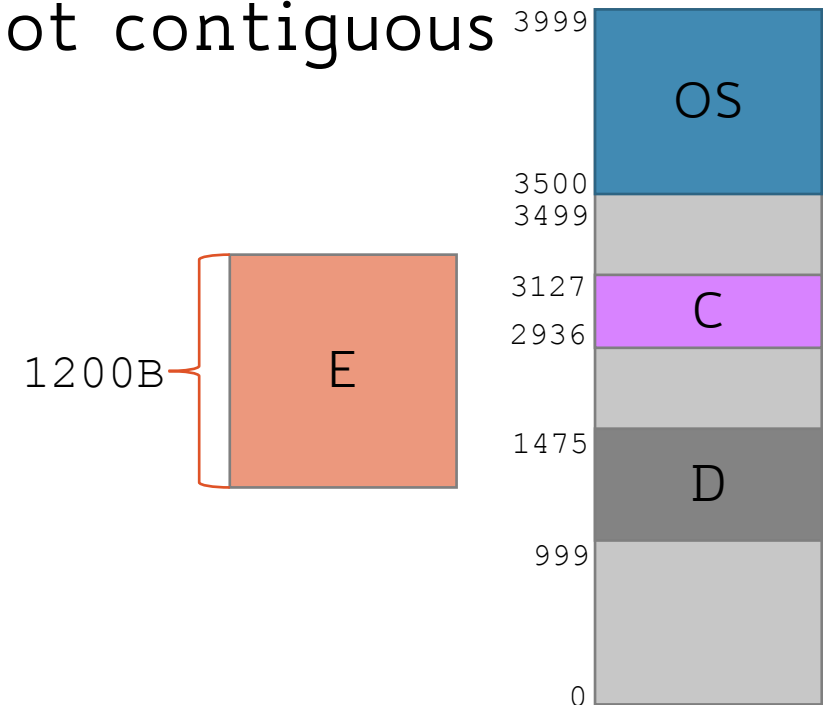
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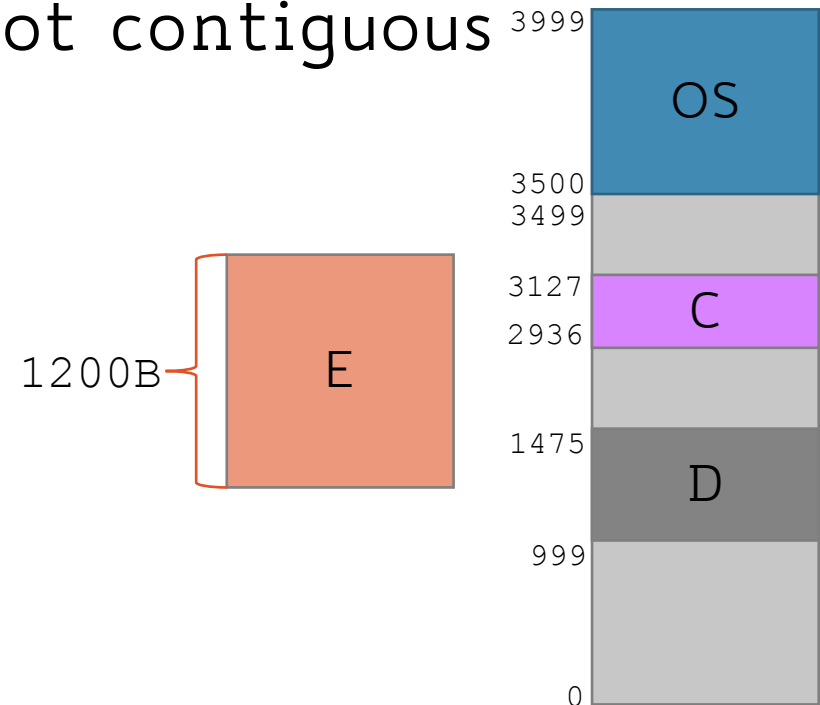


