CACHE REPLACEMENT WITH MEMORY ALLOCATION

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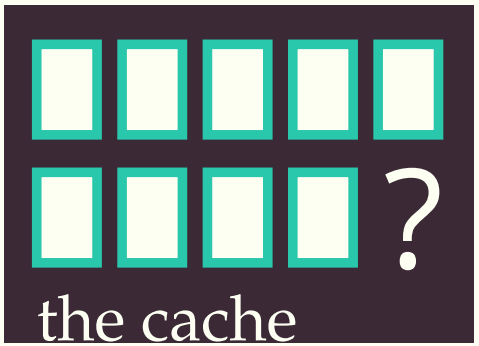
ALENEX 2015 — January 5, 2015

THE PAGING PROBLEM

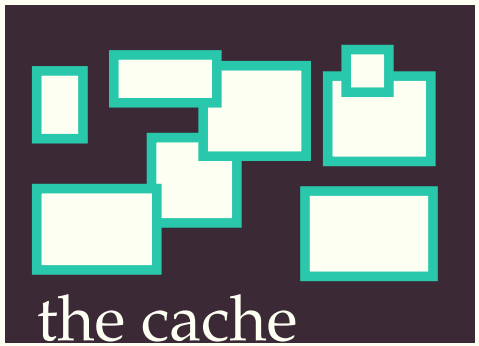


GOAL

minimize number of cache misses

THE GENERALIZED CACHING PROBLEM

variable size and cost



GOAL

minimize **total cost** of cache misses

SUBJECT TO

total size of items in cache
cannot exceed the cache size

THE MANAGED MEMORY CACHING PROBLEM

variable size and cost

every item must fit in a contiguous segment of memory

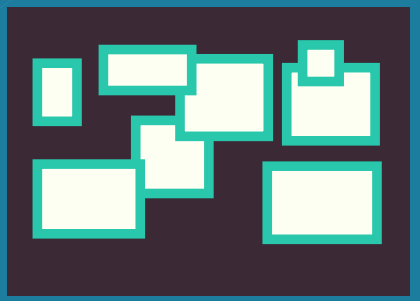
CACHE REPLACEMENT

MEMORY ALLOCATION

PAGING PROBLEM

main memory

GENERALIZED CACHING



webproxy

MANAGED MEMORY CACHING PROBLEM

key-value stores

SIMPLE ALGORITHM

for the managed memory
caching problem

COMPETITIVE RATIO

if augmented memory
against optimal offline algorithm
for the generalized caching problem

EXPERIMENTAL RESULTS

RESULTS

GDS

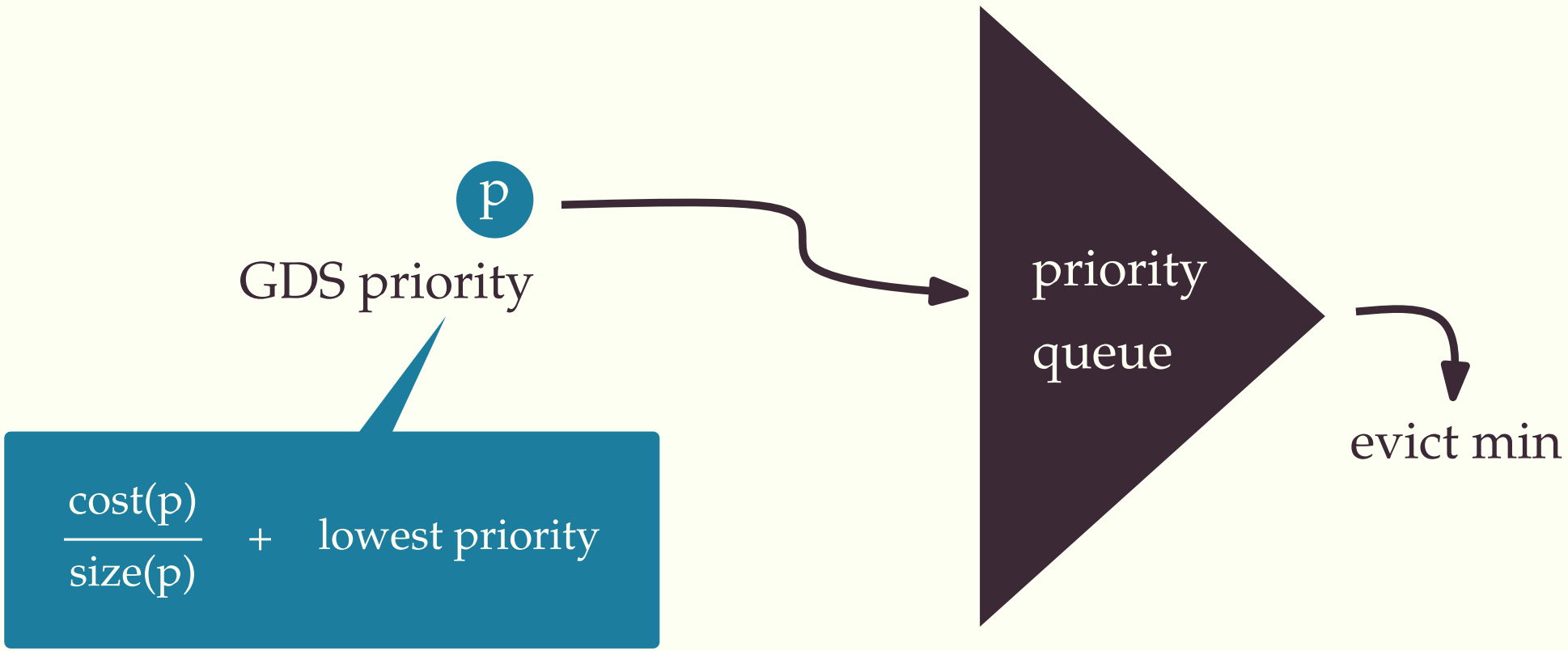
Greedy-Dual Size

CAMP

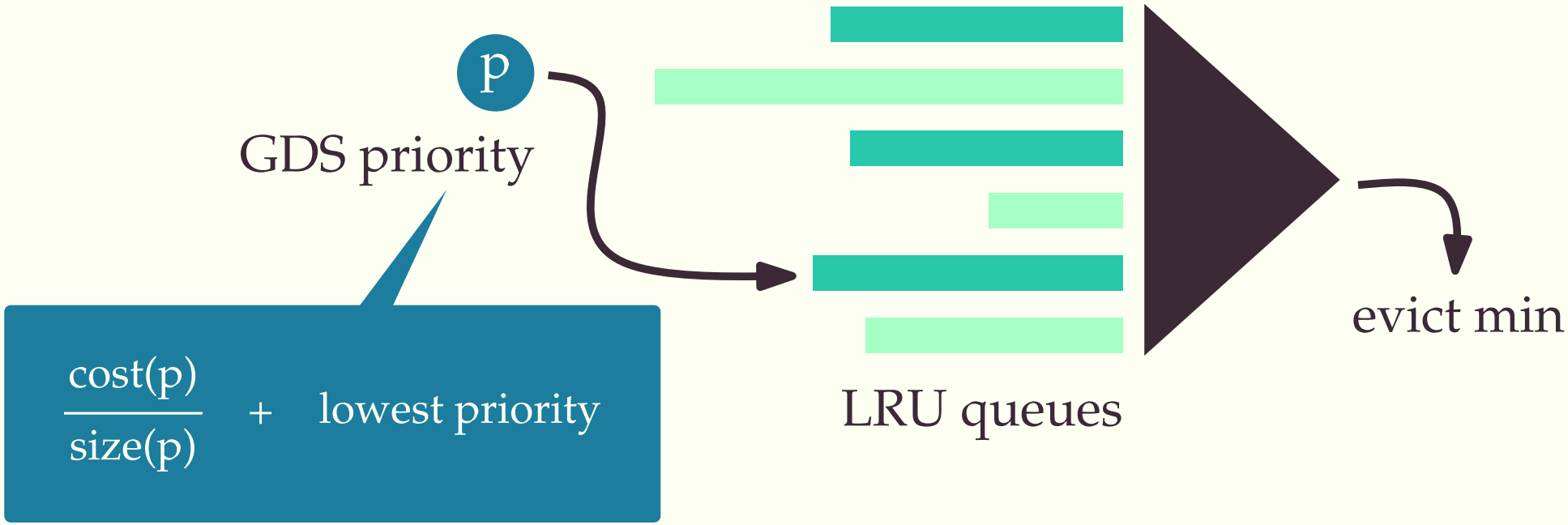
Cost-adaptive multiqueue eviction policy

OUR ALGORITHM

GDS


p
GDS priority
cost(p) / size(p) + lowest priority
priority queue
evict min

CAMP


p
GDS priority
cost(p) / size(p) + lowest priority
LRU queues
evict min

OUR ALGORITHM

LRU queues

OUR ALGORITHM

FIFO queues

OUR ALGORITHM

FIFO queue

OUR ALGORITHM

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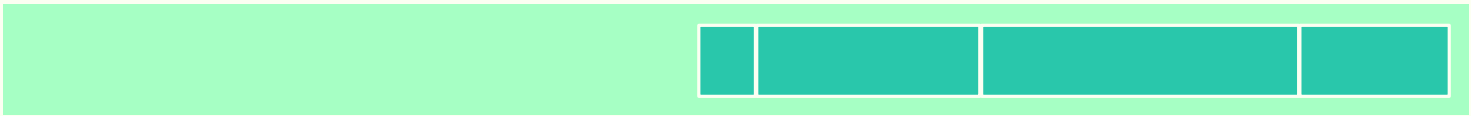
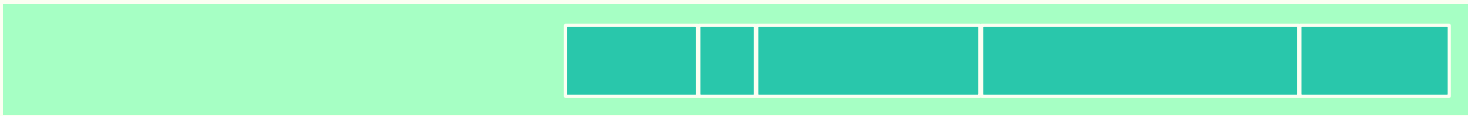


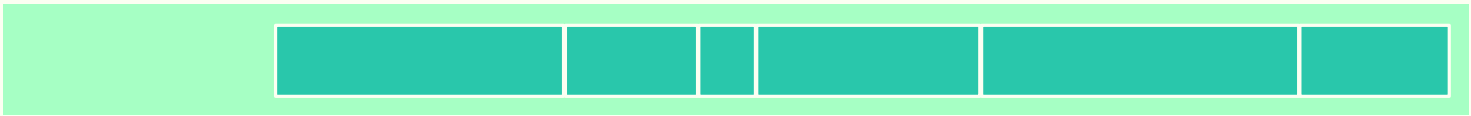
FIFO queue

OUR ALGORITHM



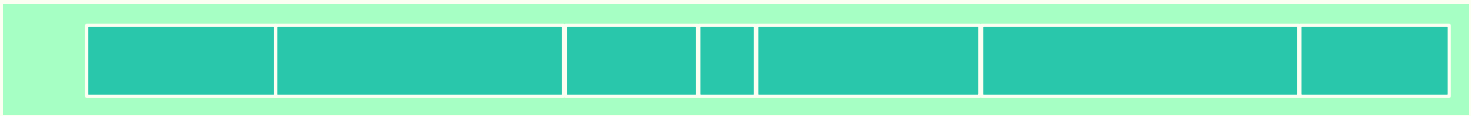
FIFO queue

OUR ALGORITHM



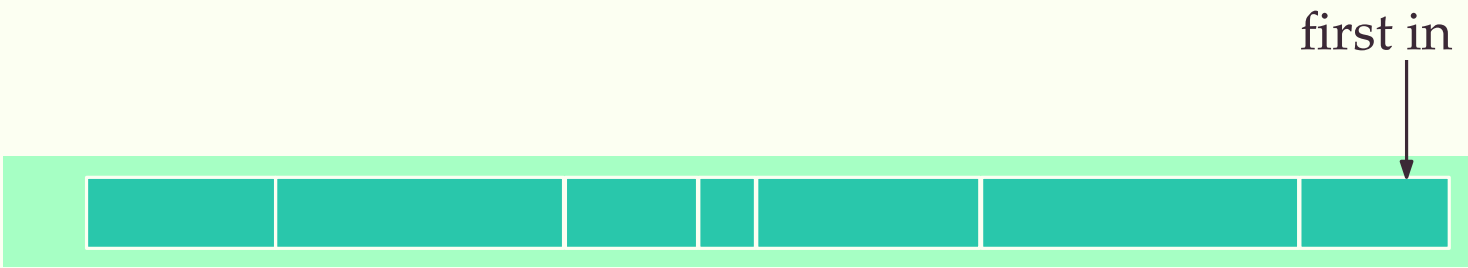
FIFO queue

OUR ALGORITHM



FIFO queue

OUR ALGORITHM



FIFO queue

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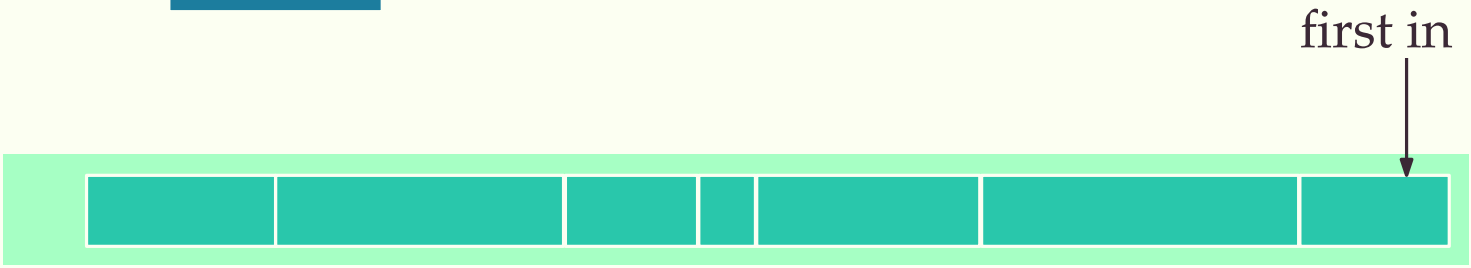

