Array, Vector, List

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Array

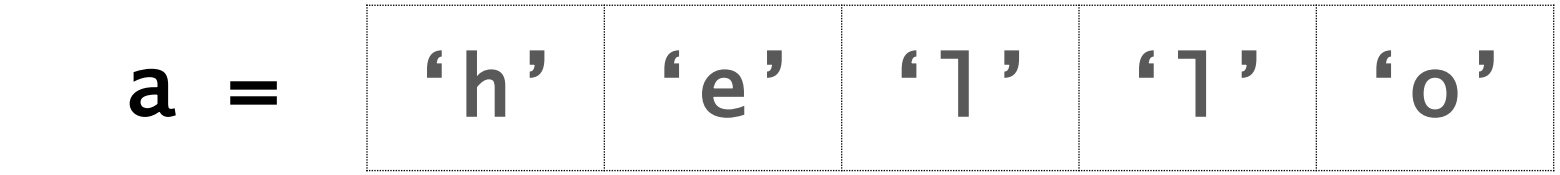
Array

a =

‘h’	‘e’	‘l’	‘l’	‘o’

- `char a[5] = {'h', 'e', 'l', 'l', 'o'};`

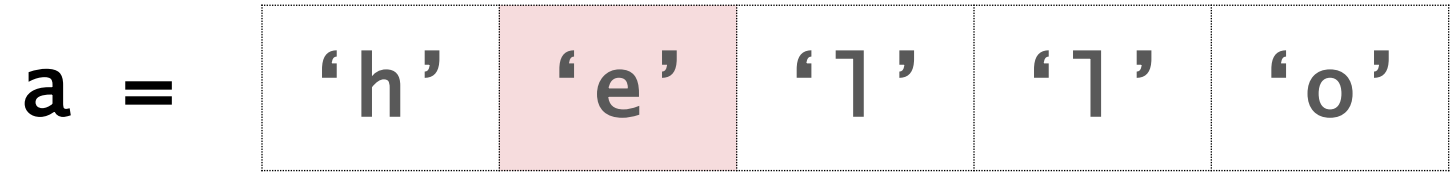
Array



- `char a[5] = {'h', 'e', 'l', 'l', 'o'};`

Array: Fixed size, contiguous memory.

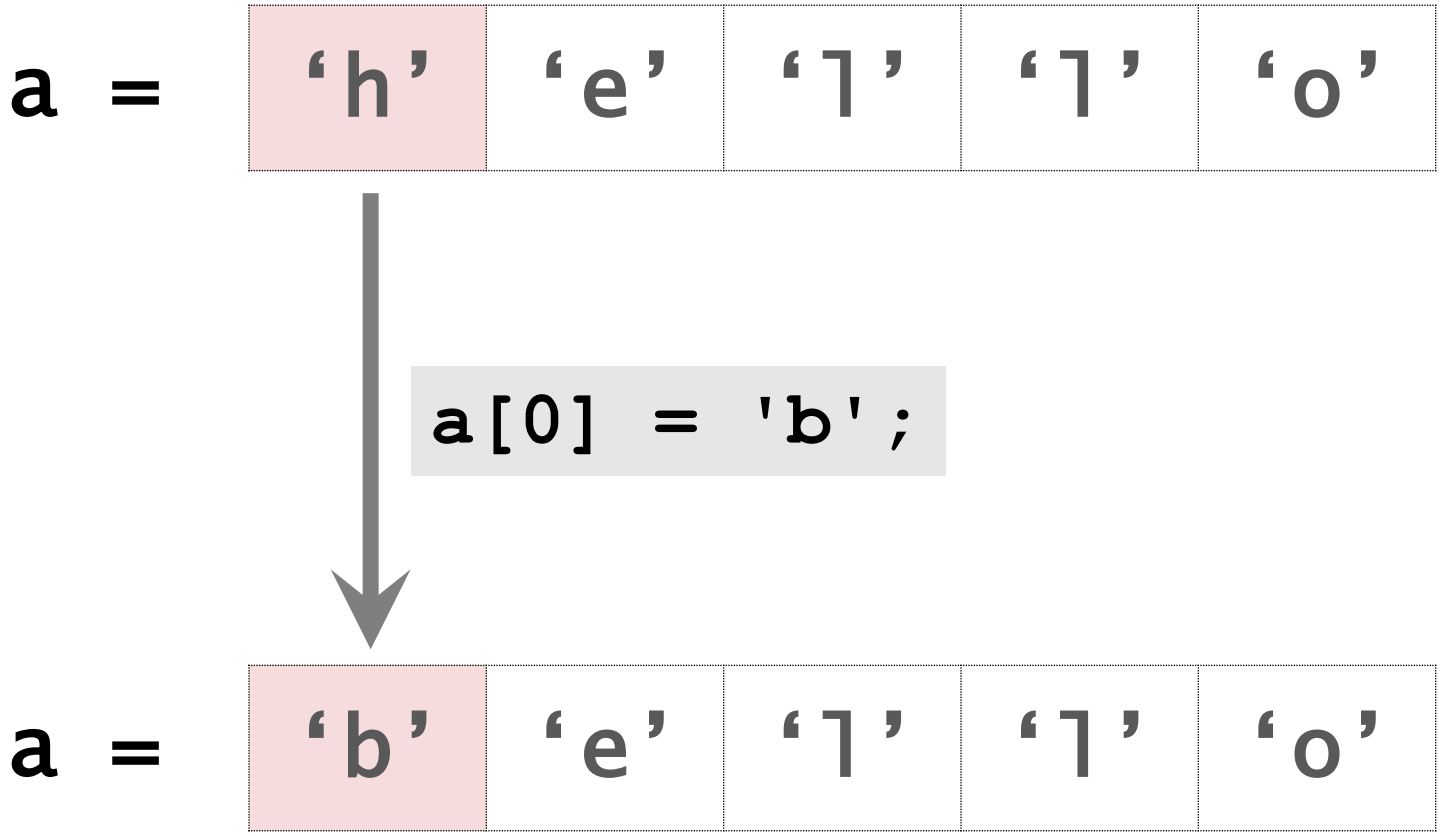
Array




```
// random access
```

- `char x = a[1];   // x is 'e'`

Array



Dynamic Allocation of Arrays

- A size-n array can be created in this way:

```
char a[n];
```

- When writing the code, n must be known.
- What if n is unknown until program is running?

Dynamic Allocation of Arrays

a = NULL

- `char* a = NULL;`

Dynamic Allocation of Arrays

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- `char* a = NULL;`
- `int n; // array size`

Dynamic Allocation of Arrays

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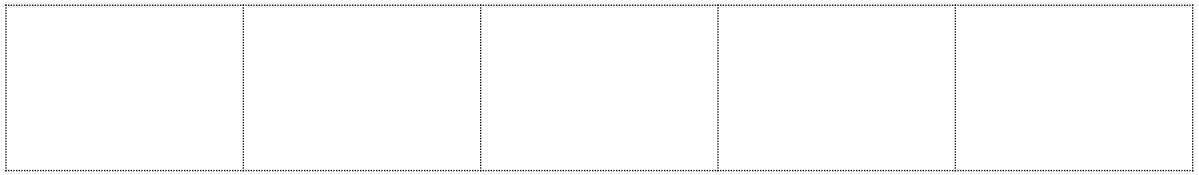
- `char* a = NULL;`
- `int n; // array size`
- `cin >> n; // read in the size, e.g., get n=5`

Dynamic Allocation of Arrays

a =



- `char* a = NULL;`
- `int n; // array size`
- `cin >> n; // read in the size, e.g., get n=5`
- `a = new char[n];`

