Contrary to Popular Belief Incremental Discretization can be Sound, Computationally Efficient and Extremely Useful for Streaming Data

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The wolf of wall street: the french adventure
Script by : D&K 2017 students

SPOILER ALERT

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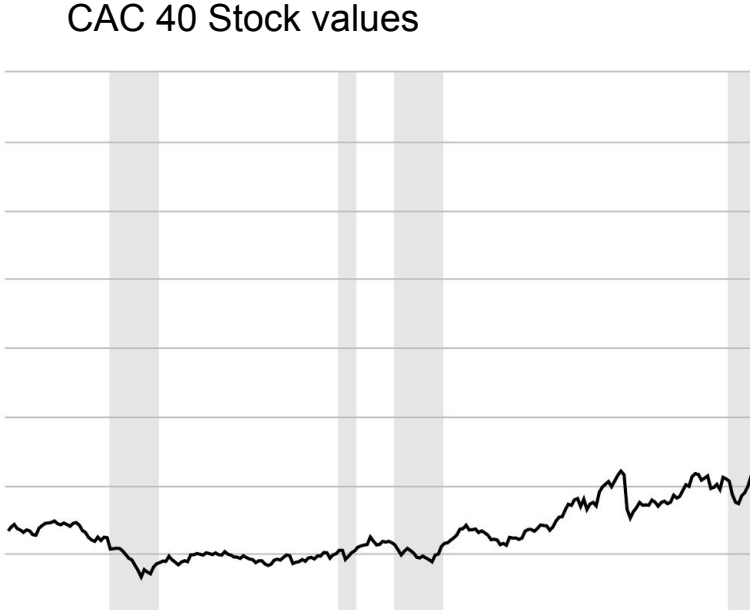
The wolf of wall street: the french adventure
Script by : D&K 2017 students


MovieStillsDB.com

2 years later (… paperwork) he went to France

Motivation



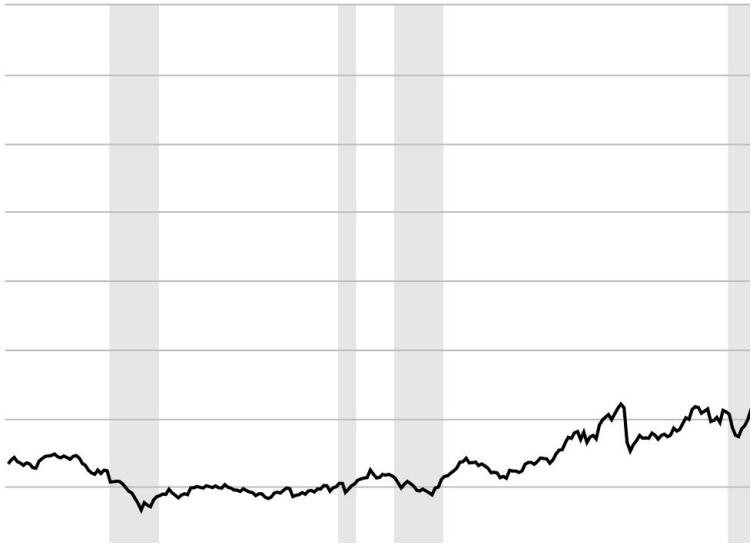
Motivation

- discretization : is to divide a continuous data into a set of buckets (bins)

- bins
  ] -∞, b_1],]b_2,b_3] …]b_{m-1},+∞ [

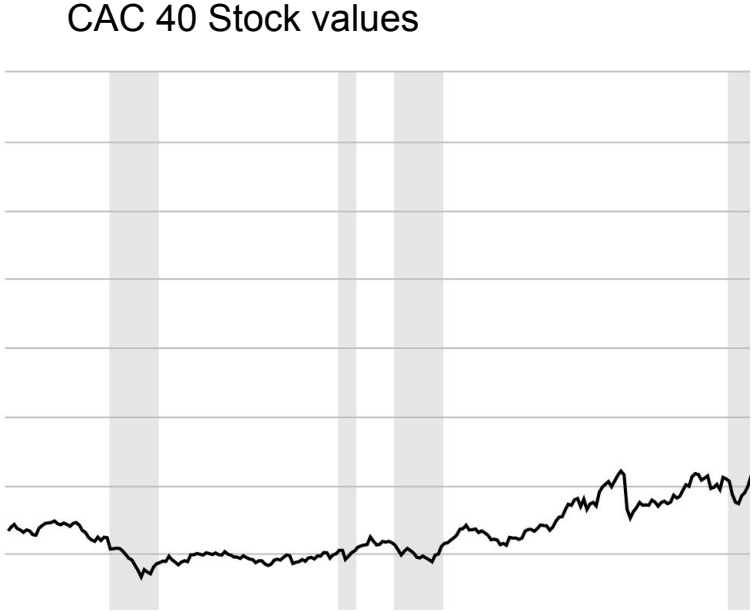
- **b_1 b_2...b_{m-1}** the cut points

CAC 40 Stock values

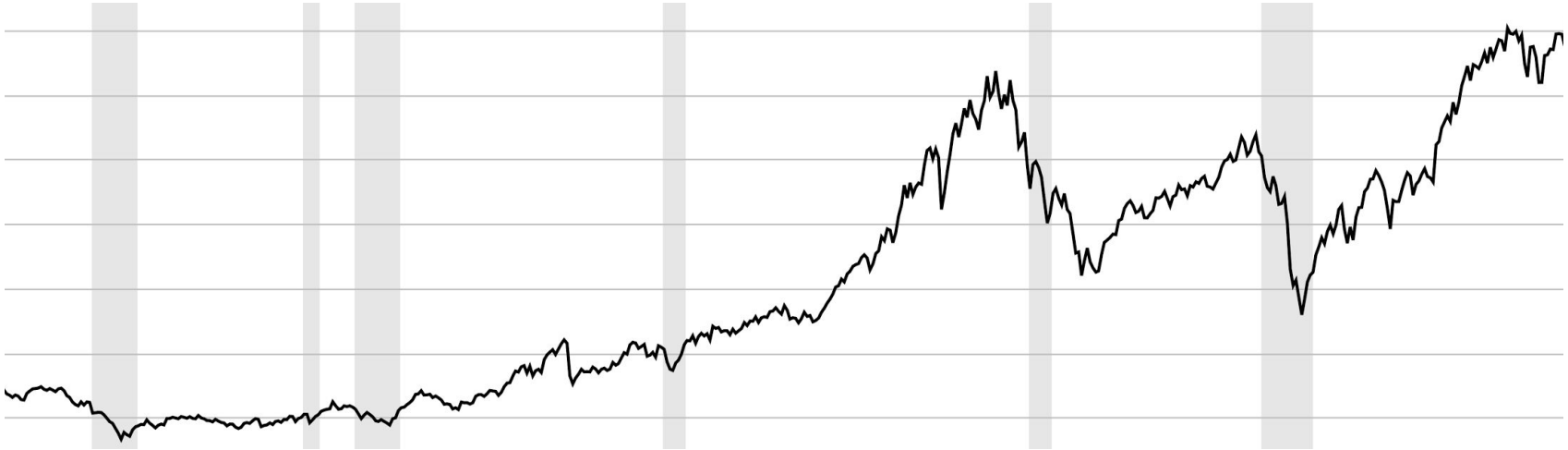


Issues

- cut points may vary over time
- unknown distribution of the data
- not easy to determine relevant intervals
- static intervals : loss of information
- some learning algorithms requires “same” bins over time



Issues



CAC 40 Stock values

Solution

- find a way to synchronize the discretization with the data distribution
- you want to keep the bins as informative as possible about the original data

