CSE 331
Software Design & Implementation

Winter 2021

Section 6 – HW6, BFS Path-Finding, and Parsing

Administrivia

- Done with HW5-1!
- HW5-2 (ADT implementation) due today!
  - Reminder (1): Use a **`DEBUG`** flag to dial down an expensive **`checkRep`**
  - Reminder (2): Address feedback on your ADT design from HW5-1
  - Reminder (3): It's ok to make some changes in the original design if good reasons – and explain those
- HW6 due next Thursday
- Any questions?

Agenda

- Overview of HW6
- Breadth-first search (BFS)
- Parsing a file in comma-separated-values (CSV) format
  - Very similar to tab-separated-values (TSV) format in HW6
- Test scripts and the new test driver

HW6: The MarvelPaths program

- You were the implementor but now are the client of your graph ADT!
- MarvelPaths is a command-line program you write to find how two Marvel characters are connected through comic book co-appearances
- Using a large dataset in tab-separated-values (TSV) format
  - Each entry is a particular appearance of a character in a comic book
- Dataset processed to initialize the social-network graph
- Main functionality is finding shortest path in this social network using BFS

Outline of the assignment

0. Understand the dataset (`marvel.tsv`) and TSV format

1. Complete `MarvelParser` class to read TSV-formatted files

2. Implement graph initialization in `MarvelPaths` class

3. Implement path-finding via BFS in `MarvelPaths` class

4. Write suites of specification tests and of implementation tests
   - Implement `MarvelTestDriver` for new test-script commands

5. Write `main` method in `MarvelPaths` for command-line usage

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Breadth-first search

- Breadth-first search (BFS) is an algorithm for path-finding
  - Works just as well on directed and undirected graphs
  - Often used to discover connectivity in a graph

- Finds a path with the least number of edges
  - Recall that a path is a chain of edges, like $\langle a, b\rangle$, $\langle b, c\rangle$, $\langle c, d\rangle$
  - Ignores edge labels, so not used for weighted graphs

- Often mentioned alongside depth-first search (DFS)
  - BFS looks "wide" whereas DFS looks "deep"
  - DFS doesn't promise to find the shortest path as measured by number of edges

The BFS algorithm – first take

```
push start node onto a queue

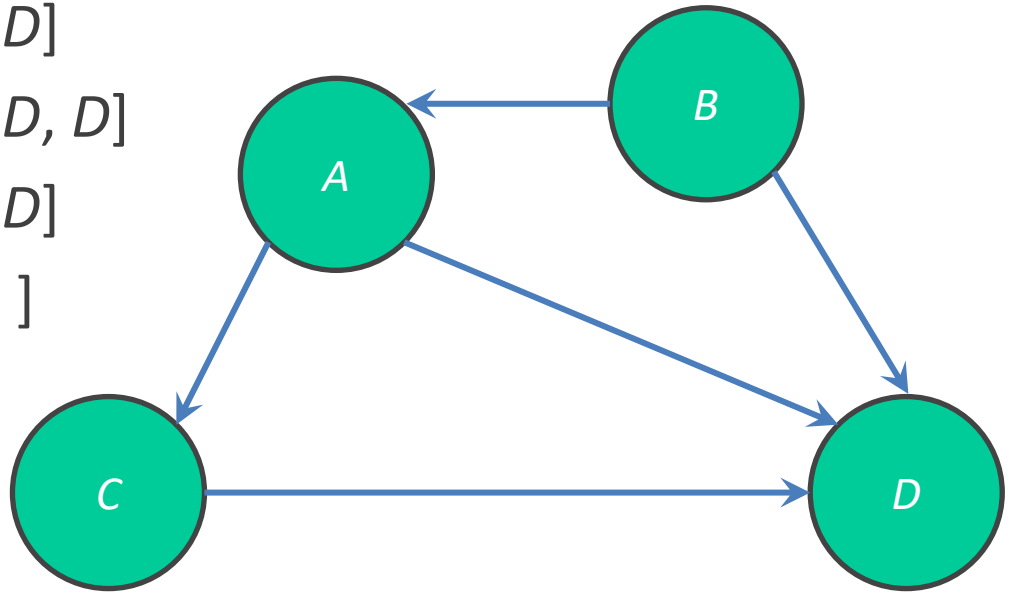
while queue is not empty:
  pop node N off queue
  if N is goal node:
    return true
  else:
    for each node O in children of N:
        push O onto queue

return false
```

BFS: example on a simple graph

push start	Q = [*A*]
pop *A*	Q = [ ]
push *C*	Q = [*C*]
push *D*	Q = [*D*, *C*]
pop *C*	Q = [*D*]
push *D*	Q = [*D*, *D*]
pop *D*	Q = [*D*]
pop *D*	Q = [ ]
return false	