FIFO queue

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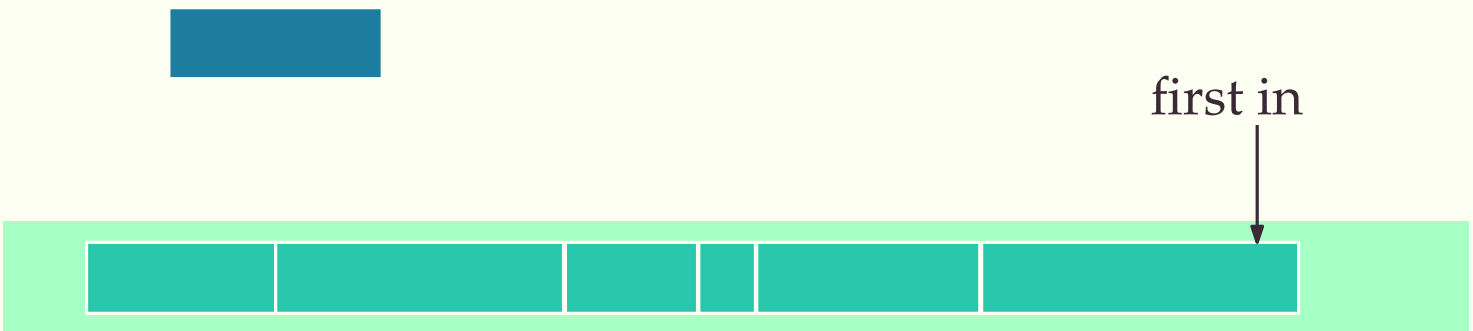
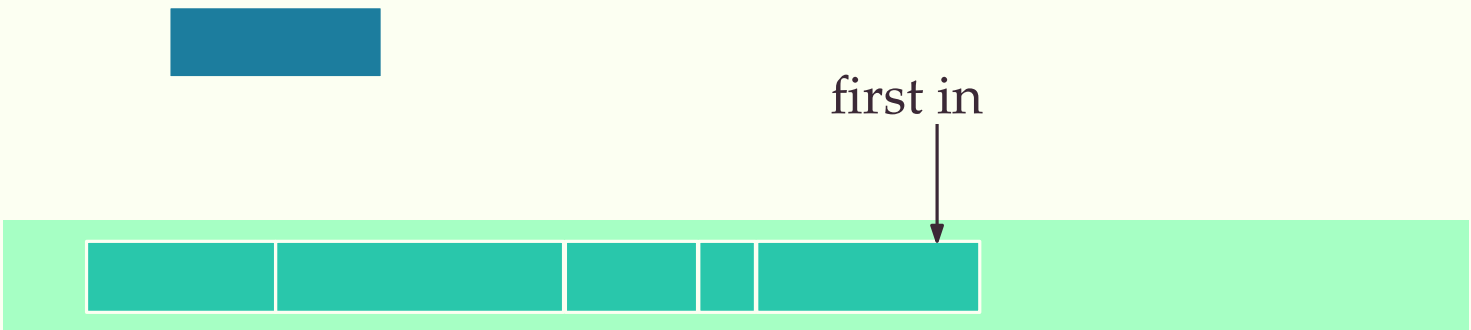


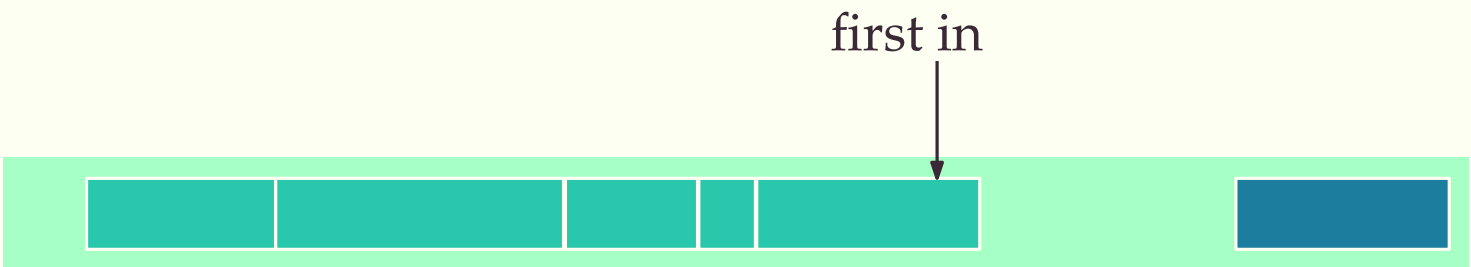
FIFO queue

OUR ALGORITHM



FIFO queue

OUR ALGORITHM



FIFO queue

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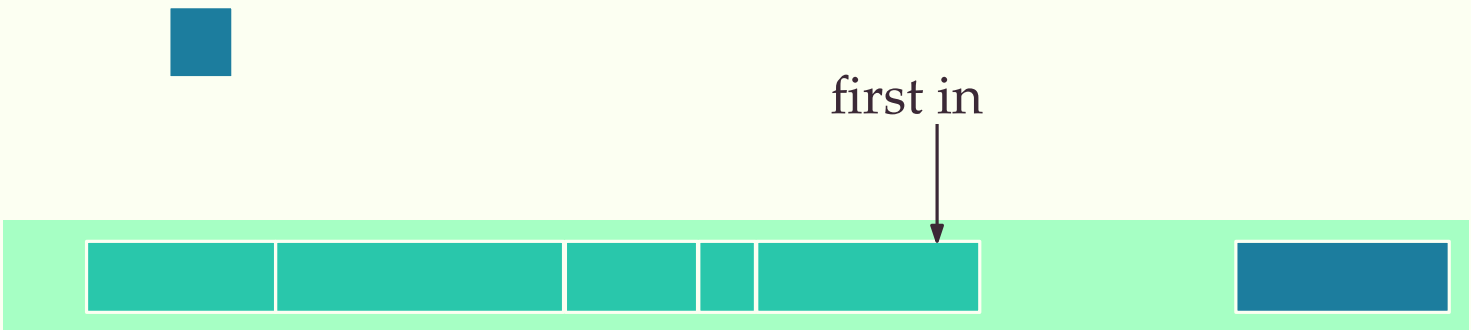

FIFO queue

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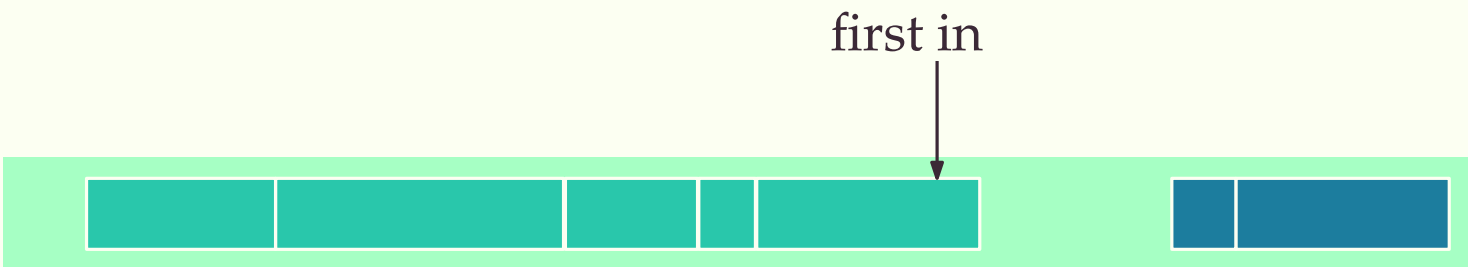

FIFO queue

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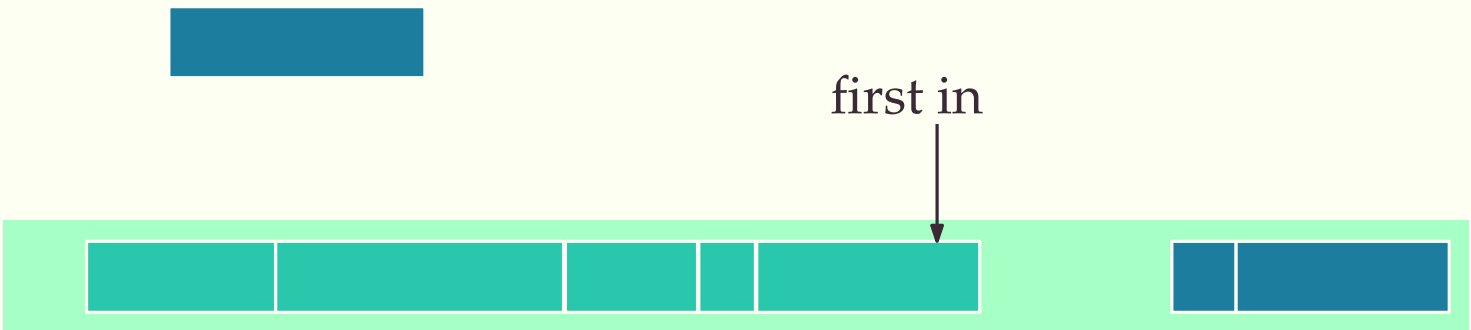

FIFO queue

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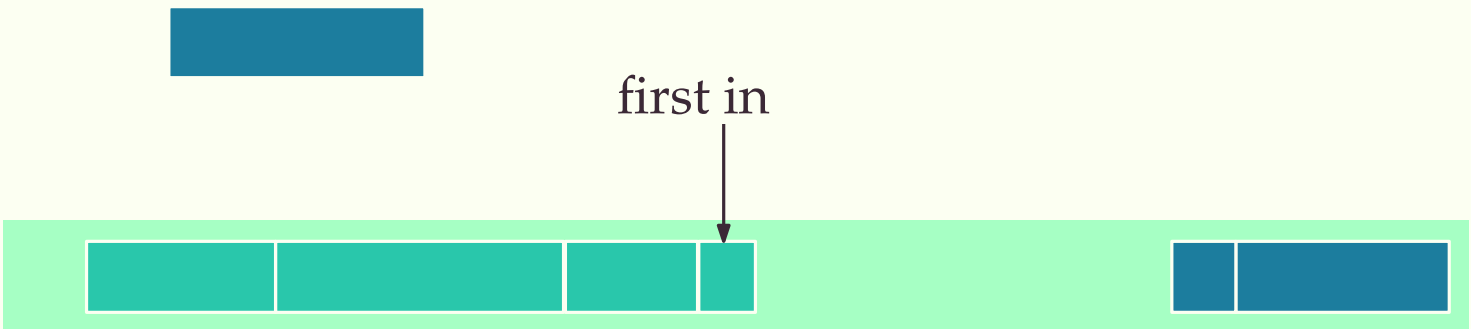

FIFO queue

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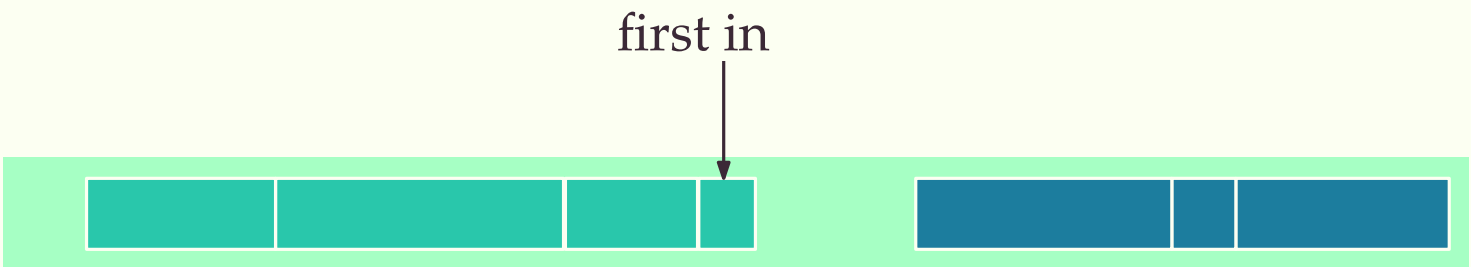