Solution: IDA & IDAW

- **I**ncremental **D**iscretization **A**lgorithme (IDA)
- approximate **quantile-based** discretization on the entire data stream encountered to date
- keeps the meaning of the bins even though the cut values drift over time

Solution: IDA & IDAW

- **I**ncremental **D**iscretization **A**lgorithme (IDA)
- approximate **quantile-based** discretization on the entire data stream encountered to date
- keeps the meaning of the bins even though the cut values drift over time

- **I**ncremental **D**iscretization **A**lgorithme with **W**indow (IDAW)
- allow the cut points to track a non stationary distribution

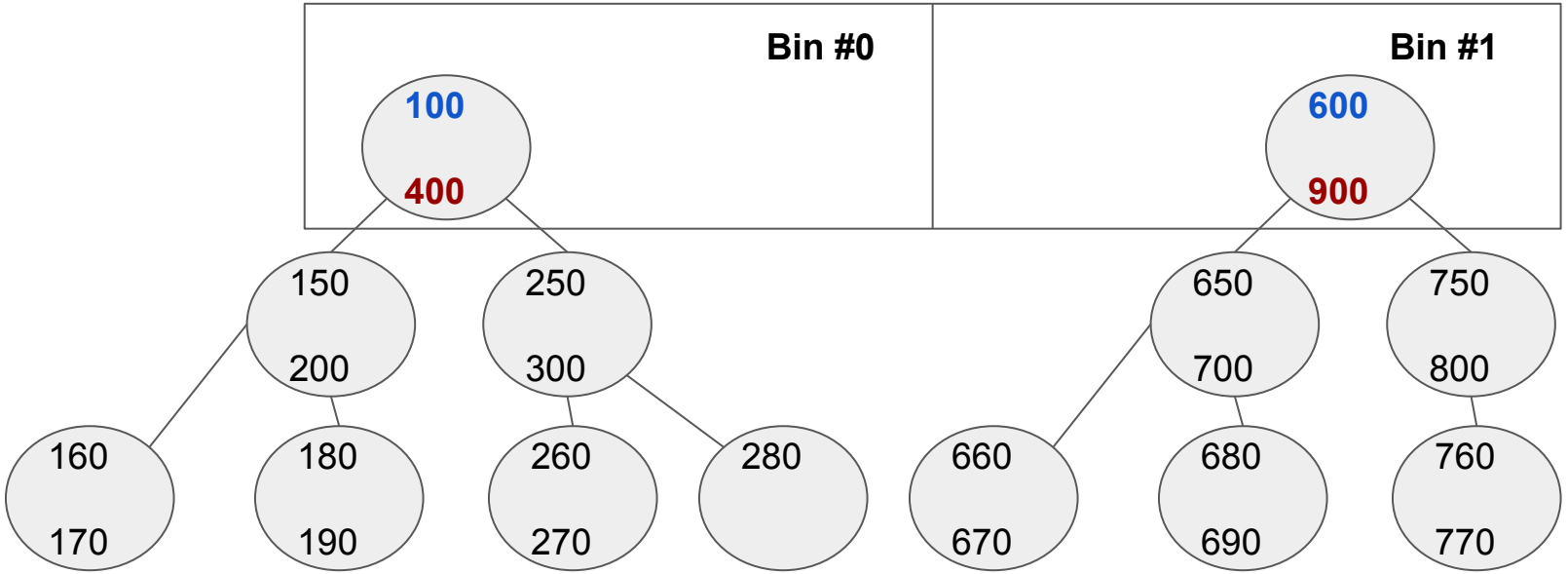
Solution: IDA

- don’t consider the entire data stream
- samples the data using reservoir sampling
  - more efficient
  - not feasible to store all the encountered data
  - put tight bounds on the estimated quantiles
- store each bin in an interval heap
- the discretization of an attribute is represented with a vector of heaps

IDA example

size of the reservoir : 28
number of bins: 2

(25: 290) (26: 780) (27: 790) …



IDA example

size of the reservoir : 28
number of bins: 2

iteration i = 25
t = i mod m = 25 mod 2 = 1
j = 0
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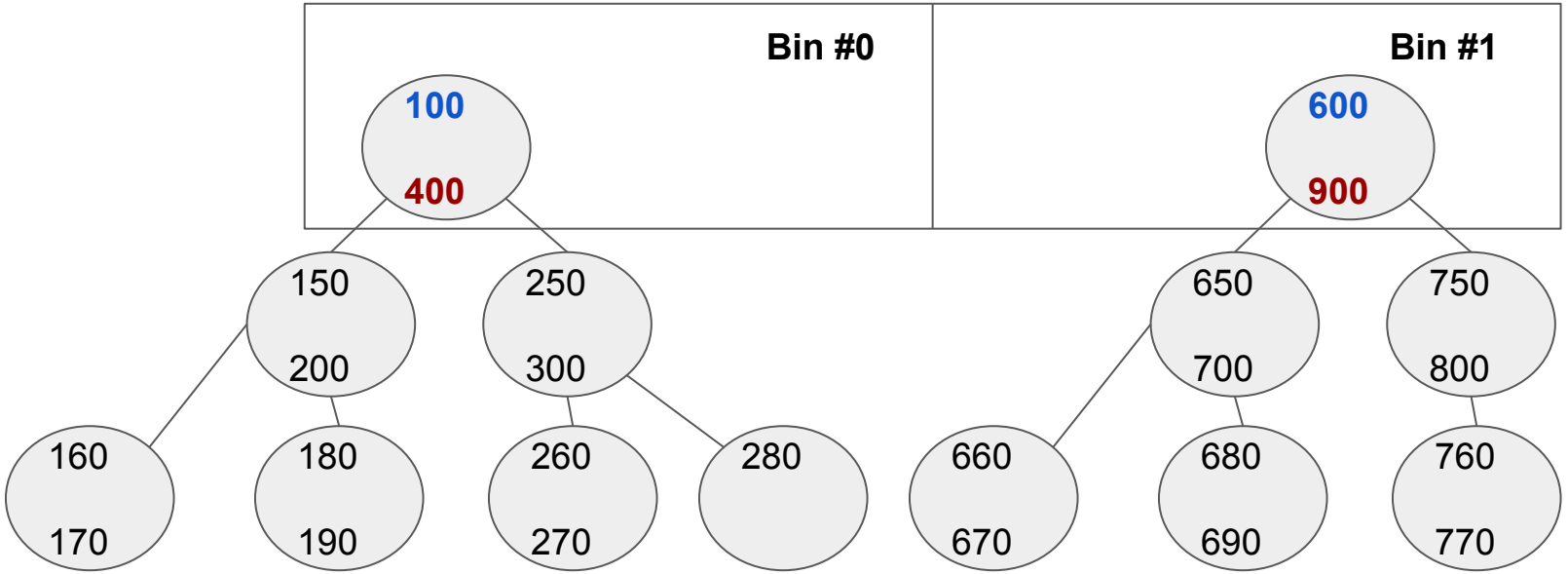
insert 290 in Bin #0
move max Bin #0 to Bin #1
reorganize the heaps

