

COMP 250

INTRODUCTORY SCIENCE

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Week 13-2: Add WeChat edu_assist_pro

Giulia Alberini, Fall 2020

Slides adapted from Michael Langer's

WHAT ARE WE GOING TO DO IN THIS VIDEO?

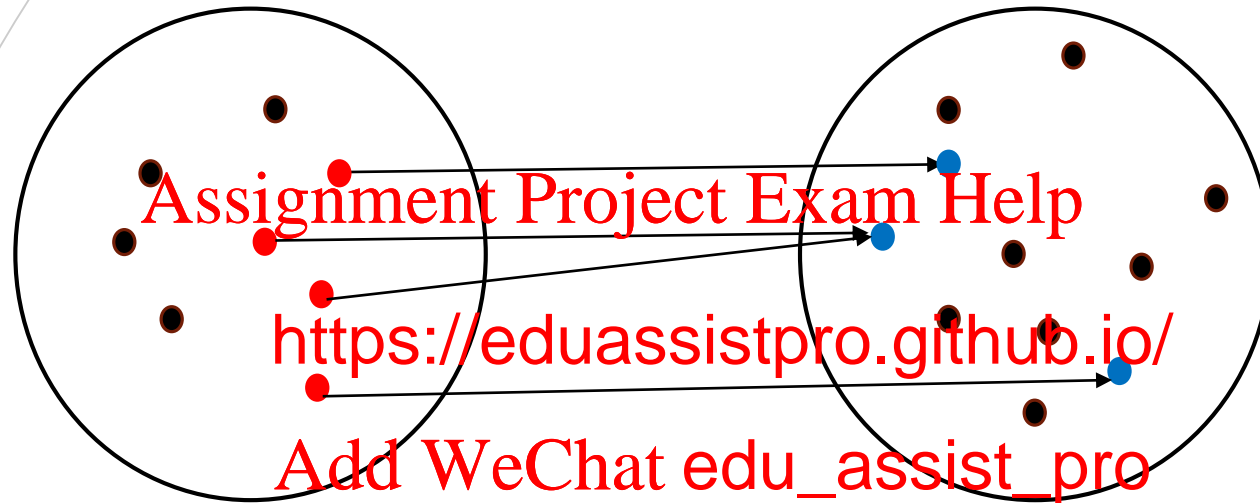


■ Hash Maps Assignment Project Exam Help

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RECALL: MAP



keys (type K)

values (type V)

Each (key, value) pairs is an “entry”.
For each key, there is at most one value.

ARRAYS OF VALUES

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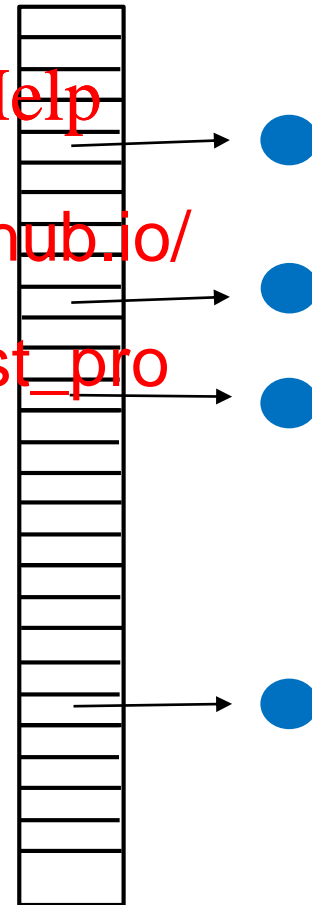
Then, we could use
type **V** (value) as
access.

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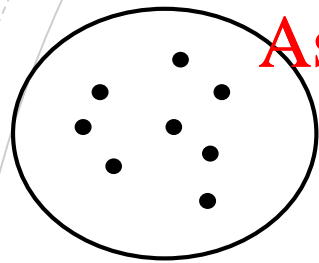
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This would work well if keys
are small integers.

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JAVA HASHCODE()