FIFO queue

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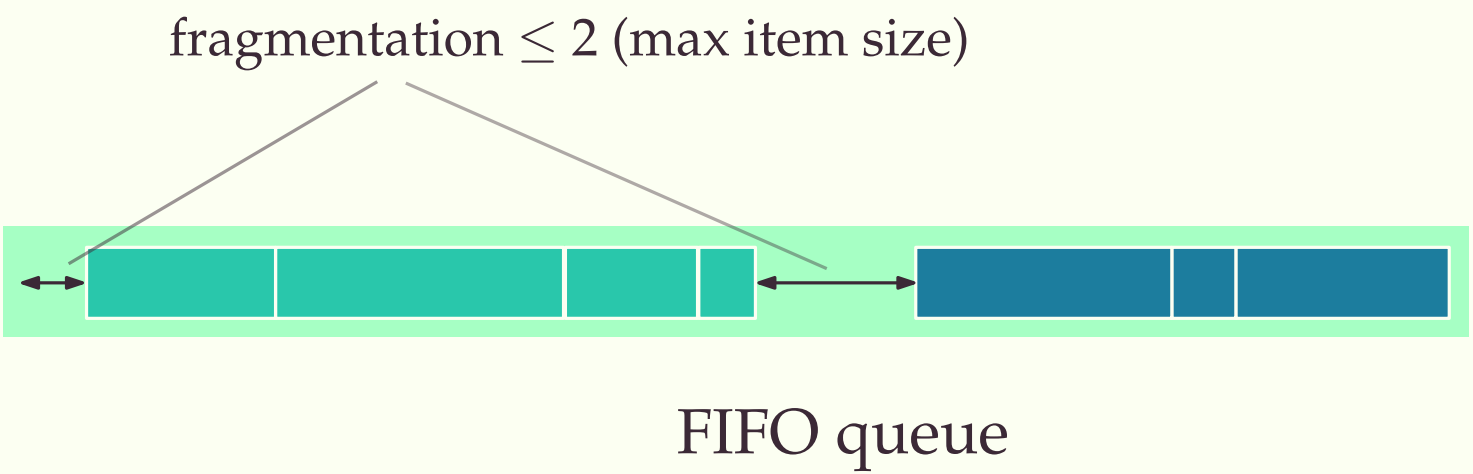

OUR ALGORITHM

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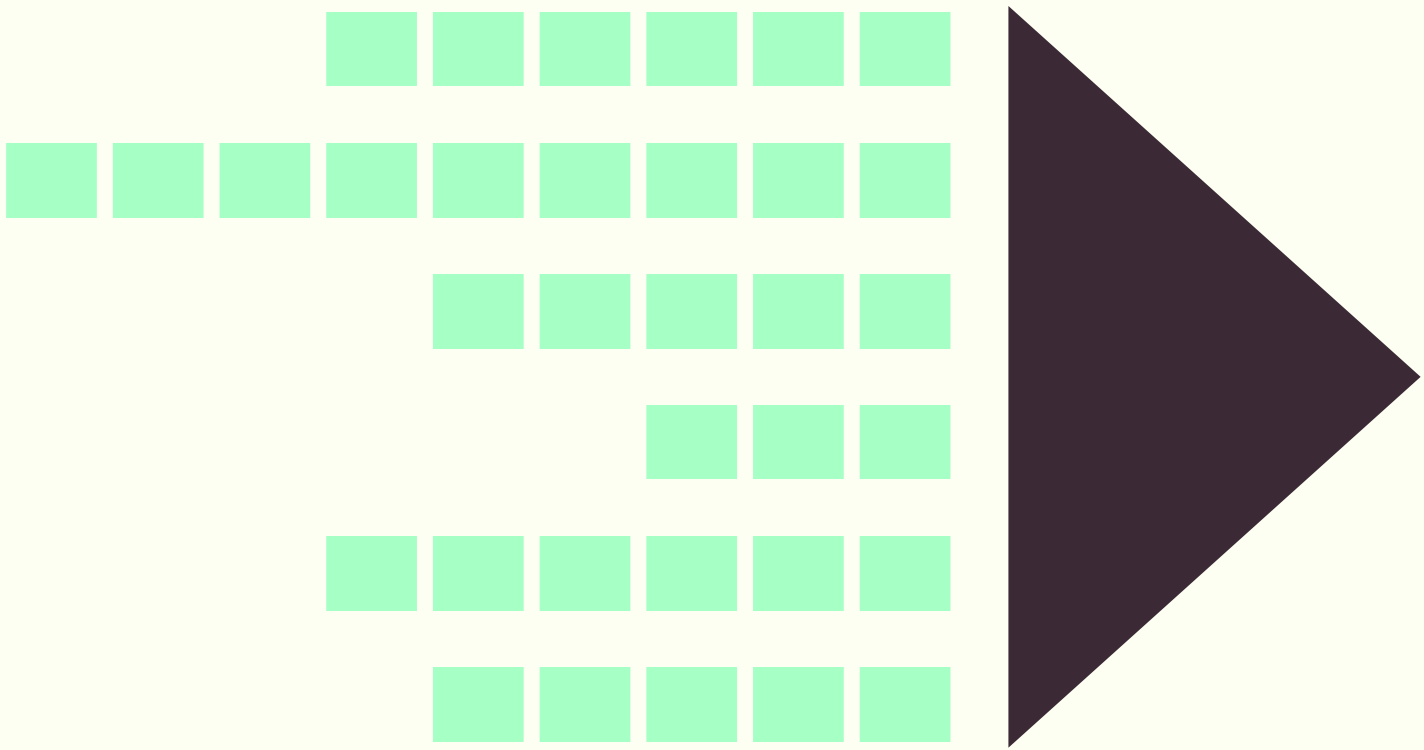

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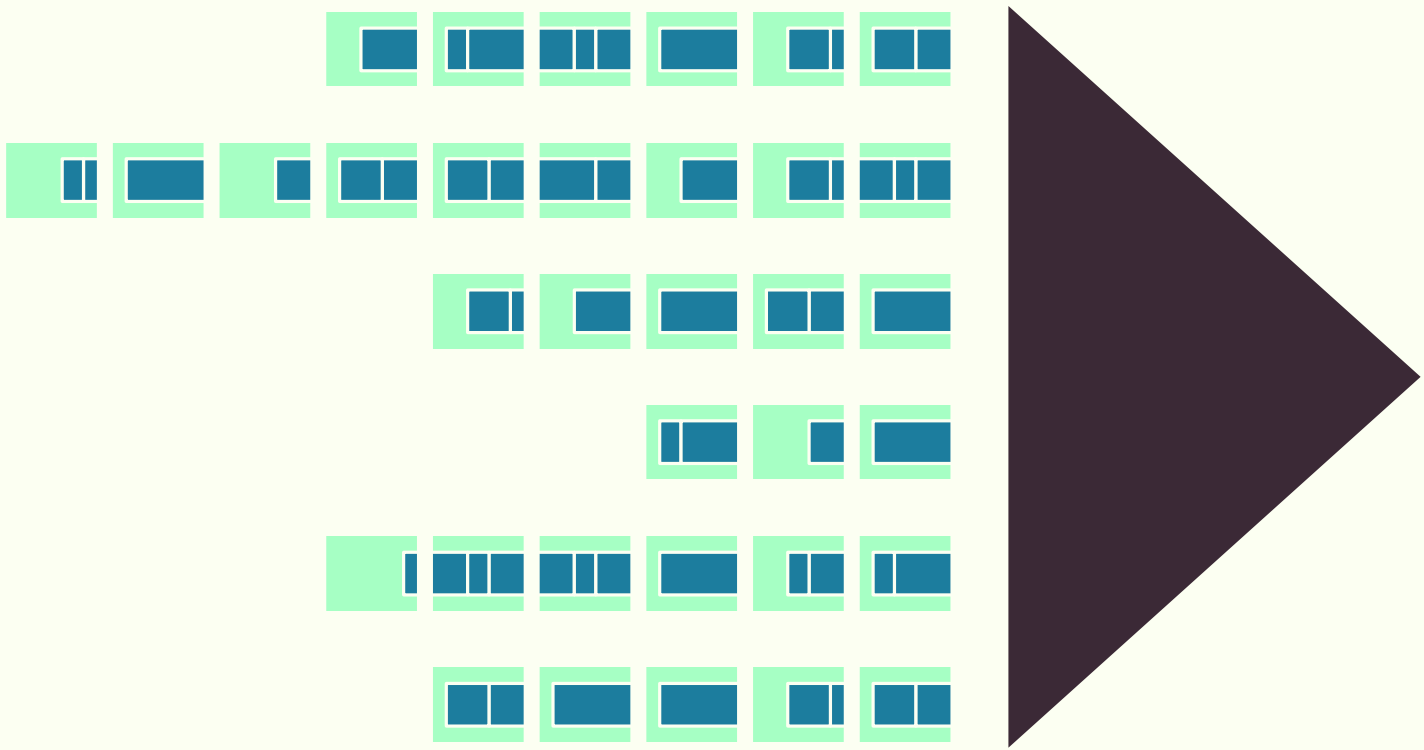

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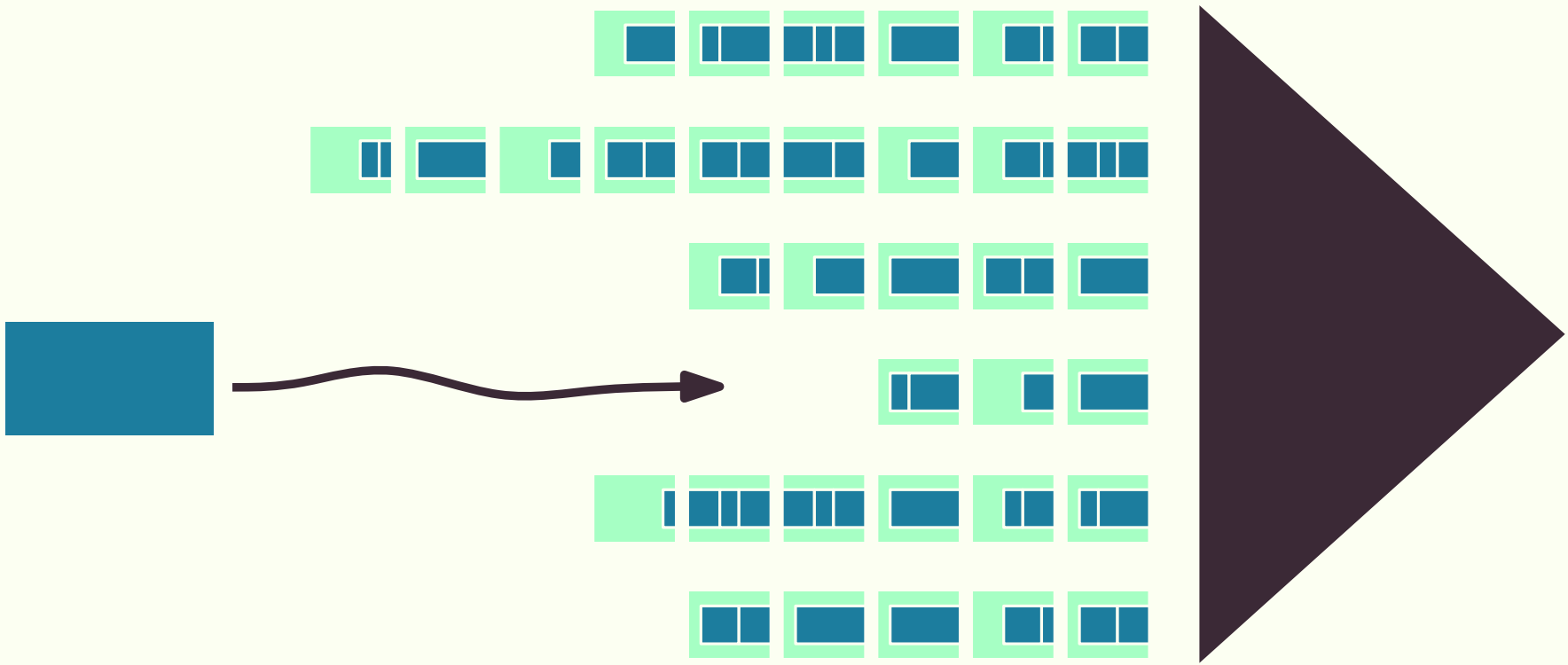