(25: 290) (26: 780) (27: 790) …



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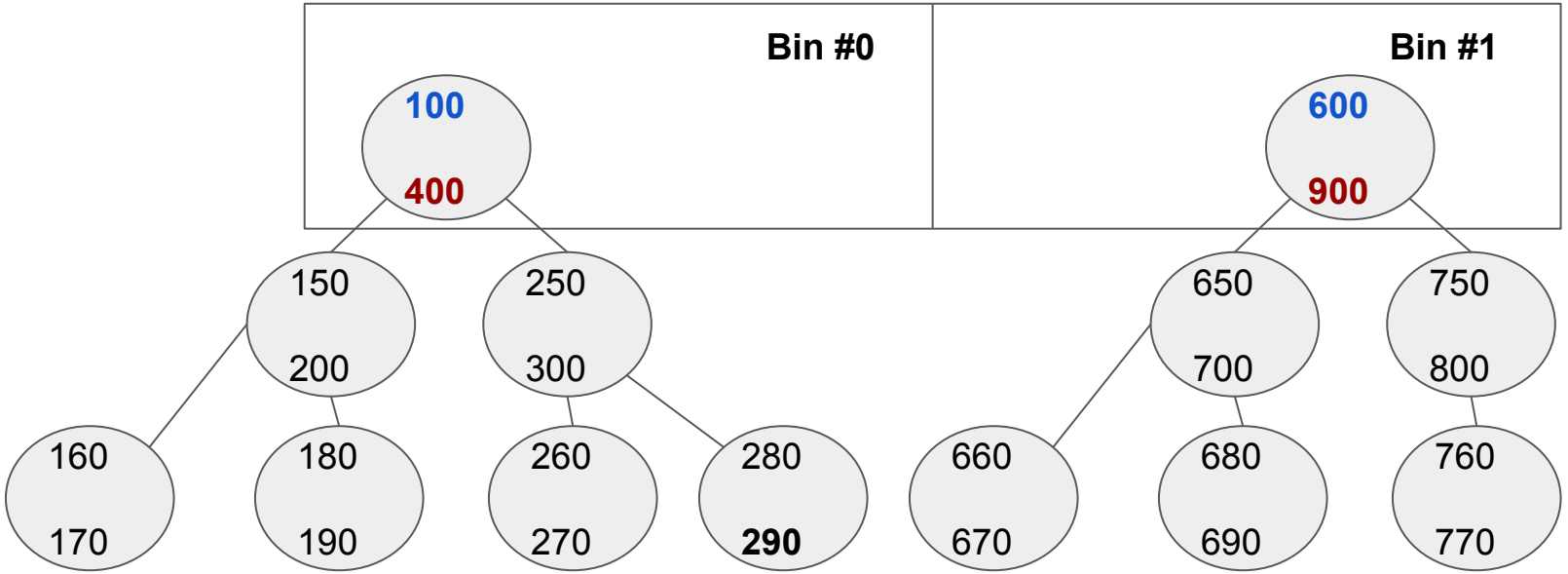

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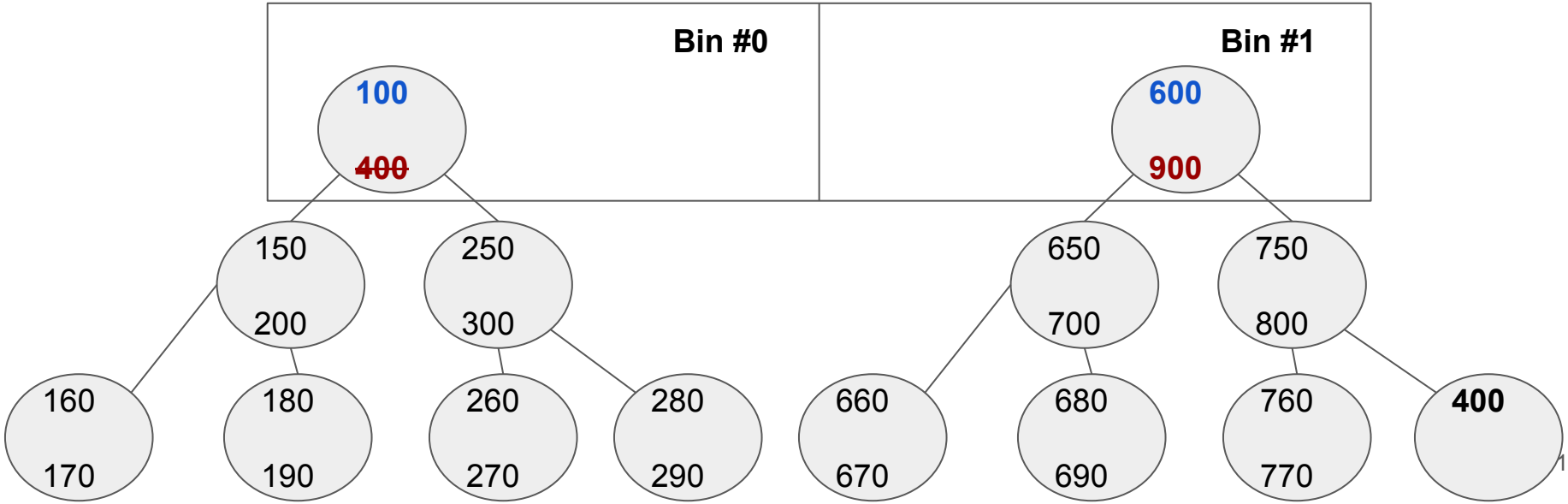

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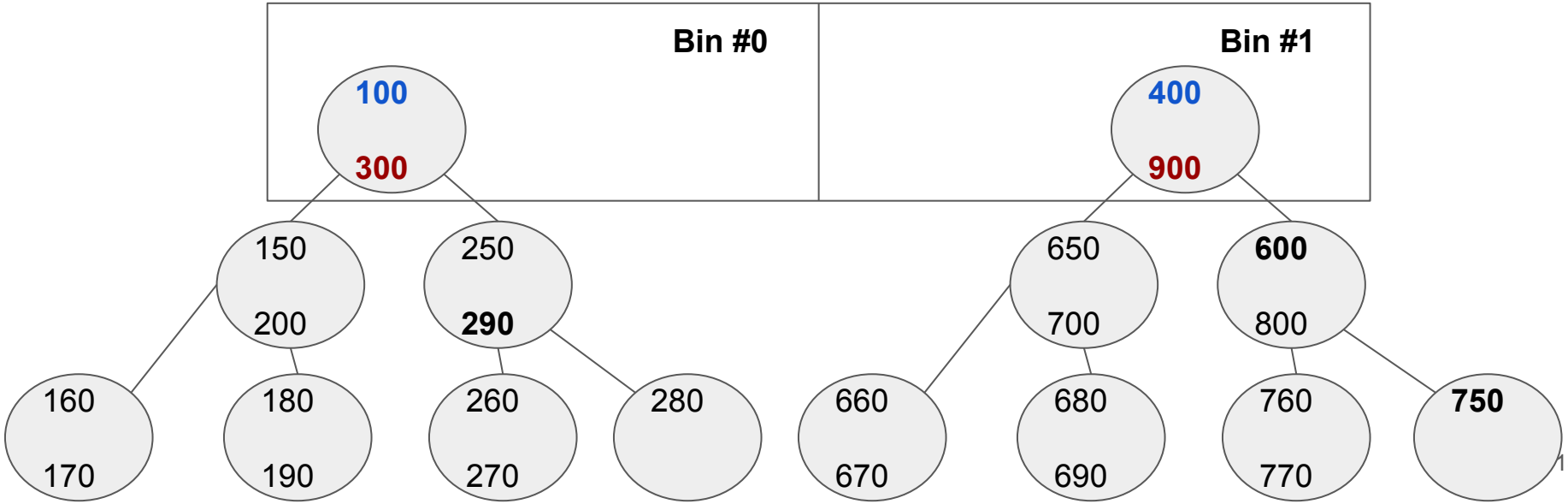