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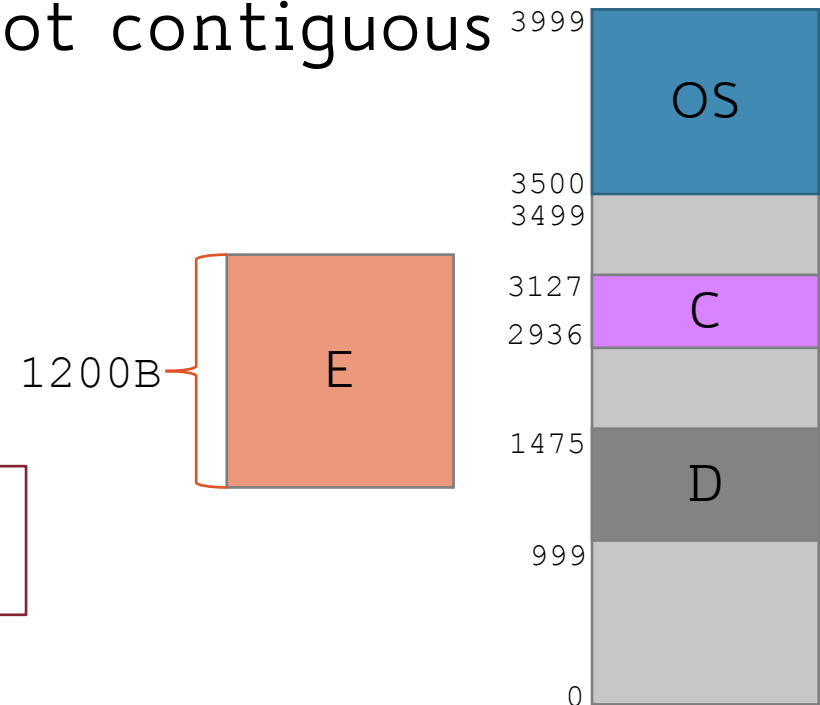
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Goal:

Allocation policy that minimizes wasted space!



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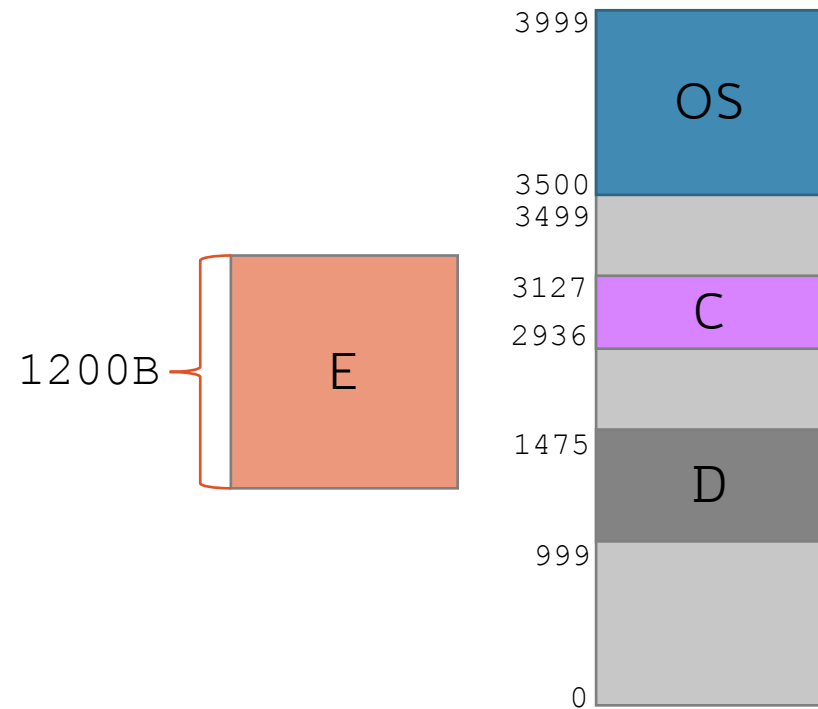
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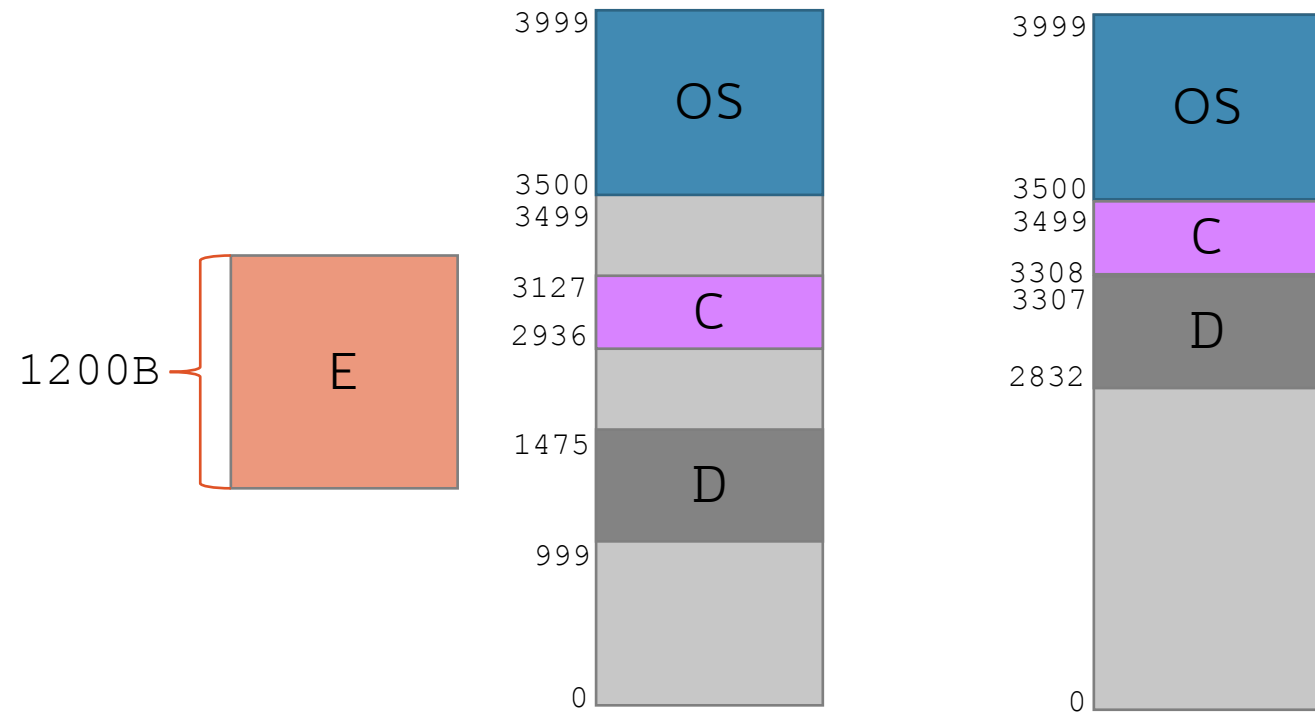
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- It may be much more efficient to allocate the process the whole block (and waste 2B) rather than keep track of a tiny 2B hole