start = *A*
goal = *B*

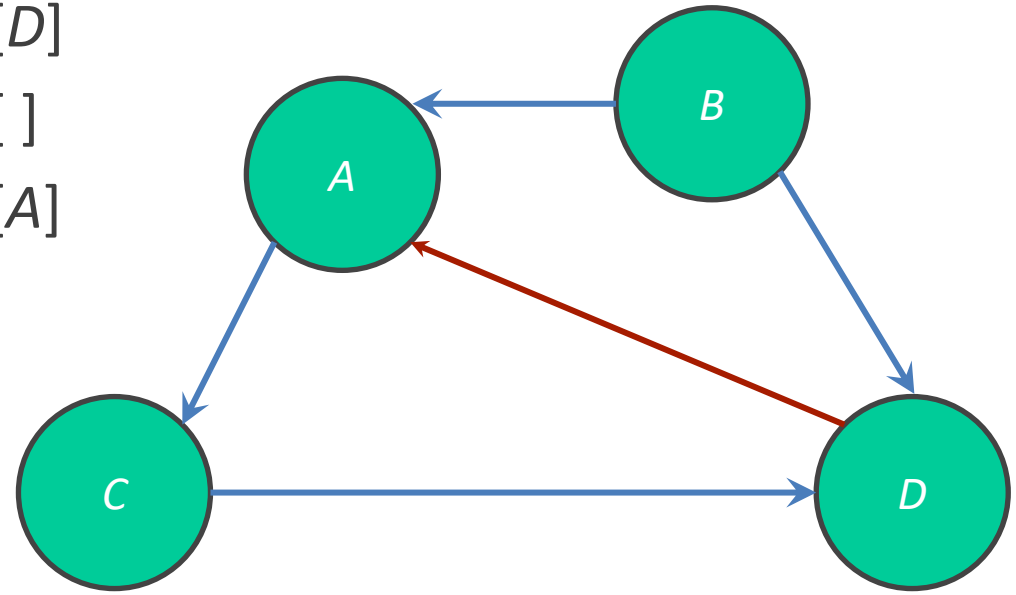


BFS: example on a cyclic graph

push start	Q = [*A*]
pop *A*	Q = [ ]
push *C*	Q = [*C*]
pop *C*	Q = [ ]
push *D*	Q = [*D*]
pop *D*	Q = [ ]
push *A*	Q = [*A*]

INFINITE LOOP!

start = *A*
goal = *B*



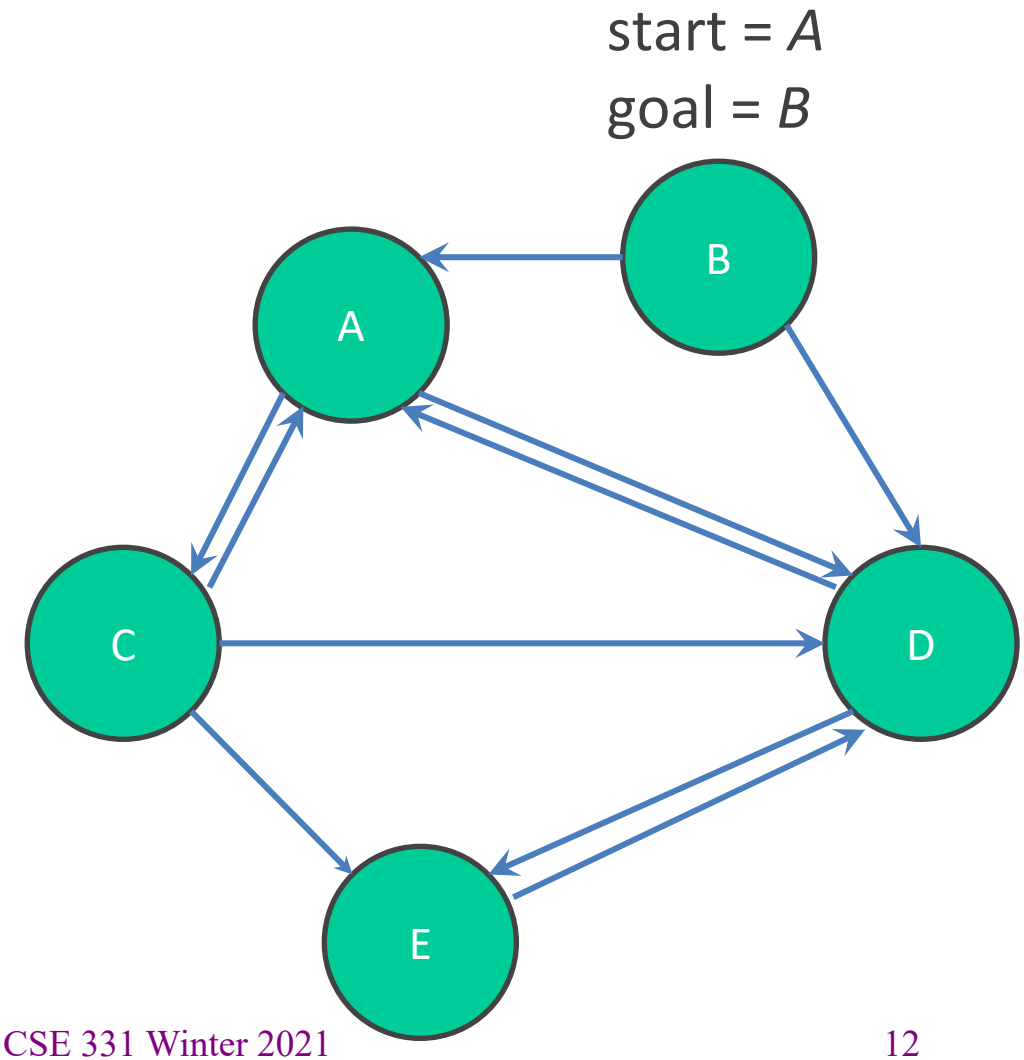
The BFS algorithm

```
push start node onto a queue
mark start node as visited

while queue is not empty:
  pop node N off queue
  if N is goal:
    return true
  else:
    for each node O that is child of N:
      if O is not marked visited:
        mark node O as visited
        push O onto queue

return false
```

