

Algorithms and Data Structures

B2. Abstract Data Types: Stacks & Queues

Gabriele Röger and Patrick Schneider

University of Basel

March 26, 2026

1 / 24

Algorithms and Data Structures

March 26, 2026 — B2. Abstract Data Types: Stacks & Queues

B2.1 Abstract Data Type

B2.2 Stack

B2.3 Queue

B2.4 Deque

B2.5 Summary

2 / 24

B2. Abstract Data Types: Stacks & Queues

Abstract Data Type

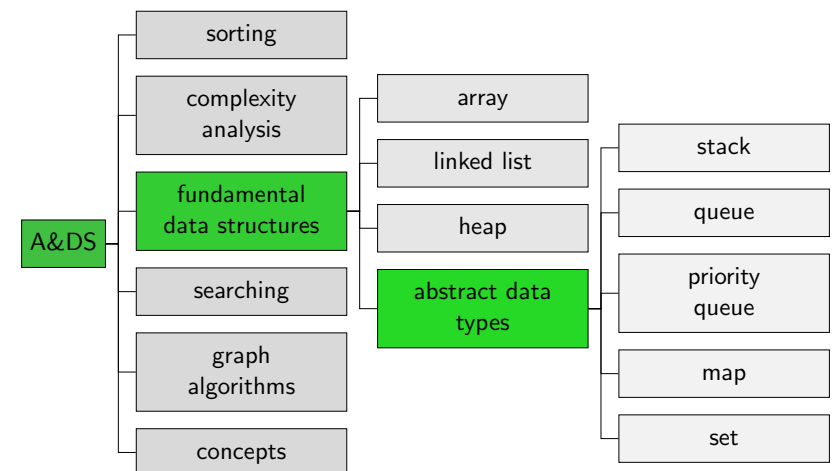
B2.1 Abstract Data Type

3 / 24

B2. Abstract Data Types: Stacks & Queues

Abstract Data Type

Content of the Course



4 / 24

Abstract Data Type

Abstract Data Type

Description of a data type, summarizing the possible data and the possible operations on this data.

- ▶ **User perspective:** How can I use the data type?
- ▶ In contrast to data structures, not specifying the concrete representation of the data.

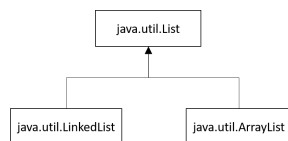
Advantages of Abstract Data Types

- ▶ User codes against an interface.
- ▶ The underlying data structure (representation) is hidden/encapsulated.
 - ▶ Representation can be replaced at any time.
- ▶ Separating two aspects:
 - 1 What is the data type doing (interface)?
 - 2 How is this achieved (internal structure)?

We can abstract away the dirty details and stay more flexible.

Abstract Data Types and Classes

- ▶ In object-oriented languages, abstract data types are often implemented as interfaces.
- ▶ For example, lists in Java:



```

interface List<E>:
  E get(int index);
  void add(E element);
  void add(int pos, E element);
  ...
  
```

Today: Stacks and Queues



Stack (of plates)



Queue (of persons)

Jupyter Notebook



Jupyter notebook: fundamental-adts.ipynb

Stack: Possible Implementation with Doubly Linked Lists

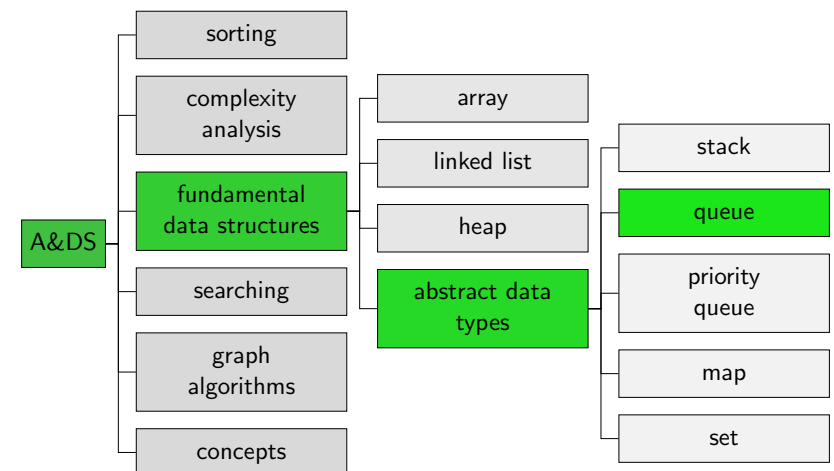
```
class Stack:
    def __init__(self):
        self.list = DoublyLinkedList()

    def push(self, item):
        self.list.prepend(item)

    def pop(self):
        if self.list.is_empty():
            raise Exception("popping from empty stack")
        else:
            return self.list.remove_first()
```

B2.3 Queue

Content of the Course



Queue

A **queue** is a data structure following the **first-in-first-out (FIFO)** principle supporting the following operations:

- ▶ **enqueue**: adds an item to the tail of the queue
- ▶ **dequeue**: removes the item at the head of the queue

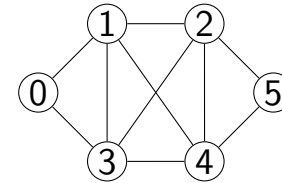


Both operations should take constant time.

Application: Breadth-first Exploration

Queues are always helpful if we need to store elements and process them in the same order.

With a breadth-first exploration, we want to visit all reachable nodes in a graph in the order of their distance from a given start node.



Starting from node 5, any of the following visitation orders would be fine:

- ▶ 5 2 4 1 3 0
- ▶ 5 4 2 1 3 0
- ▶ 5 2 4 3 1 0
- ▶ 5 4 2 3 1 0

Implementation with queue in Jupyter notebook

Jupyter Notebook



Jupyter notebook: `fundamental-adts.ipynb`

Queue: Possible Implementation with Doubly Linked Lists

```
class Queue:
    def __init__(self):
        self.list = DoublyLinkedList()

    def enqueue(self, item):
        self.list.append(item)

    def dequeue(self):
        if self.list.is_empty():
            raise Exception("dequeuing from empty queue")
        else:
            return self.list.remove_first()
```

B2.4 Deque

Deque

A **double-ended queue** (deque) generalizes both, queues and stacks:

- ▶ **append**: adds an item to the right side of the deque.
- ▶ **appendleft**: adds an item to the left side of the deque.
- ▶ **pop**: removes the item at the right end of the deque.
- ▶ **popleft**: removes the item at the left end of the deque.

Operation names can differ between programming languages.

All operations should take constant time.

How would you implement a deque?

B2.5 Summary

Summary

- ▶ **Abstract data types** (ADTs) specify the **behavior** of a data type, not the internal representation.
- ▶ **Stack**: follows last-in-first-out (LIFO) principle.
- ▶ **Queue**: follows first-in-first-out (FIFO) principle.
- ▶ **Deque**: generalizes stack and queue.
- ▶ All: in principle just lists with limited functionality.
- ▶ Limitations help clarifying intended usage and avoiding mistakes.

→ Preferably code against an ADT/interface.