LEC 04

CSE 123

Linked Nodes

BEFORE WE START

Talk to your neighbors:

What's your favorite data structure to use?

Instructor: James Wilcox

Questions during Class?

Raise hand or send here

sli.do #cse123

Lecture Outline

- Announcements
- Reference Semantics Review
- Contiguous / Non-Contiguous Memory Review
- ListNode Practice

Announcements

- Creative Project 0 feedback is out!
- Resubmission Cycle 0 opens today, closes on Fri (Oct 10)
  - Normally resubmissions will be open Mon – Fri each week
- Programming Assignment 0 due tonight, Oct 8 at 11:59pm!
  - See generic Programming Assignment rubric posted on website
- Creative Project 1 will be released tomorrow, Thurs Oct 9
  - Focused on design and implementation of data structures
- Quiz 0 next week (Tues, Oct 14)
  - See Quiz Logistics announcement on Ed
  - Practice quiz available (practice solutions Friday)

Lecture Outline

- Announcements
- **Reference Semantics Review** 
- Contiguous / Non-Contiguous Memory Review
- ListNode Practice

Reference Semantics

- In Java, variables are treated two different ways:

Value Semantics	Reference Semantics
Primitive types (`int, double, boolean`) + `Strings`	Object types (`int[], Scanner, ArrayList`)
Values stored locally	Values stored in memory, reference stored locally
Initialization copies value (many copies of value)	Initialization copies reference (only one value)

```
int x = 10;
int y = x;

y++;     // x remains unchanged
```

```
int[] x = new int[5];
int[] y = x;

y[0]++;    // x[0] changed
```

- We often draw "**reference diagrams**" to keep track of everything

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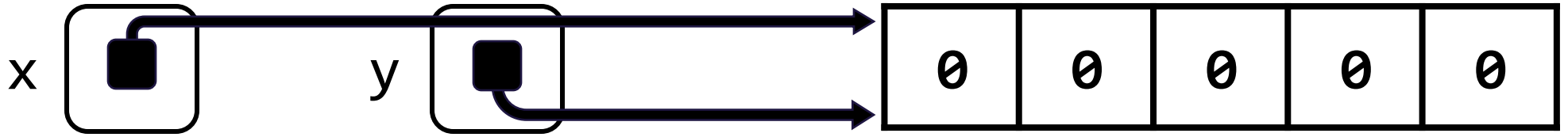

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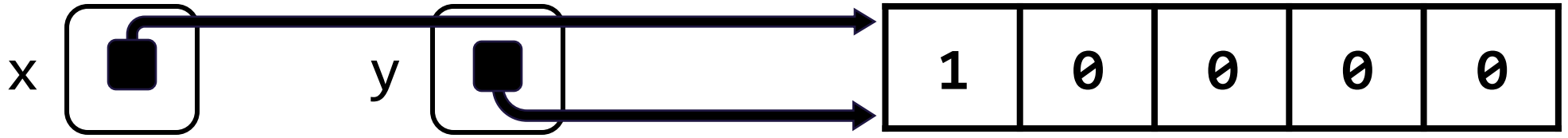


Lecture Outline

- Announcements
- Reference Semantics Review
- **Contiguous / Non-Contiguous Memory Review**
- ListNode Practice

Contiguous vs. Non-contiguous: Memory

- Computer memory = one really, *really* big array.

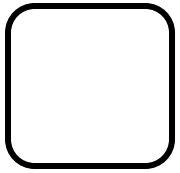
Memory

85	47	-51	44	-38	35	-58	79	27	-14
-24	-38	-66	-27	36	-1	23	20	31	-40
-34	38	37	-52	-15	99	6	68	-67	-58
13	-17	-85	-99	-20	-33	54	38	-66	8
36	24	27	90	-32	72	-73	11	-85	29
-90	-64	29	-27	91	64	28	-97	44	59
-68	76	-1	-6	-52	77	21	37	80	69

Contiguous vs. Non-contiguous: array (1)

- Computer memory = one really, *really* big array.
  - `int[] arr = new int[10];`