BFS: example on a cyclic graph



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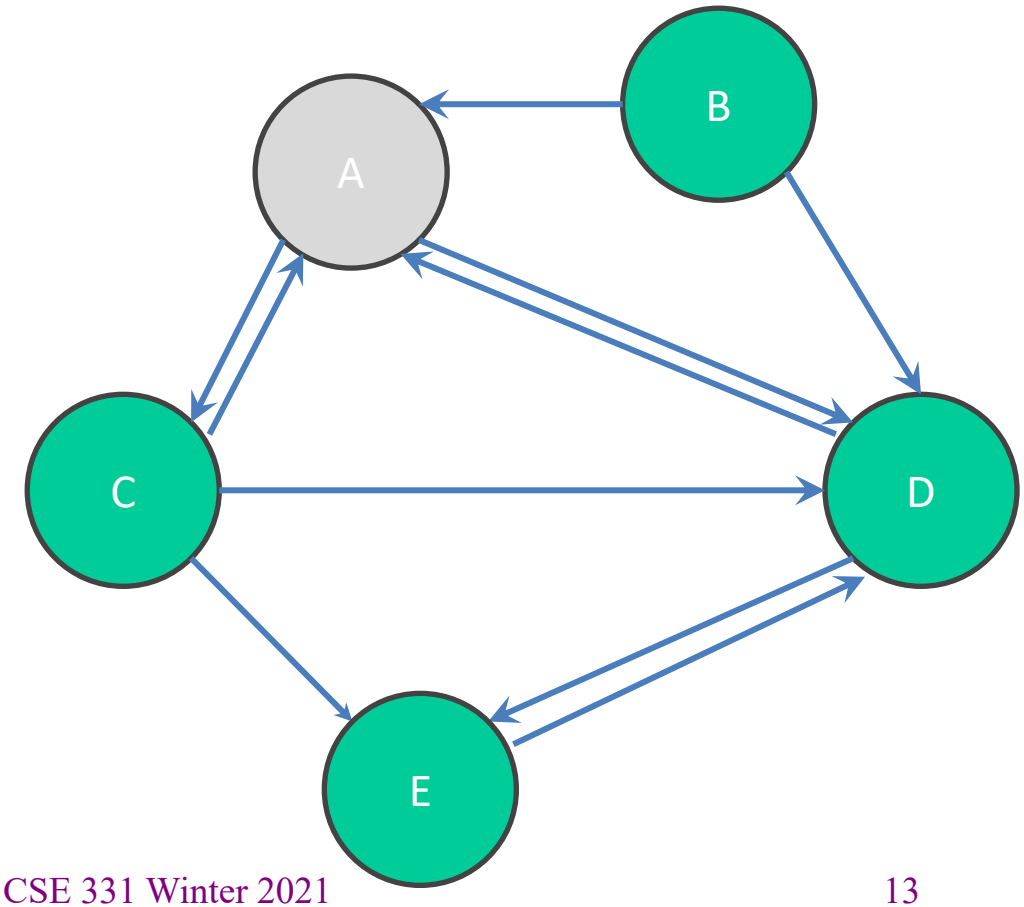

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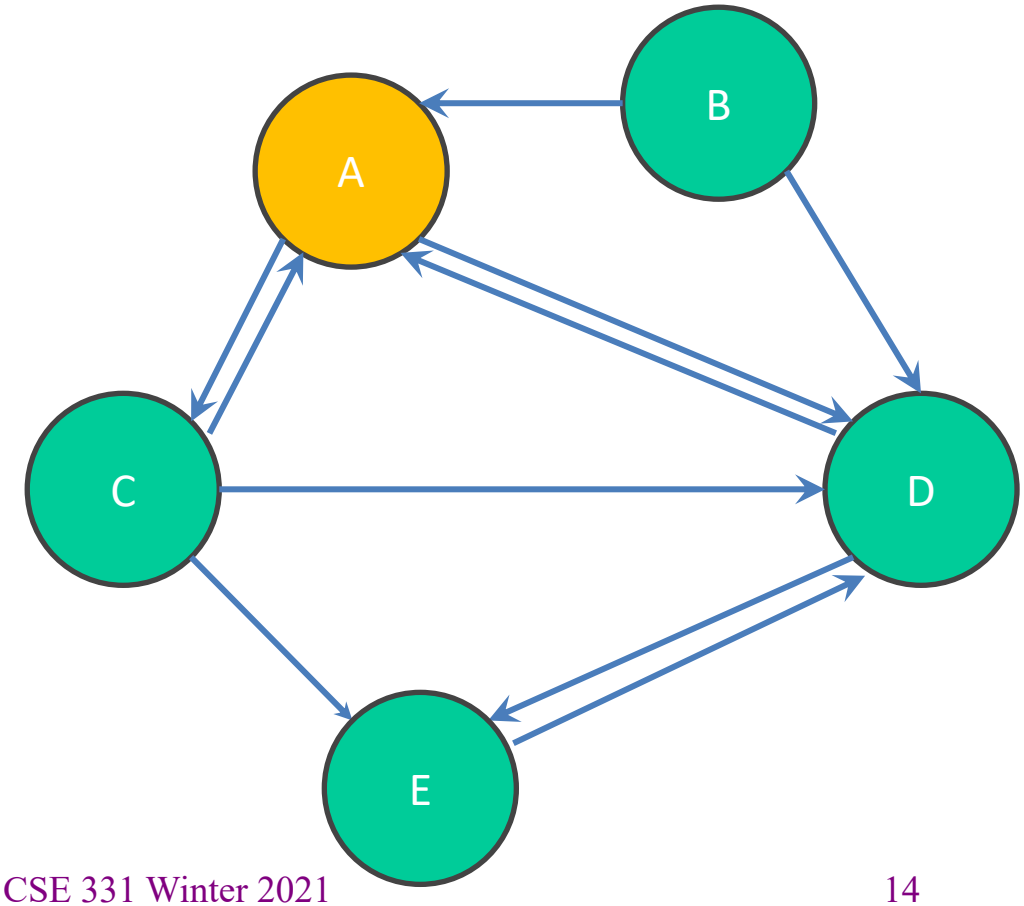