Dynamic Allocation of Arrays

a =

‘h’	‘e’	‘l’	‘l’	‘o’

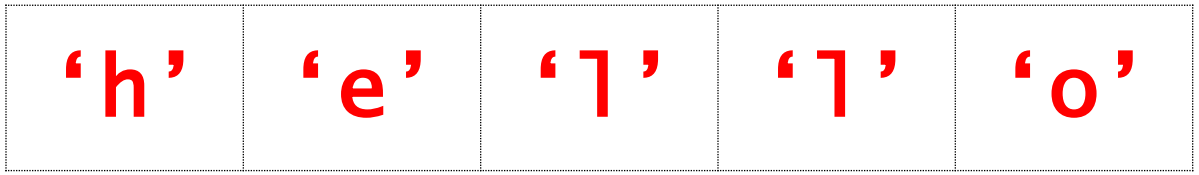
```
// store something in the array
```

- `a[0] = 'h';`
- `a[1] = 'e';`

⋮

- `a[4] = 'o';`

Dynamic Allocation of Arrays

a = 


```
// When done, free memory.
// Otherwise, memory leak can happen.
```

- **`delete [] a;`**

Dynamic Allocation of Arrays

```
a =  NULL
```

```
// When done, free memory.
// Otherwise, memory leak can happen.
```

- `delete [] a;`
- `a = NULL;`

Properties of Array

a =	'h'	'e'	'l'	'l'	'o'

1. The size is fixed. (New elements cannot be appended.)
2. Random access using `a[i]` has $O(1)$ time complexity.
3. Removing an element in the middle has $O(n)$ time complexity. (Require moving the remaining items leftward.)

Vector

Vector

- Vector is almost the same as array.
- The main difference is that vector's capacity can automatically grow.
- New elements can be appended using `push_back()` in $O(1)$ time (on average).
- The last element can be removed using `pop_back()` in $O(1)$ time.

Vector

v =

‘h’	‘e’	‘l’	‘l’	‘o’

- `vector<char> v = {'h', 'e', 'l', 'l', 'o'};`

Vector

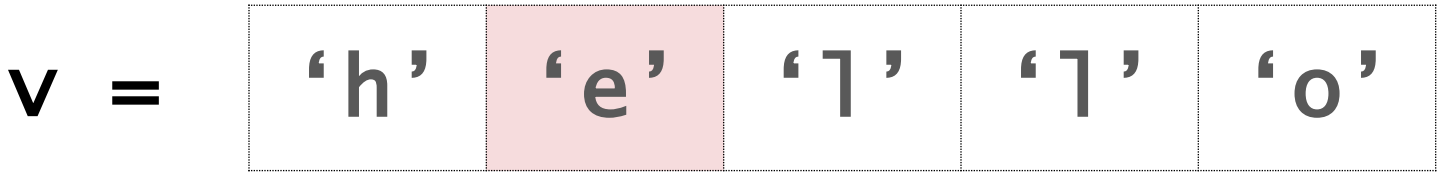
v =

‘h’	‘e’	‘l’	‘l’	‘o’

- `vector<char> v = {'h', 'e', 'l', 'l', 'o'};`

Vector: dynamic size, contiguous memory.