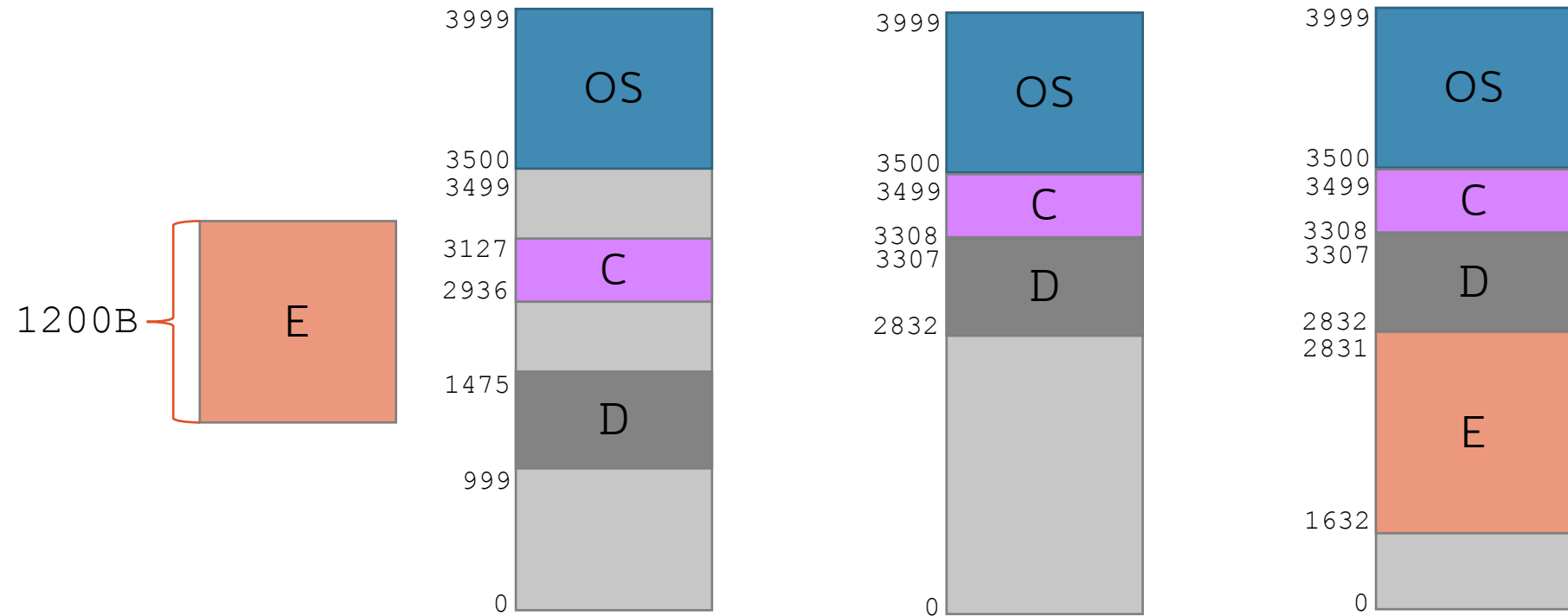
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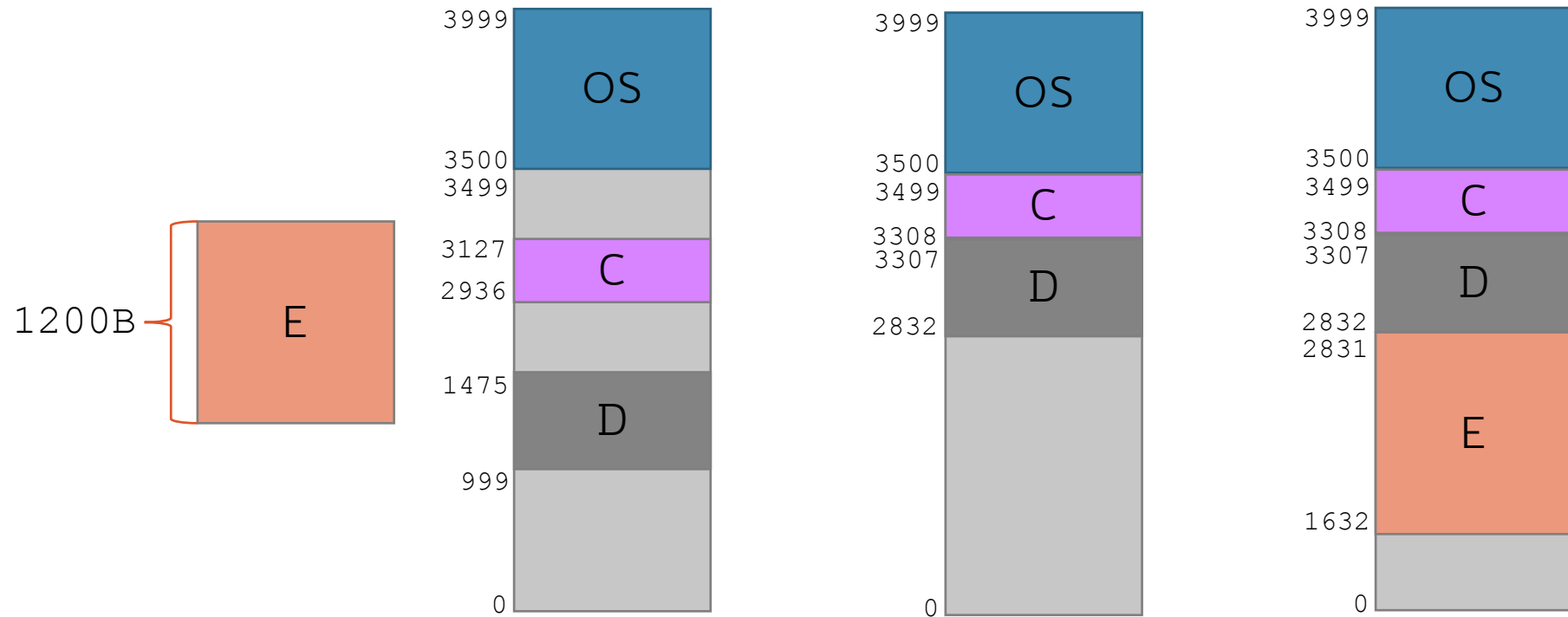