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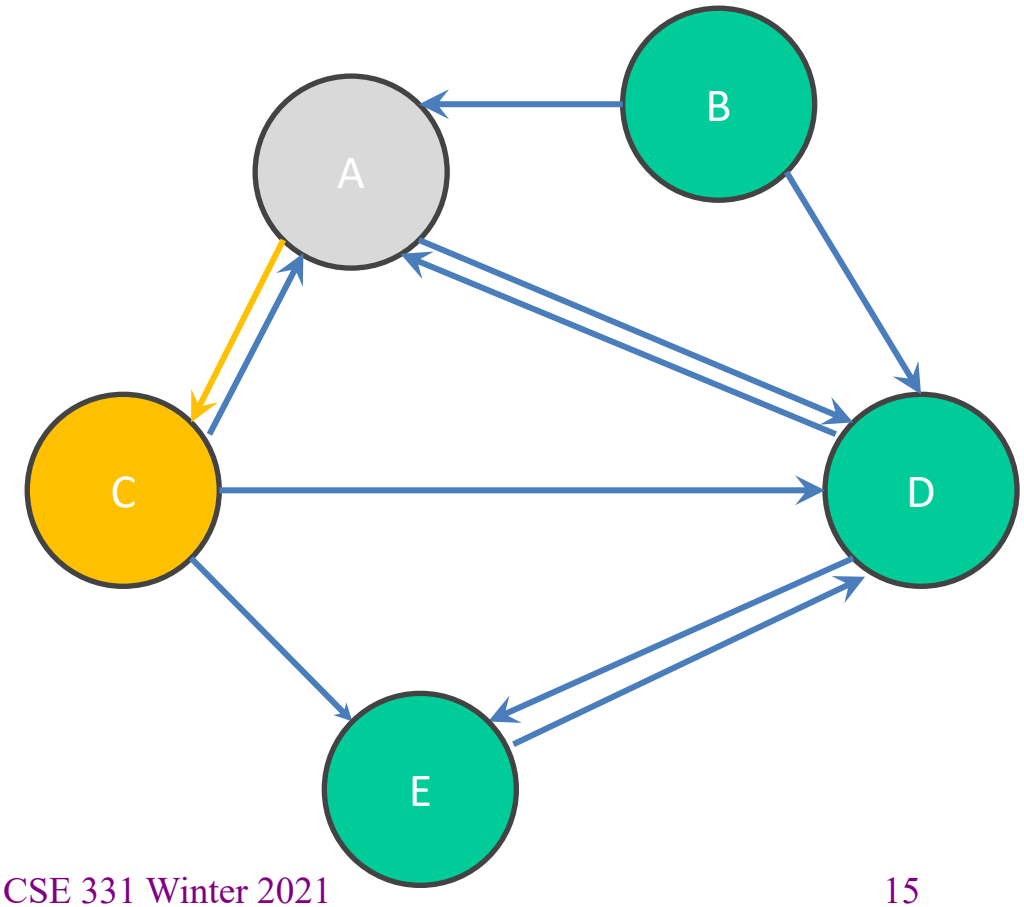

BFS: example on a cyclic graph

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push *C*	Q = [*C*]
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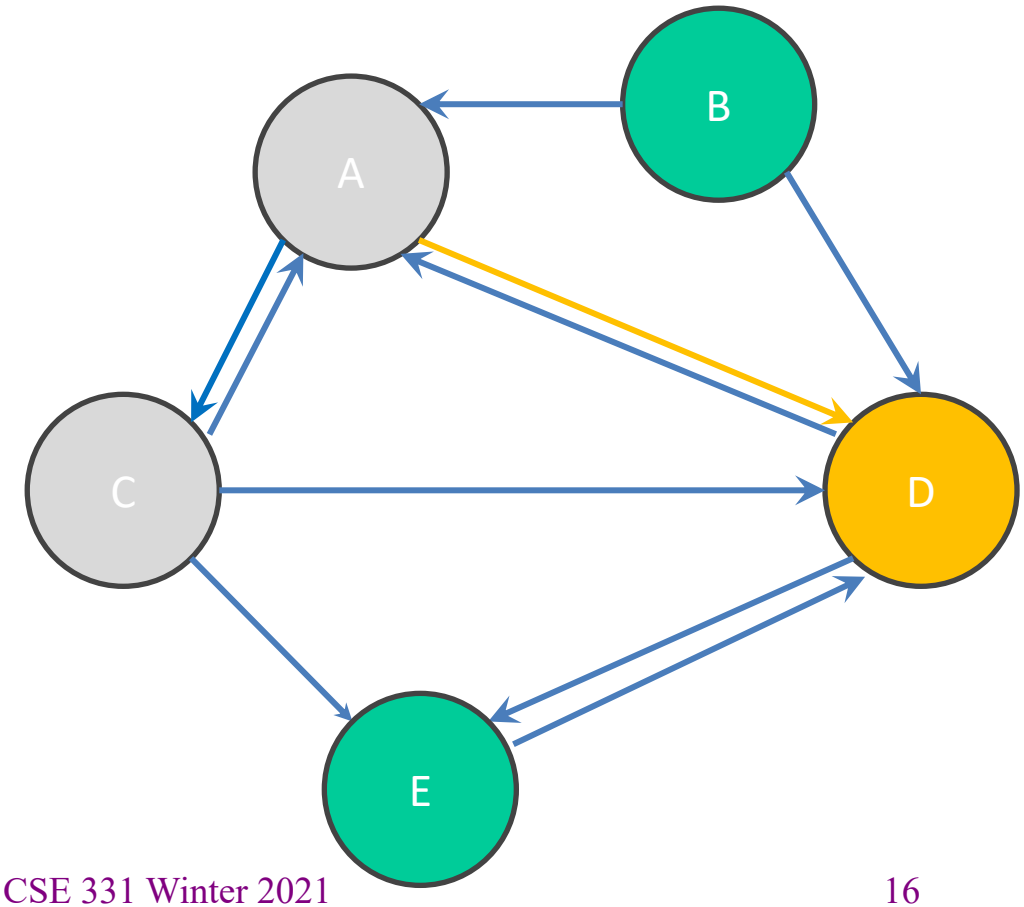