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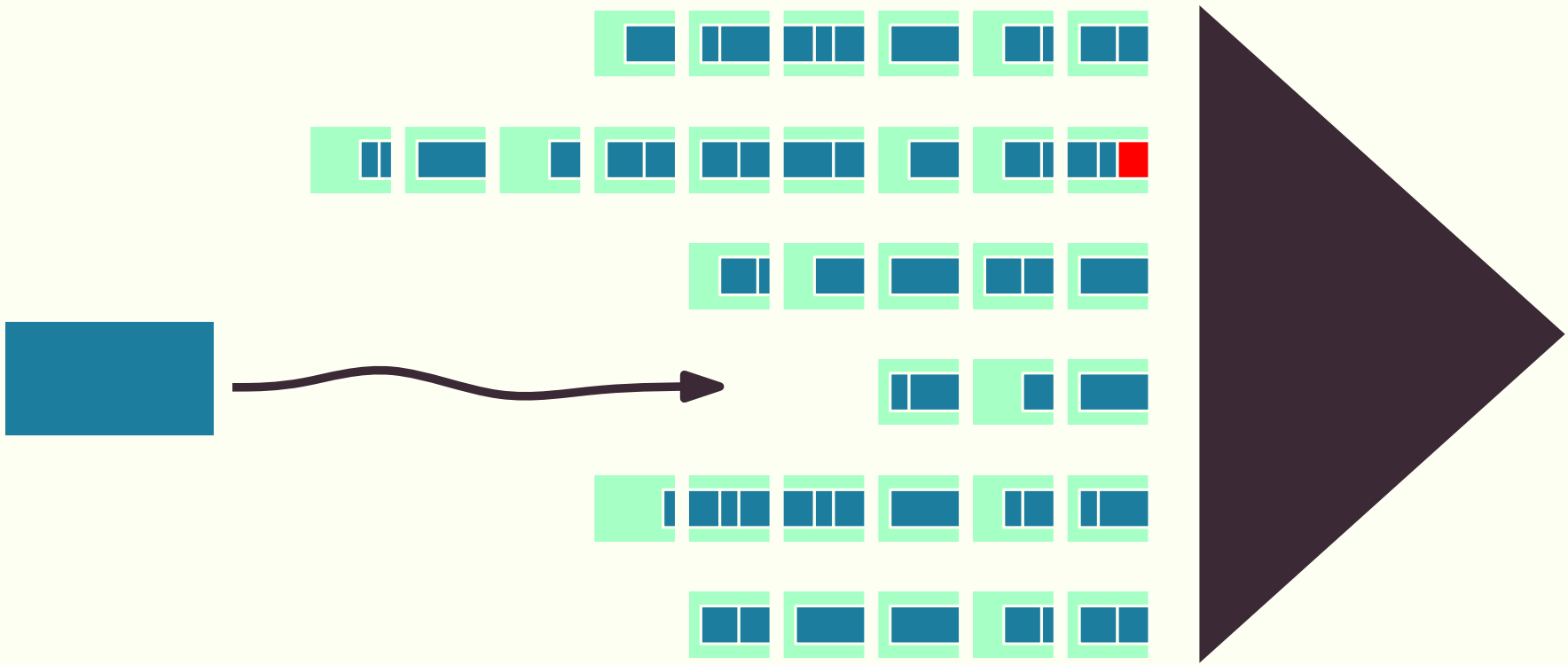

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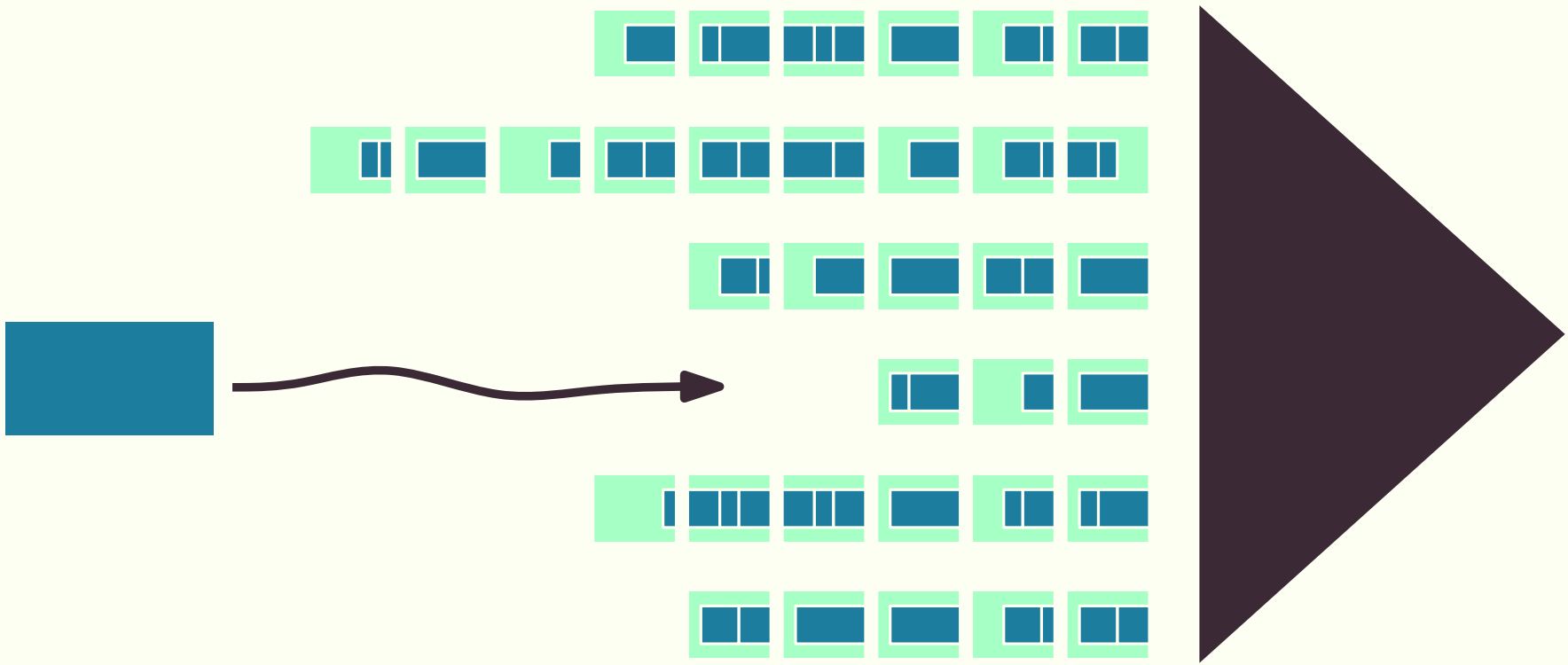

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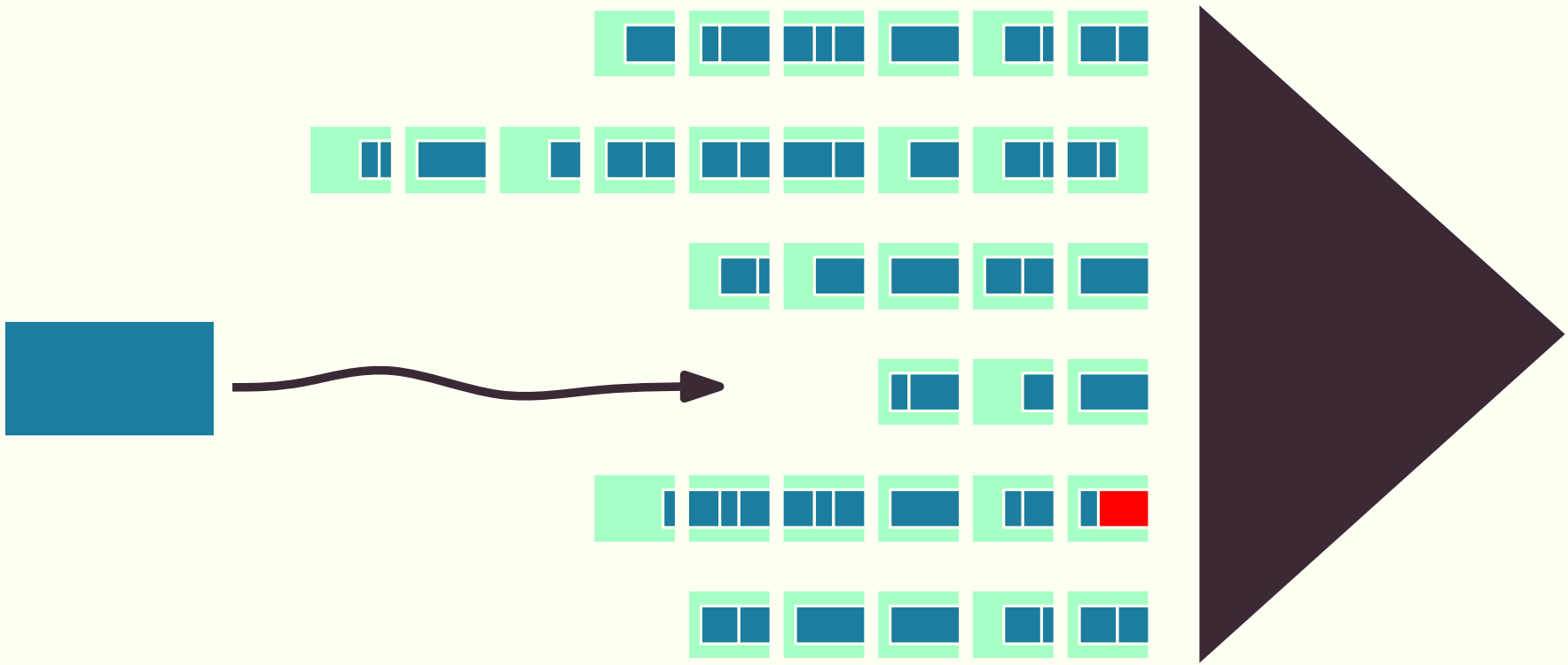

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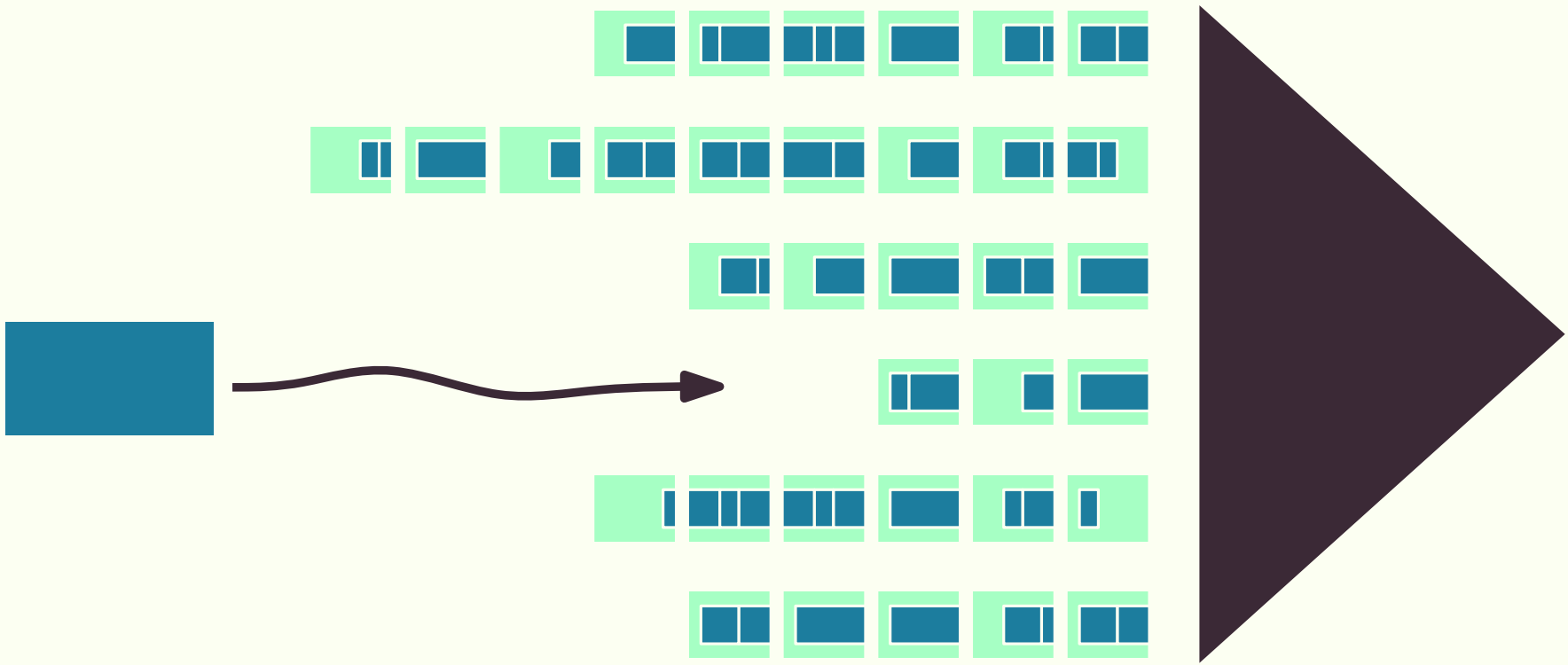