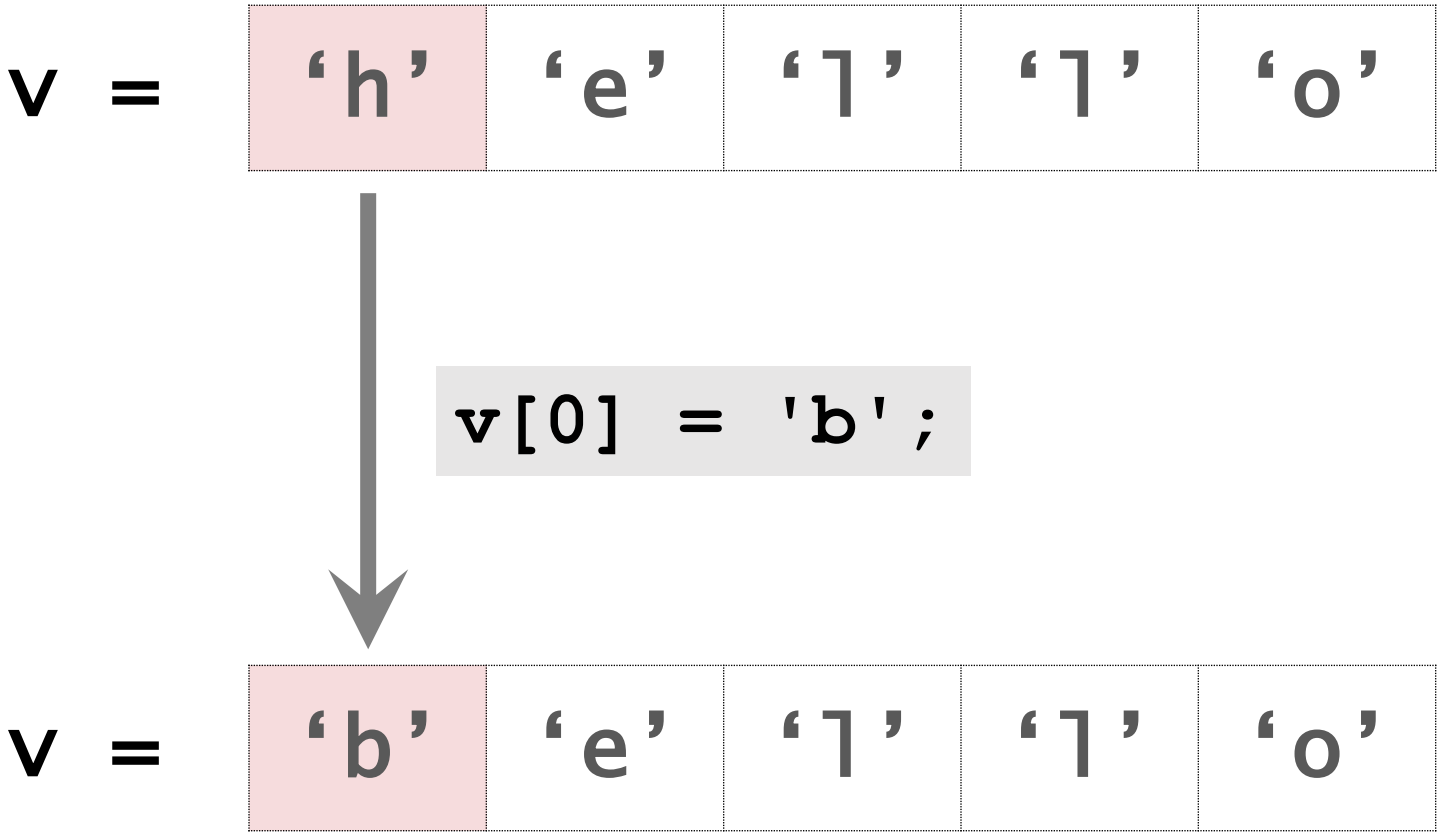
Vector



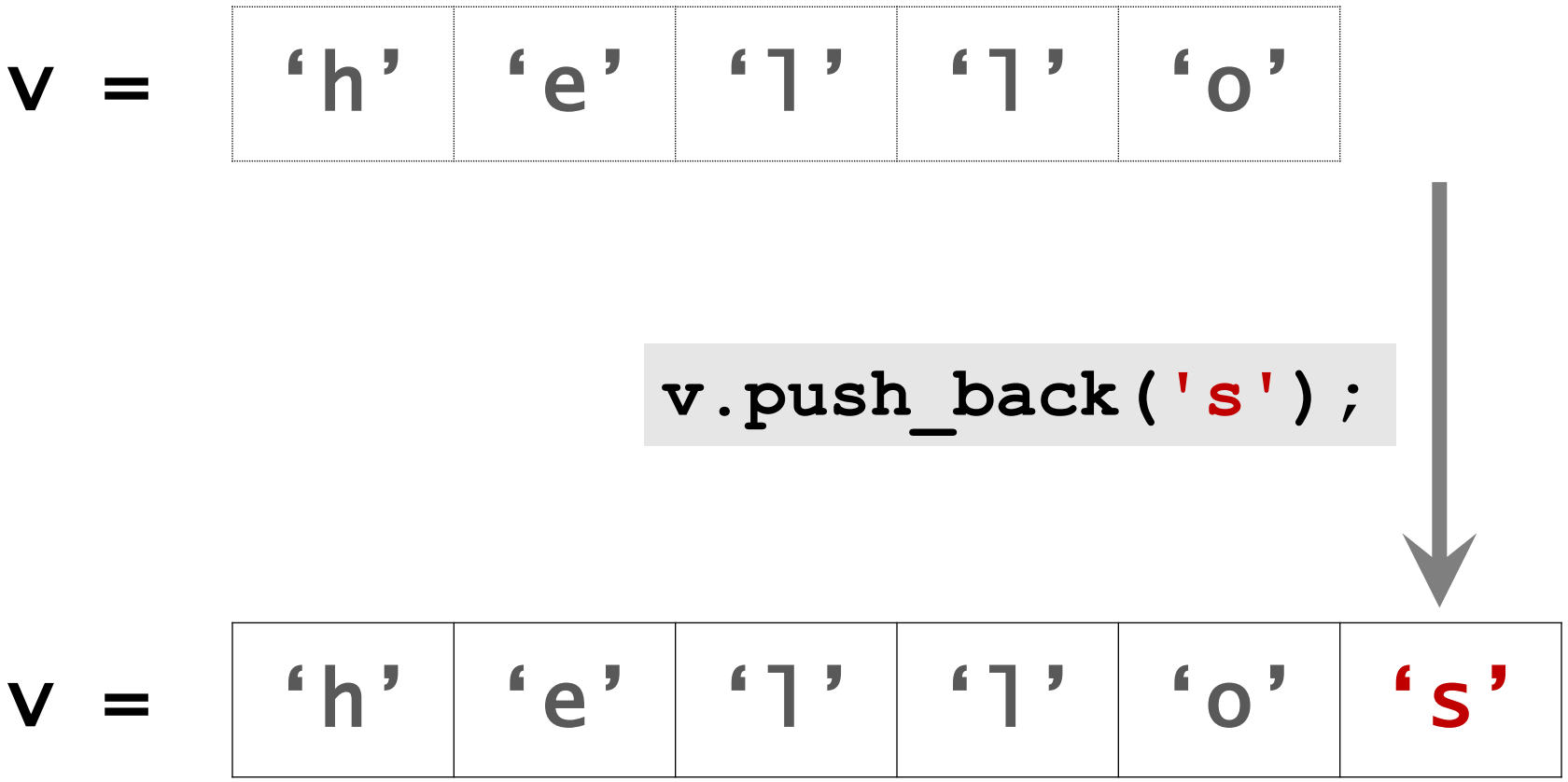

```
// random access
```

- `char x = v[1];   // x is 'e'`

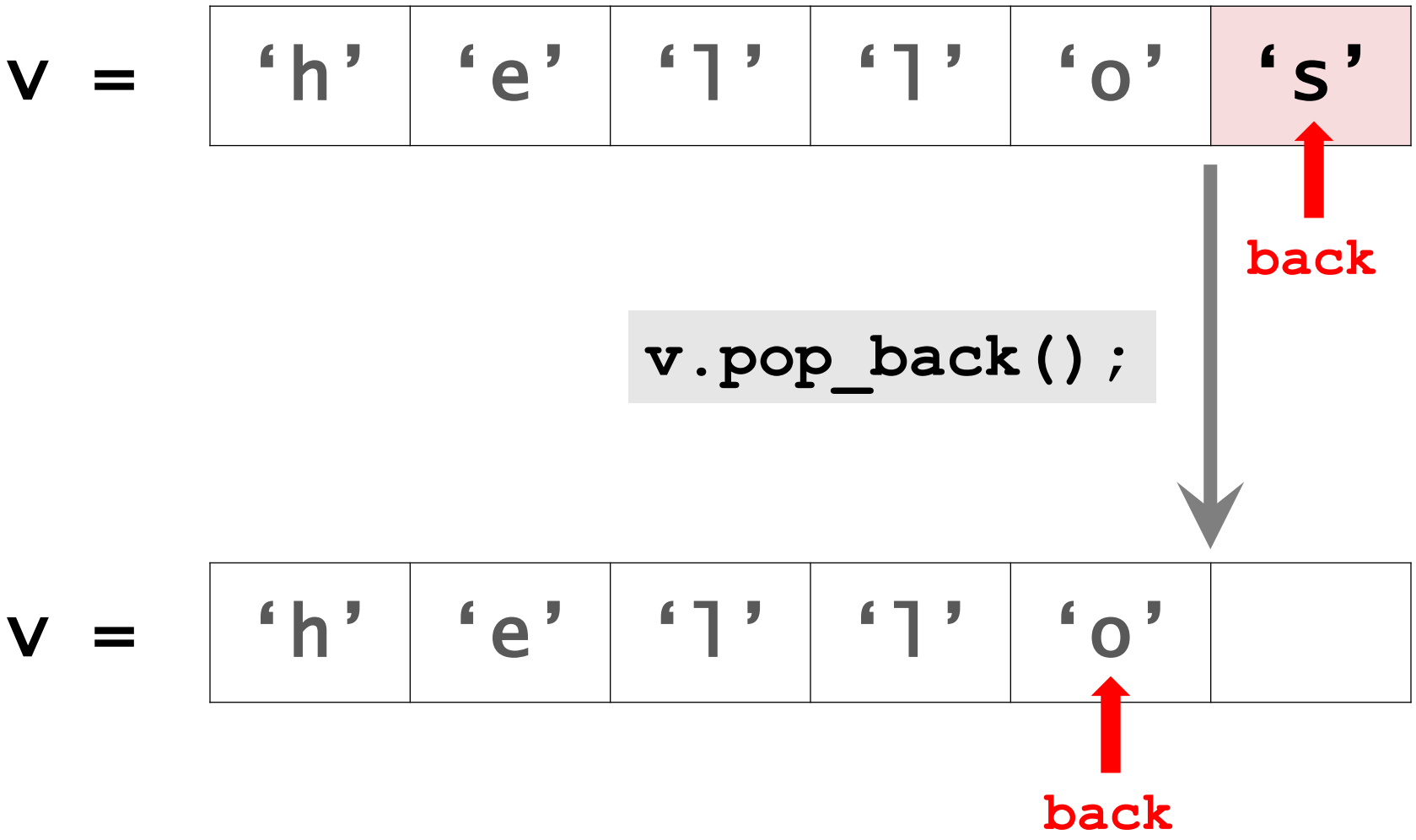
Vector



Insert



Delete



Delete

v =

‘h’	‘e’	‘l’	‘l’	‘o’

```
v.erase(v.begin()+1);
```

Delete

v =

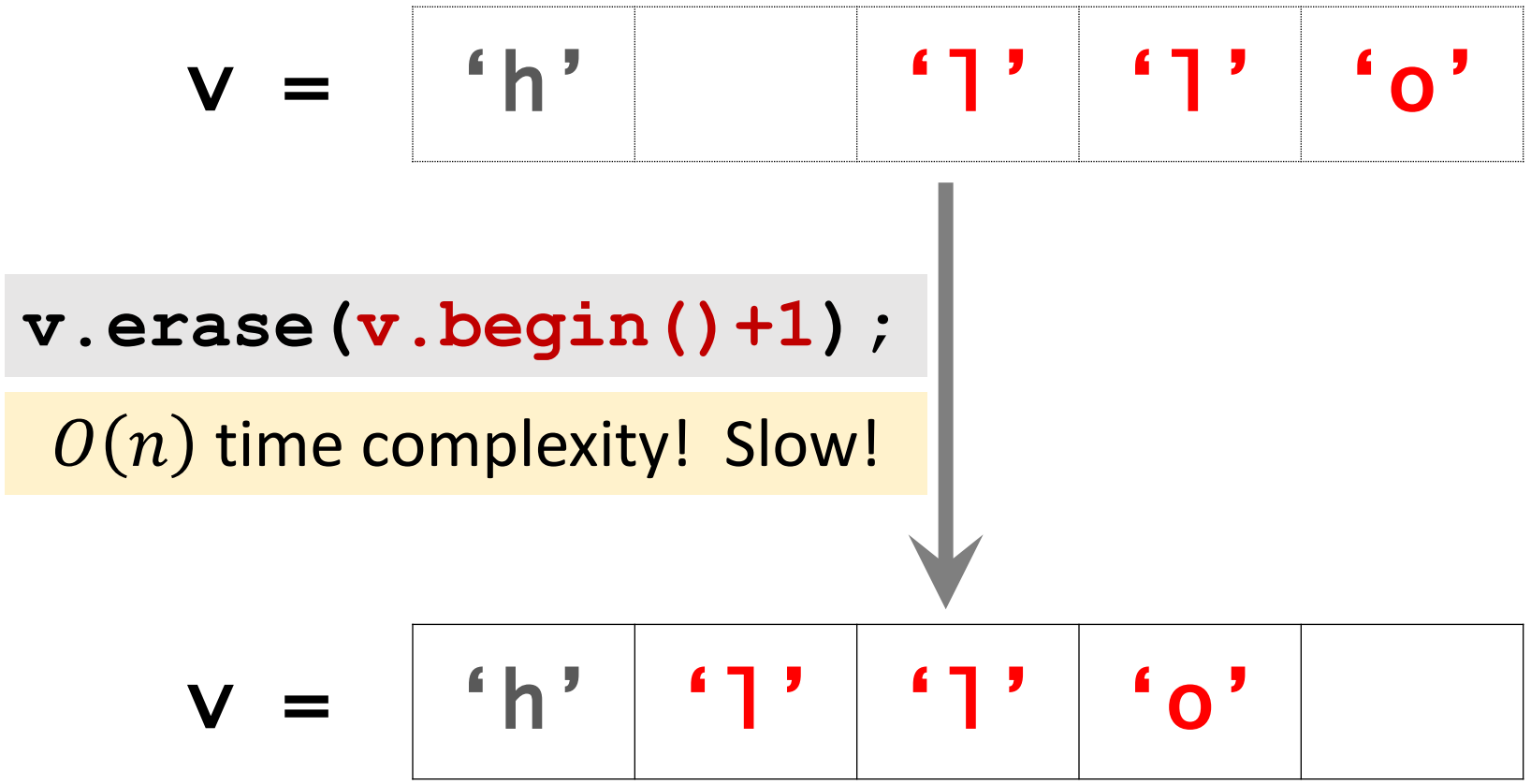
‘h’		‘l’	‘l’	‘o’

```
v.erase(v.begin()+1);
```

v =

‘h’	‘l’	‘l’	‘o’	

Delete



Vector capacity can grow

- `vector<char> v(100);`
- `cout << v.size();` `// print “100”`
- `cout << v.capacity();` `// print “100”`

Vector capacity can grow

- `vector<char> v(100);`
- `cout << v.size();` `// print “100”`
- `cout << v.capacity();` `// print “100”`

