

Data Structures

Chapter 3

Problem set

1. Stack

- Stack Concept
 - STL stack class
- Stack Implementations
 - Using Fixed Array
 - Using Dynamic Array
 - Using Vector
 - Using Template

2. Queue

Stack: version.1 – using a stack class in C++ STL

stack1_stl.cpp

```
int main () { // stack initialization using range-based for
    // int list[] = {1, 2, 3, 4, 5, 0, 6, 0, 0, 7, 0, 0, 0, 8};
    string list[] = {"to", "be", "or", "not", "to", "-", "be", \
                    "-", "-", "that", "-", "-", "-", "is"};

    stack<string> s;
    for (auto item : list) {    // to be not that or be (5 6 4 7 3 2)
        if (item != "-")        // type specific
            s.push(item);
        else {
            cout << s.top() << ' ';
            s.pop();
        }
    }
    cout << "\nsize: " << s.size(); // 2
    cout << "\ntop : " << s.top();  // is (8)
    cout << "\nstack T: "; printStack(s);           // is to (8 1)
    cout << "\nstack B: "; printStack_fromBottom(s); // to is (1 8)
    cout << "\nHappy Coding";
}
```

```
void printStack(stack<string> s) {
    while (!s.empty()) {
        cout << s.top() << ' ';
        s.pop();
    }
    // cout << endl; // now, s is empty
}
```

Stack: version.1 – using a stack class in C++ STL

stack1_stl.cpp

```
int main () { // stack initialization using range-based for
    // int list[] = {1, 2, 3, 4, 5, 0, 6, 0, 0, 7, 0, 0, 0, 8};
    string list[] = {"to", "be", "or", "not", "to", "-", "be", \
                    "-", "-", "that", "-", "-", "-", "is"};

    stack<string> s;
    for (auto item : list) {    // to be not that or be (5 6 4 7 3 2)
        if (item != "-")        // type specific
            s.push(item);
        else {
            cout << s.top() << ' ';
            s.pop();
        }
    }
    cout << "\nsize: " << s.size(); // 2
    cout << "\ntop : " << s.top();  // is (8)
    cout << "\nstack T: "; printStack(s);           // is to (8 1)
    cout << "\nstack B: "; printStack_fromBottom(s); // to is (1 8)
    cout << "\nHappy Coding";
}
```

Step 1:

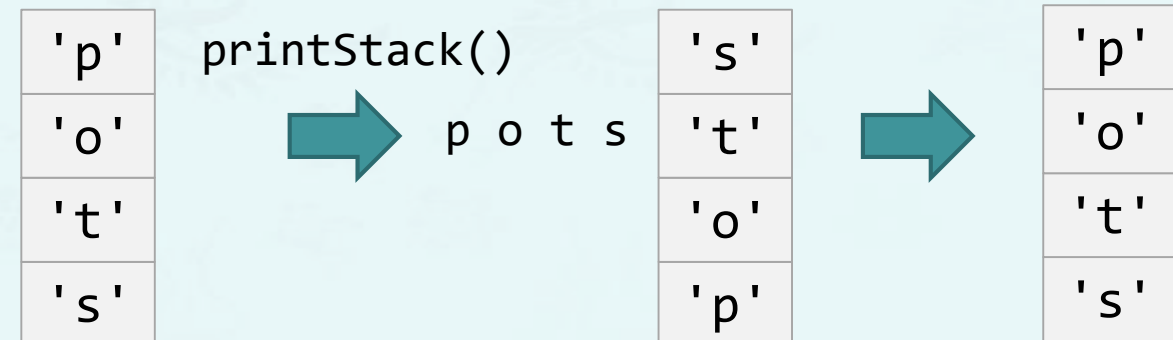
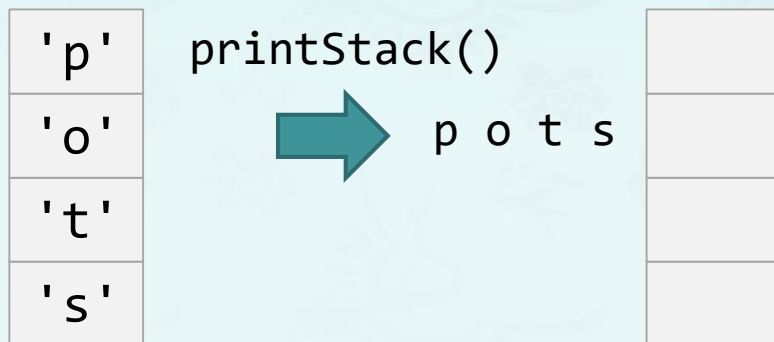
- Test this driver with "**int list[]**".
- Change a few places as needed.
- Fix printStack() not to empty the stack.
- Add **printStack_fromBottom()**.
- Be familiar with the concepts of stack.