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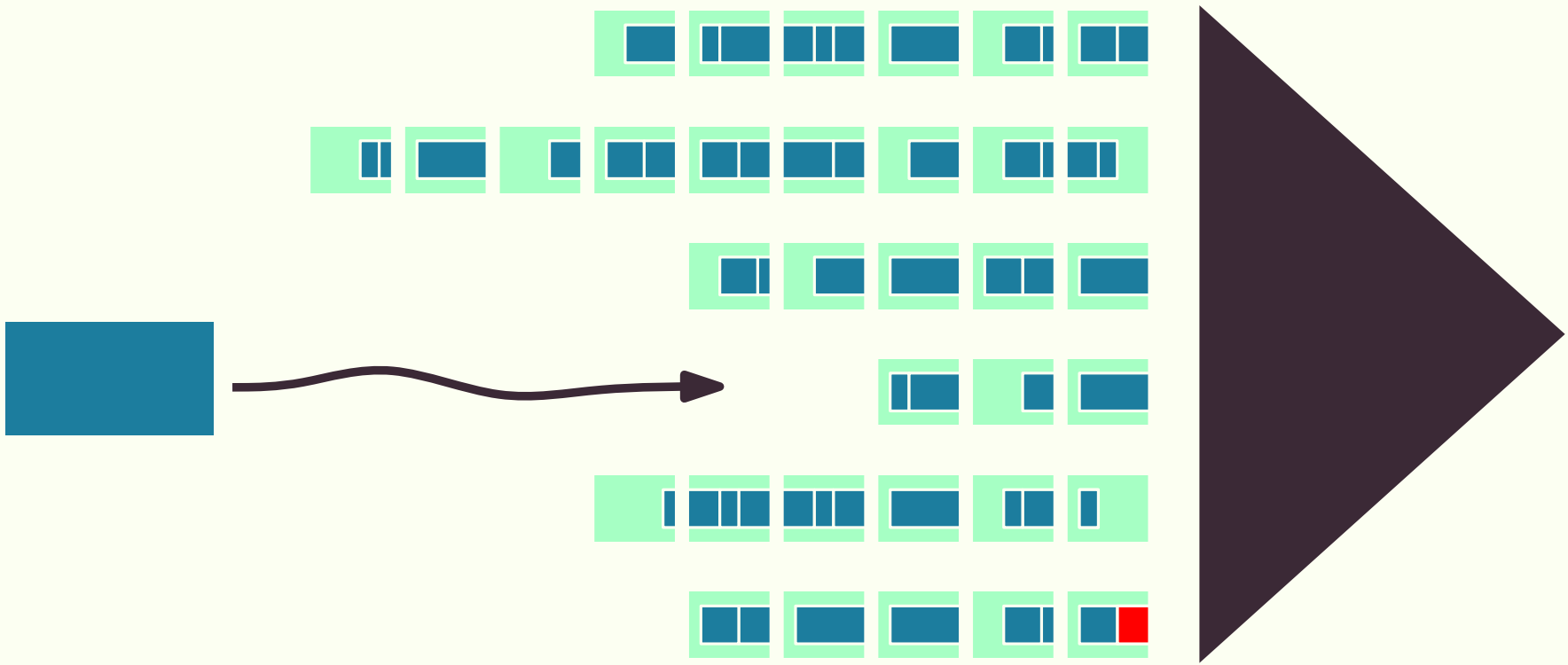

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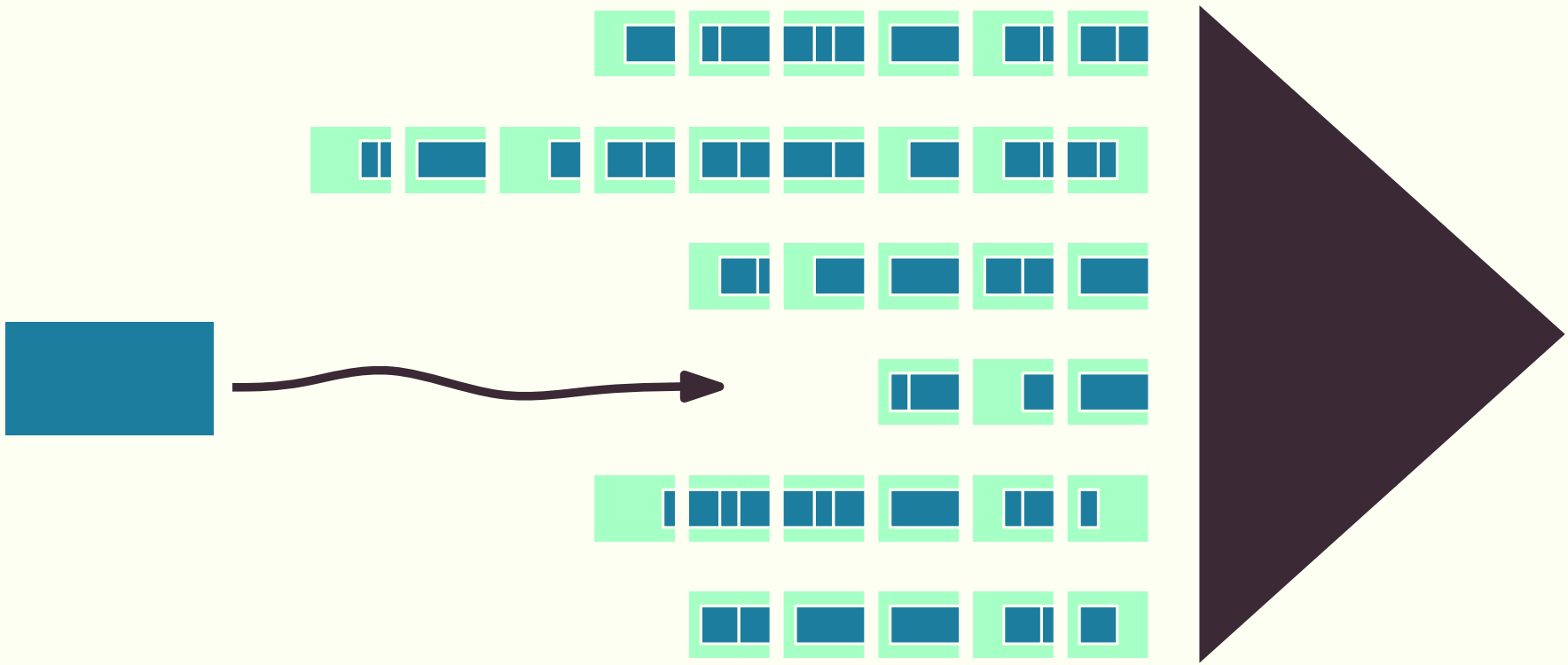

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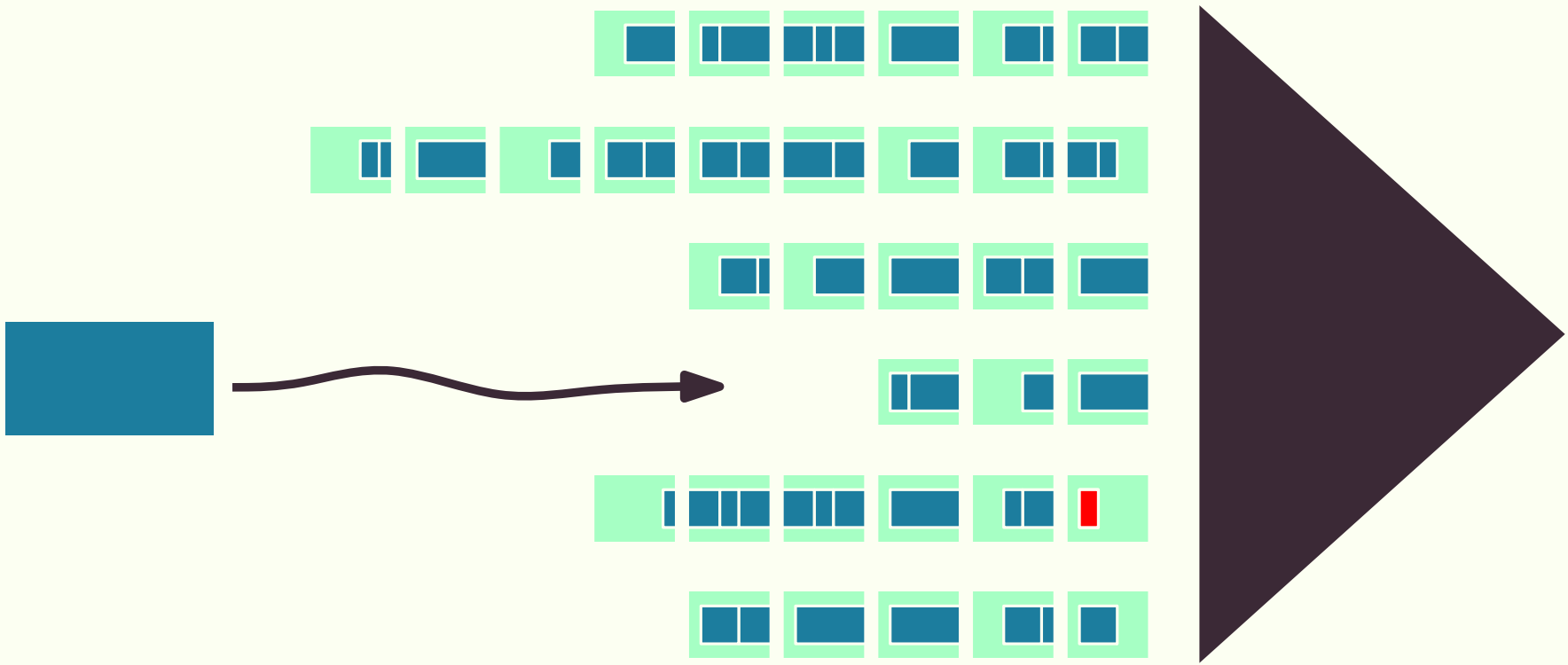

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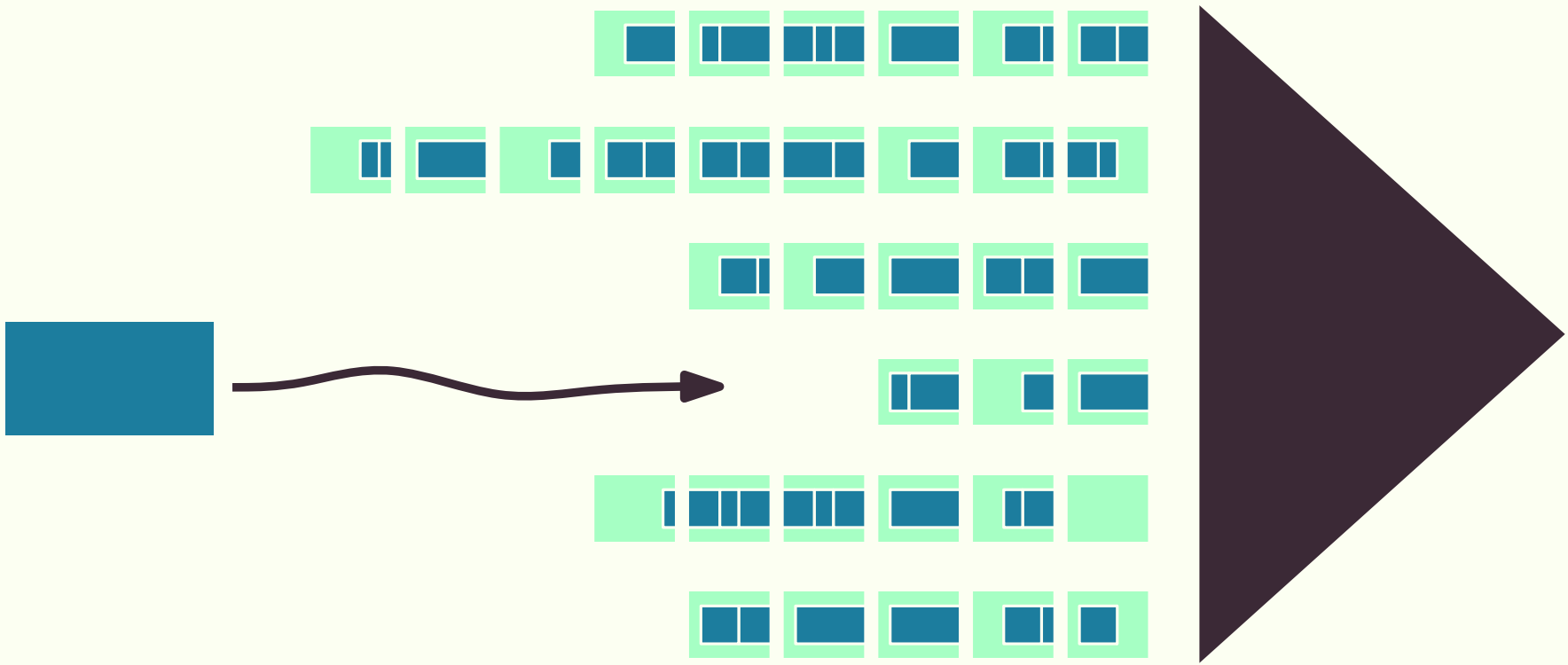