IDA example

size of the reservoir : 28
number of bins: 2

iteration i = 26
t = i mod m = 26 mod 2 = 0
j = 1
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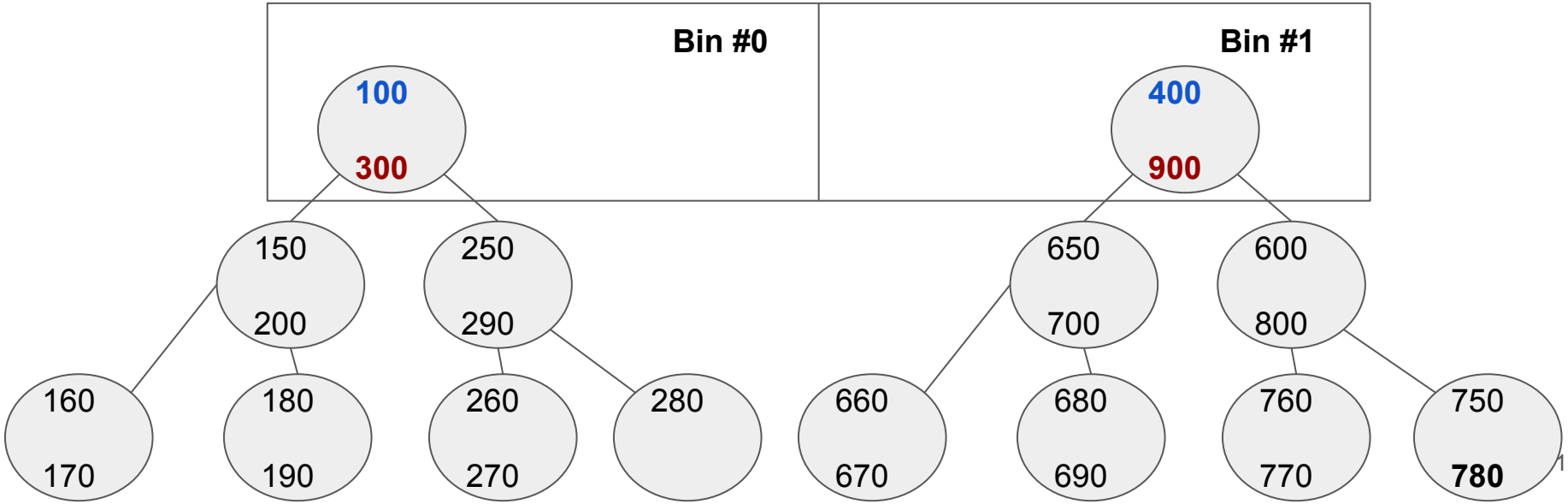
insert 780 in Bin #1
move min Bin #1 to Bin #0
reorganize the heaps

(~~26: 780~~) (27: 790) …



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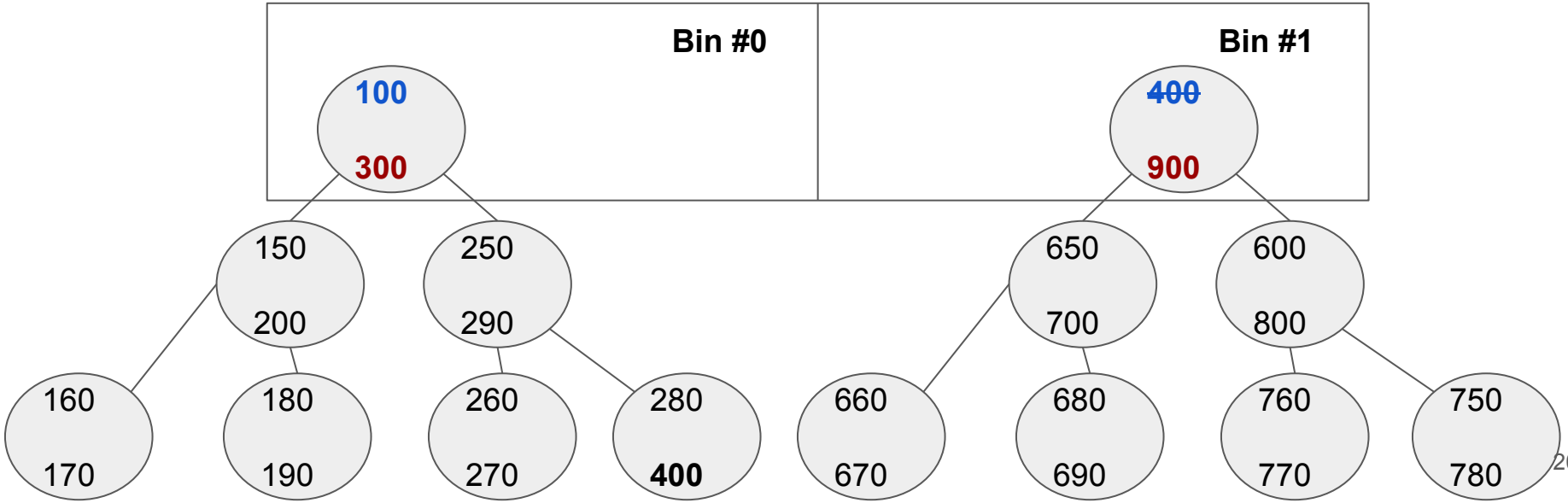

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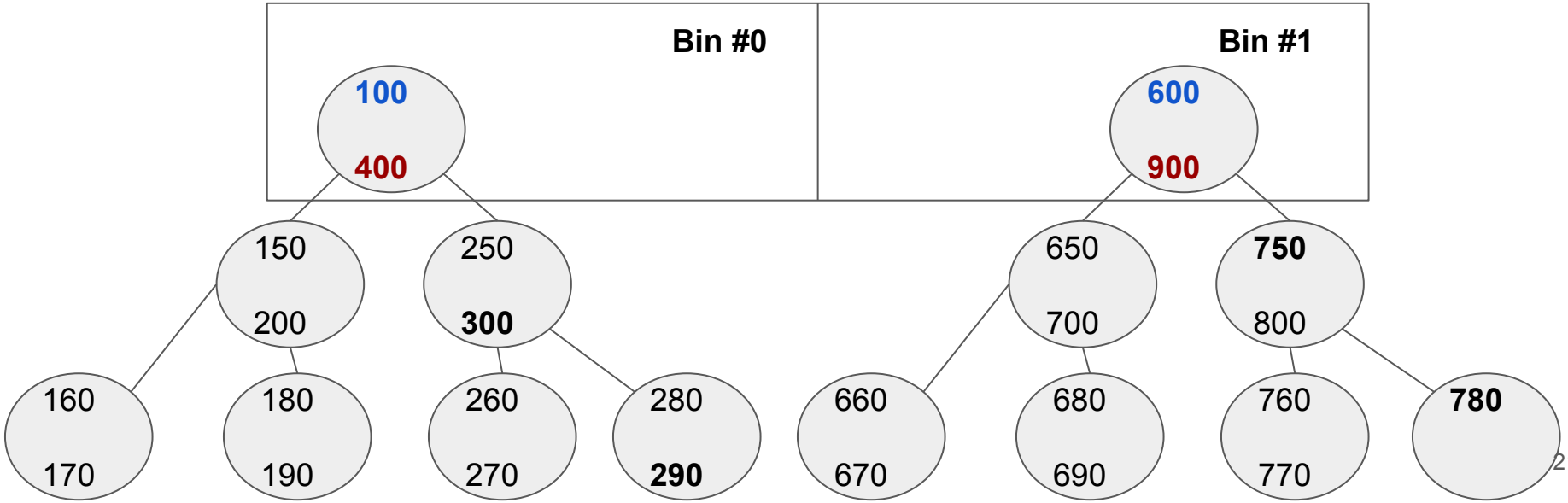

IDA example

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number of bins: 2

iteration i = 27
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insert 790 in Bin #1
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reorganize the heaps