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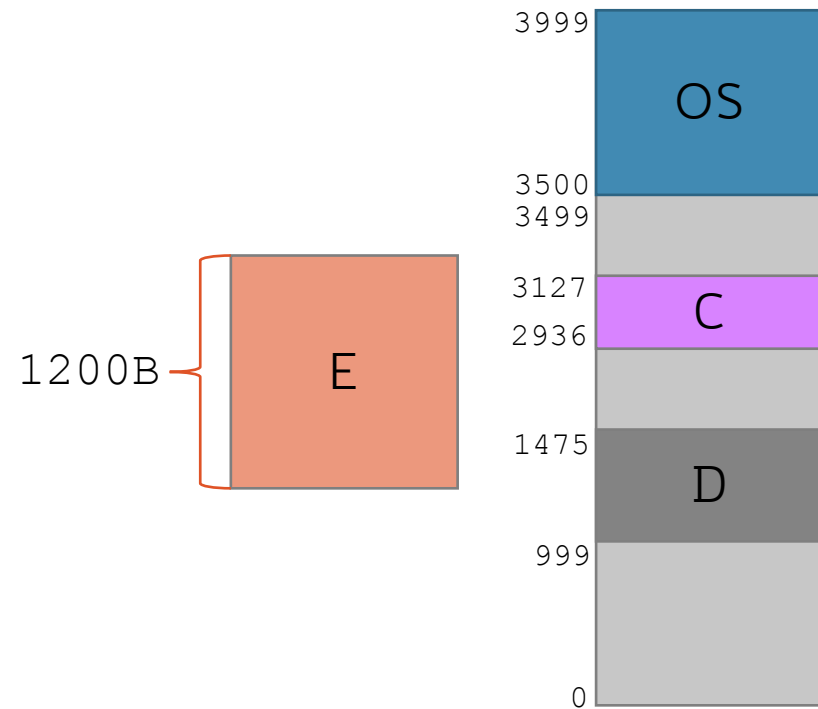