Stack: version.1 – using a stack class in C++ STL

stack1_stl.cpp

- In-house programming principles: DRY, KISS, NMN, NSE
 - Remove the side effect of printStack().

```
void printStack(stack<string> s) {  
    while (!s.empty()) {  
        cout << s.top() << ' ';  
        s.pop();  
    }  
}
```

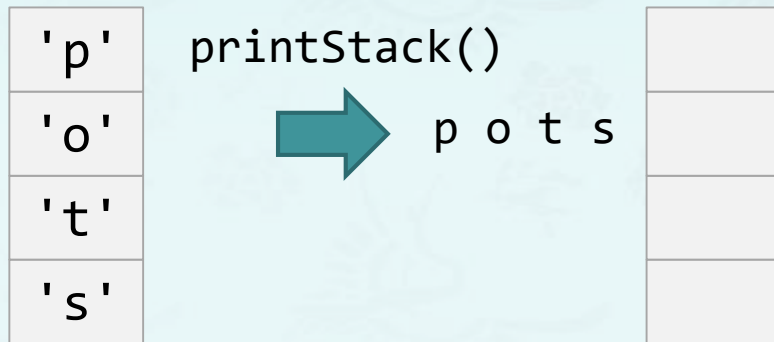


Stack: version.1 – using a stack class in C++ STL

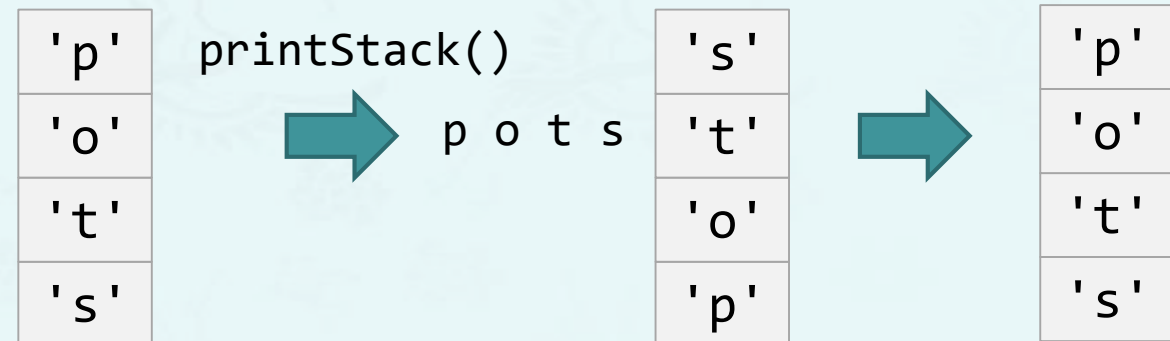
stack1_stl.cpp

- In-house programming principles: DRY, KISS, NMN, NSE
 - Remove the side effect of printStack().

```
void printStack(stack<string> s) {  
    while (!s.empty()) {  
        cout << s.top() << ' ';  
        s.pop();  
    }  
}
```



```
void printStack(stack<string> s) {  
    stack<string> t;  
    while (!s.empty()) {  
        cout << s.top() << ' ';  
        t.push(s.top());  
        s.pop();  
    }  
    while (!t.empty()) {  
        s.push(t.top());  
        t.pop();  
    }  
} // brute-force version
```

