LEC 04

# CSE 123

# Linked Nodes

Questions during Class?

Raise hand or send here

sli.do #cse123

## BEFORE WE START

***Talk to your neighbors:***

*What's your favorite data structure to use?*

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Cynthia
Amy
Trien

Neha
Hayden
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Rushil
Srihari
Andras
Kieran
Cora
Liza

Johnathan
Benoit
Jessica
Rohan
Dixon
Helena

Nicholas
Isayiah
Kavya
Eeshani
Nichole

Music: CSE 123 25wi Lecture Tunes

# Lecture Outline

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

# Announcements

- Creative Project 0 feedback will be released today
  - Minimum Grade Calculator
- Resubmission Cycle 0 open, closes on Fri (Jan 24)
  - Normally resubmissions will be open Mon – Fri each week
- Programming Assignment 0 due tonight, Wed Jan 22 at 11:59pm!
  - See generic Programming Assignment rubric posted on website
- Creative Project 1 will be released tomorrow, Thurs Jan 23
  - Focused on design and implementation of data structures
- Quiz 0 next week (Tues, Jan 28)
  - Ed announcement

# 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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x 10 y 11

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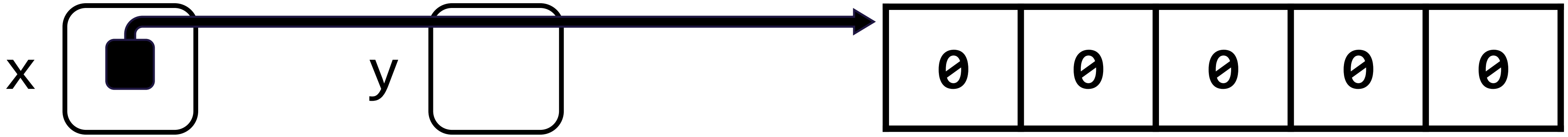

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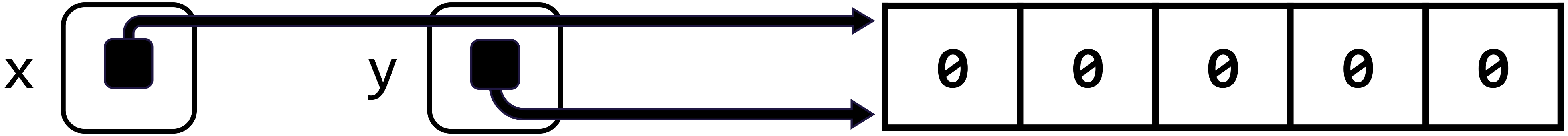

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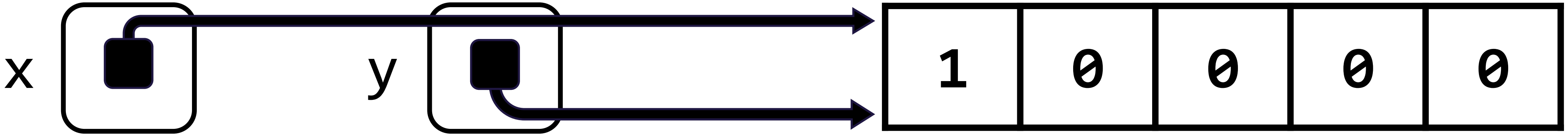

# Lecture Outline

- 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*

arr

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 85 | 47 | -51 | 44 | -38 | 35 | -58 | 79 | 27 | -14 |
| -24 | -38 | -66 | -27 | 36 | -1 | 23 | 20 | 31 | -40 |
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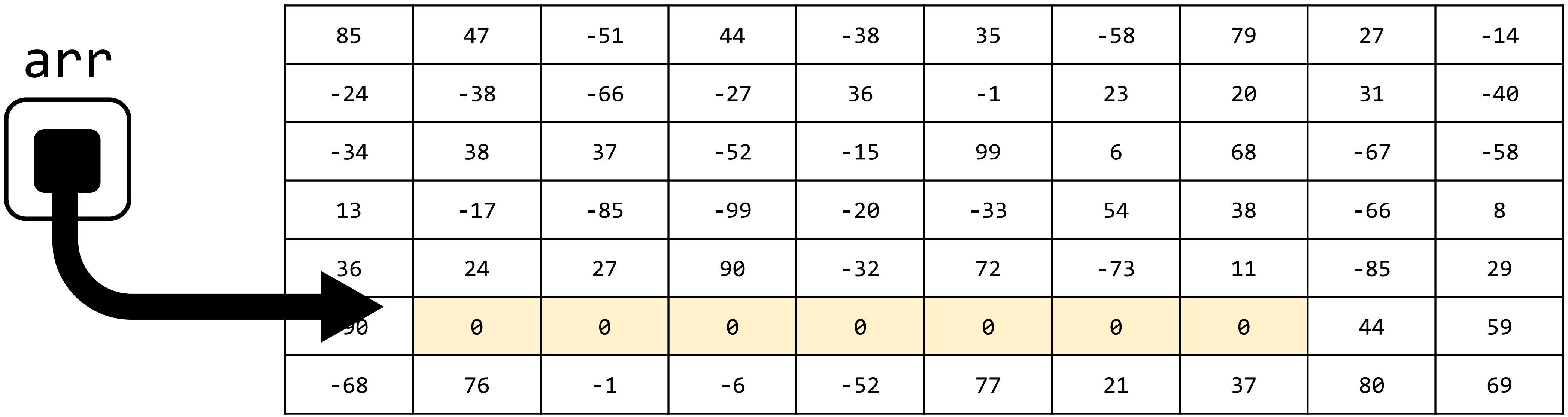
| -68 | 76 | -1 | -6 | -52 | 77 | 21 | 37 | 80 | 69 |