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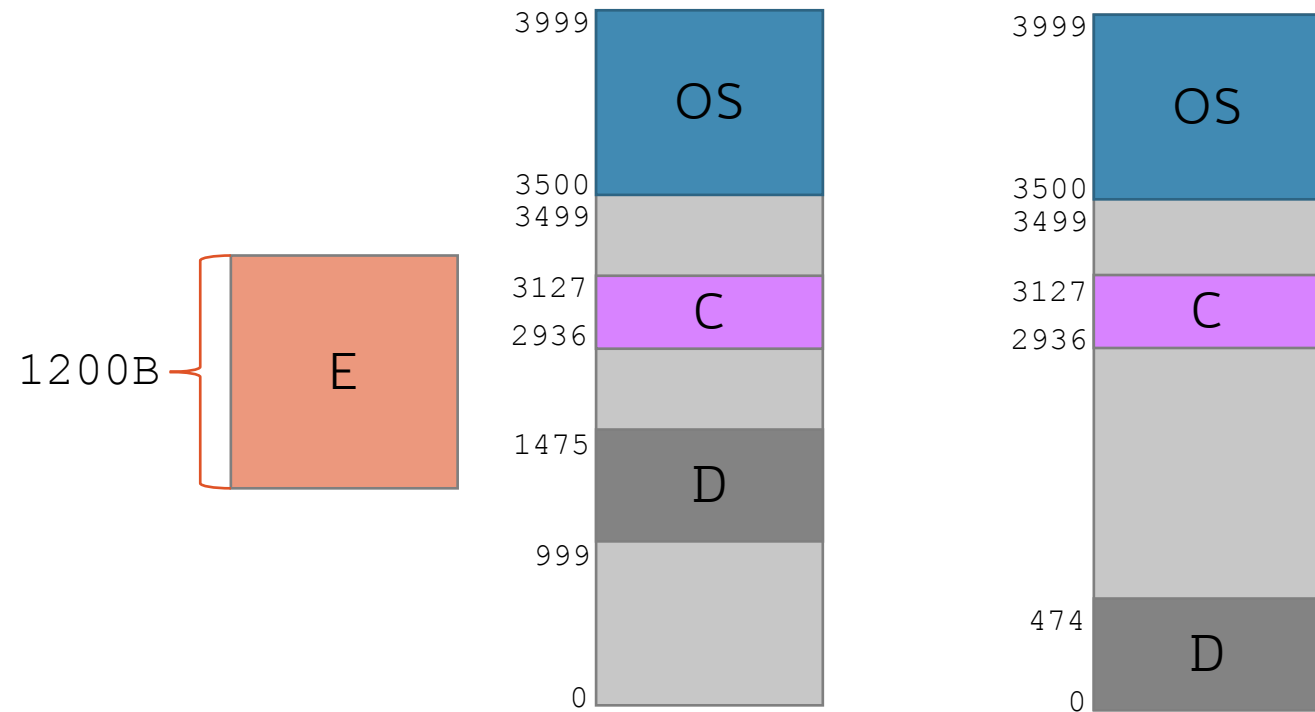