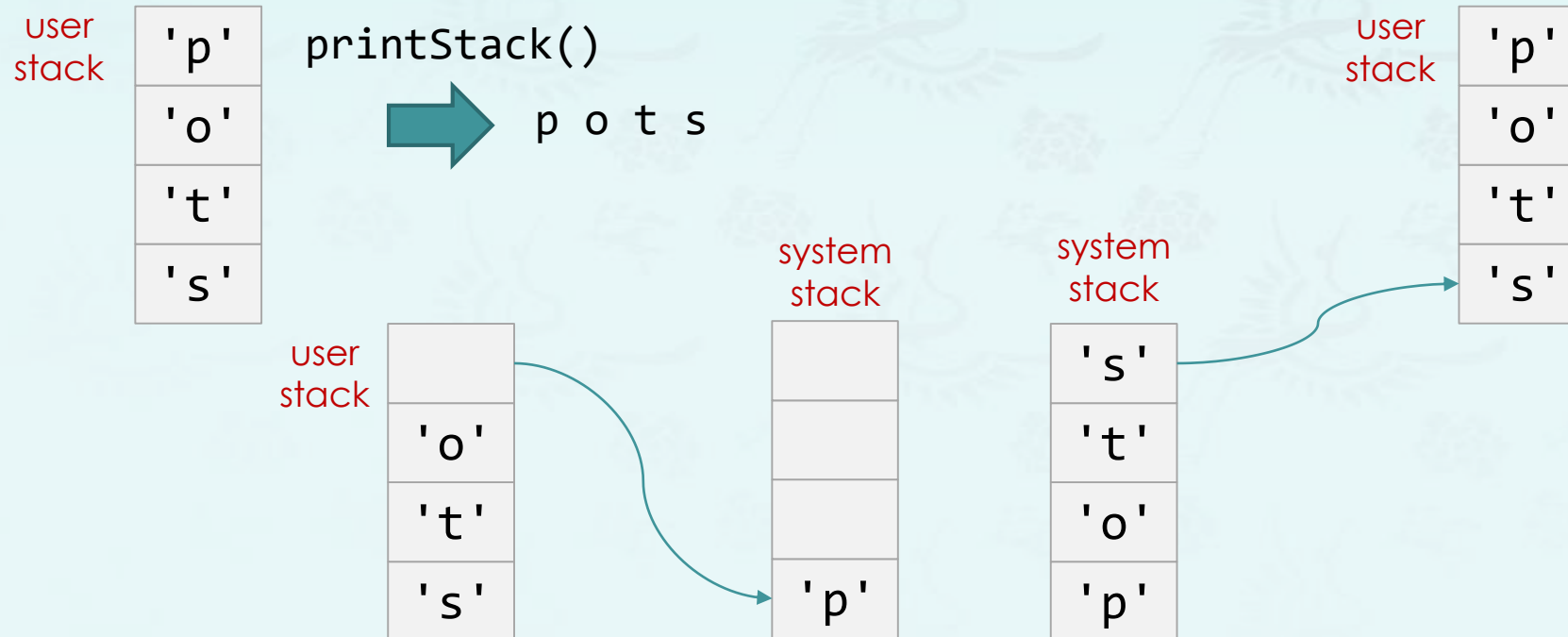


Stack: version.1 – using a stack class in C++ STL

stack1_stl.cpp

- Using recursion, print stack items from **top to bottom**.
 - Utilize the fact that the recursion uses the **system stack**.

```
void printStack(stack<string> s) {  
    if (s.empty()) return;  
  
    // your code here – print & pop & recursive call & push  
  
} // recursion version
```