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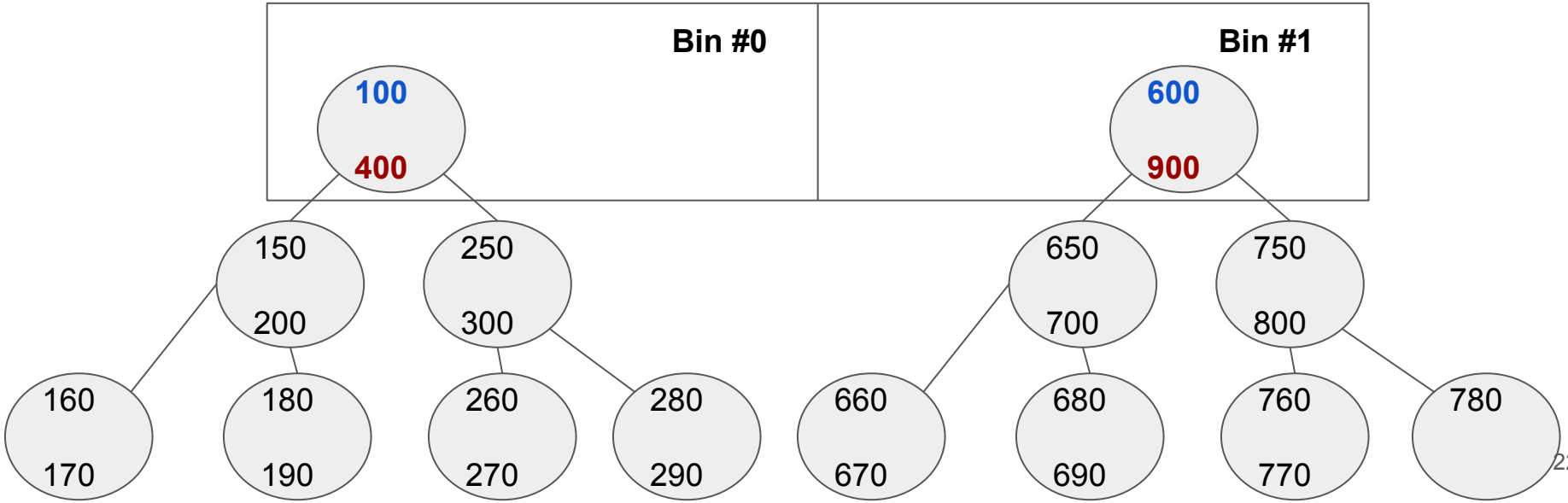

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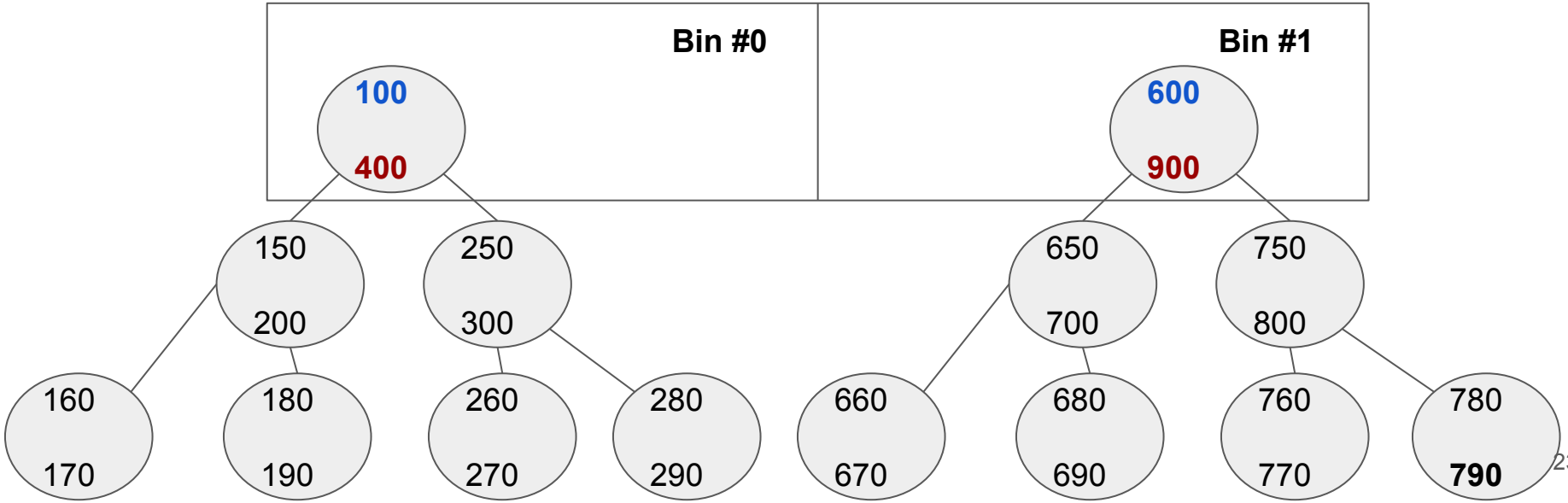

IDA example

size of the reservoir : 28
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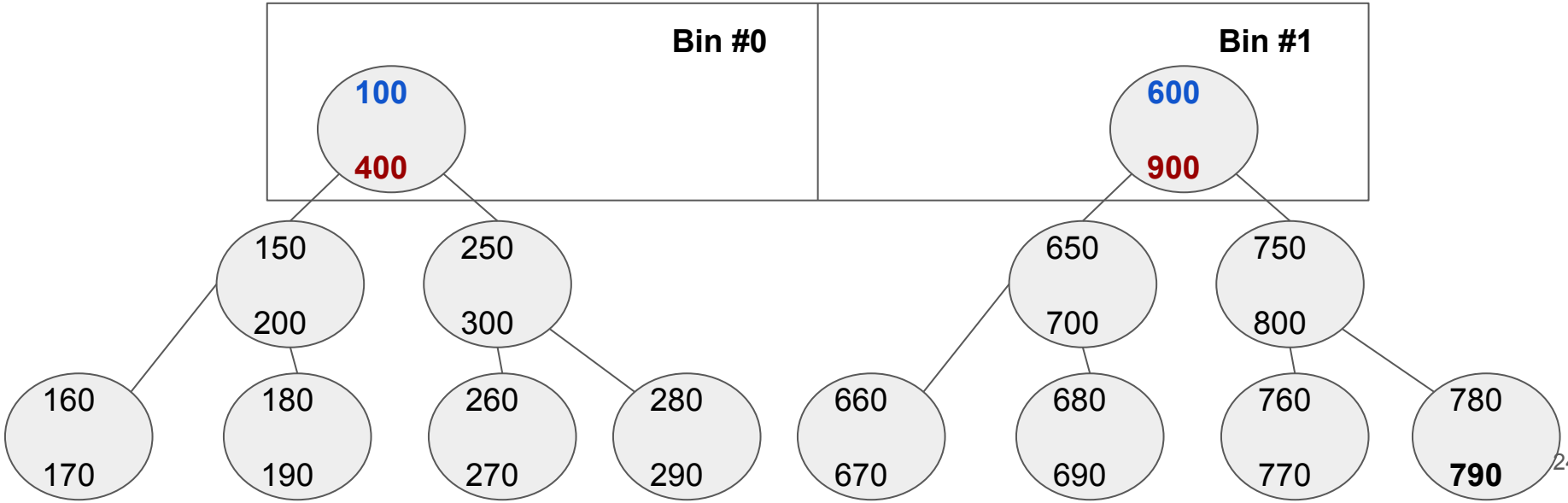
iteration i = 27
t = i mod m = 27 mod 2 = 1
j = 1
---
insert 790 in Bin #1
~~**move min Bin #1 to Bin #0**~~ **because t=j**
~~**reorganize the heaps**~~