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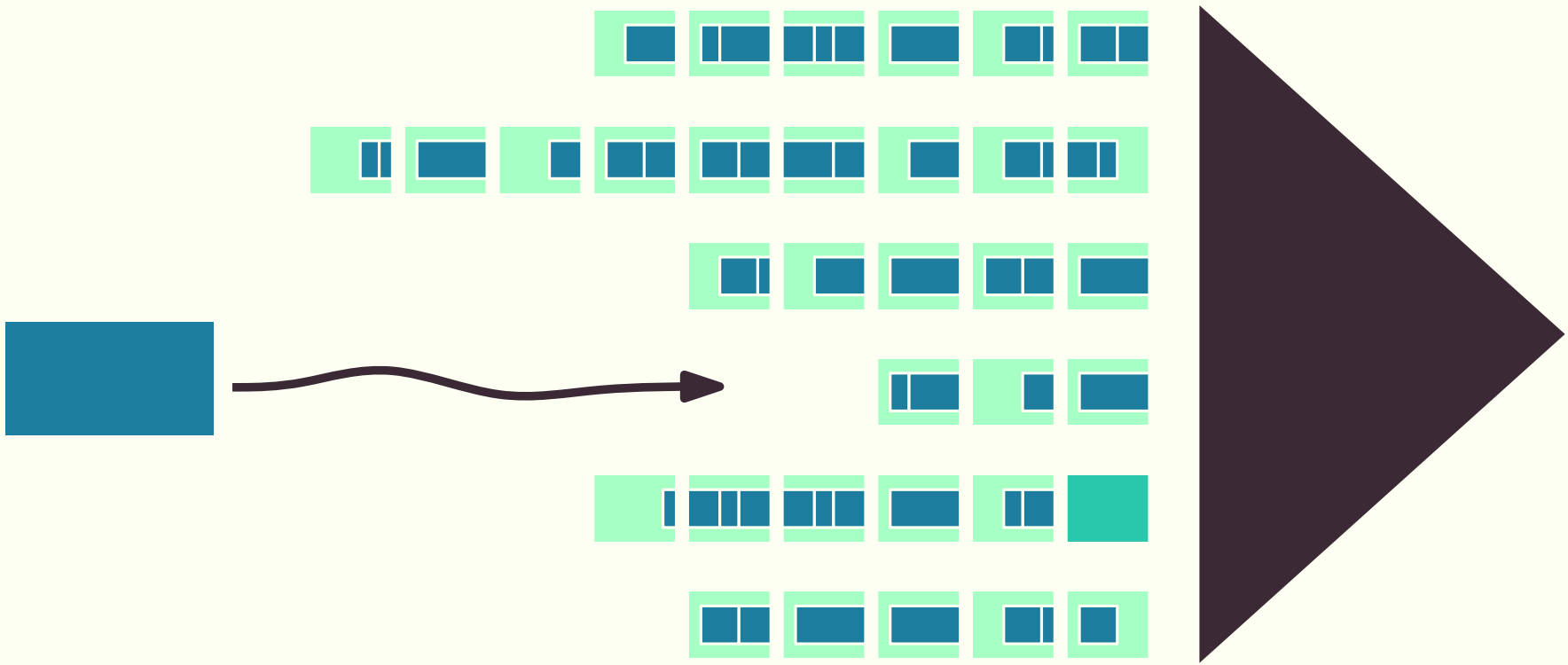

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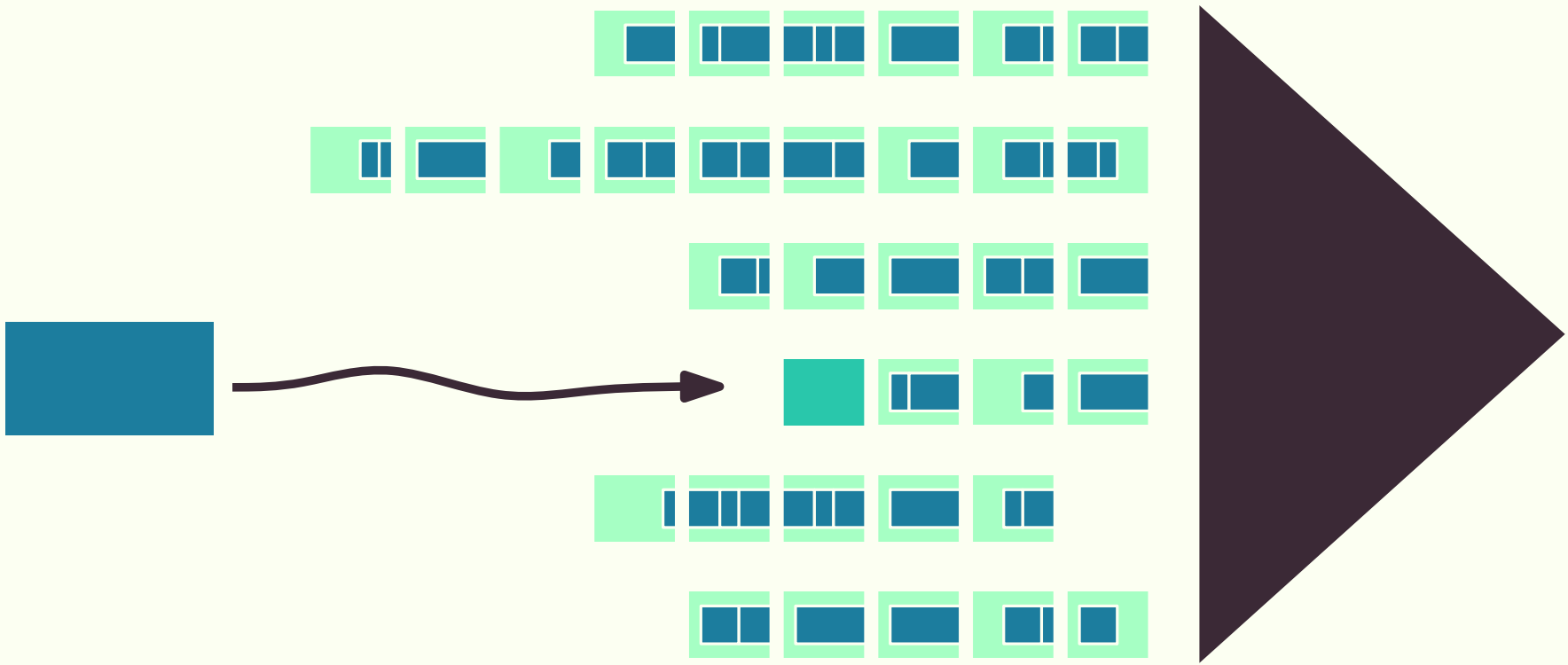

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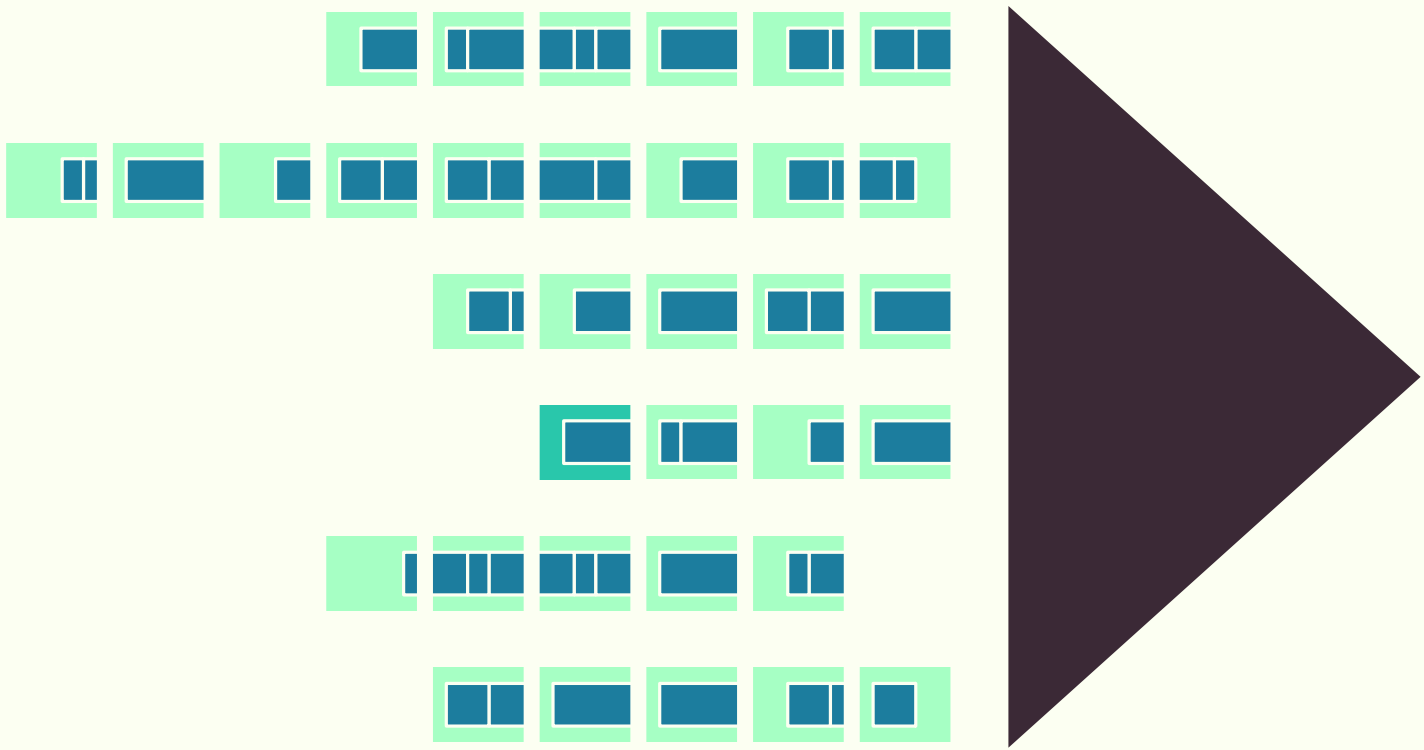

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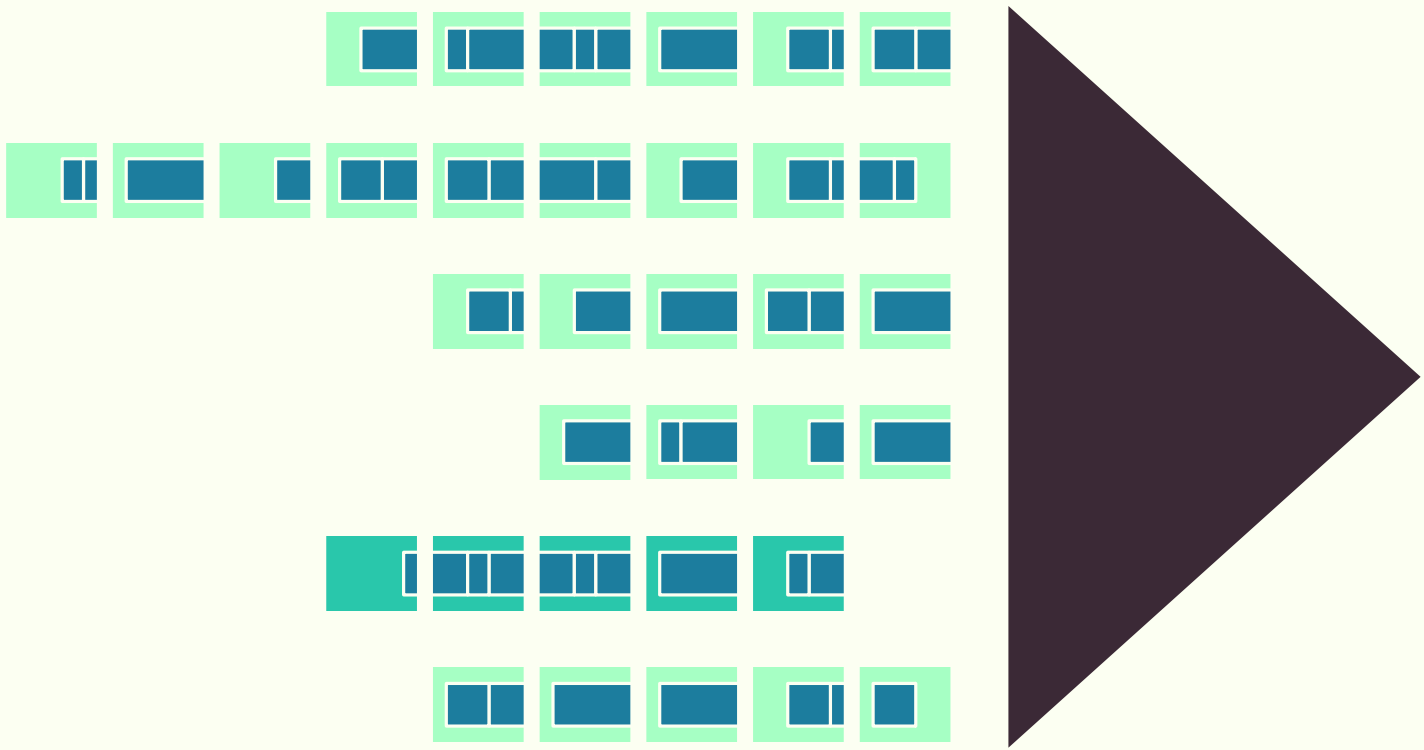