Only one hole is left but two processes need to be moved (C and D)

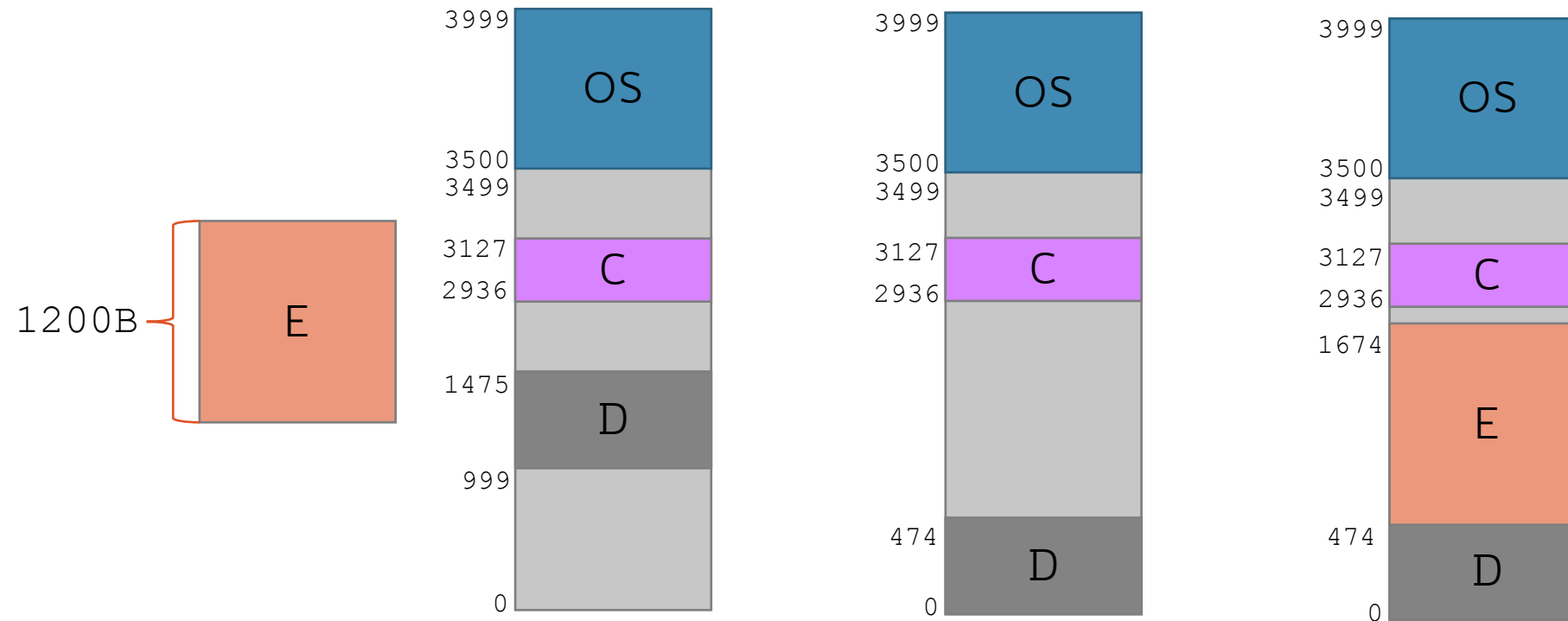
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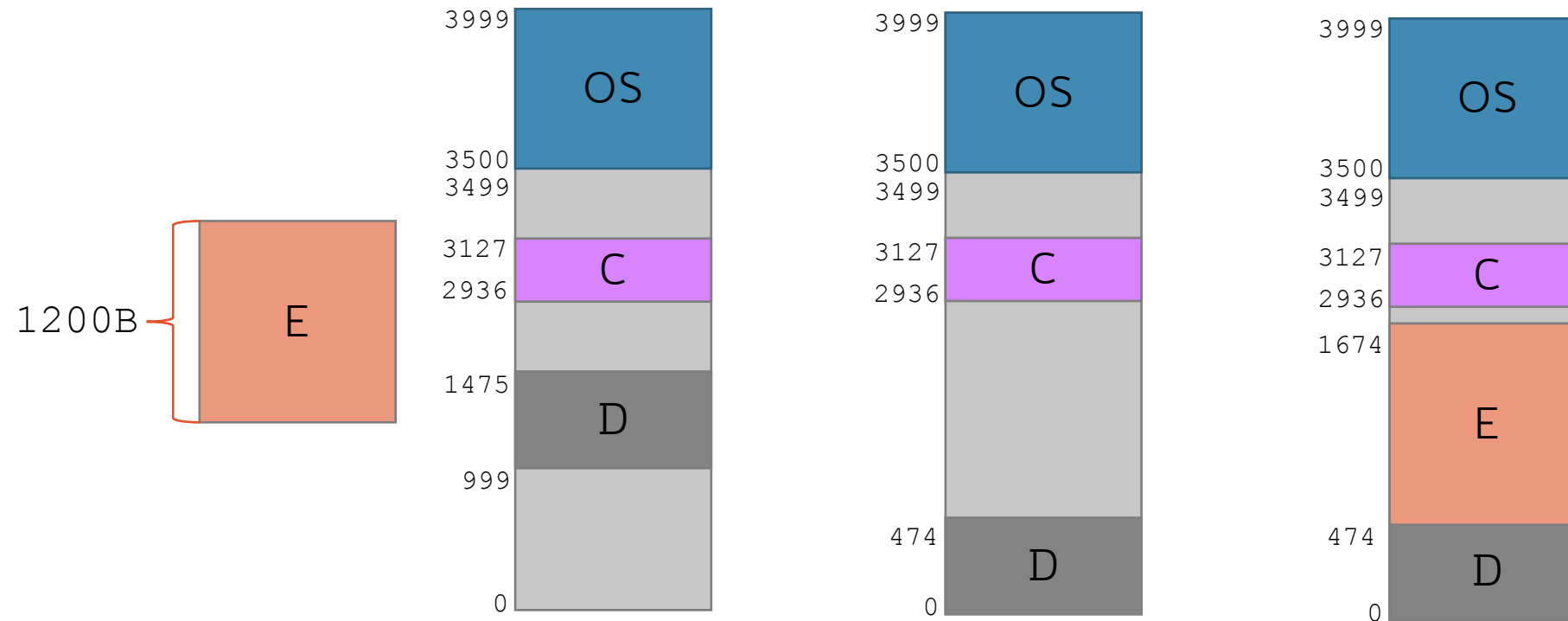
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Still some holes left but only one process is moved (D) rather than two