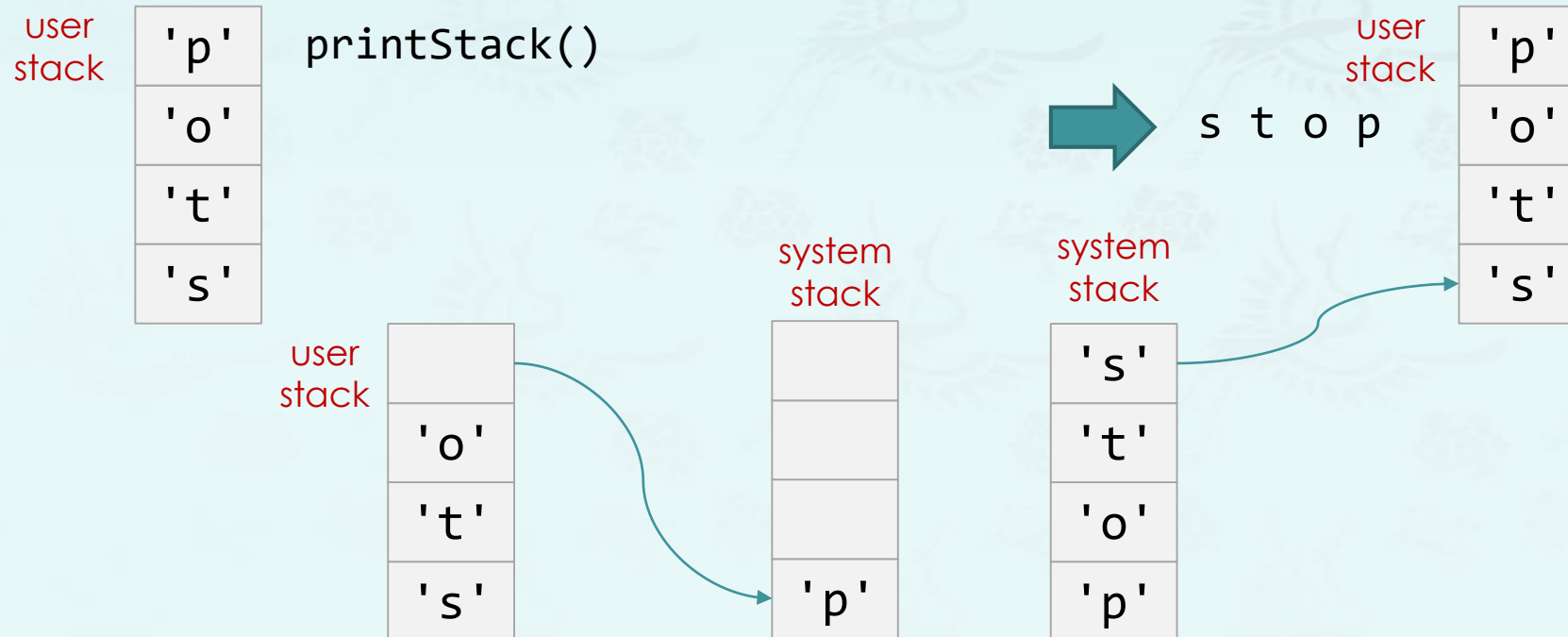


Stack: version.1 – using a stack class in C++ STL

stack1_stl.cpp

- Using recursion, print stack items from **bottom to top**.
 - Utilize the fact that the recursion uses the **system stack**.

```
void printStack(stack<string> s) {  
    if (s.empty()) return;  
  
    // your code here - top & pop & recursive call & print/push  
}  
// recursion version
```



Stack: version.1 – using a stack class in C++ STL

stack1_stl.cpp

- Using recursion, print stack items from **bottom to top**.
 - Utilize the fact that the recursion uses the **system stack**.

```
void printStack(stack<string> s) {  
    if (s.empty()) return;  
  
    // your code  
  
} // recursion
```

user
stack

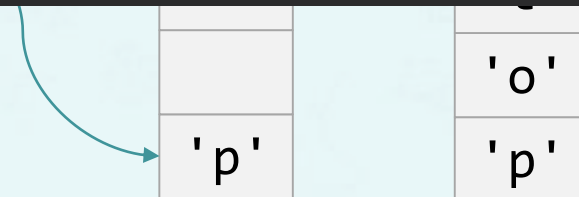


prints

user
stack



```
PS C:\GitHub\nowicx\src> g++ stack1_stl.cpp; ./a  
to be not that or be  
size: 2  
top : is  
stack T: is to  
stack B: to is  
Happy Coding  
PS C:\GitHub\nowicx\src>
```



Stack: version.2 – using a fixed size array

stack2_arr.cpp

```
struct Stack {
    string *item;
    int N;
    int capacity;
};
using stack = Stack *;

stack newStack(int capacity) {
    stack s = new Stack;
    s->item = new string[capacity];
    s->N = 0;
    s->capacity = capacity;
    return s;
}
void free(stack s) {
    delete[] s->item;
    delete s;
}
```

a shortcoming
(stay tuned)

item[N] is next to be filled if any.

```
int size(stack s) { return s->N; }

bool empty(stack s) { return s->N == 0; }

void pop(stack s) { s->N--; }

string top(stack s) {
    return s->item[s->N - 1];
}

void push(stack s, string item) {
    s->item[s->N++] = item;
}

void printStack(stack s) {
    // your code here
}

void printStack_fromBottom(stack s) {
    // your code here
}
```

N is not decremented


use N and incremented
N points an empty slot

Stack: version.2 – using a fixed size array

stack2_arr.cpp

```
struct Stack {  
    string *item;  
    int N;  
    int capacity;  
};  
using stack = Stack *;  
  
stack newStack(int capacity) {  
    stack s = new Stack;  
    s->item = new string[capacity];  
    s->N = 0;  
    s->capacity = capacity;  
    return s;  
}
```

a shortcoming
(stay tuned)



```
int size(stack s)    { return s->N; }  
  
bool empty(stack s) { return s->N == 0; }  
  
void pop(stack s)    { s->N--; }  
  
string top(stack s) {  
    return s->item[s->N - 1];  
} N is not decremented  
  
void push(stack s, string item) {  
    s->item[s->N++] = item;  
} use N and incremented  
N points an empty slot  
  
void printStack(stack s) {  
    // your code here  
}
```

Step 2:

- Make this code snippet into a program, and name it **stack2_arr.app**.
- Create **main()** that works like **stack1_st1.cpp**.
- Test it with string data type.
- Create **stack2i_arr.app** such that it can handle **int** data type.
- Test it with **int** data type.