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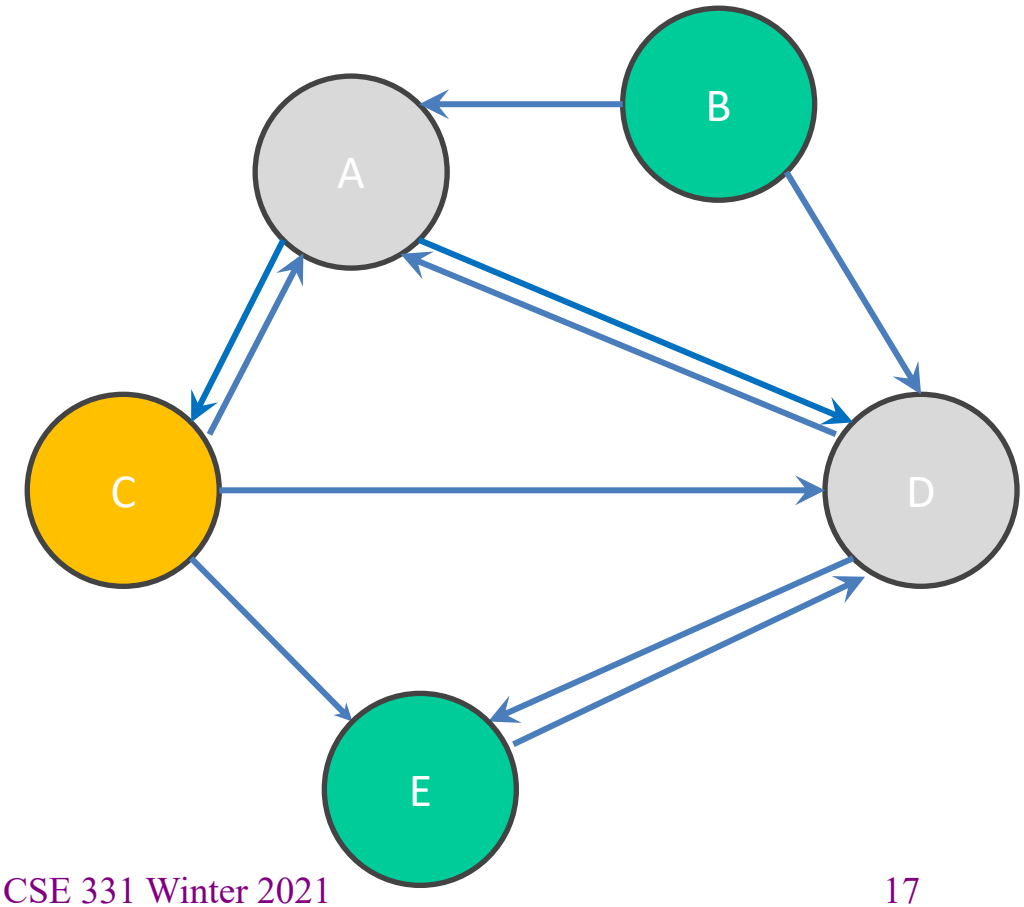

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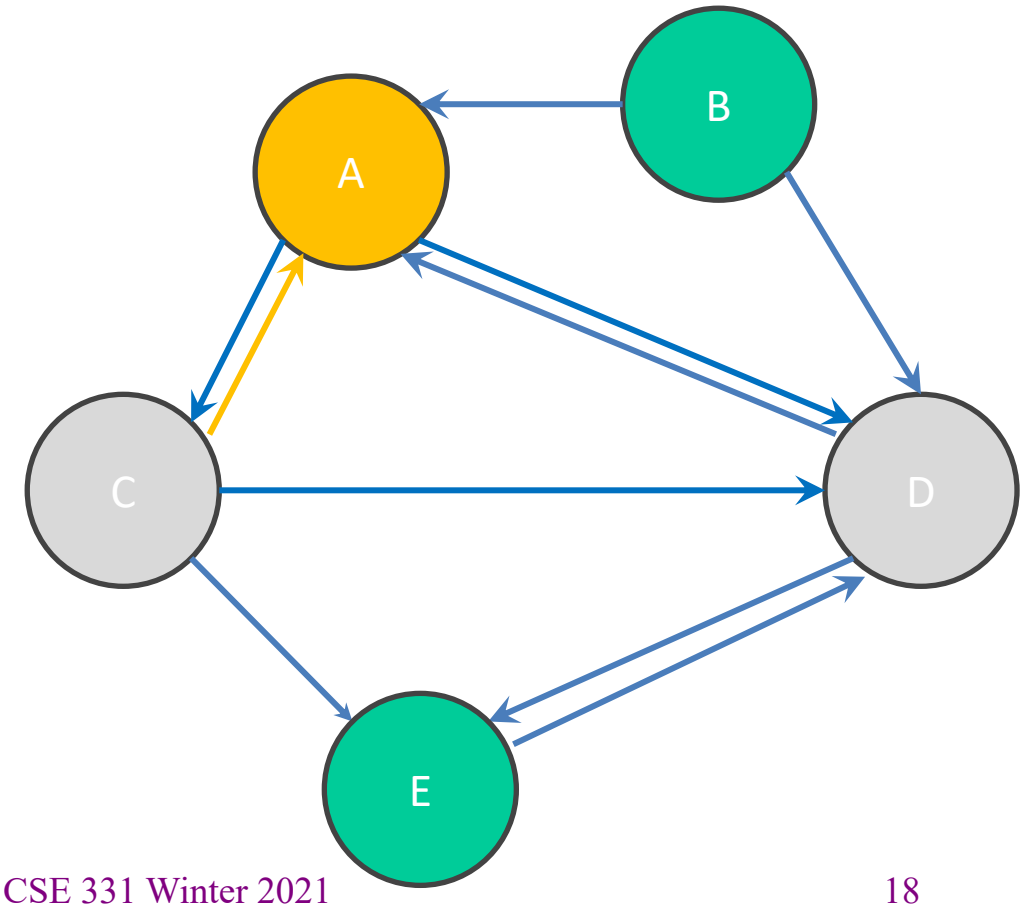

