CS302 - Data Structures

using C++

Topic: Understanding Big O Notation

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AUTONOMOUS ROBOTS LAB

Picturing Efficiency

- An O(n) algorithm

```
for i = 1 to n
   sum = sum + I
```

Picturing Efficiency

- An O(n) algorithm

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for i = 1 to n
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- An O(1) algorithm

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for i = 1 to 1000
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Picturing Efficiency

- An $O(n^2)$ algorithm

```
for i = 1 to n
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```

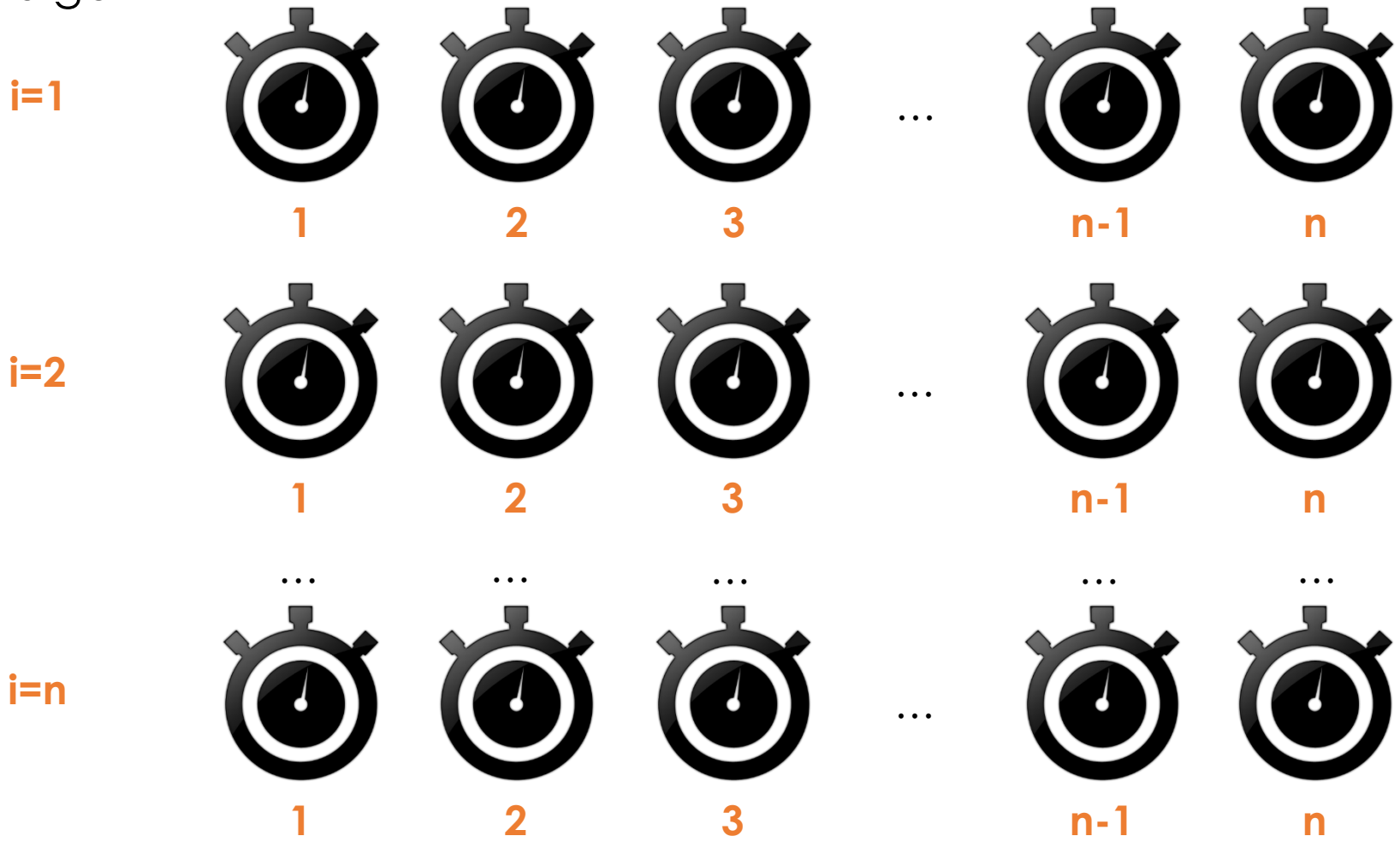

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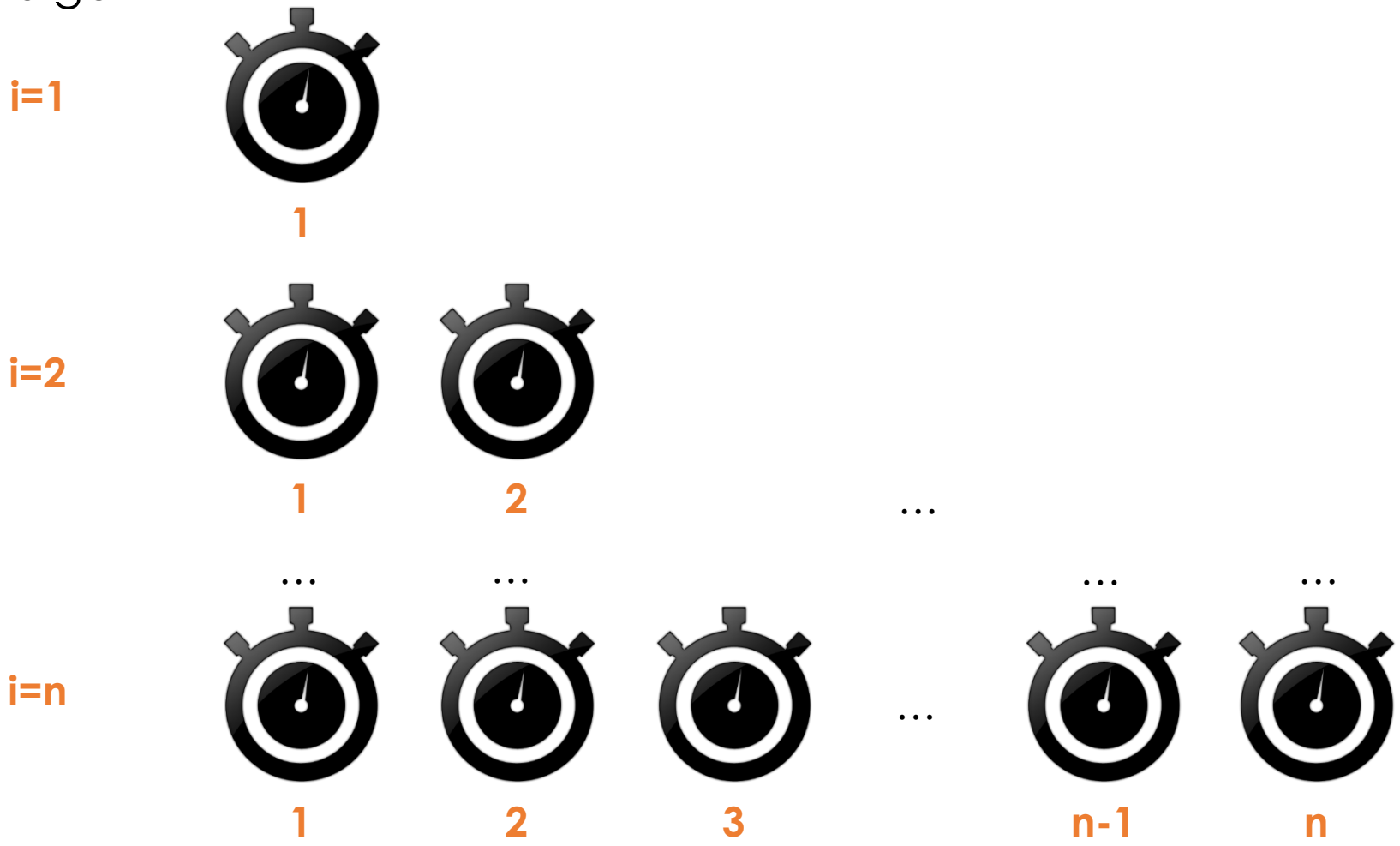

Comparing Implementations

- Choosing an implementation
  - Look for significant differences in efficiency
  - Frequency of operations
    - Consider how frequently particular ADT operations occur in a given application
    - Sometimes seldom-used but critical operations must be efficient

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  - Determine minimum amount of time an algorithm requires to solve problems of size `n`

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  - Determine minimum amount of time an algorithm requires to solve problems of size `n`
- **Worst-case analysis**
  - Determine maximum amount of time an algorithm requires to solve problems of size `n`

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    - Consider how frequently particular ADT operations occur in a given application
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- **Best-case analysis**
  - Determine minimum amount of time an algorithm requires to solve problems of size `n`
- **Worst-case analysis**
  - Determine maximum amount of time an algorithm requires to solve problems of size `n`
- **Average-case analysis**
  - Determine average of time an algorithm requires to solve problems of size `n`
  - Very hard to estimate

ADT Bag Interface

ADT Bag Interface