- `v.push_back('x');`
- `cout << v.size();` `// print “101”`
- `cout << v.capacity();` `// print “200”`

Vector capacity can grow

What happens when size is going to exceed capacity?

- Create a new array of capacity 200.
- Copy the 100 elements from the old array to the new.
- Put the new element in the 101st position.
- Free the old array from memory.

Vector capacity can grow

What happens when size is going to exceed capacity?

- Create a new array of capacity 200.
- Copy the 100 elements from the old array to the new.
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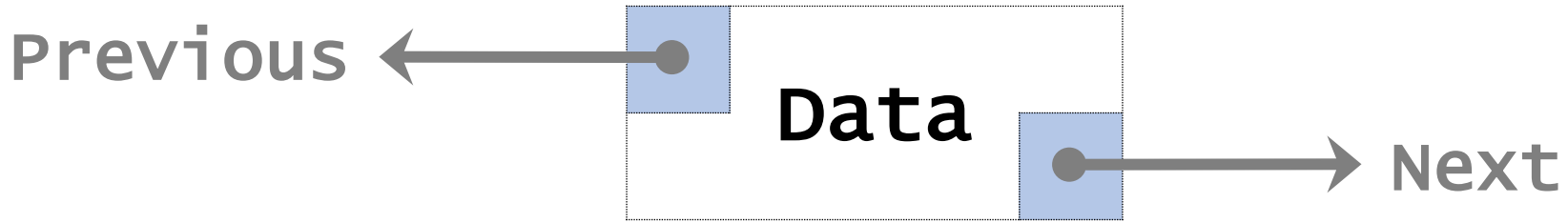
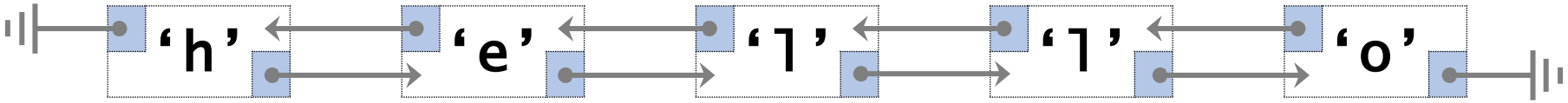
List