keys K

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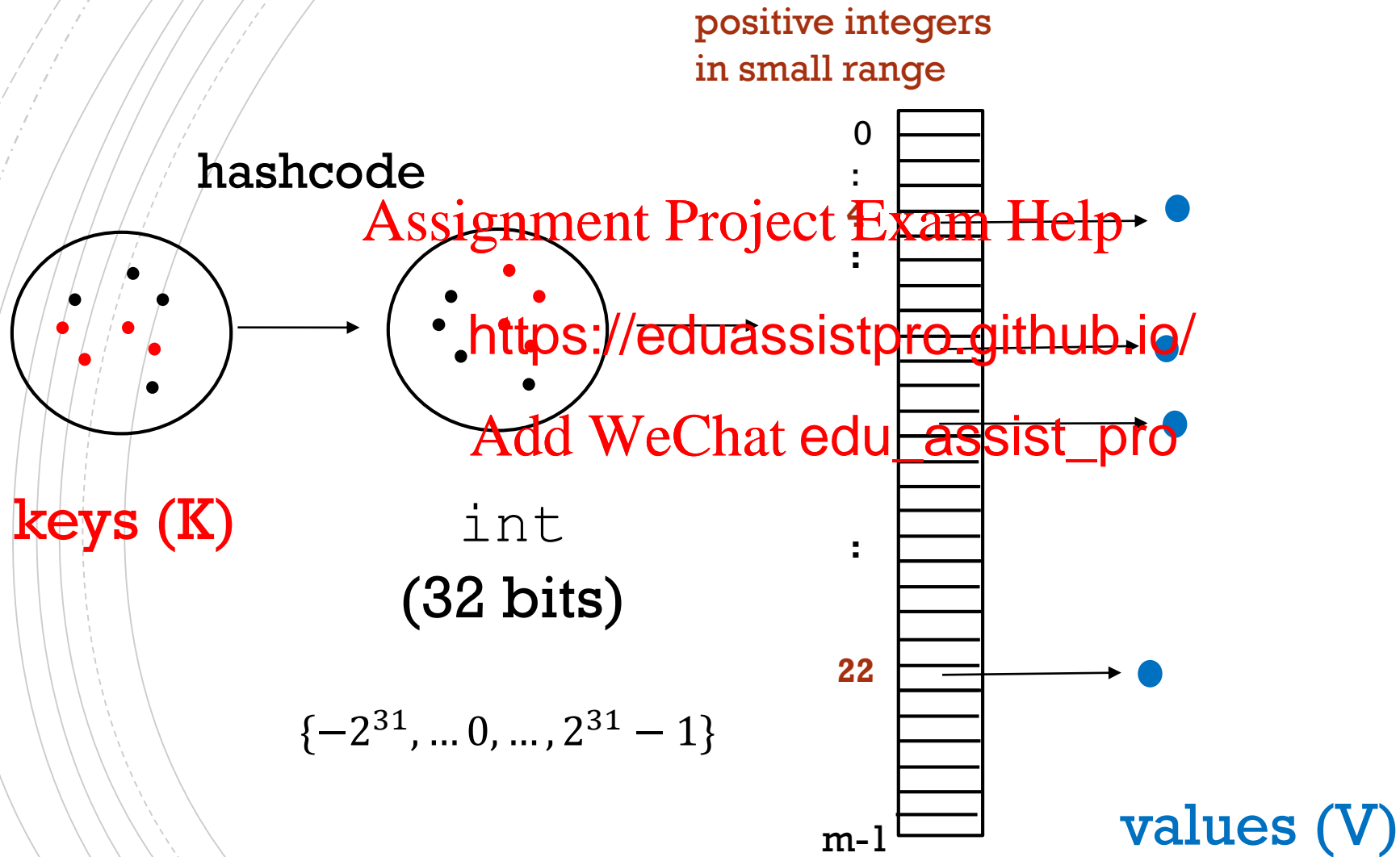
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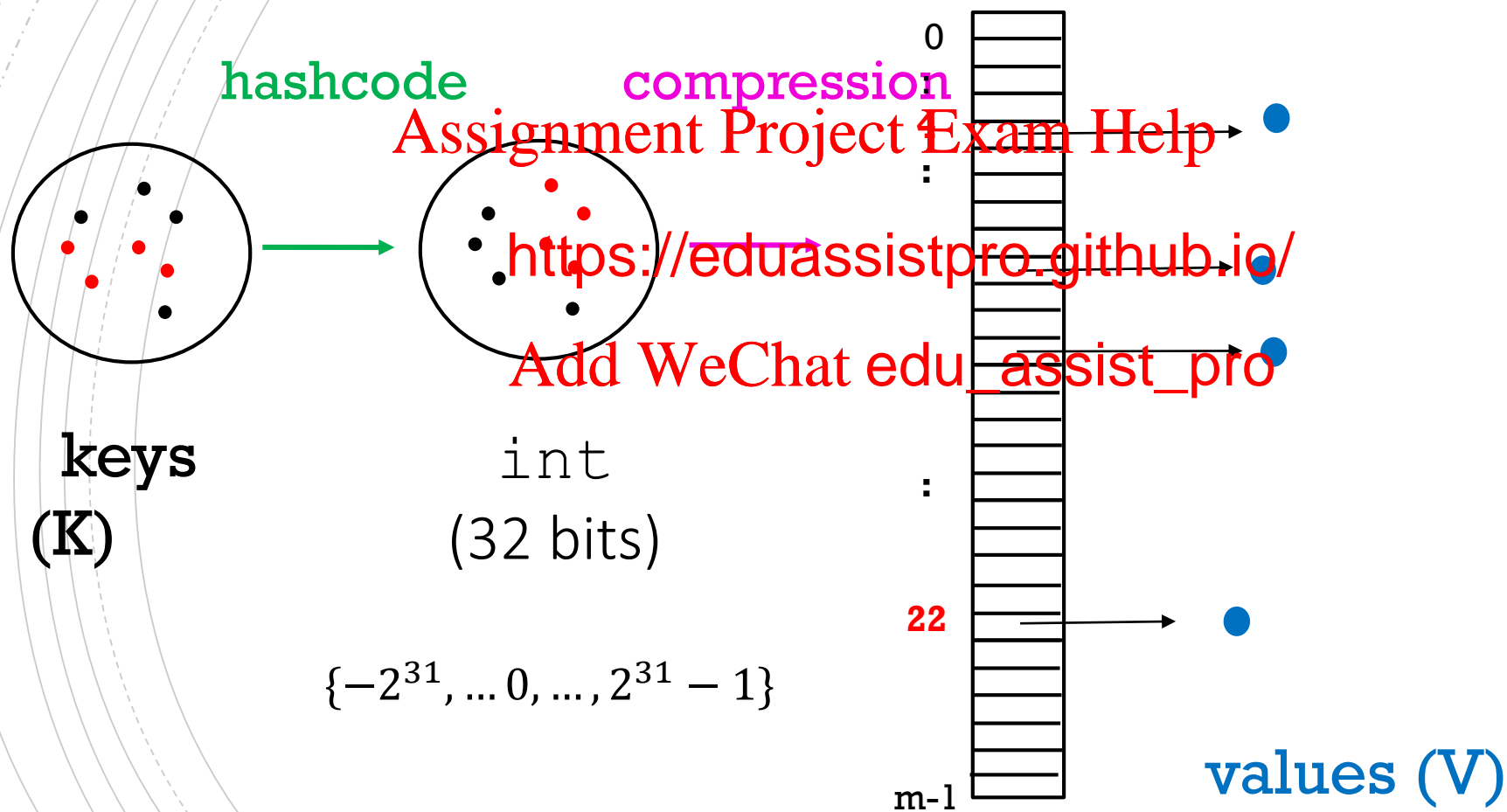


int
(32 bits)