```
template<class ItemType>
class BagInterface
{
public:
     virtual int getCurrentSize() const = 0;
     virtual bool isEmpty() const = 0;
     virtual bool add(const ItemType& newEntry) = 0;
     virtual bool remove(const ItemType& target) = 0;
     virtual void clear() = 0;
     virtual int getFreuqnecyOf(const ItemType& target) const = 0;
     virtual bool contains(const ItemType& anEntry) const = 0;
     virtual std::vector<ItemType> toVector() const = 0;
     virtual ~BagInterface() { }
}; // end BagInterface
```

```
template<class ItemType>
class ArrayBag : public BagInterface<ItemType>
{
private:
     static const int DEFAULT_CAPACITY = 6;
     ItemType items[DEFAULT_CAPACITY];  // bag items
     int itemCount;                     // count of bag items
```

```
template<class ItemType>
class LinkedBag : public BagInterface<ItemType>
{
private:
     Node<ItemType>* headPtr; // pointer to first node
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ADT Bag – ADD implementations

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template<class ItemType>
bool ArrayBag<ItemType>::add(const ItemType& newEntry)
{
     bool hasRoomToAdd = (itemCount < maxItems);
     if (hasRoomToAdd)
     {
          items[itemCount] = newEntry;
          itemCount++;
     } // end if
     return hasRoomToAdd;
} // end add
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template<class ItemType>
bool LinkedBag<ItemType>::add(const ItemType& newEntry)
{
     Node<ItemType>* nextNodePtr = new Node<ItemType>();
     nextNodePtr->setItem(newEntry);
     nextNodePtr->setNext(headPtr);
     headPtr = nextNodePtr;
     itemCount++
     return true;
} // end add
```

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ADT Bag – CONTAINS implementations

```
template<class ItemType>
bool ArrayBag<ItemType>::contains ItemType& anEntry) const
{
     bool found = false;
     int searchIndex = 0;
     while (!found && (searchIndex < itemCount))
     {
          found = (items[searchIndex] == anEntry);
          if (!found)
               searchIndex++;
     } // end while
     return found;
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```
template<class ItemType>
bool LinkedBag<ItemType>::contains ItemType& anEntry) const
{
     bool found = false;
     Node<ItemType>* curPtr = headPtr;
     while (!found && (curPtr != nullptr))
     {
          found = (anEntry == curPtr->getItem());
          if (!found)
               curPtr = curPtr->getNext;
     } // end while
     return found;
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O(1) Best-case

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Comparing Implementations

ADT Bag Method	ArrayBag Implementation	LinkedBag Implementation
`getCurrentSize()`	O(1)	O(1)
`isEmpty()`	O(1)	O(1)
`add(ItemType anEntry)`	O(1)	O(1)
`remove(ItemType anEntry)`	O(1) to O(n)	O(1) to O(n)
`clear()`	O(1)	O(1) to O(n)
`getFrequencyOf(ItemType anEntry)`	O(n)	O(n)
`contains(ItemType anEntry)`	O(1) to O(n)	O(1) to O(n)
`toVector()`	O(n)	O(n)

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ArrayBag

```
void ArrayBag::clear()
{
      itemCount = 0;
} // end clear
```

LinkedBag

```
void LinkedBag::clear()
{
      Node<ItemType>* deleteMe =
      nullptr;
      while (headPtr != nullptr)
      {
            deleteMe = headPtr;
            headPtr = headPtr-
      >getNext();
            delete deleteMe;
            itemCount--;
      } // end while
} // end clear
```

Comparing Implementations

- If problem size is always small
  - Possible to ignore algorithm's efficiency
- Weight trade-offs between
  - Algorithm's time and memory requirements
- Compare algorithms for style and efficiency

Thank you