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- That process can be "swapped out" from memory to disk to make room for other processes

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- Using swapping, fragmentation can be tackled easily
 - Just run compaction before swapping-in a process

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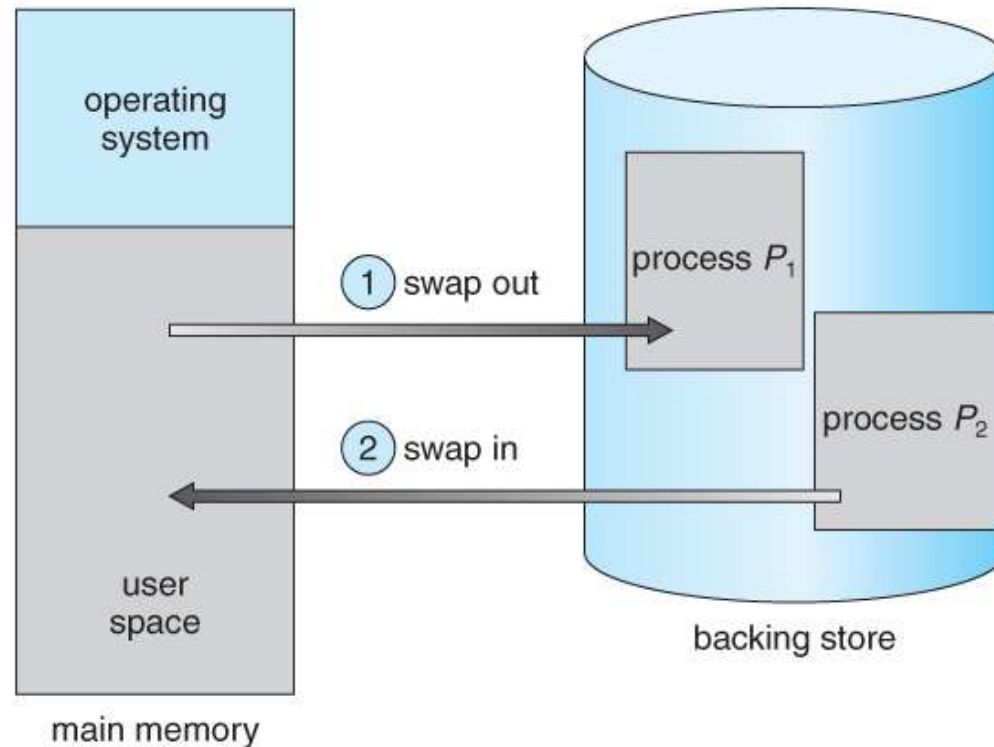
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- Time slice is usually way smaller than that!

Swapping



Most modern OSs no longer use swapping, because it is too slow and there are faster alternatives available (e.g., **paging**)

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- Process entirely loaded
 - Swapping helps but it may be too inefficient