(~~27: 790~~) …

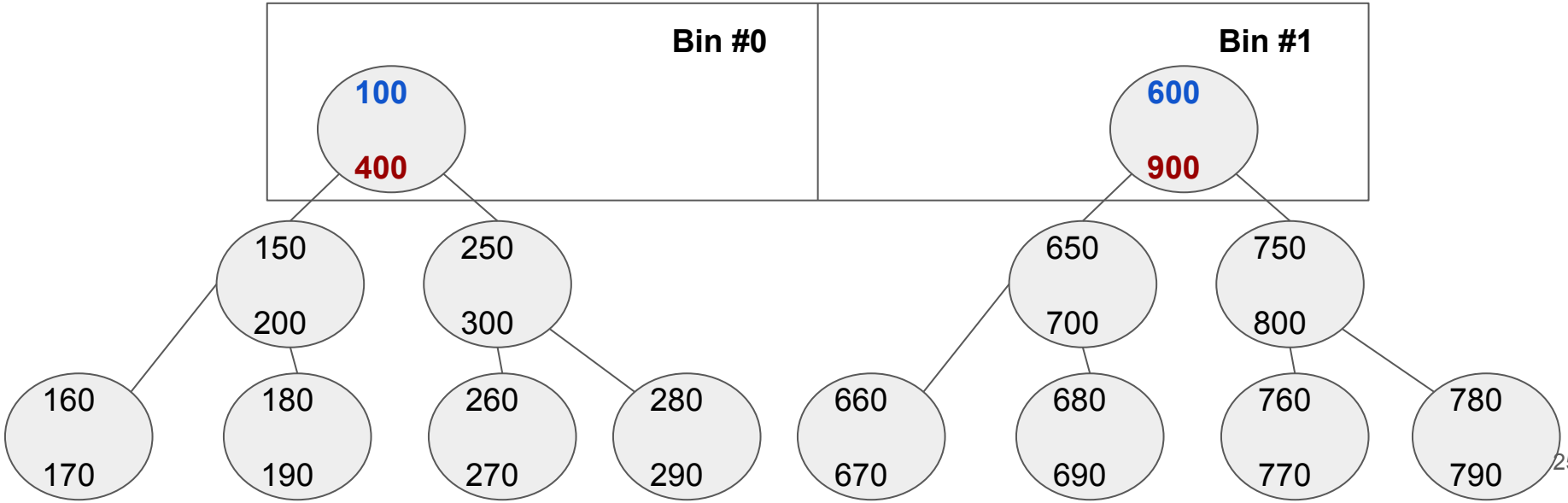


IDA example

size of the reservoir : 28
number of bins: 2

iteration i = 28
keep = random () < s/29
---
if keep :
  remove a random element from Bin #0 U Bin #1
  insert the new element
else skip the element

(28: 850)….



IDA example

size of the reservoir : 28
number of bins: 2

iteration i = 28
keep = random () < s/29 #true
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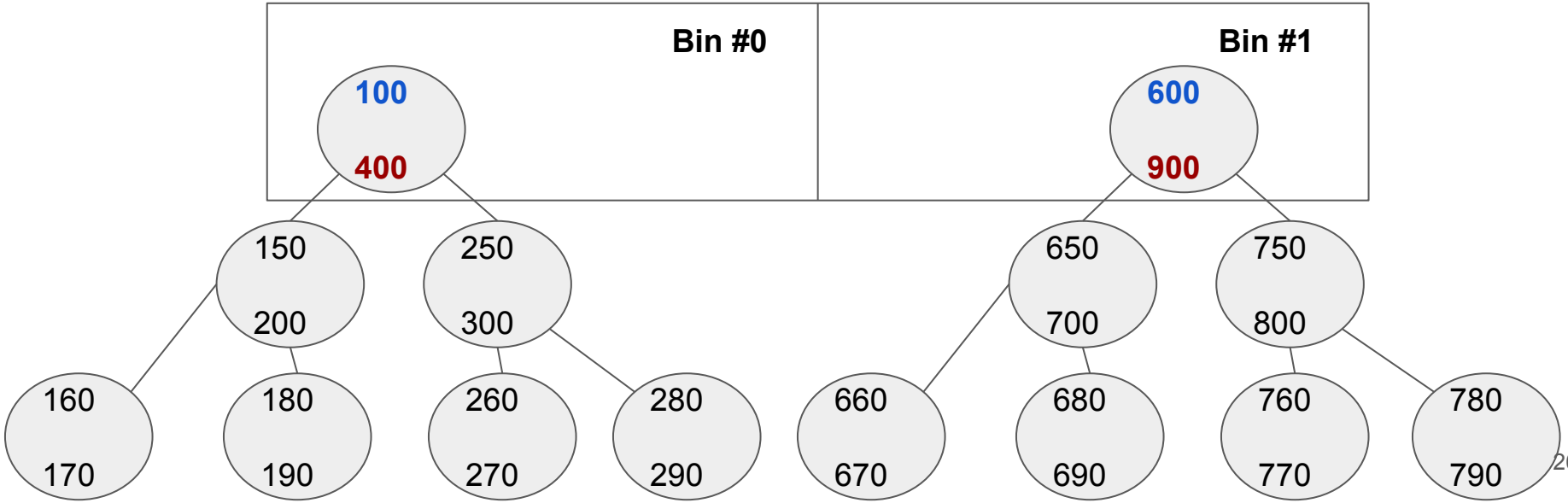
(~~28: 850~~)….



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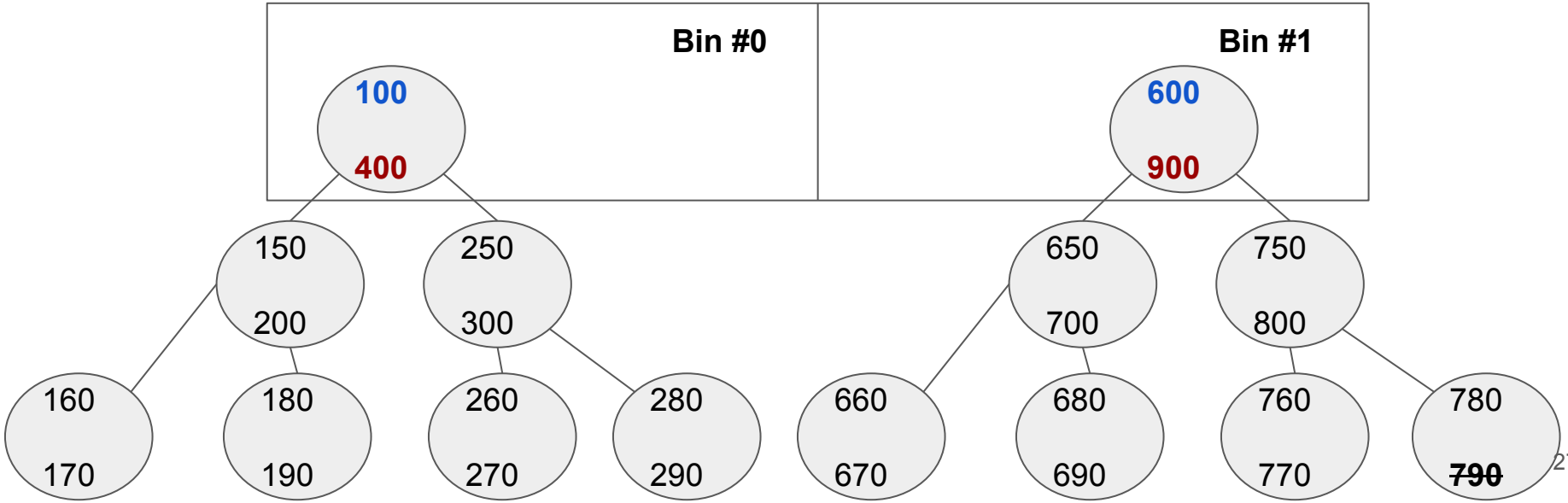