TODAY: MAP COMPOSITION



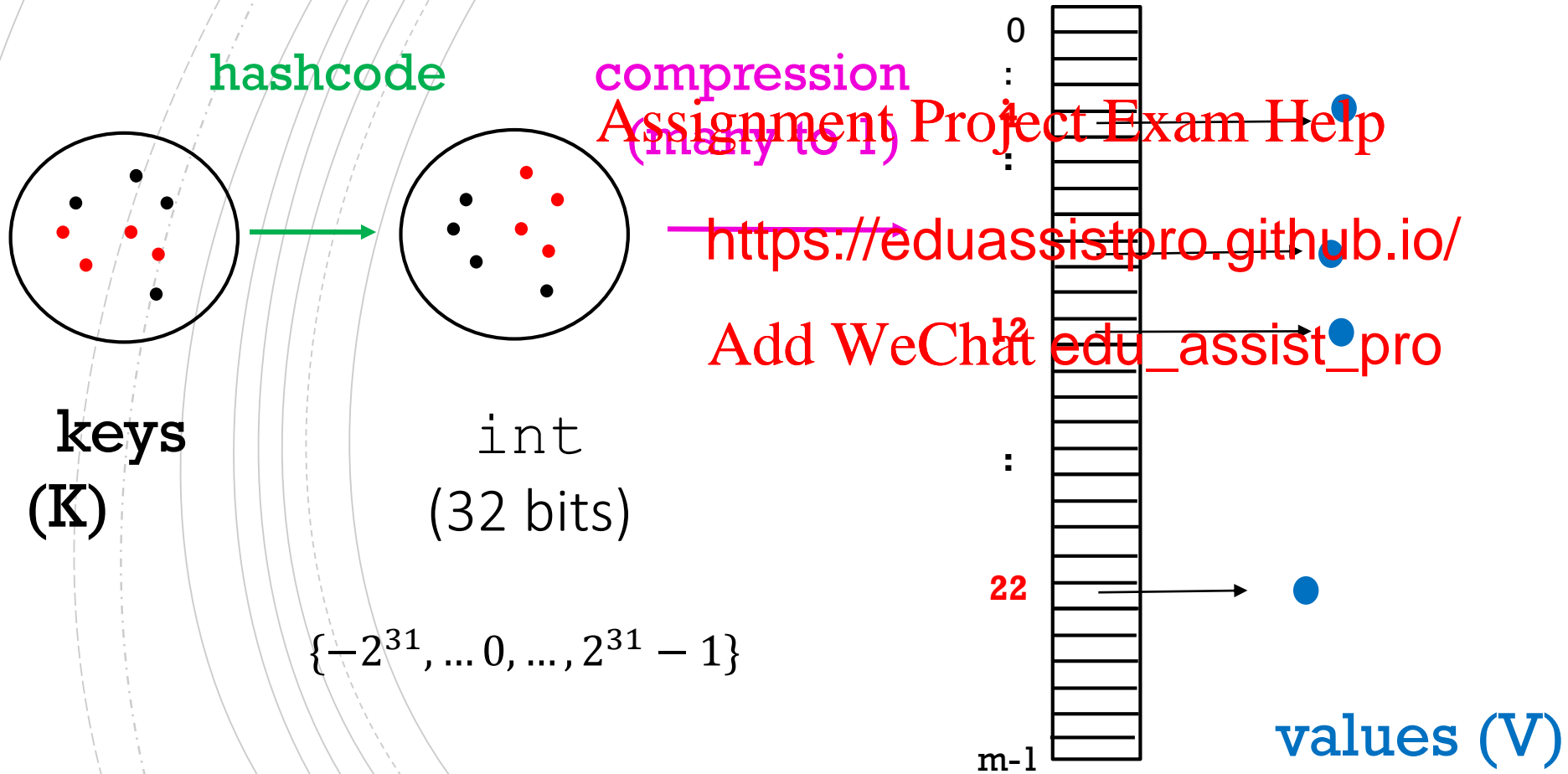
COMPRESSION MAP



compression: $i \rightarrow |i| \bmod m,$

COMPRESSION MAP

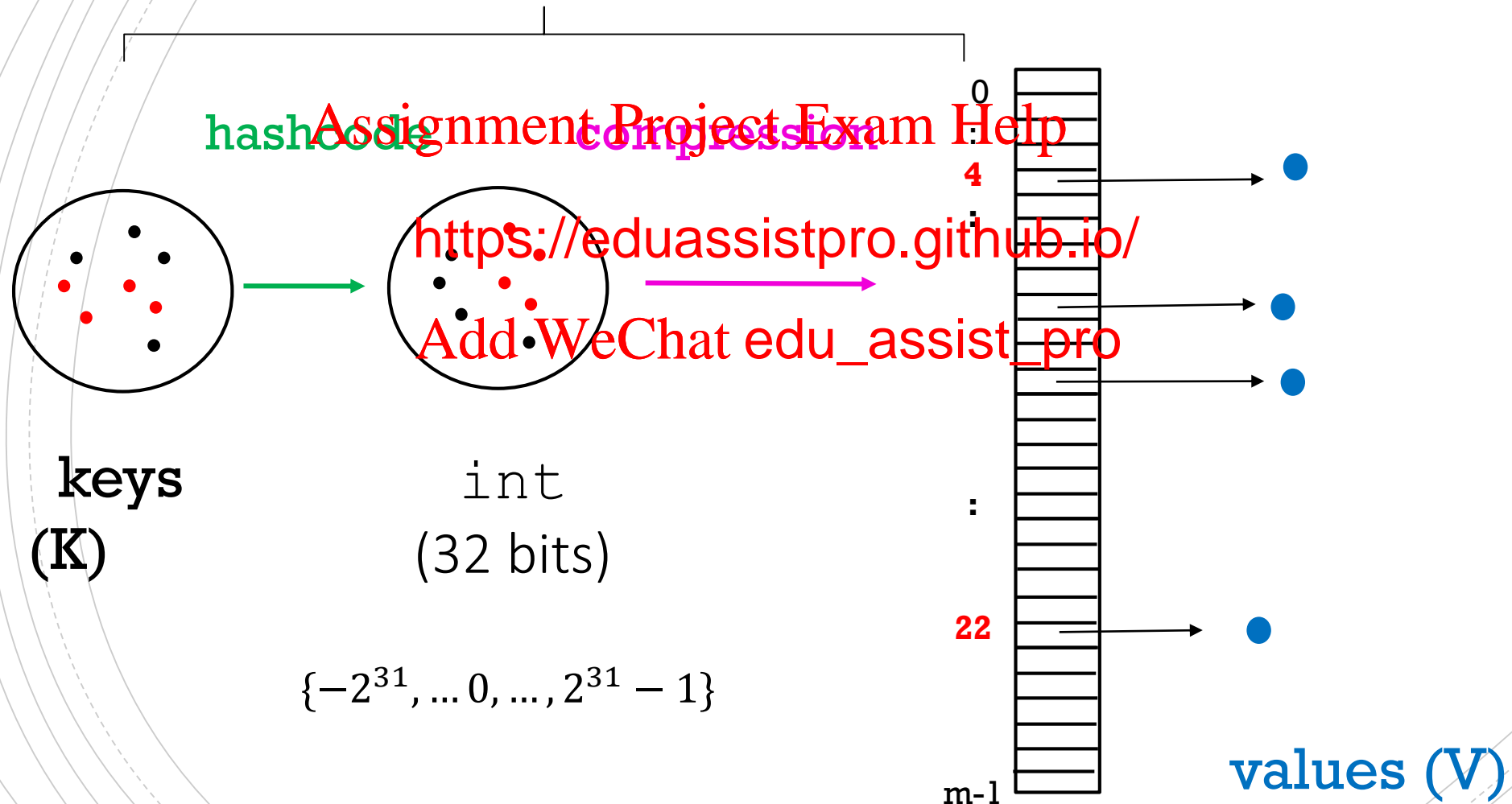
where m is the length of the array.



HASH FUNCTION

“hash values”

hash function : keys $\rightarrow \{0, \dots, m-1\}$



EXAMPLE

- Let $m = 7$

“hash function” \equiv `compression` \circ `hashCode`

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hash code hash value (hash code % 7)