A Node

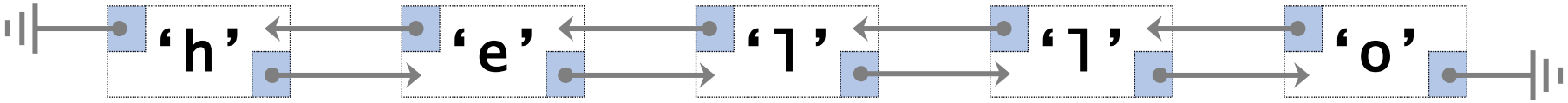


Doubly Linked List



- `list<char> l = {'h', 'e', 'l', 'l', 'o'};`

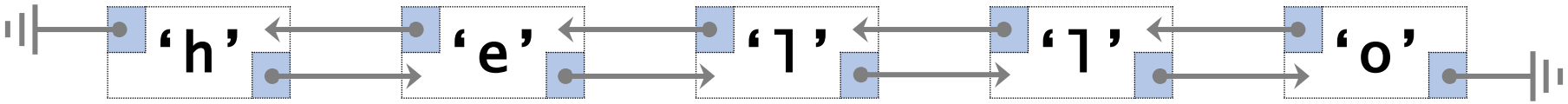
Doubly Linked List



- `list<char> l = {'h', 'e', 'l', 'l', 'o'};`

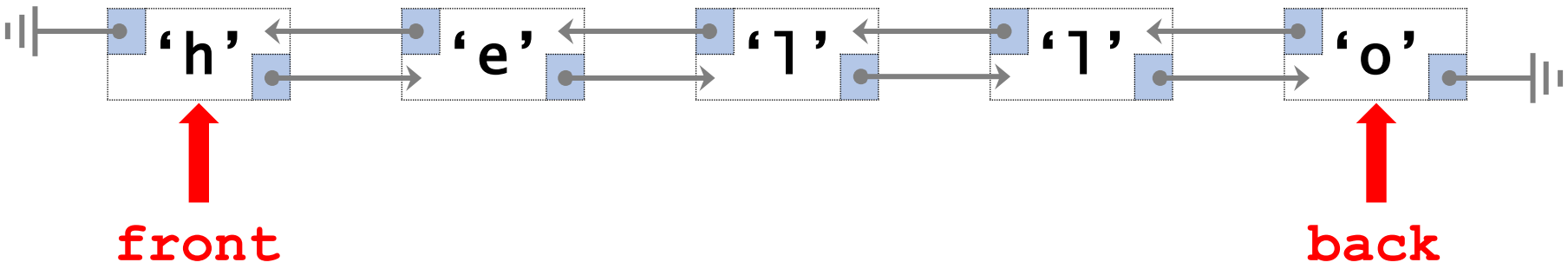
List: dynamic size, not contiguous memory.

Doubly Linked List



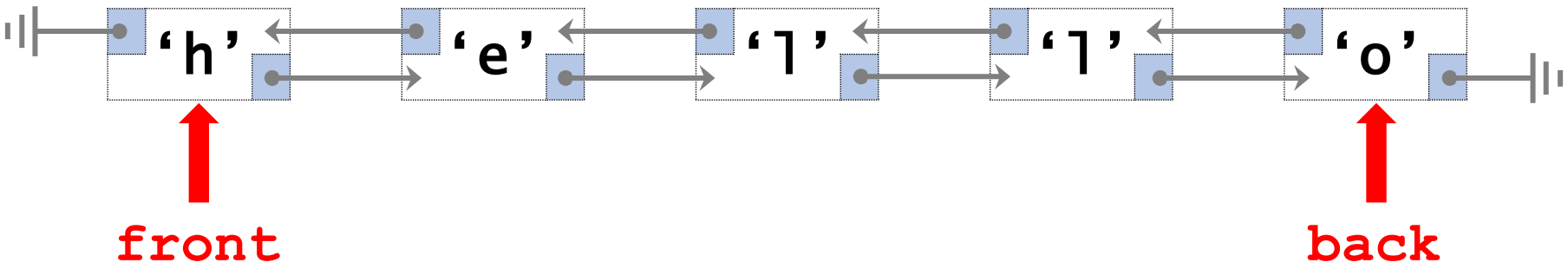
- `cout << l[2]; // does not work`
- `l[0] = 'a';  // does not work`

Doubly Linked List



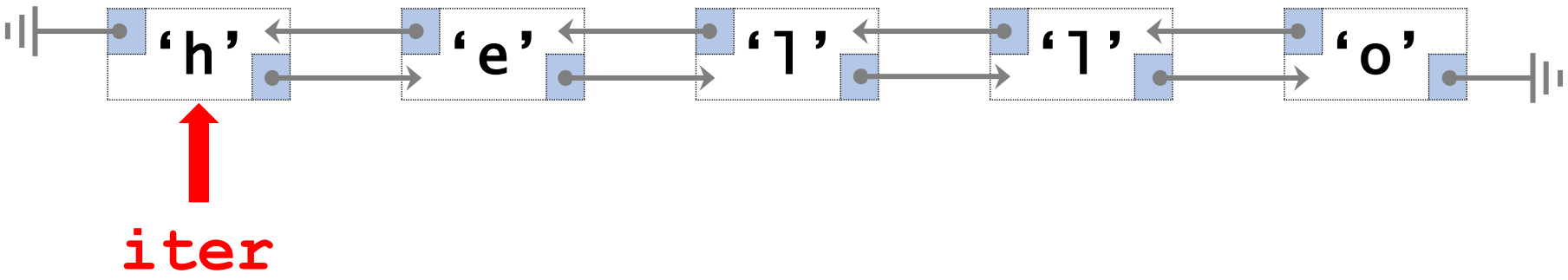
- `cout << l.front(); // print 'h'`

Doubly Linked List



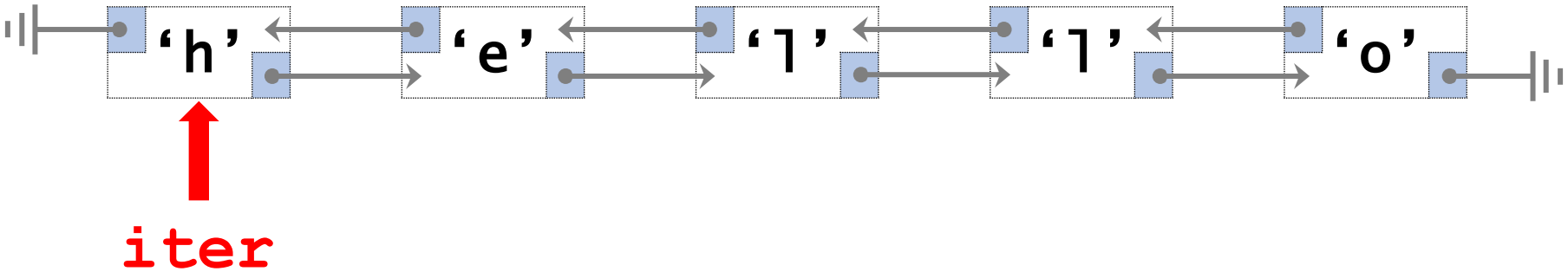
- `cout << l.front(); // print 'h'`
- `cout << l.back();  // print 'o'`