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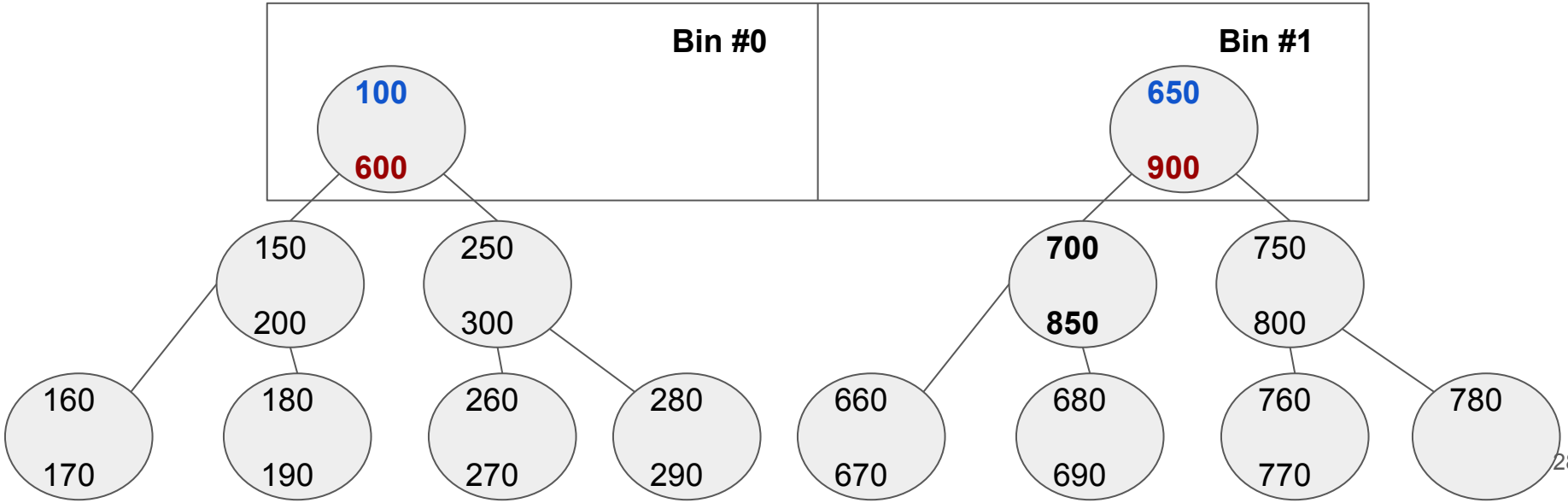
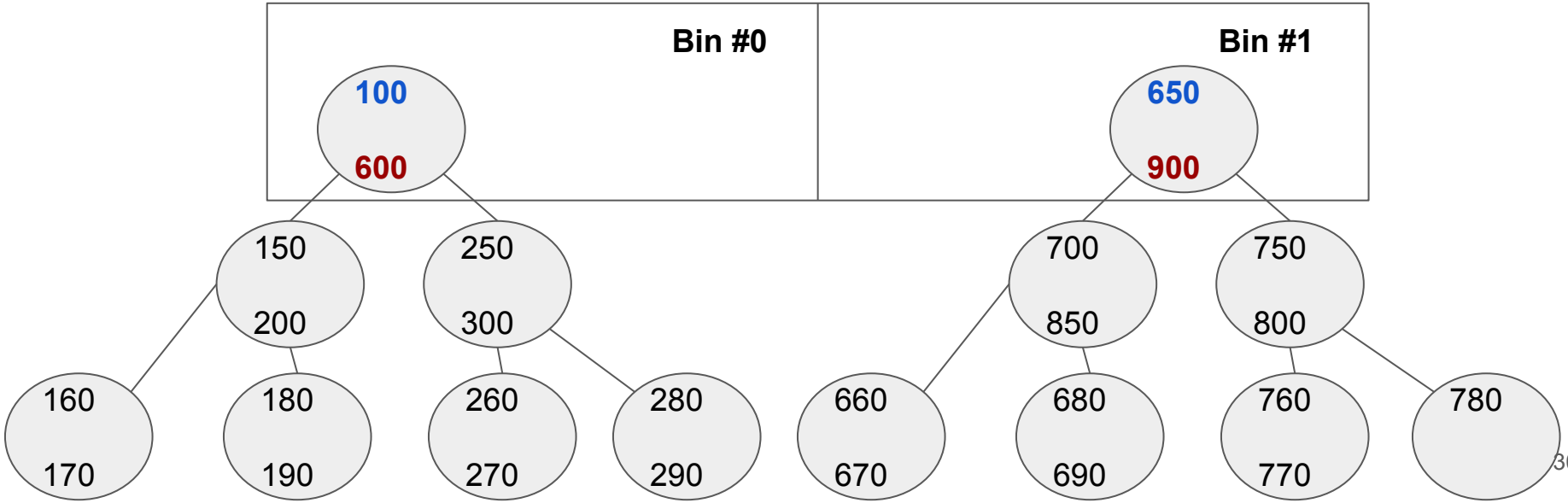


IDA example

size of the reservoir : 28
number of bins: 2

iteration i = 999
keep = random () < s/1000
---
if keep :
  remove a random element from Bin #0 U Bin #1
  insert the new element
else skip the element

(**999**: 890)….



IDA example

size of the reservoir : 28
number of bins: 2

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keep = random () < s/1000 # false
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if keep :
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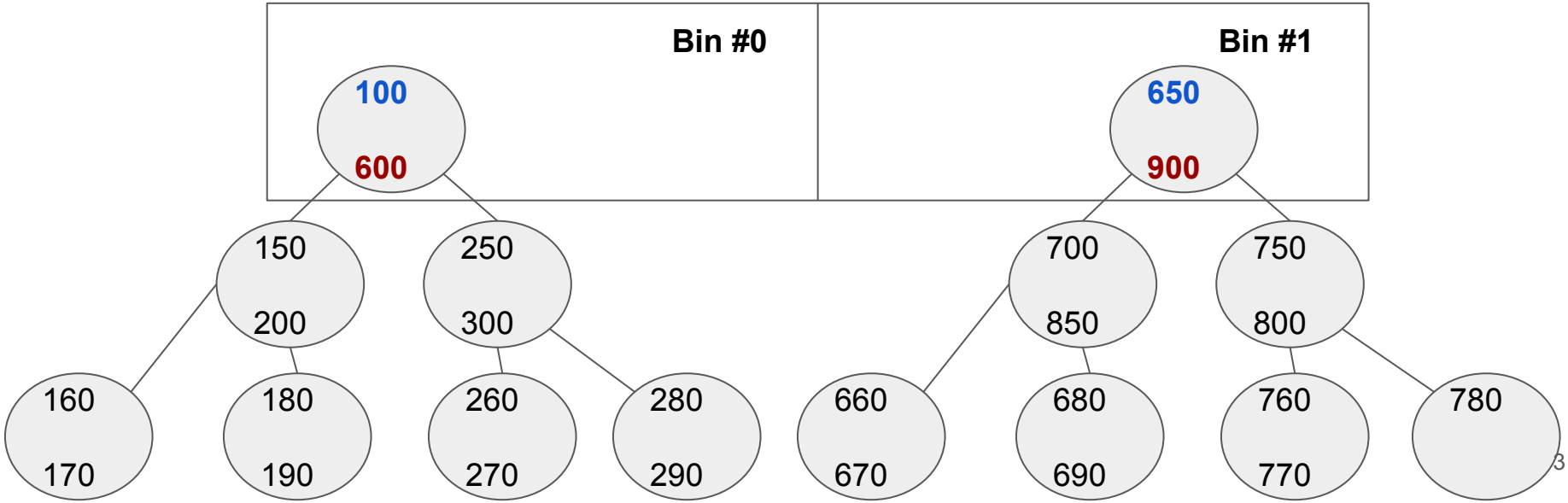