bottom(stack s) {

Stack: version.3 – using a dynamic size array

stack3_arr.cpp

```
struct Stack {
    string *item;
    int N;
    int capacity;
};

using stack = Stack *;

stack newStack(int capacity = 1) {
    stack s = new Stack;
    s->item = new string[capacity];
    s->N = 0;
    s->capacity = capacity;
    return s;
}

void free(stack s) {
    delete[] s->item;
    delete s;
}

int size(stack s) { return s->N; }
```

```
bool empty(stack s) { return s->N == 0; }

void pop(stack s) {
    s->N--;
    // your code here
}

string top(stack s) {
    return s->item[s->N - 1];
}

void push(stack s, string item) {
    // your code here
    s->item[s->N++] = item;
}

void printStack(stack s) {
    // your code here
}

void printStack_fromBottom(stack s) {
    // your code here
}
```

Stack: version.3 – using a dynamic size array

stack3_arr.cpp

```
struct Stack {
    string *item;
    int N;
    int capacity;
};

using stack = Stack *;

stack newStack(int capacity = 1) {
    stack s = new Stack;
    s->item = new string[capacity];
    s->N = 0;
    s->capacity = capacity;
    return s;
}
```

```
bool empty(stack s) { return s->N == 0; }
void pop(stack s) {
    s->N--;
    // your code here
}
string top(stack s) {
    return s->item[s->N - 1];
}
void push(stack s, string item) {
    // your code here
    s->item[s->N++] = item;
}
void printStack(stack s) {
```

Step 3:

- Make this code snippet into a program, and name it **stack3_arr.app**.
- Create or modify functions as needed that works like **stack1_stl.cpp**.
- Add **DPRINT** to show its **size** and **capacity** right after every **push()** call.
- Test it with **string** data type.
- Create **stack3i_arr.app** such that it can handle **int** data type.
- Test it with **int** data type.

(stack s) {

Stack: version.4 – using a vector in C++ STL

stack4_vec.cpp

```
struct Stack {  
    vector<string> item;  
};  
using stack = Stack *;  
  
void free(stack s) {  
    delete s;  
}  
  
int size(stack s) {  
    return s->item.size();  
}  
  
bool empty(stack s) {  
    return s->item.empty();  
}  
  
void pop(stack s) {  
    s->item.pop_back();  
}
```

Step 4:

- Make this code snippet into a program, and name it **stack4_vec.app**.
- Create functions as needed that works like **stack1_stl.cpp**.
- Add **DPRINT** to show its **size** and **capacity** right after every **push()** call. Capacity increases automatically, not decreases.
- Test it with **string** data type.
- Create **stack4i_arr.cpp** such that it can handle **int** data type.
- Test it with **int** data type.

Stack: version.4T – using a vector<> in C++ STL

stack4_vecT.cpp

```
struct Stack {  
    vector<string> item;  
};  
using stack = Stack *;  
  
void free(stack s) {  
    delete s;  
}  
  
string top(stack s) {  
    return s->item.back();  
}
```

Compare these two program segments and see how to use **Templates** in C++ for generic programming.

```
template<typename T>  
struct Stack {  
    vector<T> item;  
};  
  
template<typename T>  
using stack = Stack<T> *;  
  
template<typename T>  
void free(stack<T> s) {  
    delete s;  
}  
  
template<typename T>  
T top(stack<T> s) {  
    return s->item.back();  
}
```

Stack: version.4T – using a vector<> in C++ STL

stack4_vecT.cpp

```
struct Stack {  
    vector<string> item;  
};  
using stack = Stack *;  
  
void free(stack s) {  
    delete s;  
}  
  
string top(stack s) {  
    return s->item.back();  
}
```

stack4_vec.cpp

```
template<typename T>  
struct Stack {  
    vector<T> item;  
};  
  
template<typename T>  
using stack = Stack<T> *;  
  
template<typename T>  
void free(stack<T> s) {  
    delete s;  
}  
  
template<typename T>
```

Compare these two program segments and see how to use **Templates** in C++ programming.

Step 5:

- Based on **stack4_vec.cpp**, create **stack4_vecT.cpp** such that it uses Templates in C++.
- Based on **stack2_arr.cpp**, create **stack2_arrT.cpp** such that it uses Templates in C++.
- Test it with **int** data type.

Pset - Stack:

- Files provided: this pdf file
- Files to submit:
 - **step 3: `stack3_arr.cpp`**
 - **step 4: `stack4_vec.cpp`**
 - **step 5: `stack4_vecT.cpp`, `stack2_arrT.cpp`**
- Due:
 - 11:55 pm

Data Structures

Chapter 3

1. Stack

- Stack Concept
 - STL stack class
- Stack Implementations
 - Using Fixed Array
 - Using Dynamic Array
 - Using Vector
 - Using Template

2. Queue