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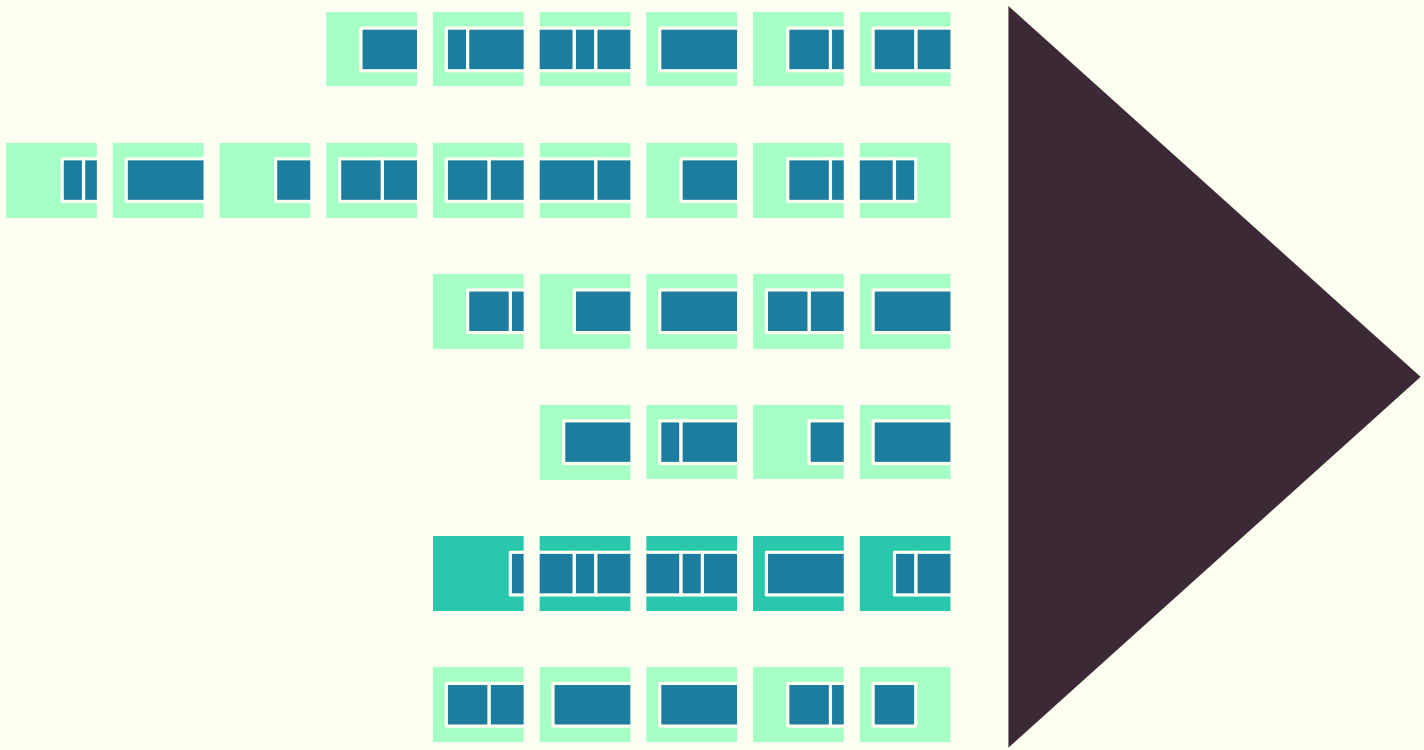

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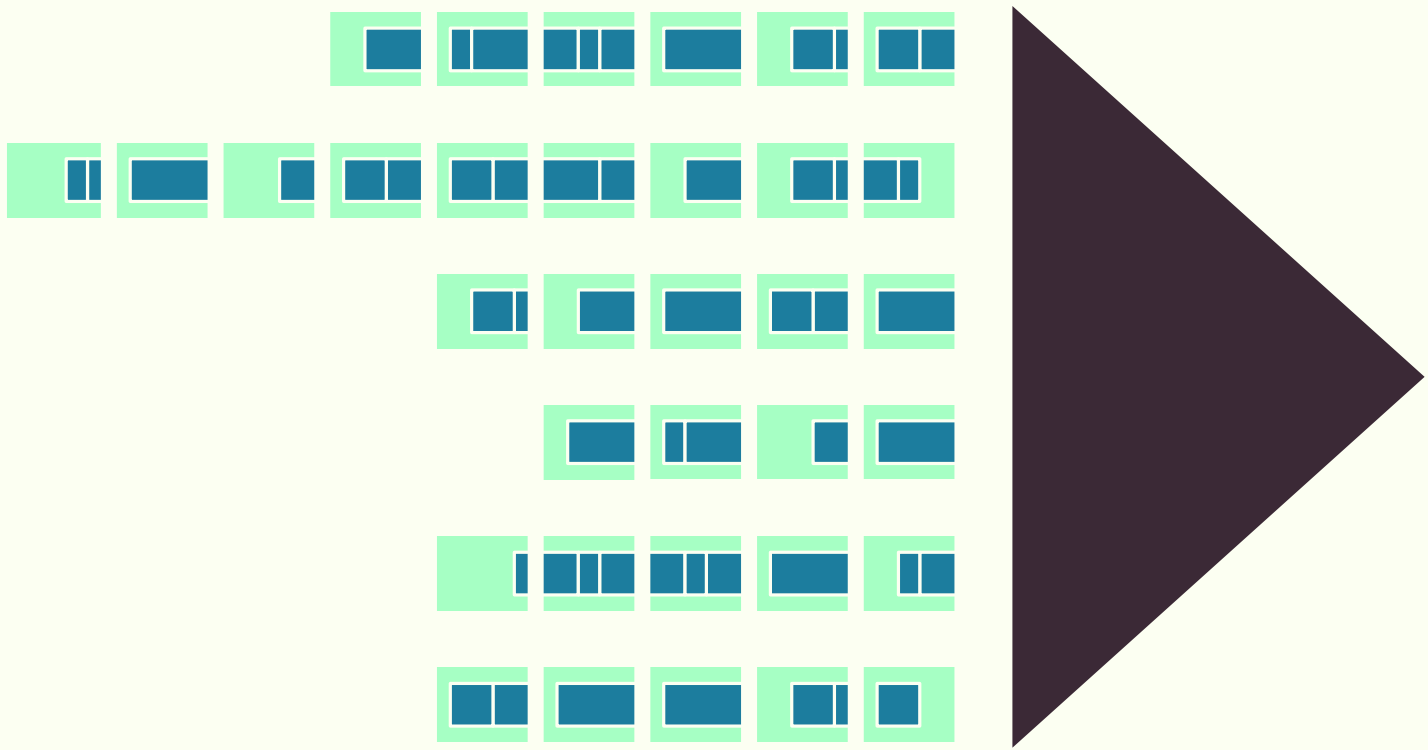

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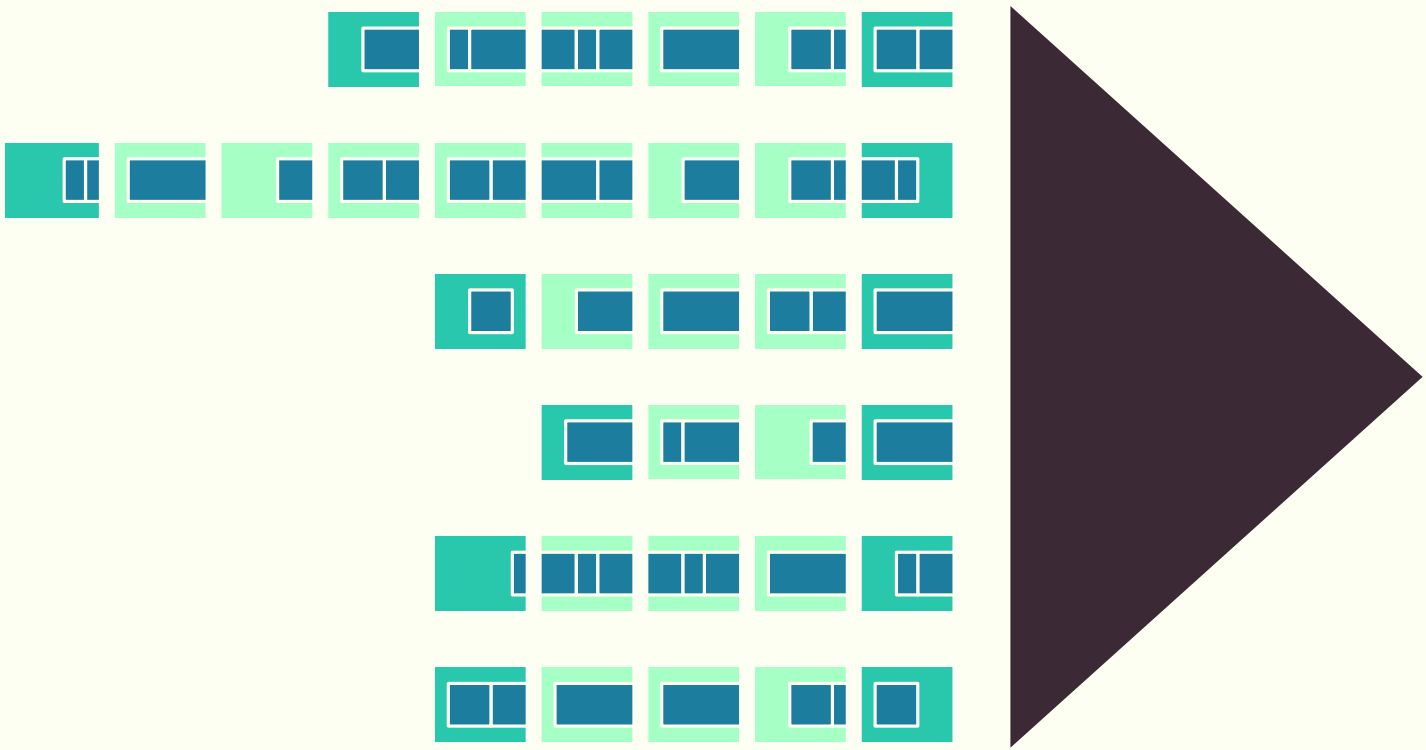


fragmentation $\leq$ 2 (num queues) (block size) + (num blocks) (max item size)

OUR ALGORITHM

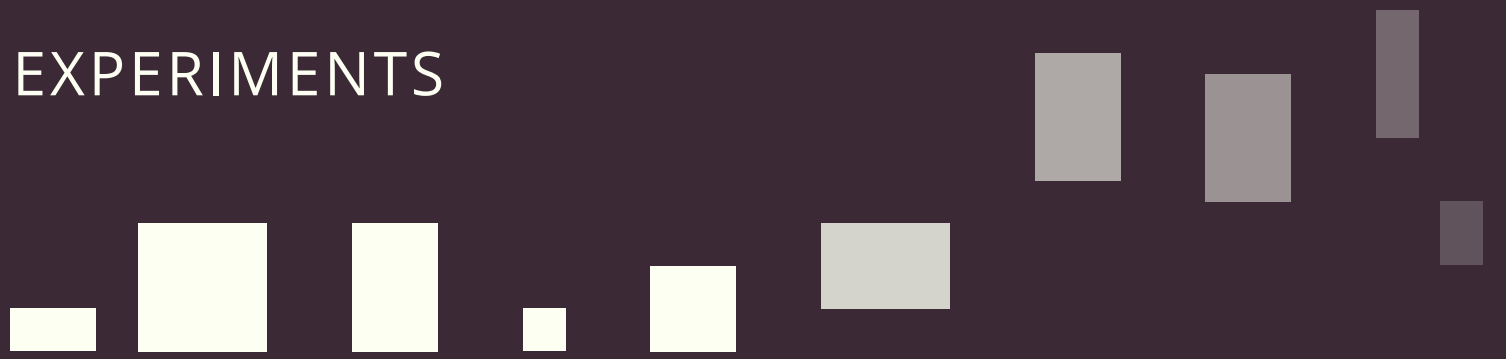
is competitive if memory augmented

$$\text{if} \quad \begin{matrix}\text{OPT's}\\ \text{cache size}\end{matrix} \leq \begin{matrix}\text{ALG's}\\ \text{cache size}\end{matrix} - \begin{matrix}\text{fragmentation}\\ \text{bound}\end{matrix}$$

$$\text{then} \quad \text{cost(ALG)} \leq \frac{\begin{matrix}\text{ALG's}\\ \text{cache size}\end{matrix}}{\text{min item size}} \text{cost(OPT)}$$

fragmentation $\leq$ 2 (num queues) (block size) + (num blocks) (max item size)