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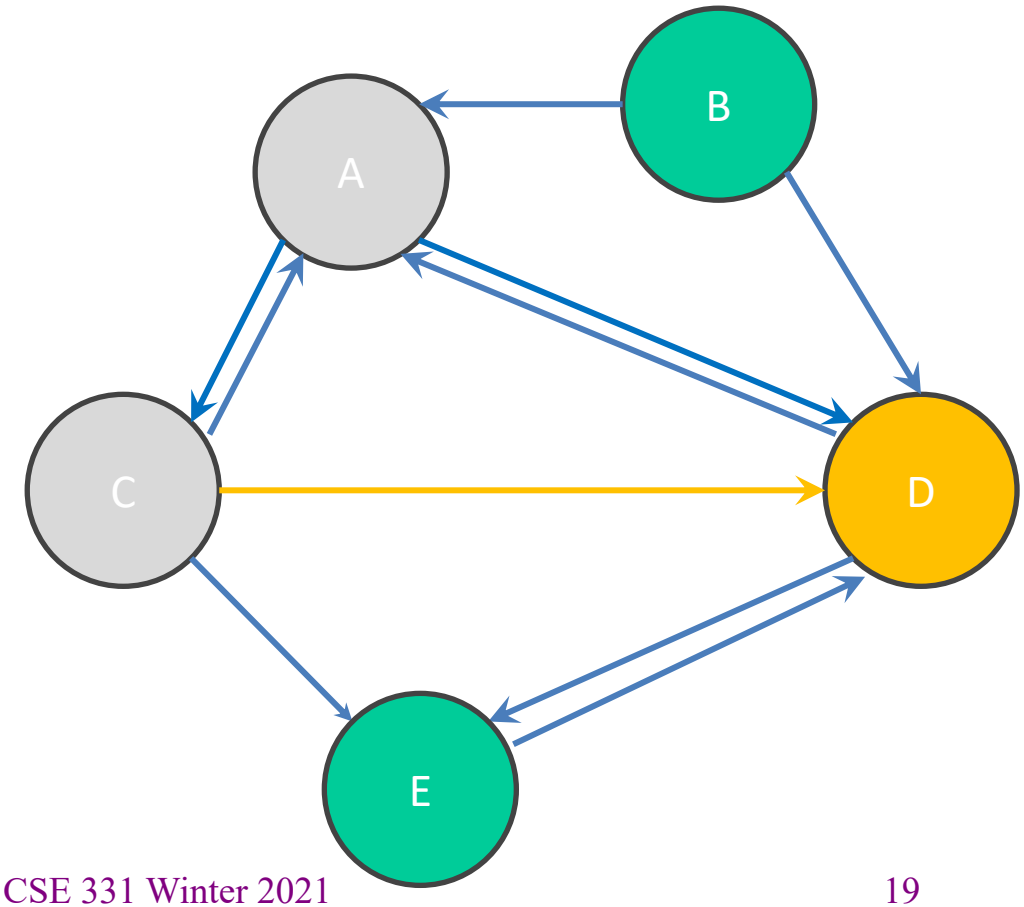

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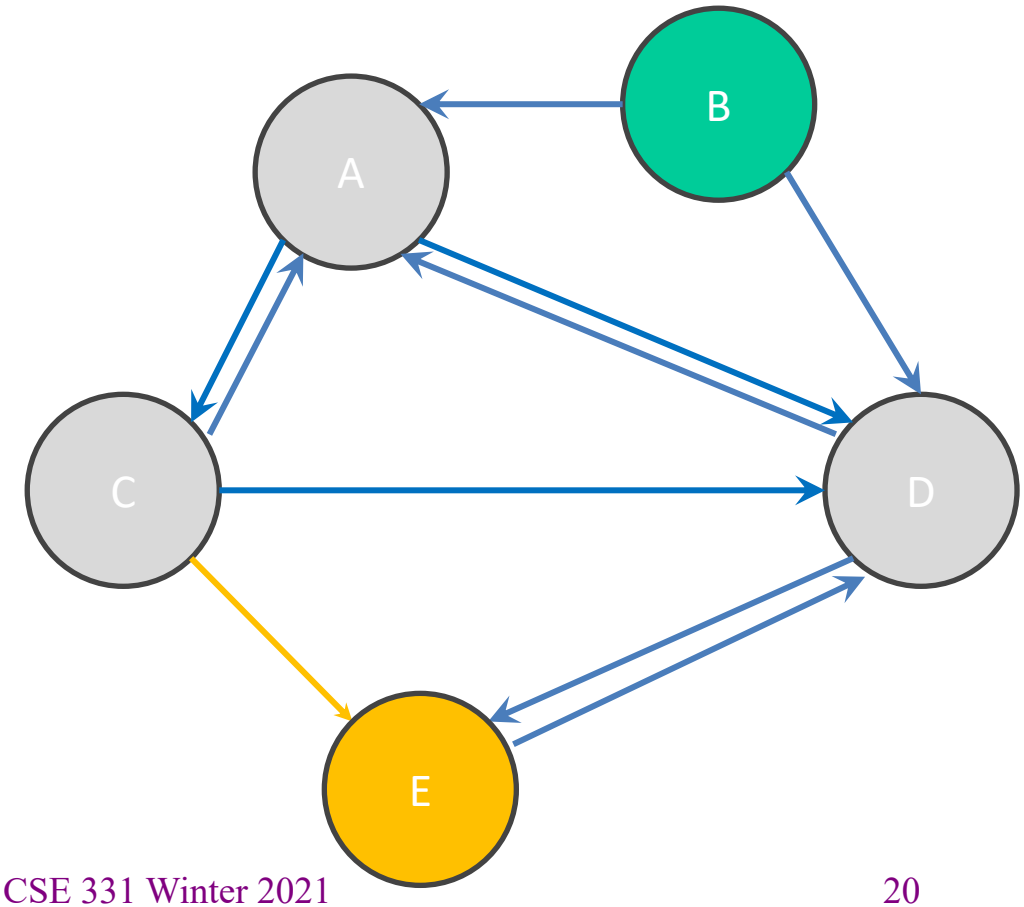