Memory



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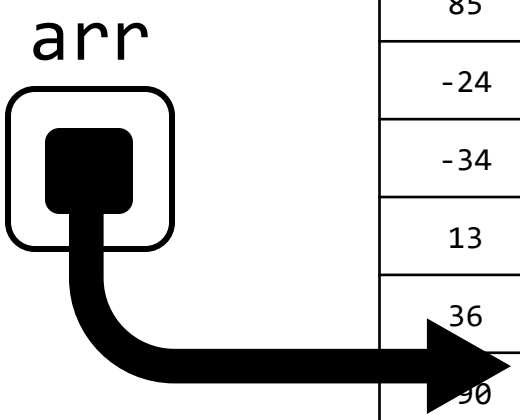
-68	76	-1	-6	-52	77	21	37	80	69

Contiguous vs. Non-contiguous: array (2)

- Computer memory = one really, *really* big array.
  - `int[] arr = new int[7];`

Memory



85	47	-51	44	-38	35	-58	79	27	-14
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-34	38	37	-52	-15	99	6	68	-67	-58
13	-17	-85	-99	-20	-33	54	38	-66	8
36	24	27	90	-32	72	-73	11	-85	29
90	0	0	0	0	0	0	0	44	59
-68	76	-1	-6	-52	77	21	37	80	69

*We call this "**contiguous**" memory*

ListNode

- Java class representing a "**node**"
- Two fields to store discussed state:
  - Fields are public?! We'll come back to this

- Why can `ListNode` be a field in the `ListNode` class?

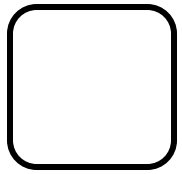
```
public class ListNode {
    public int data;
    public ListNode next;
}
```

Contiguous vs. Non-contiguous: ListNode (1)

- Computer memory = one really, *really* big array.
  - `ListNode list = new ListNode(1, new ListNode(2));`

Memory

`list`



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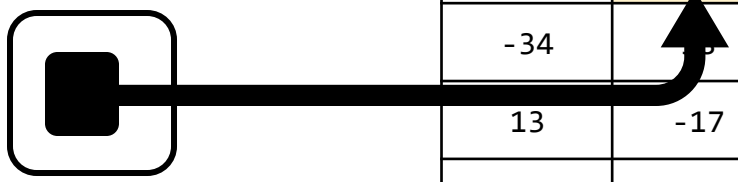
-24	-38	-1	-27	36	-1	23	20	31	-40
-34	38	37	-52	-15	99	6	68	-67	-58
13	-17	-85	-99	-20	-33	54	38	-66	8
36	24	27	90	-32	72	-73	11	-85	29
-90	-64	29	-27	91	64	28	-97	44	59
-68	76	-1	-6	-52	77	21	37	80	69

Contiguous vs. Non-contiguous: ListNode (2)

- Computer memory = one really, *really* big array.

```
ListNode list = new ListNode(1, new ListNode(2));
```

Memory



85	47	-51	44	-38	35	-58	79	27	-14
-24	1		-27	36	-1	23	20	31	-40
-34		37	-52	-15	99	6	68	-67	-58
13	-17	-85	-99	-20	-33	54	38	-66	8
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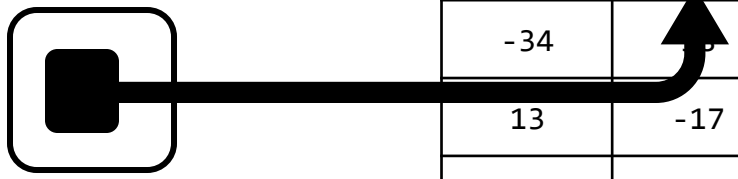
-90	-64	29	-27	91	64	28	-97	44	59
-68	76	-1	-6	-52	77	21	37	80	69

Contiguous vs. Non-contiguous: ListNode (3)

- Computer memory = one really, *really* big array.

```
ListNode list = new ListNode(1, new ListNode(2));
```