IDA example

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number of bins: 2

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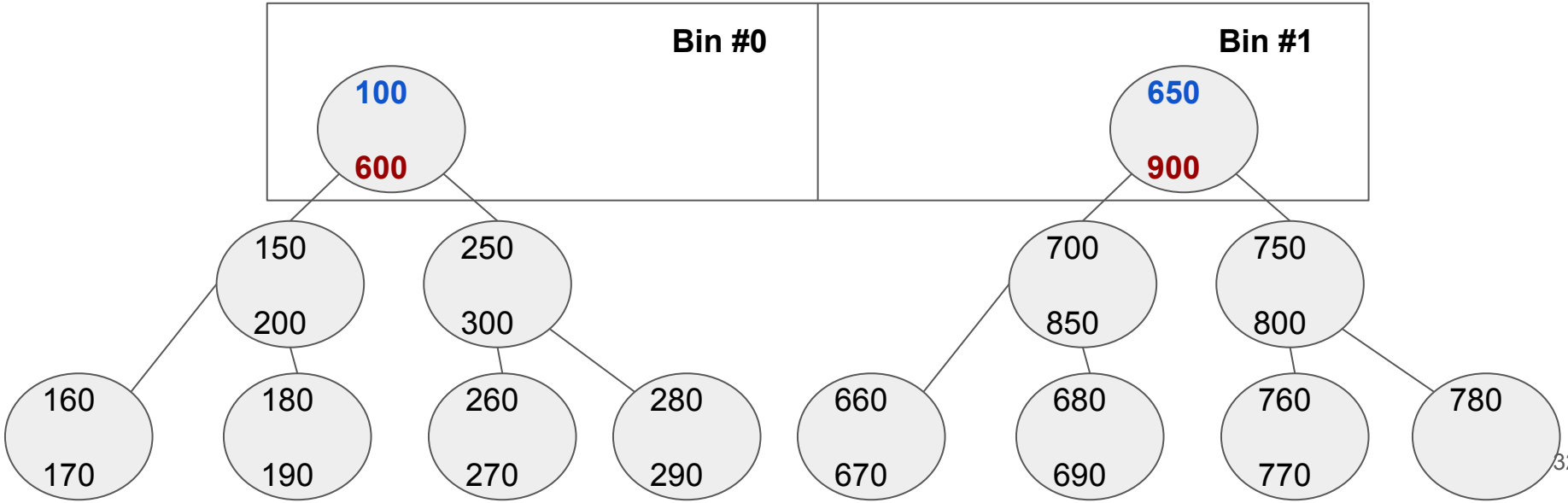


IDA: performance

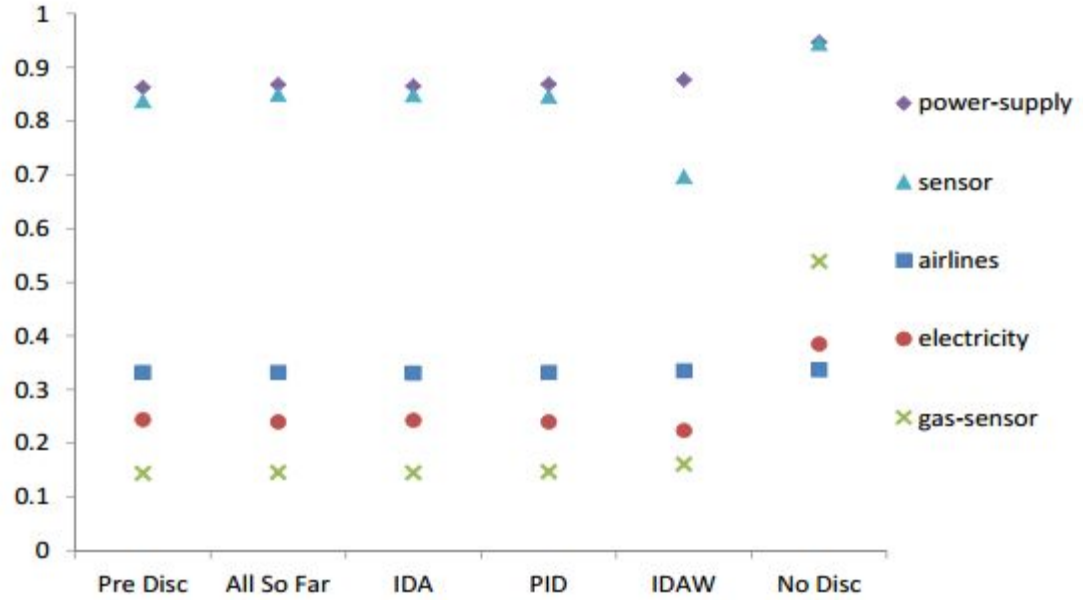
- constant time access for values of a bin (vector, heap)
- insertion/deletion in a bin O(log(s/m)) (heap)
- replacement in the vector of bins
  may require the update of m bins, O(m log(s/m))

- But, the complexity decreases over time because updates occur less often (reservoir sampling)

IDAW: performance

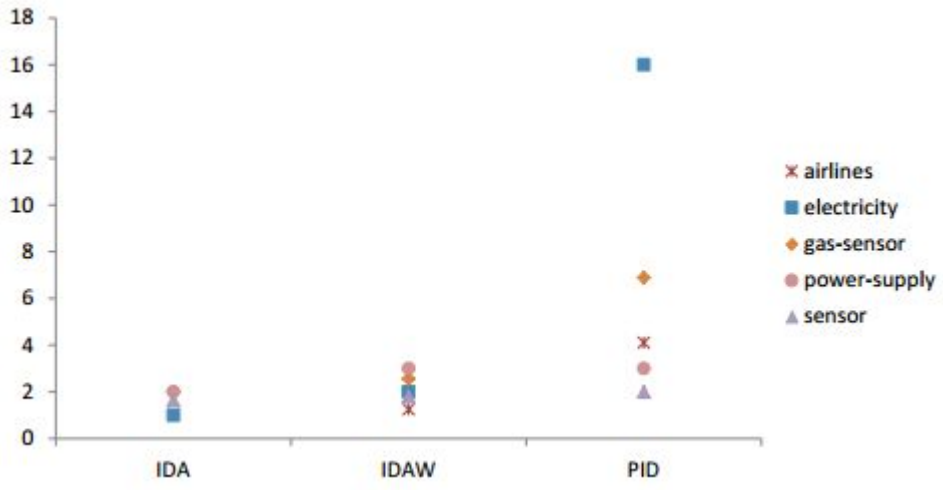
- we replace the oldest value (no randomness)
- a sliding window is used instead of a reservoir
- balanced binary trees for the bins
- the complexity for updates/accesses is O(log(s/m)) **every time**

Evaluation: with other approaches, LRSGD



Errors for each approach on each data stream

Evaluation: execution time, LRSGD



execution time for each approach, for each data set, expressed in terms of mutiples of the execution time taken without discretization

Conclusion

- IDA/IDAW maintain an equal frequency discretization
- Efficient computation (IDA) especially after a number of iterations thanks to the use of random sampling
- IDAW track more closely the distribution of the data
- discretization of the data can reduce the error for LRSGD with little cost on execution time