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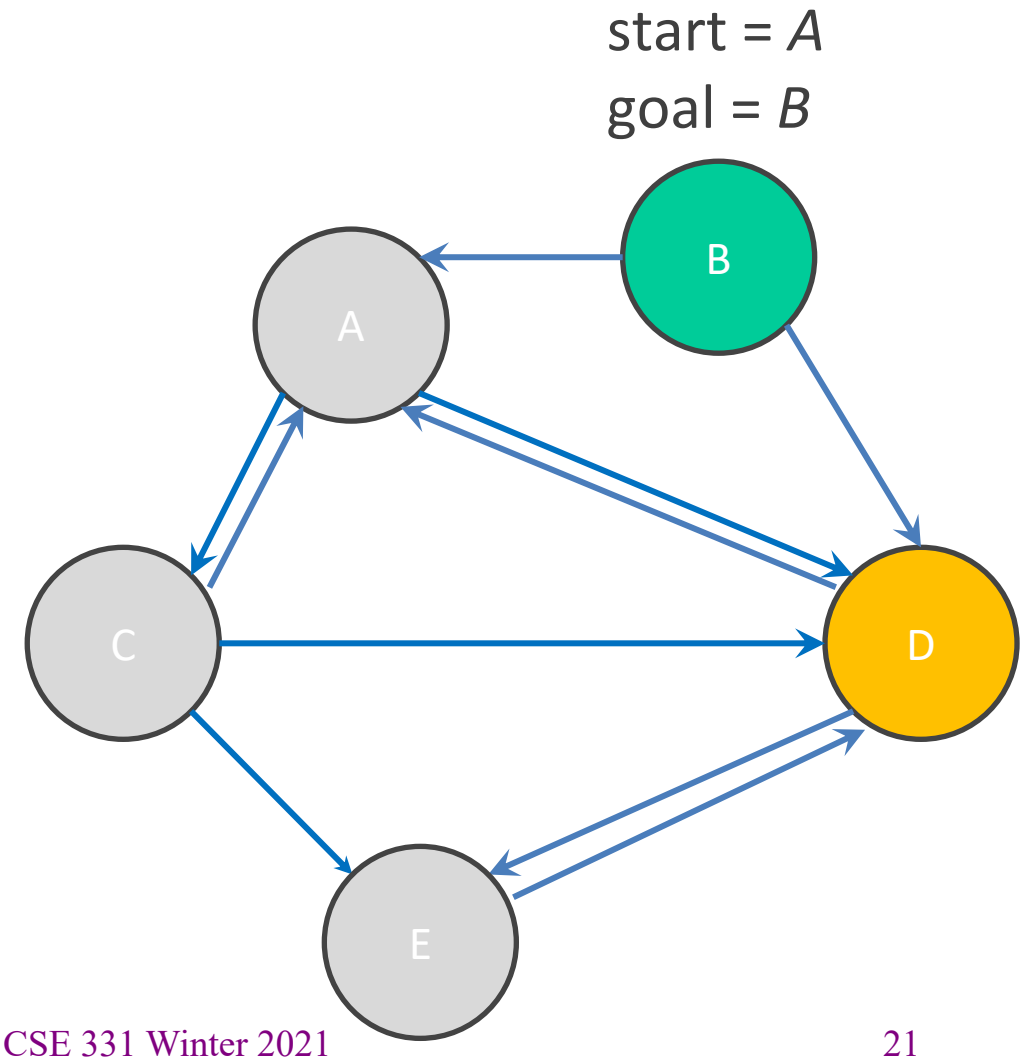

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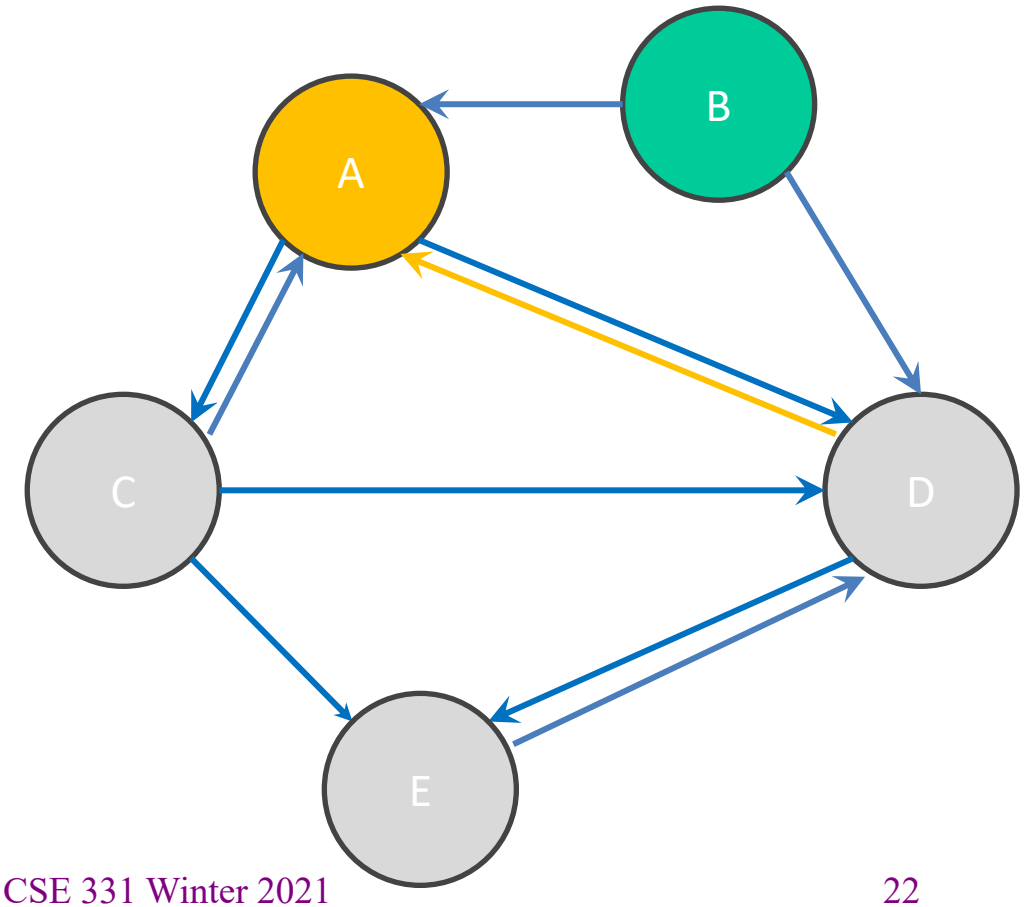