# 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 |
| -24 | -38 | -66 | -27 | 36 | -1 | 23 | 20 | 31 | -40 |
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| 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`

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 85 | 47 | -51 | 44 | -38 | 35 | -58 | 79 | 27 | -14 |
| -24 | -38 | -1 | -27 | 36 | -1 | 23 | 20 | 31 | -40 |
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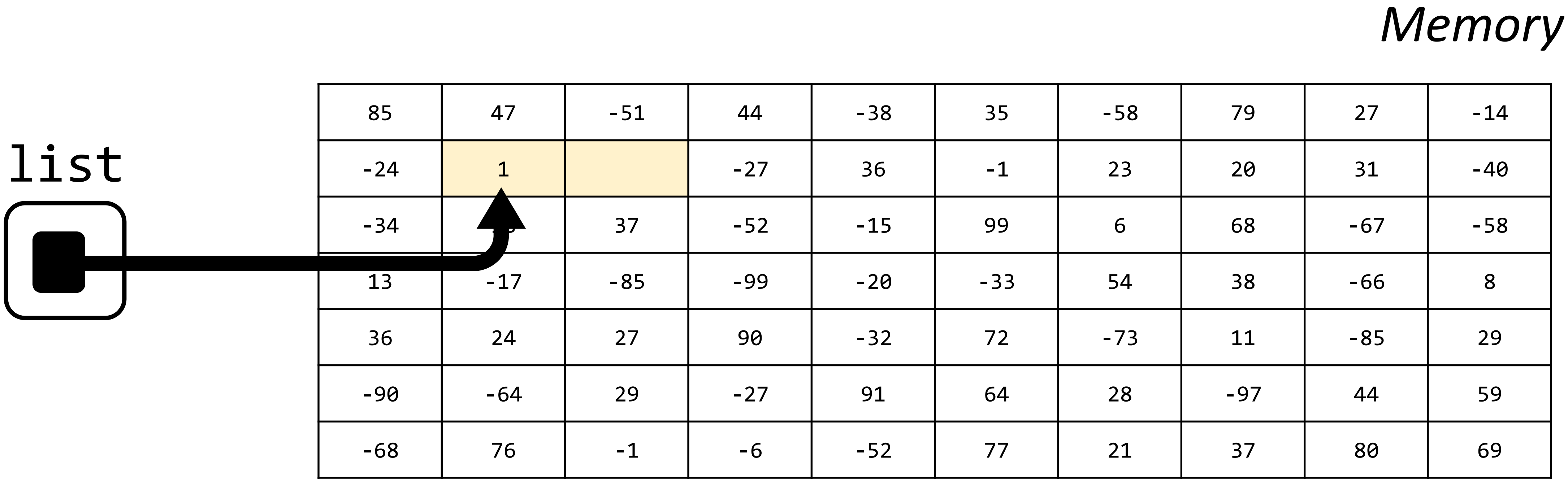
# Contiguous vs. Non-contiguous: ListNode (2)

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

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



| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 85 | 47 | -51 | 44 | -38 | 35 | -58 | 79 | 27 | -14 |
| -24 | 1 | | -27 | 36 | -1 | 23 | 20 | 31 | -40 |
| -34 | [illegible] | 37 | -52 | -15 | 99 | 6 | 68 | -67 | -58 |
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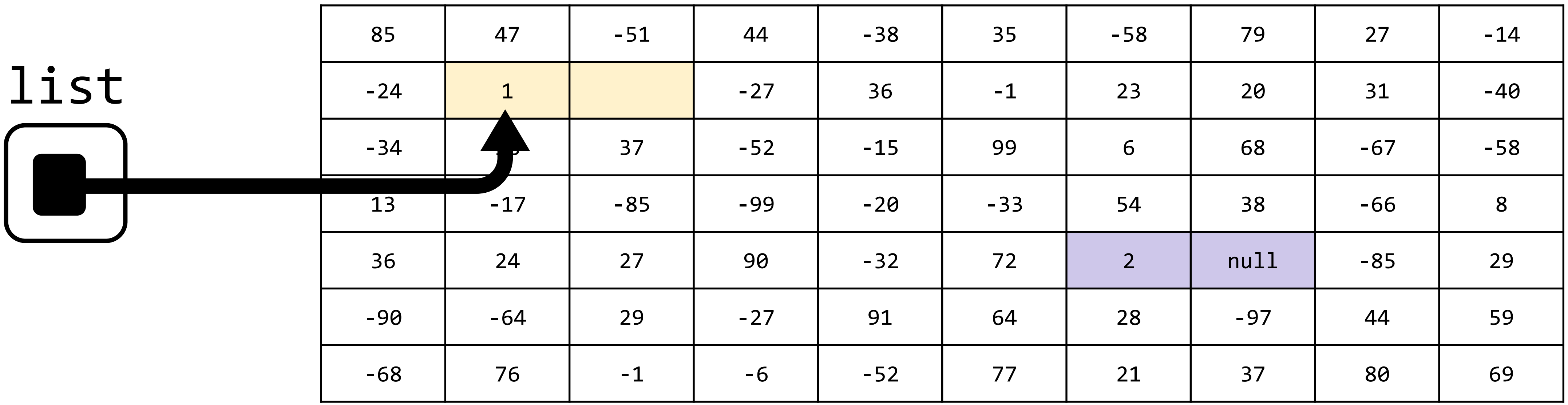
# Contiguous vs. Non-contiguous: ListNode (3)