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16

2

25

4

21

0

36

1

35

0

53

4

0

□

□

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TERMINOLOGY

- A "hashCode" maps keys to `int`

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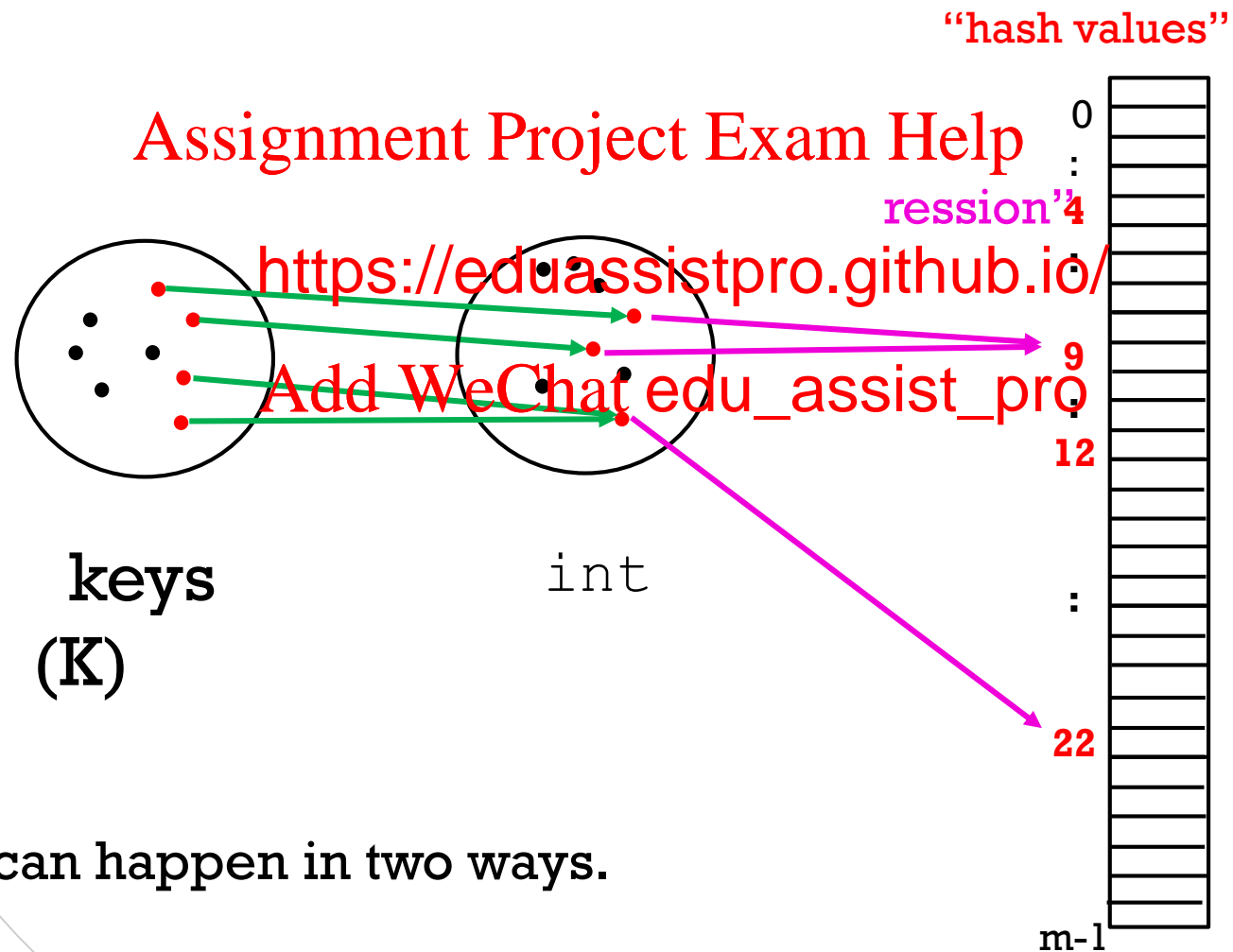
- A "hash function" maps keys to `int` values"
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- We use values both to refer to `int` if the hash function as well as the values in the key-value pairs of the map we want to represent!