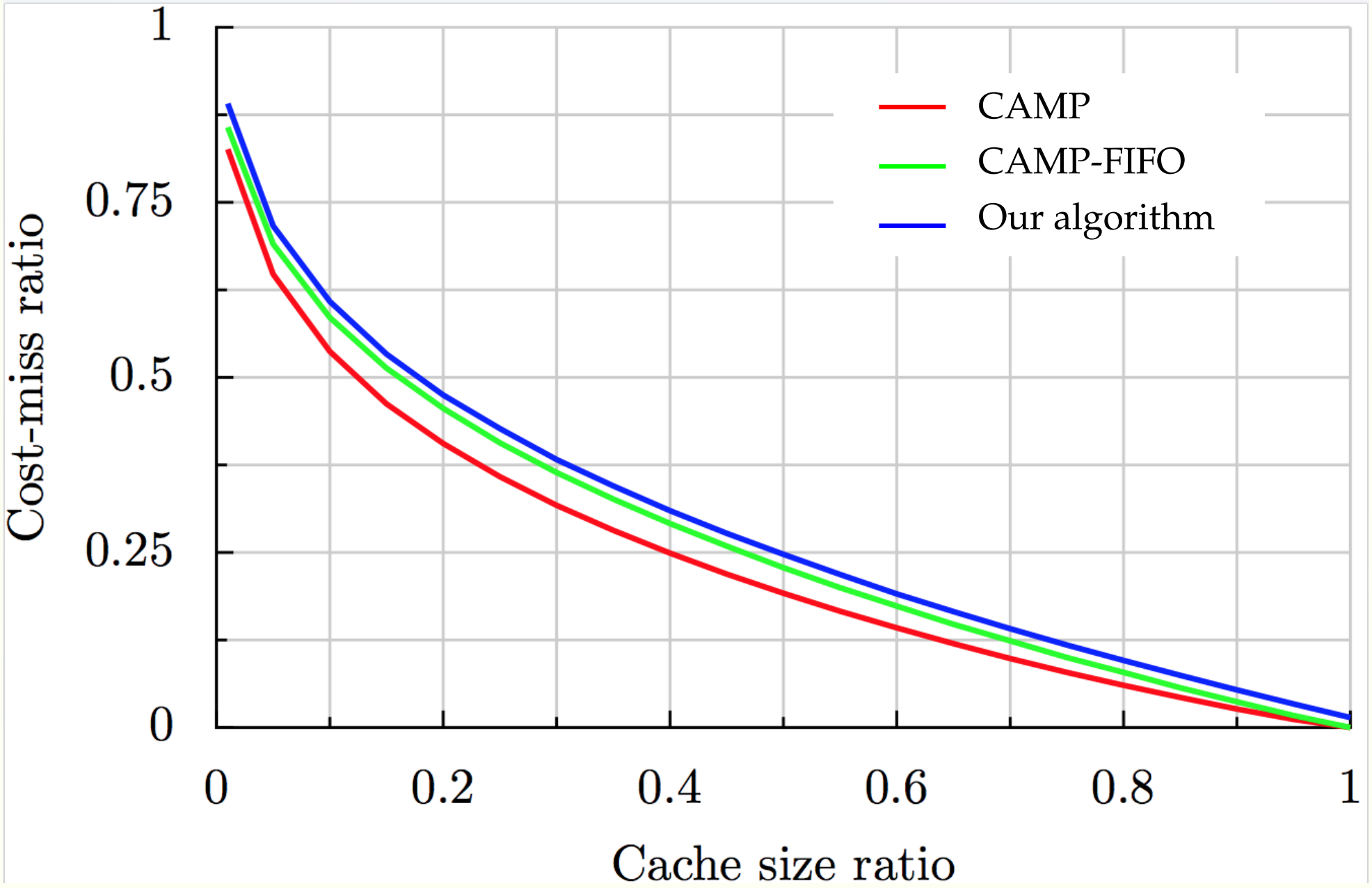
EXPERIMENTS

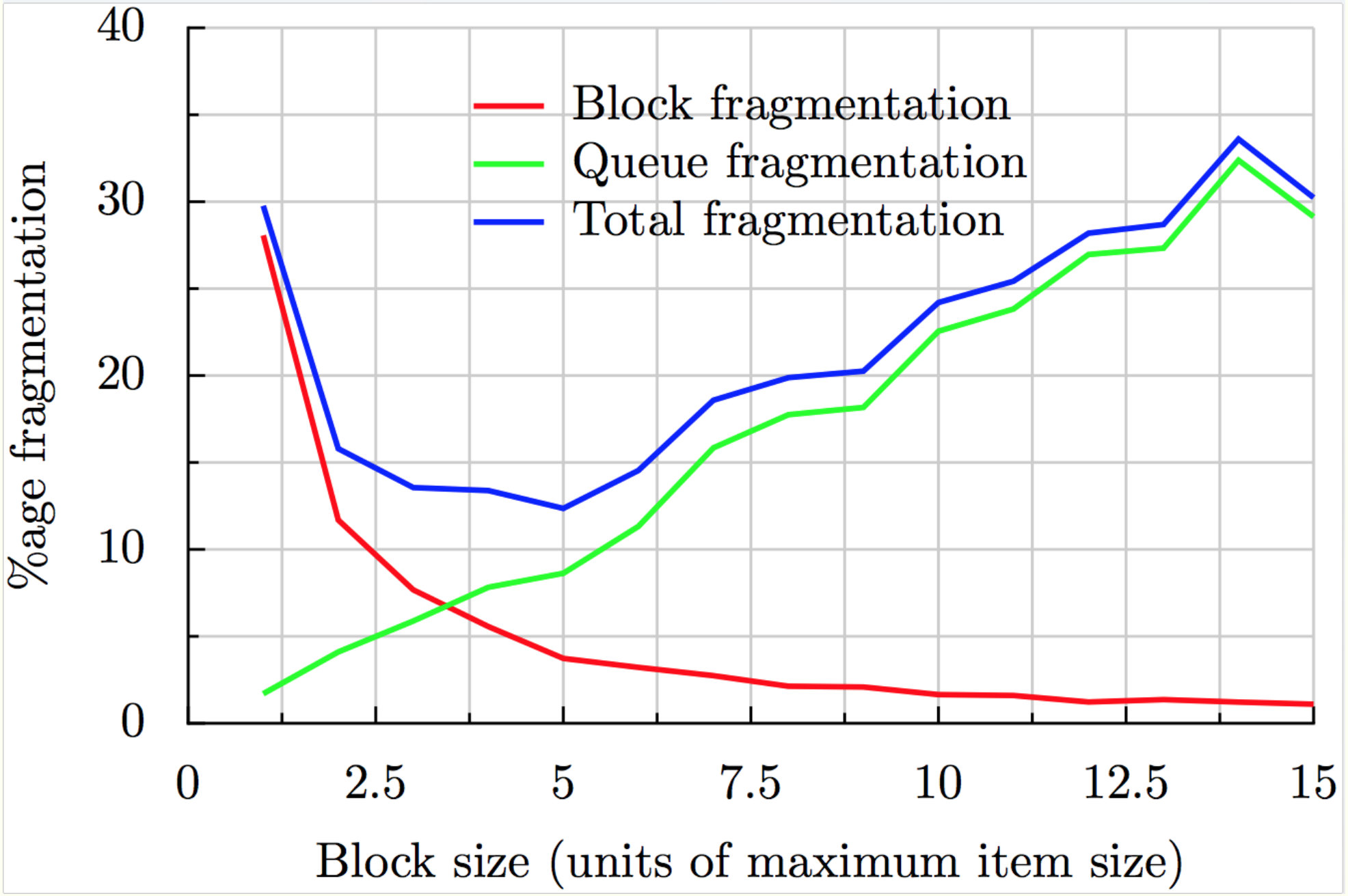


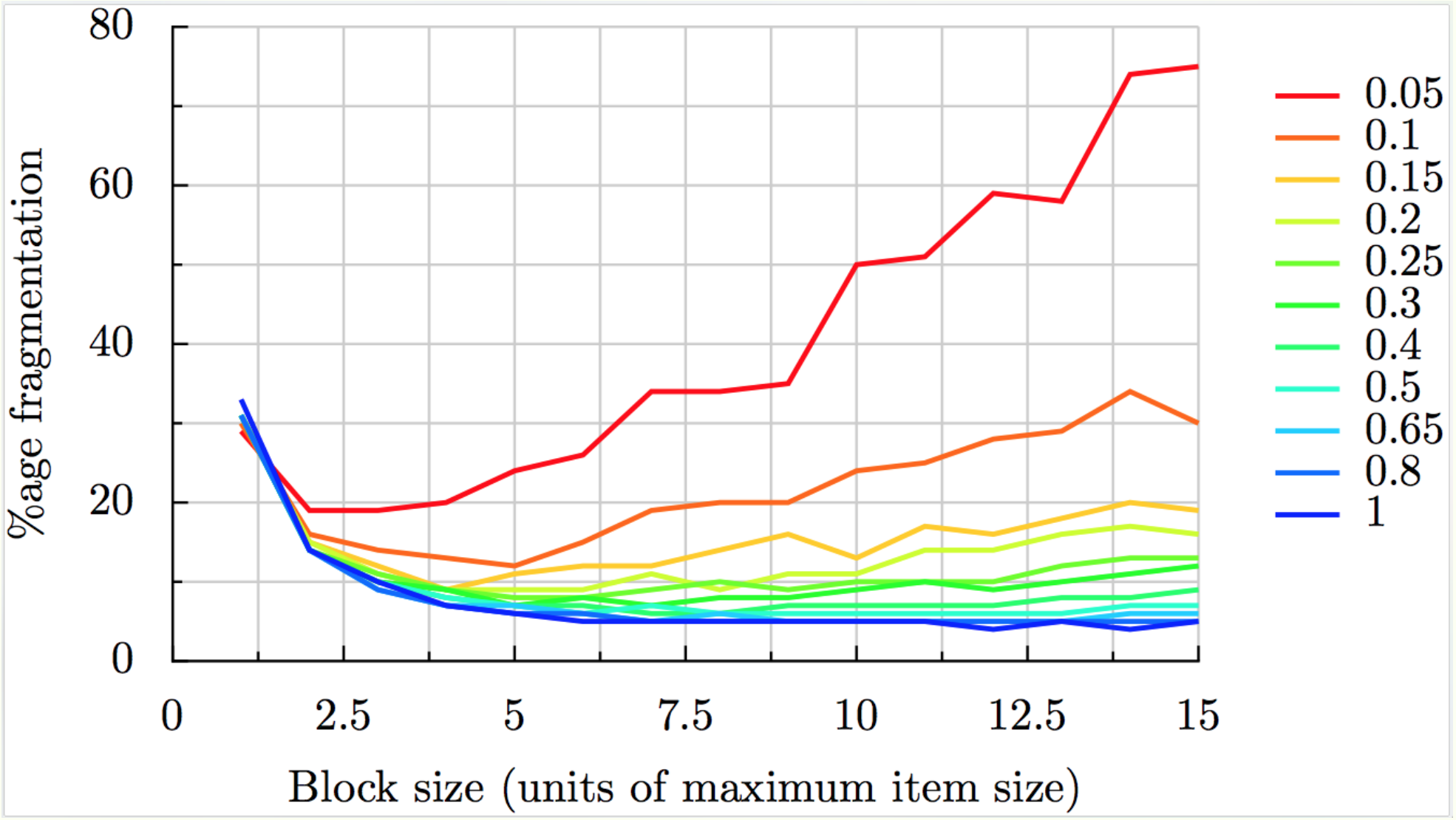
trace generated by BG, a social networking benchmark

4 million requests

i.i.d. with 70% of requests to 20% of items


CAMP
CAMP-FIFO
Our algorithm
Cost-miss ratio
Cache size ratio
0
0.25
0.5
0.75
1
0
0.2
0.4
0.6
0.8
1


Block fragmentation
Queue fragmentation
Total fragmentation
%age fragmentation
Block size (units of maximum item size)
0
10
20
30
40
0
2.5
5
7.5
10
12.5
15


80
60
40
20
0
%age fragmentation
0
2.5
5
7.5
10
12.5
15
Block size (units of maximum item size)
0.05
0.1
0.15
0.2
0.25
0.3
0.4
0.5
0.65
0.8
1

CONCLUSION

biggest performance degradation
going from LRU to FIFO queues

FUTURE RESEARCH

design a better algorithm for
the managed-memory caching problem
allowing moving items once in cache