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

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

*Memory*



| | | | | | | | | | |
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| 85 | 47 | -51 | 44 | -38 | 35 | -58 | 79 | 27 | -14 |
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| 36 | 24 | 27 | 90 | -32 | 72 | 2 | null | -85 | 29 |
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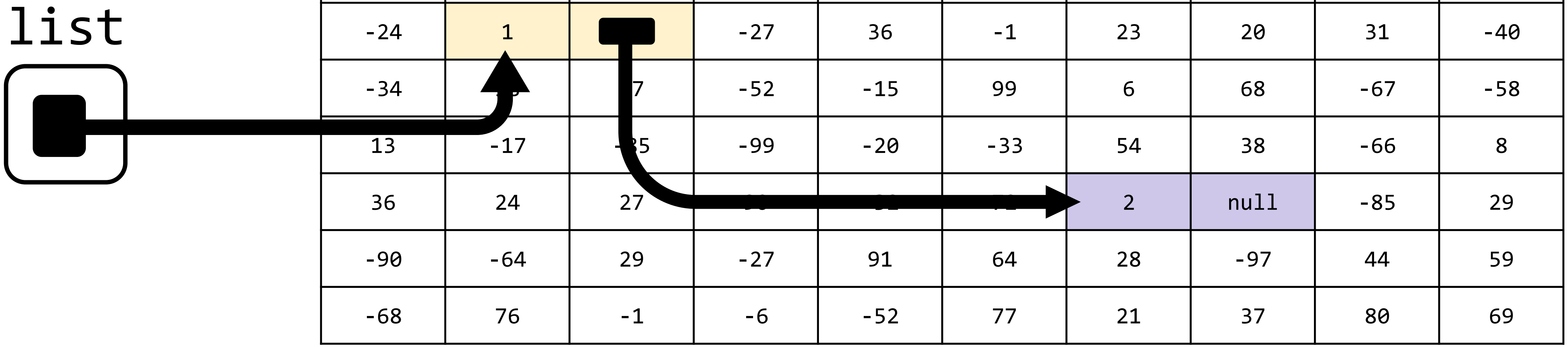
# Contiguous vs. Non-contiguous: ListNode (4)

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

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

*Memory*



list

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 85 | 47 | -51 | 44 | -38 | 35 | -58 | 79 | 27 | -14 |
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# 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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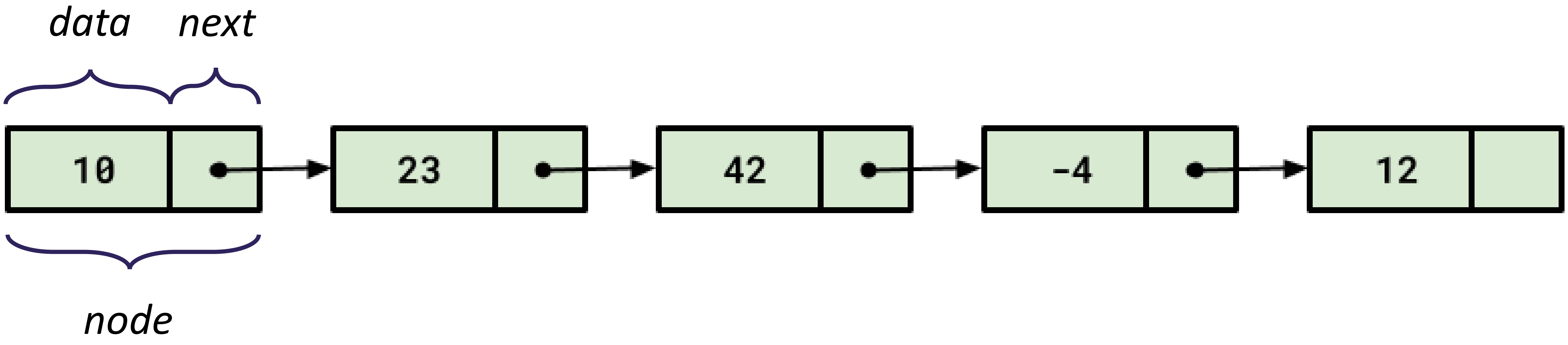
- **ListNode Practice**

# 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;
}
```