PROBLEM : COLLISIONS

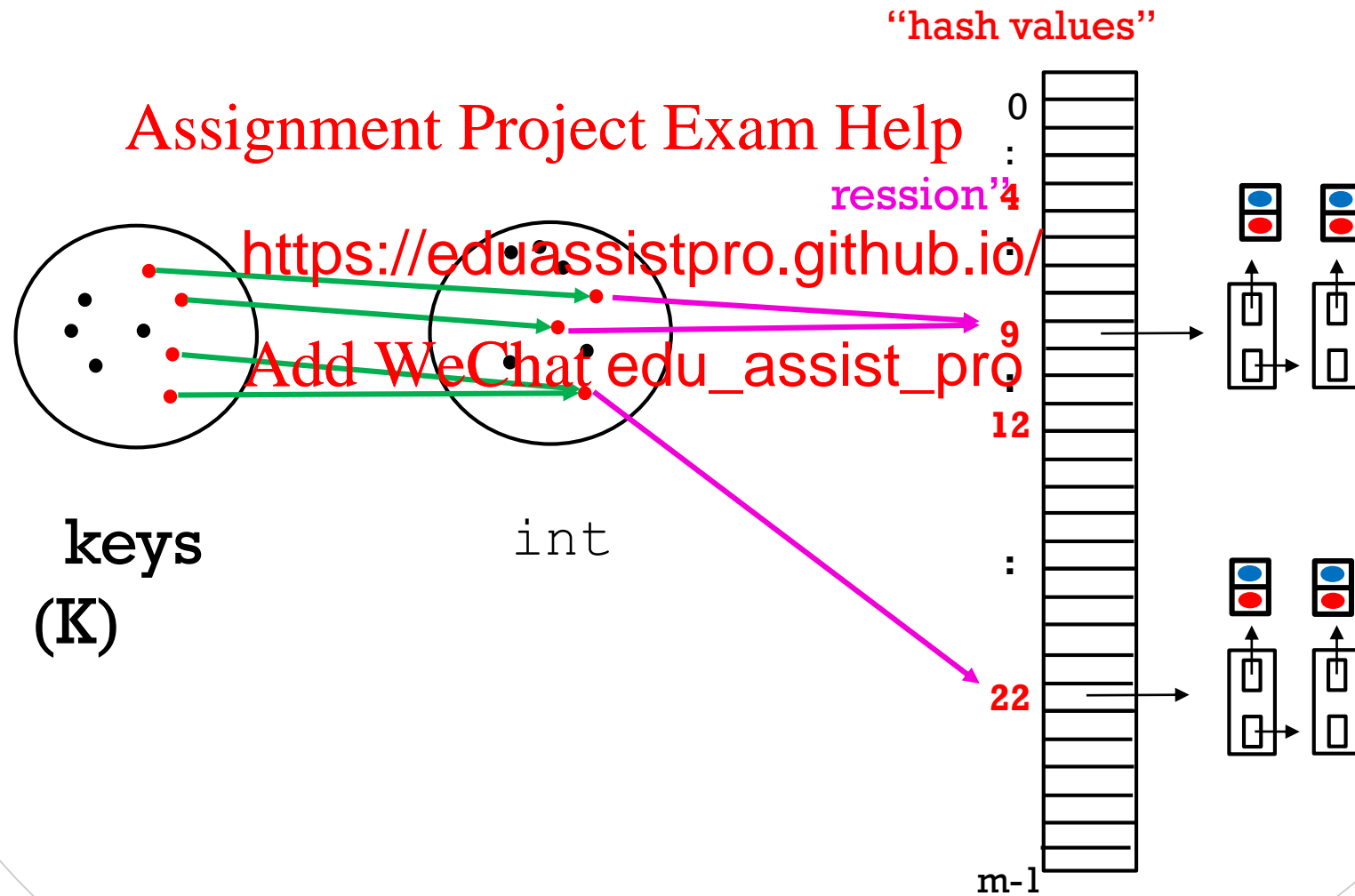
Two or more keys can map to the same **hash value**.