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90/10 Rule

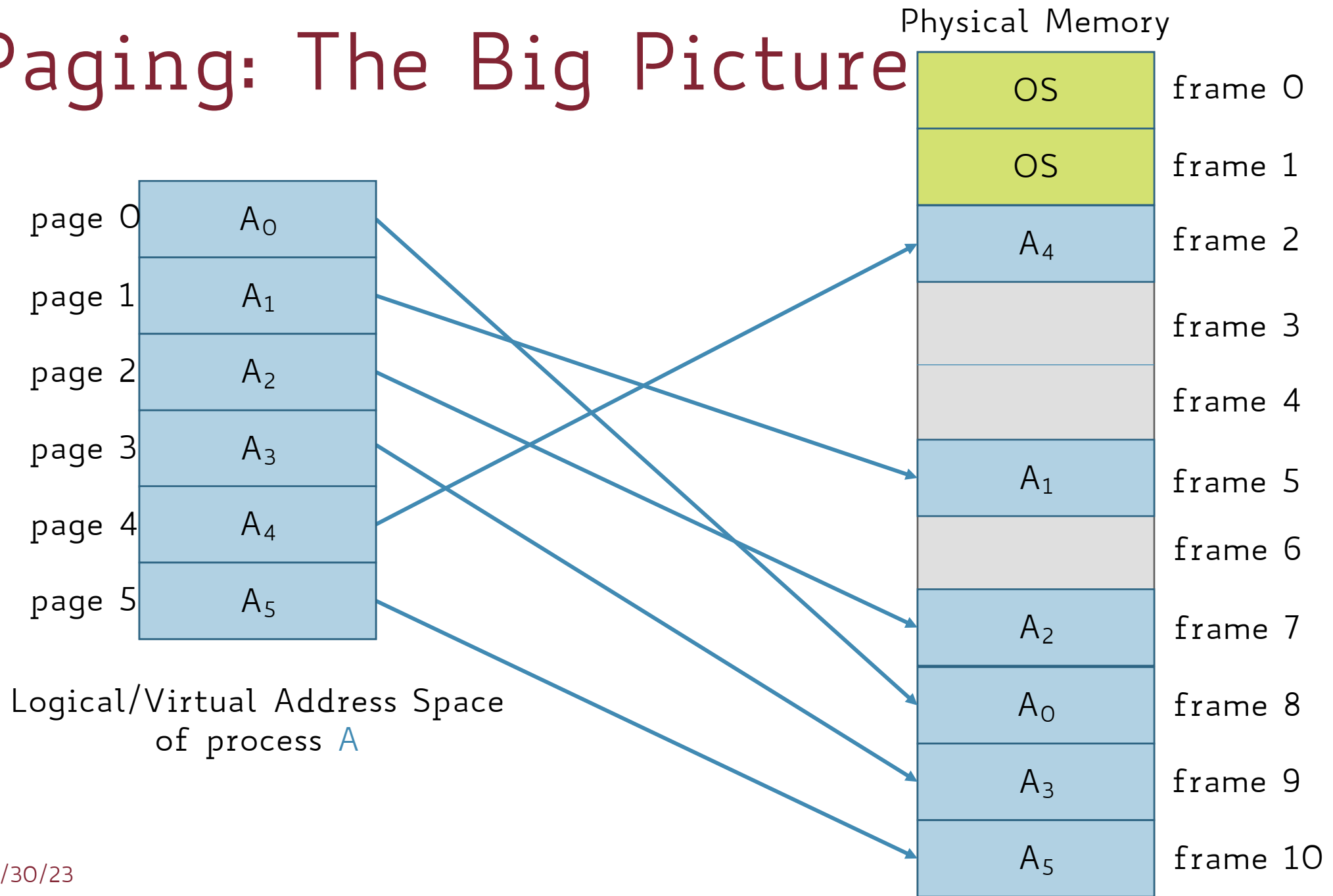
Processes spend **90%** of their time accessing only **10%** of their allocated memory space

Paging: The Big Picture

page 0	A_0
page 1	A_1
page 2	A_2
page 3	A_3
page 4	A_4
page 5	A_5

Logical/Virtual Address Space
of process A

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 - Remember, memory addresses are referenced all the time
- OS needs dedicated support for doing it → **Page Table**

Page Table: Mapping Pages to Frames

0	A ₀
1	A ₁
2	A ₂
3	A ₃
4	A ₄
5	A ₅

OS	0
OS	1
A ₄	2
	3
	4
A ₁	5
	6
A ₂	7
A ₀	8
A ₃	9
A ₅	10

Page Table: Mapping Pages to Frames

Lookup table to retrieve what frame a page is stored in

0	A ₀
1	A ₁
2	A ₂
3	A ₃
4	A ₄
5	A ₅

Page	Frame
0	8
1	5
2	7
3	9
4	2
5	10

OS	0
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A ₀	8
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0	A ₀	Page	Frame	OS	0
1	A ₁	0	8	OS	1
2	A ₂	1	5	A ₄	2
3	A ₃	2	7		3
4	A ₄	3	9		4
5	A ₅	4	2	A ₁	5
		5	10		6
				A ₂	7
				A ₀	8
				A ₃	9
				A ₅	10

We have assumed **all** pages of a process are mapped to physical frames, but this is not always the case

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- Paging solves all these issues!