Memory



85	47	-51	44	-38	35	-58	79	27	-14
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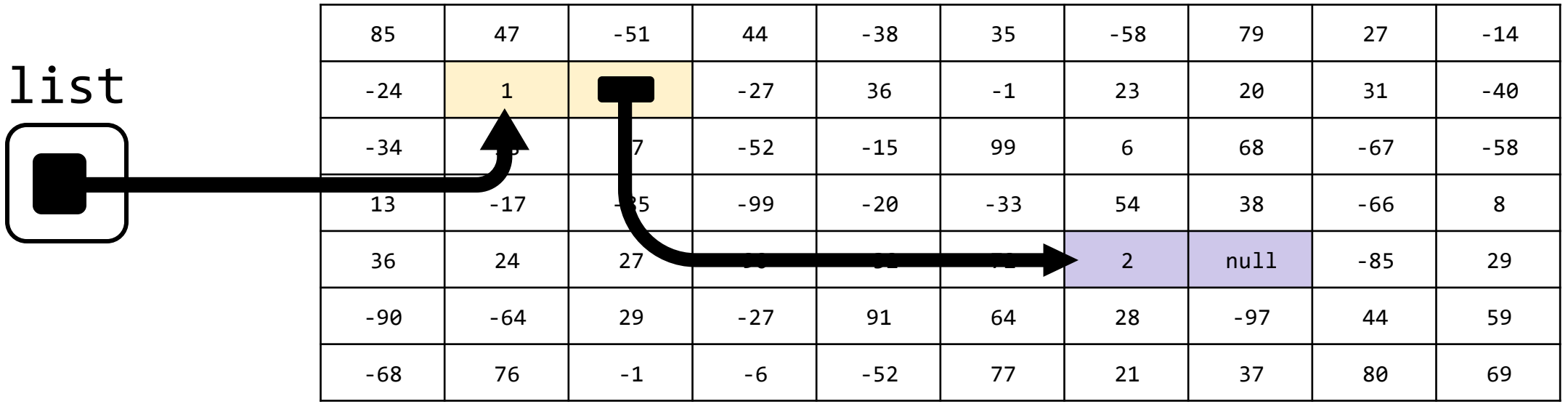
13	-17	-85	-99	-20	-33	54	38	-66	8
36	24	27	90	-32	72	2	null	-85	29
-90	-64	29	-27	91	64	28	-97	44	59
-68	76	-1	-6	-52	77	21	37	80	69

Contiguous vs. Non-contiguous: ListNode (4)

- Computer memory = one really, *really* big array.

```
ListNode list = new ListNode(1, new ListNode(2));
```

Memory



Contiguous vs. Non-contiguous: Summary

- Computer memory = one really, *really* big array.

- Contiguous memory = impossible to resize directly
  - Surrounding stuff in memory (we can't just overwrite)
  - Best we can manage is get more space and copy
- Non-contiguous memory = easy to resize
  - Just get some more memory and link it to the rest

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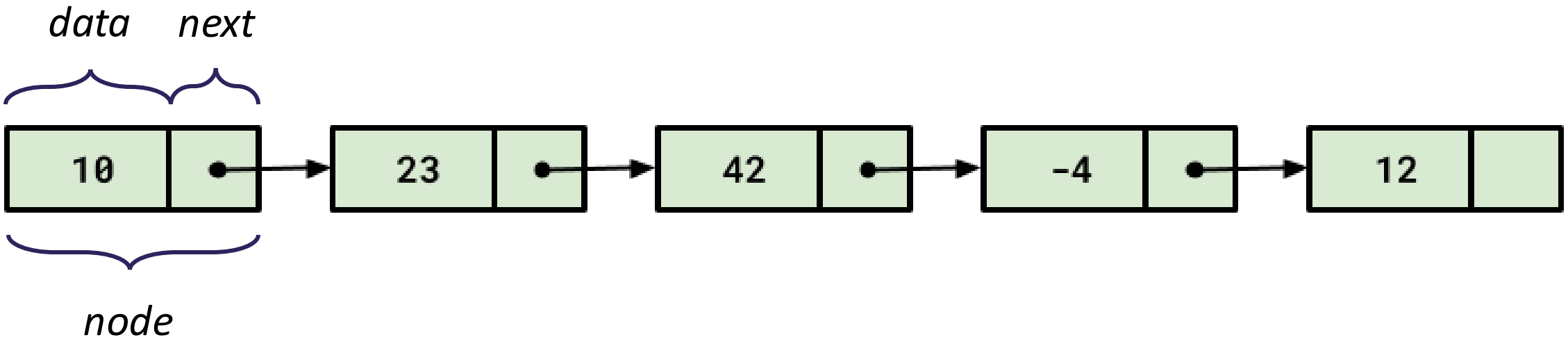
Linked Nodes

- We want to chain together `ints` "**non-contiguously**"

- Accomplish this with nodes we link together
  - Each node stores an `int` (*data*) and an reference to the next node (*next*)



Iterating over `ListNodes`

- General pattern iteration code will follow:

```
ListNode curr = front;
while (curr != null) {
    // Do something

    curr = curr.next;
}
```