Collisions can happen in two ways.

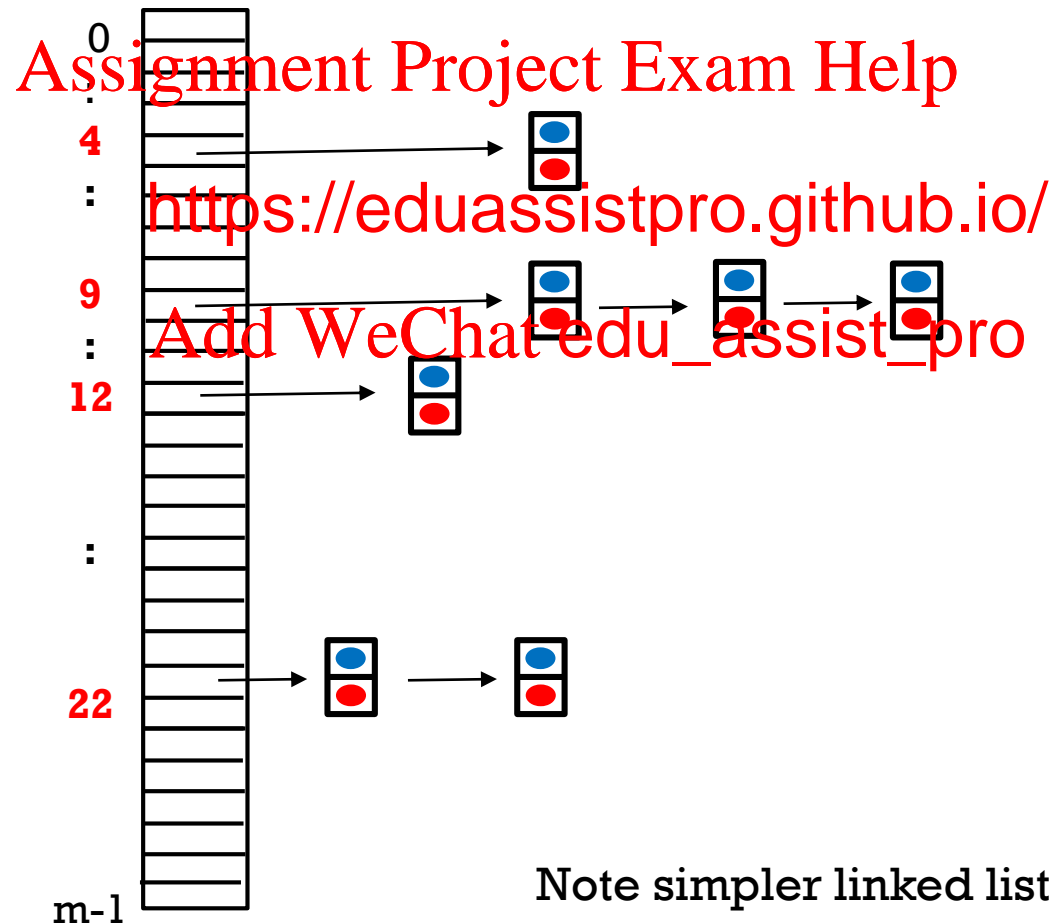
SOLUTION : HASH TABLE (OR HASH MAP)

Each array slot holds a singly linked list of entries



BUCKETS

Each array slot + linked list is called a bucket. This map has m buckets.



OBSERVATIONS

- Why is it necessary to store (key, value) pairs in the linked list?
Why not just the va

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LOAD FACTOR

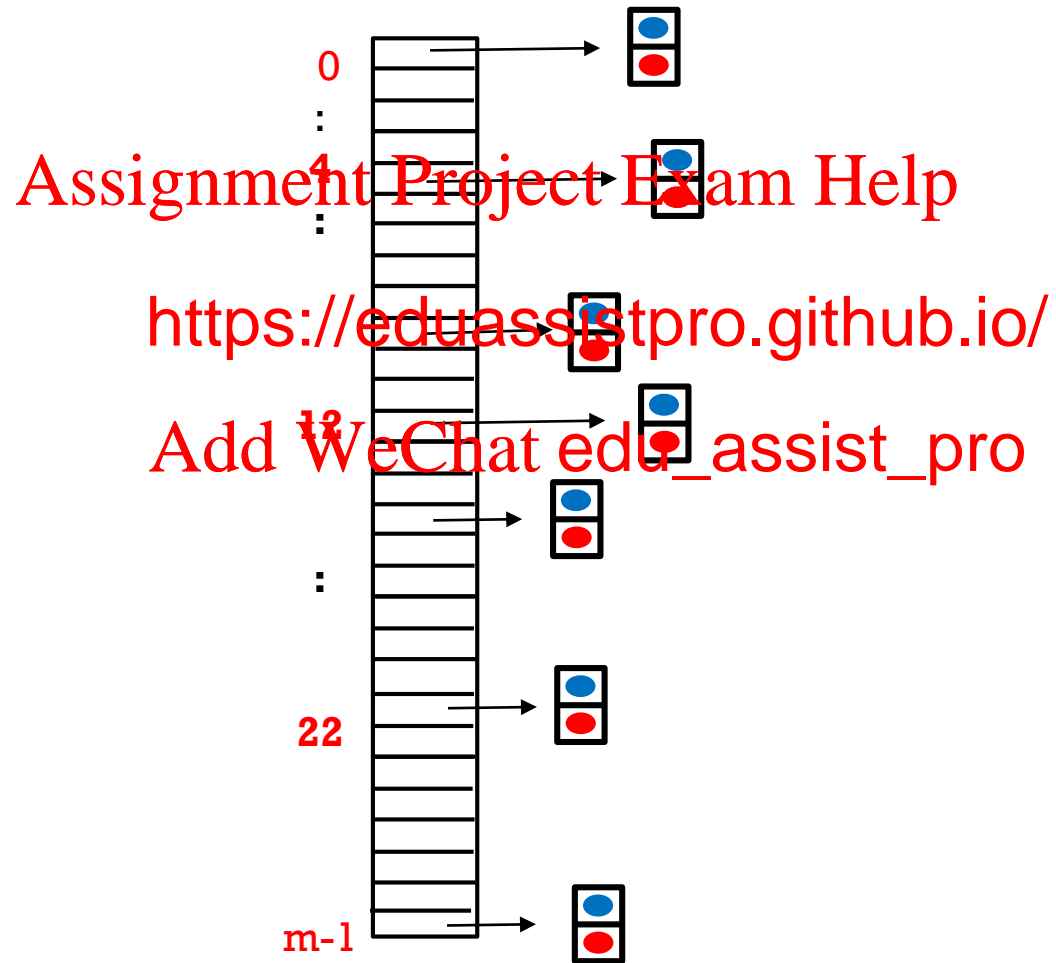
$$\text{LOAD FACTOR} = \frac{\text{number of (key, value) pairs in map}}{m}$$