Iterator



- `list<char>::iterator iter = l.begin();`
- `cout << *iter; // print 'h'`

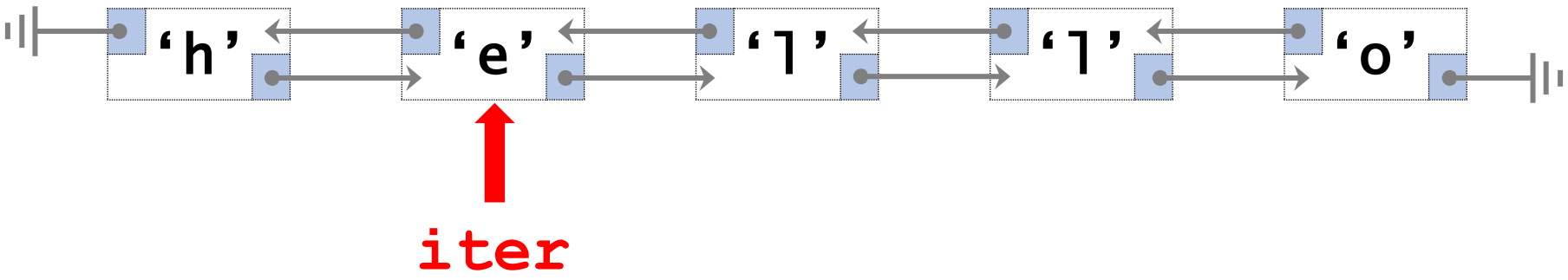
Iterator



- `list<char>::iterator iter = l.begin();`
- `cout << *iter; // print 'h'`

- `iter++;`

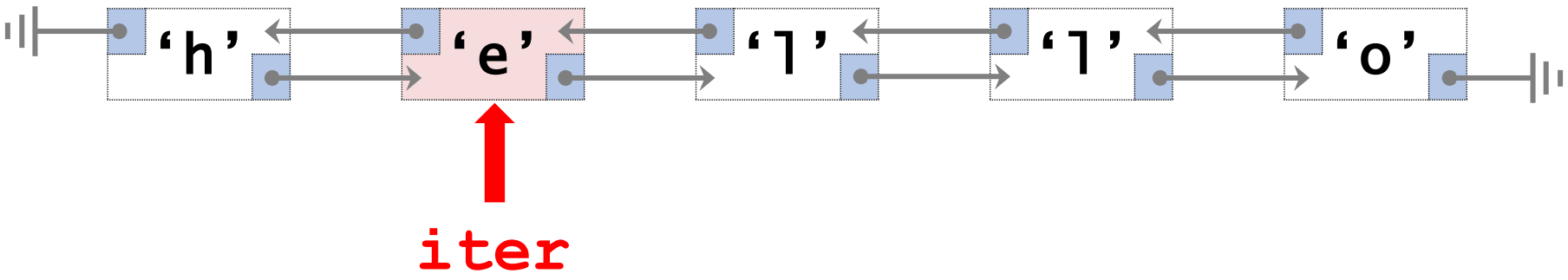
Iterator



- `list<char>::iterator iter = l.begin();`
- `cout << *iter; // print 'h'`

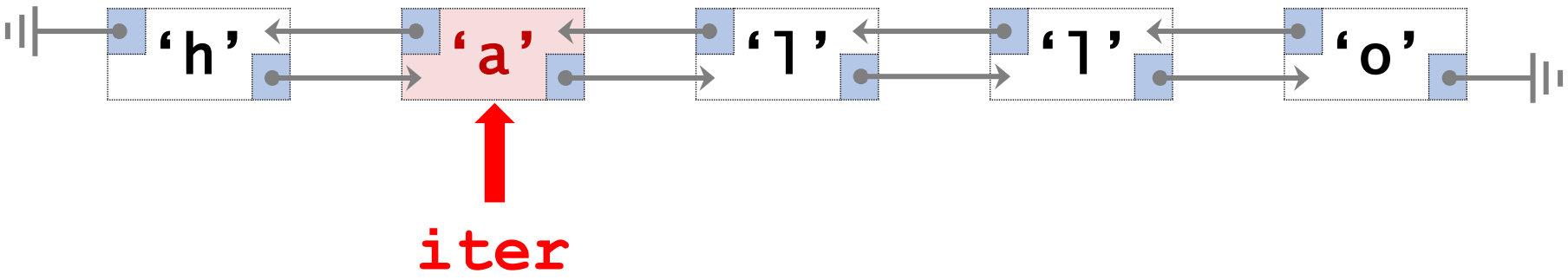
- `iter++;`
- `cout << *iter; // print 'e'`

Iterator



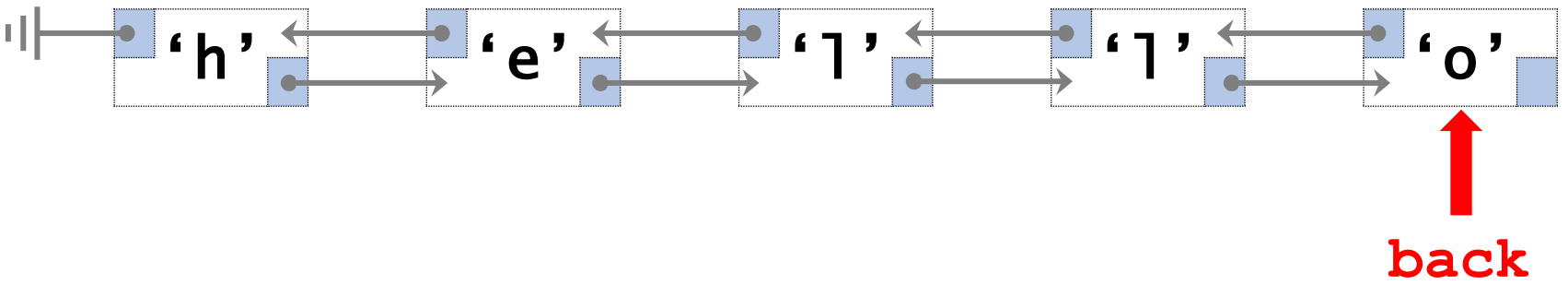
- `*iter = 'a'; // change 'e' to 'a'`

Iterator



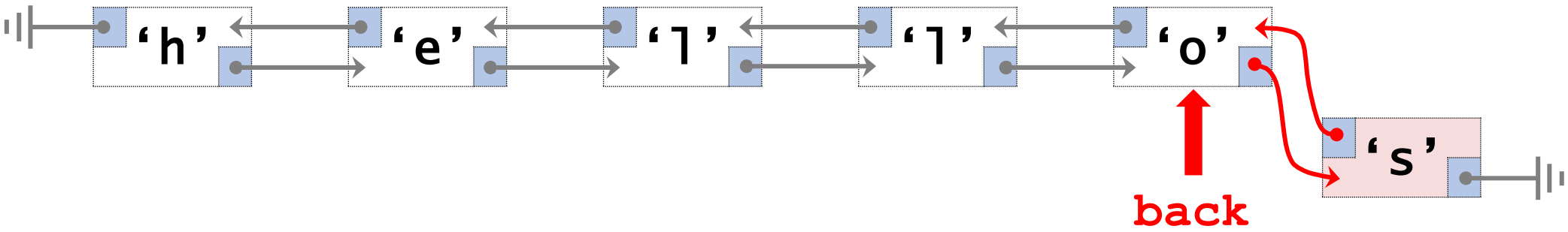
- `*iter = 'a'; // change 'e' to 'a'`

Insertion




```
l.push_back('s');
```

Insertion

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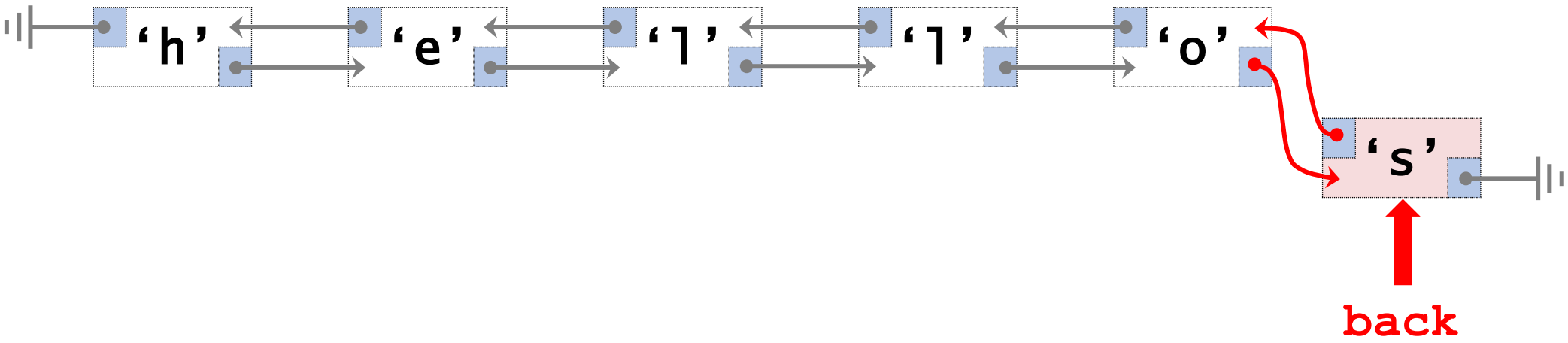
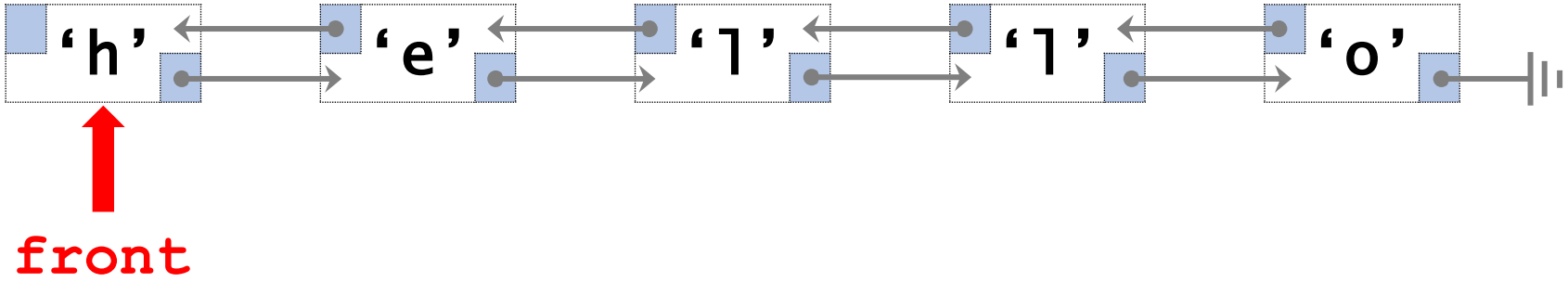
Insertion




```
l.push_back('s');
```

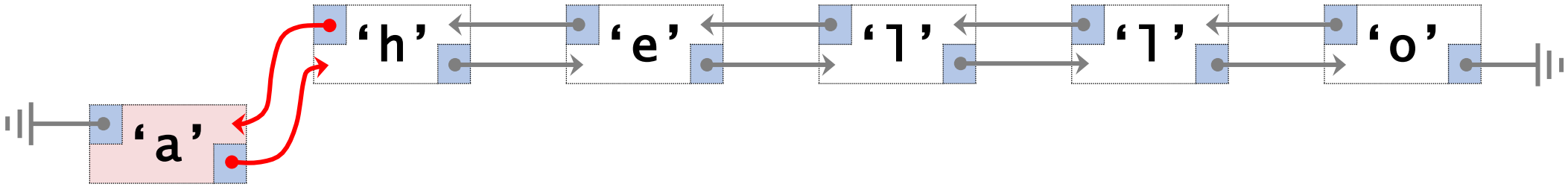
Only O(1) time.

Insertion




```
l.push_front('a');
```

Insertion

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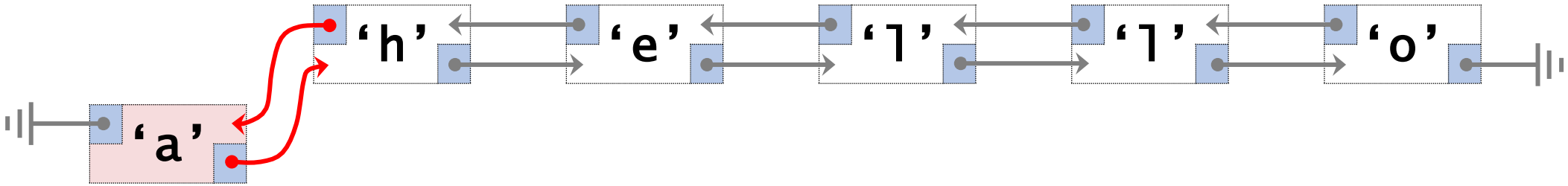
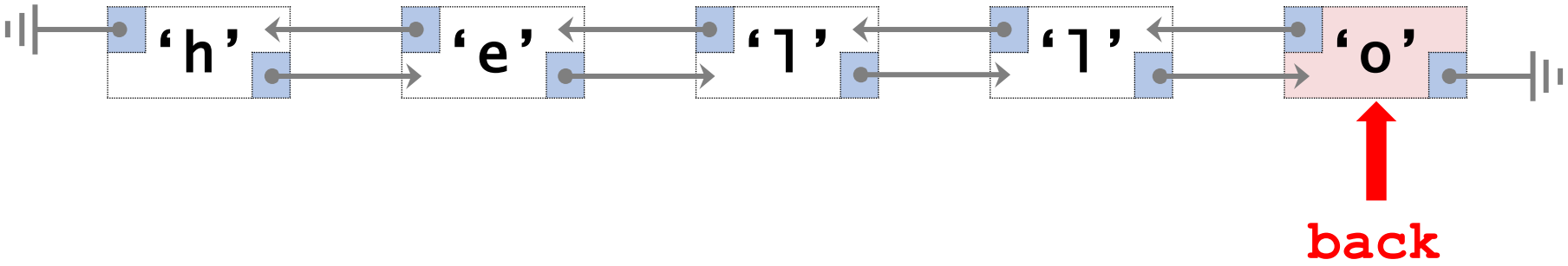



```
l.push_front('a');
```

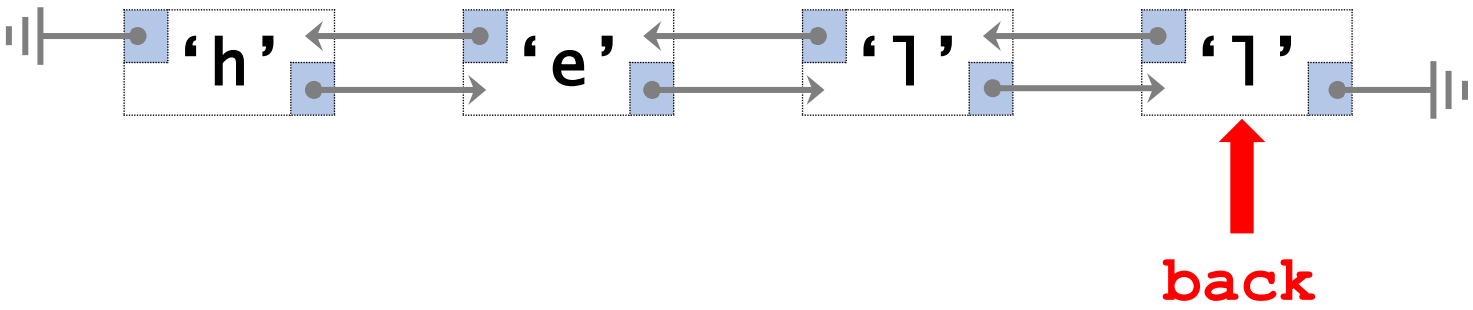
Only O(1) time.