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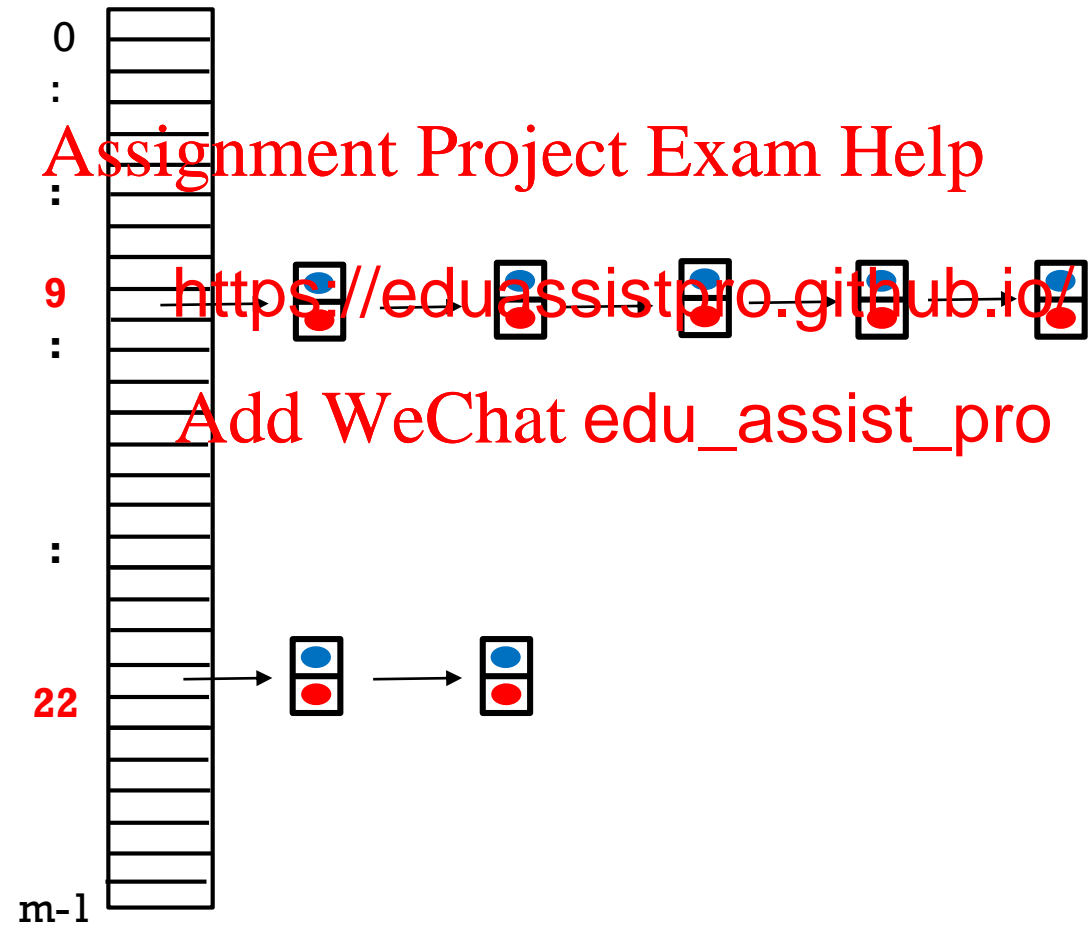
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One typically keeps the load factor below 1.
In the Java `HashMap` class, the default **MAXIMUM**
load factor is 0.75

EXAMPLE OF A "GOOD HASH"



EXAMPLE OF A "BAD HASH"



EXAMPLE

$$h : K \rightarrow \{0, 1, \dots, m-1\}$$

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Example: Suppose n IDs,
e.g. 260745918.
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How many buckets to choose ?

Good hash function?

Bad hash function ?

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How many buckets to choose ? \rightarrow number of entries

Good hash function? \rightarrow rightmost 5 digits

Bad hash function ?

EXAMPLE

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How many buckets to choose \rightarrow number of entries

Good hash function? \rightarrow rightmost 5 digits

Bad hash function ? \rightarrow leftmost 5 digits

PERFORMANCE OF HASH MAPS

- `put(key, value)`
- `get(key)`
- `remove(key)`

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If load factor is less than 1 and if h is good, then operations are $O(1)$ “in practice”. This beats all potential map data structures we discussed last video.

If we have a bad hash, we can choose a different hash function.

PERFORMANCE OF HASH MAPS

- `put(key, value)`
- `get(key)`
- `remove(key)`
- `contains(value) ?`

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PERFORMANCE OF HASH MAPS

- `put(key, value)`
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We will need to look through each of the m buckets (i.e. search each linked list for that value)

PERFORMANCE OF HASH MAPS

- `put(key, value)`

- `get(key)`

- `remove(key)`

- `contains(value)`

- `getKeys()`

- `getValues()`

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These last three methods all require traversing the hash table which takes time $O(n + m)$ where n is the number of entries and m is the number of buckets.

JAVA HashMap<K, V> CLASS

- In constructor, you can specify initial number m of buckets, and maximum load factor

(by default $m = 16$, and max load factor = 0.75)

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- How is hash function specified?

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JAVA HashMap<K, V> CLASS

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- How is hash function specified?

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Use key's hashCode(), take absolute value, and compress it by taking mod of the number of buckets.

$$i \rightarrow |i| \bmod m$$

JAVA HashSet<E> CLASS

Similar to HashMap, but there are no values. Just use it to store a *set* of objects of some type. Operations:

- add(e)
- contains(e)
- remove(e)
- ...

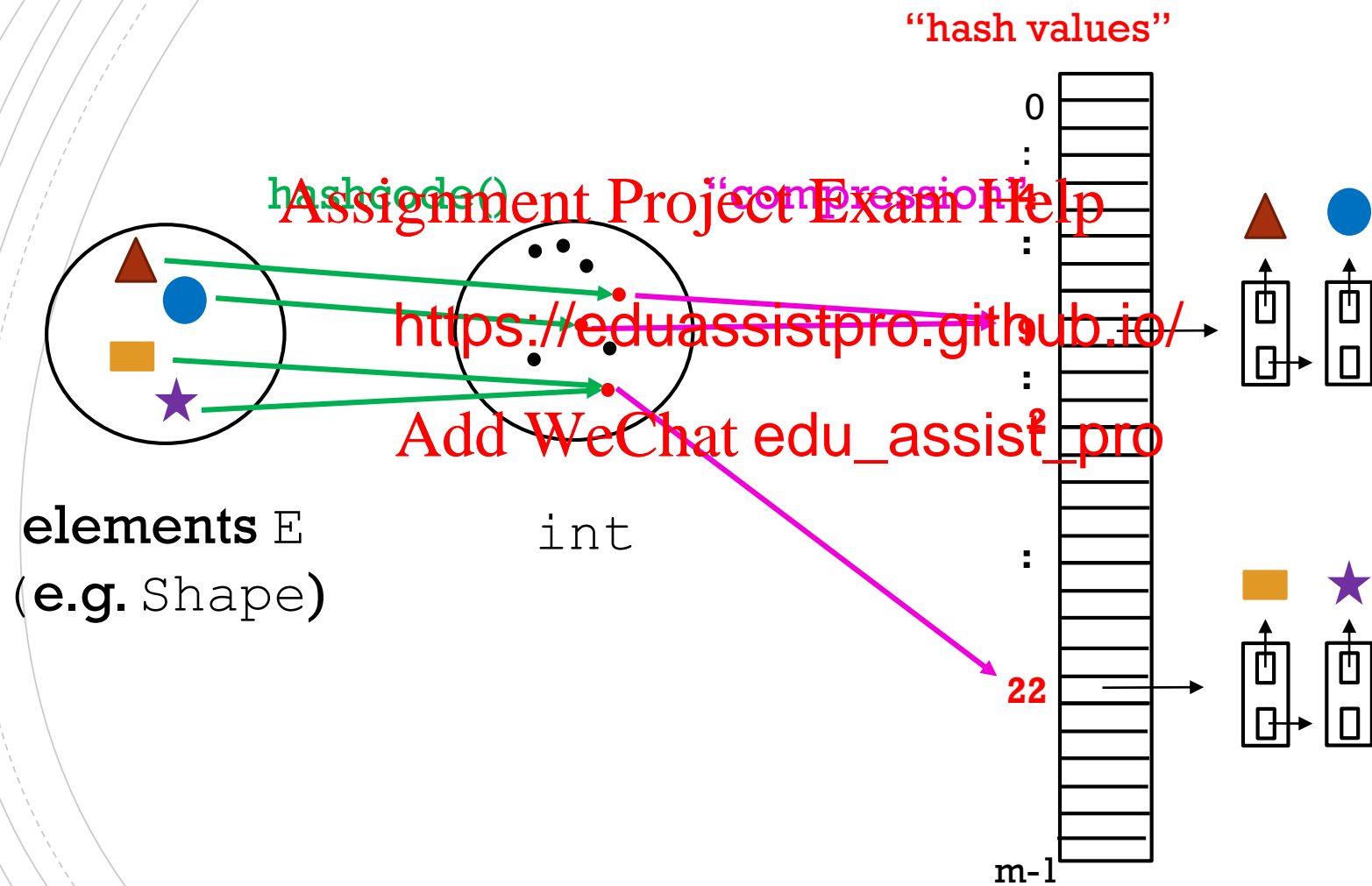
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If hash function is good, then these operations are $O(1)$. Note that this is not a list! There's no order in the elements and elements must be unique.

JAVA HashSet<E>



An orange paint roller with a red handle, positioned horizontally. The roller is partially filled with orange paint, and there are orange paint splatters and drips around it. The text "Coming Soon" is written in white on the orange part of the roller.

Coming Soon

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In the next

- Graphs <https://eduassistpro.github.io/>
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