Delete Node




```
l.pop_back();
```

Delete Node

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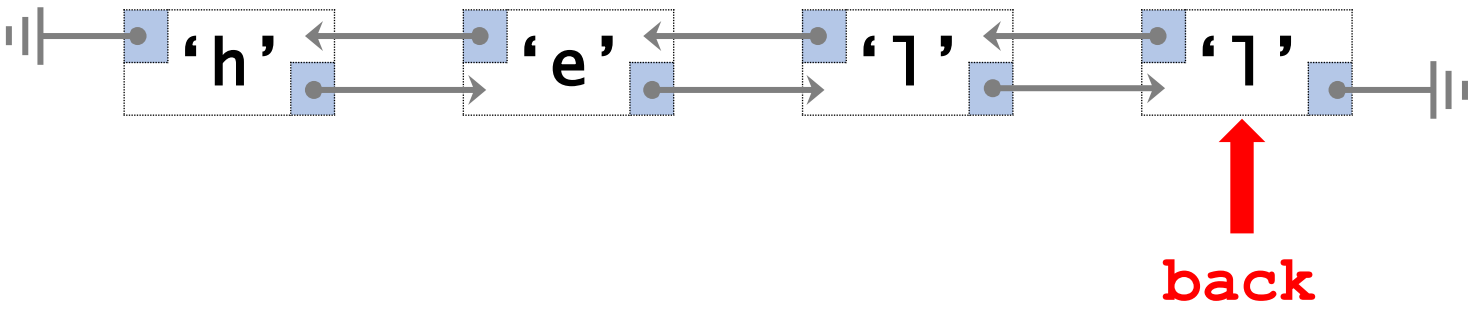
Delete Node

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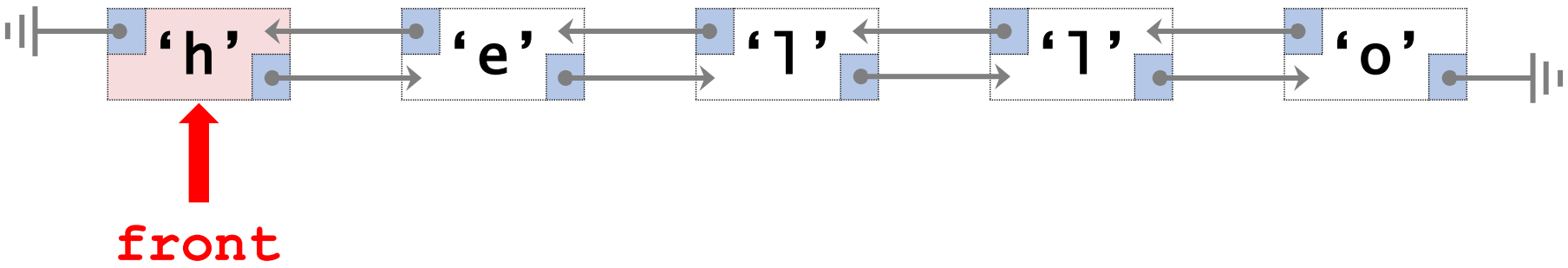
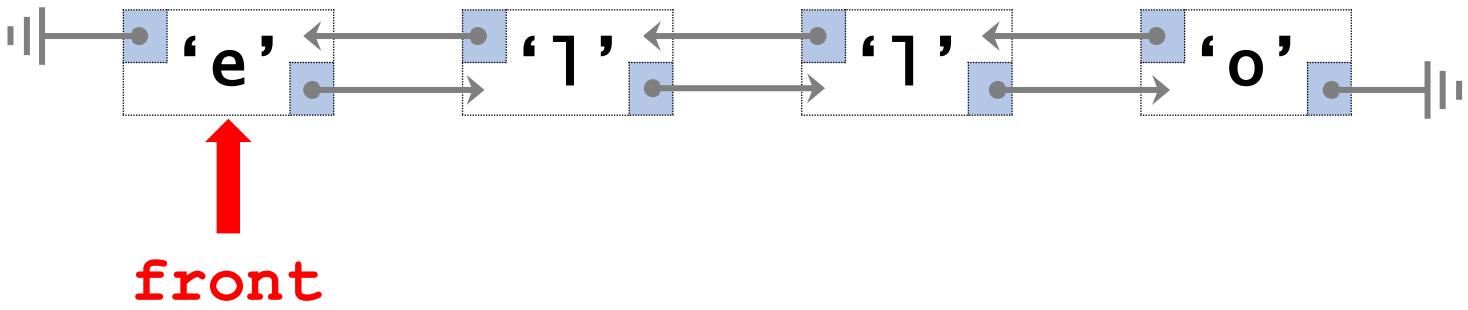
Delete Node




```
l.pop_front();
```

Delete Node




```
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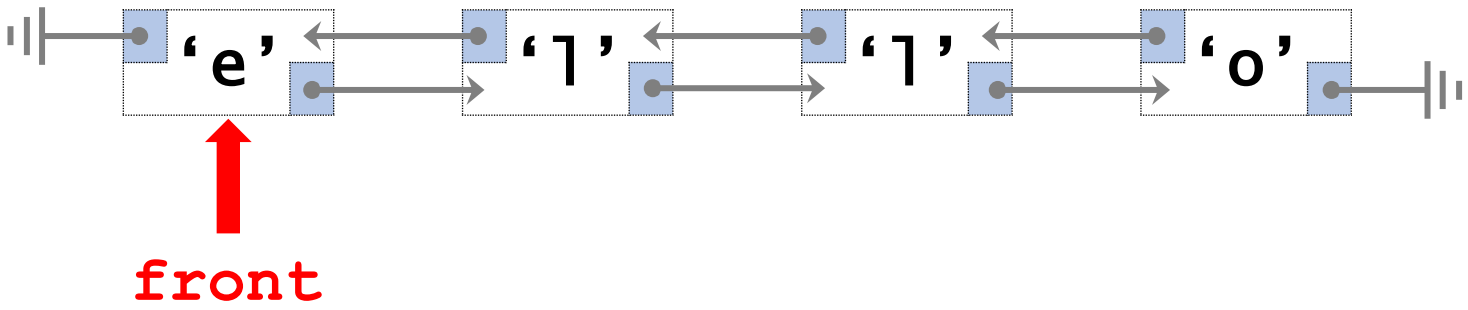
Delete Node

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Summary

Properties

	Array	Vector	List
Size	fixed	can increase and decrease	can increase and decrease

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Size	fixed	can increase and decrease	can increase and decrease
Memory	contiguous	contiguous	not contiguous

Time Complexities

	`Array`	`Vector`	`List`
Rand Access	$O(1)$	$O(1)$	---

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Rand Access	$O(1)$	$O(1)$	---
`push_back()`	---	$O(1)$ (average)	$O(1)$

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	`Array`	`Vector`	`List`
Rand Access	$O(1)$	$O(1)$	---
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Time Complexities

	`Array`	`Vector`	`List`
Rand Access	$O(1)$	$O(1)$	---
`push_back()`	---	$O(1)$ (average)	$O(1)$
`pop_back()`	---	$O(1)$	$O(1)$
`insert()`	---	$O(n)$ (average)	$O(1)$

Time Complexities

	`Array`	`Vector`	`List`
Rand Access	$O(1)$	$O(1)$	---
`push_back()`	---	$O(1)$ (average)	$O(1)$
`pop_back()`	---	$O(1)$	$O(1)$
`insert()`	---	$O(n)$ (average)	$O(1)$
`erase()`	---	$O(n)$ (average)	$O(1)$

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- **Array:** Fixed size throughout.

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  - Random access, i.e., read or write the i-th element for any i, is fast.
  - Insertion and deletion at the end are fast.
  - Insertion and deletion in the front and middle are slow.

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- **Array:** Fixed size throughout.
- **Vector:**
  - Random access, i.e., read or write the i-th element for any i, is fast.
  - Insertion and deletion at the end are fast.
  - Insertion and deletion in the front and middle are slow.
- **List:**
  - Sequentially visiting elements is fast; random access is not allowed.
  - Frequent insertion and deletion at any position are OK.

Thank You!

http://wangshusen.github.io/