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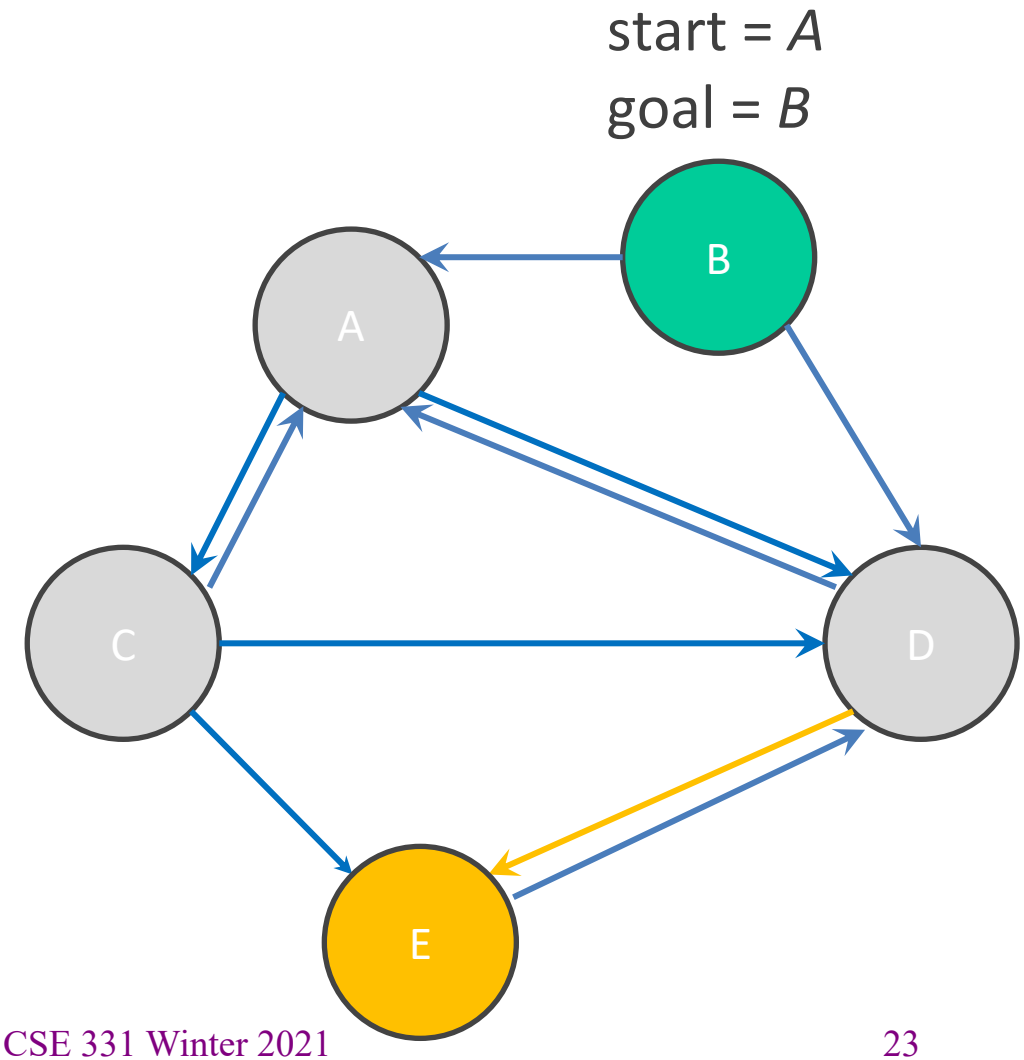

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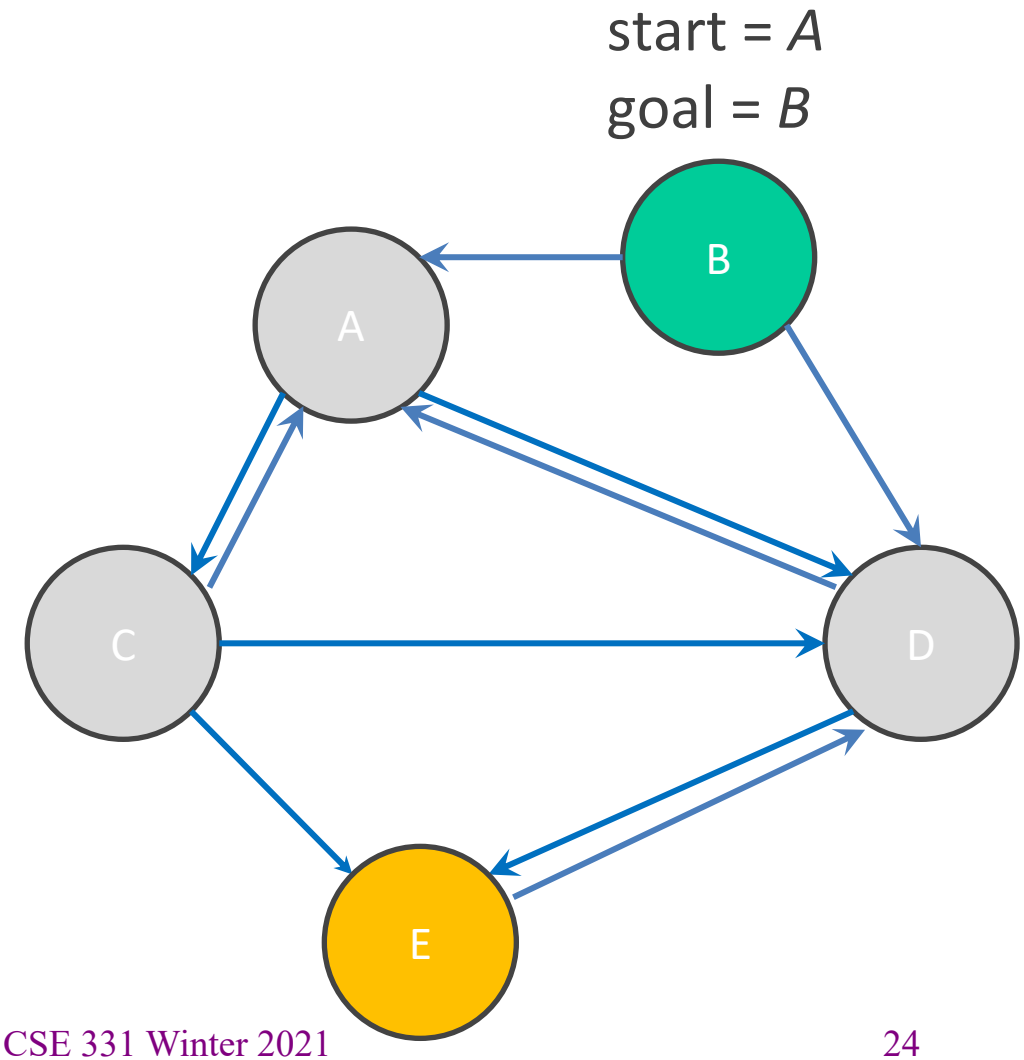

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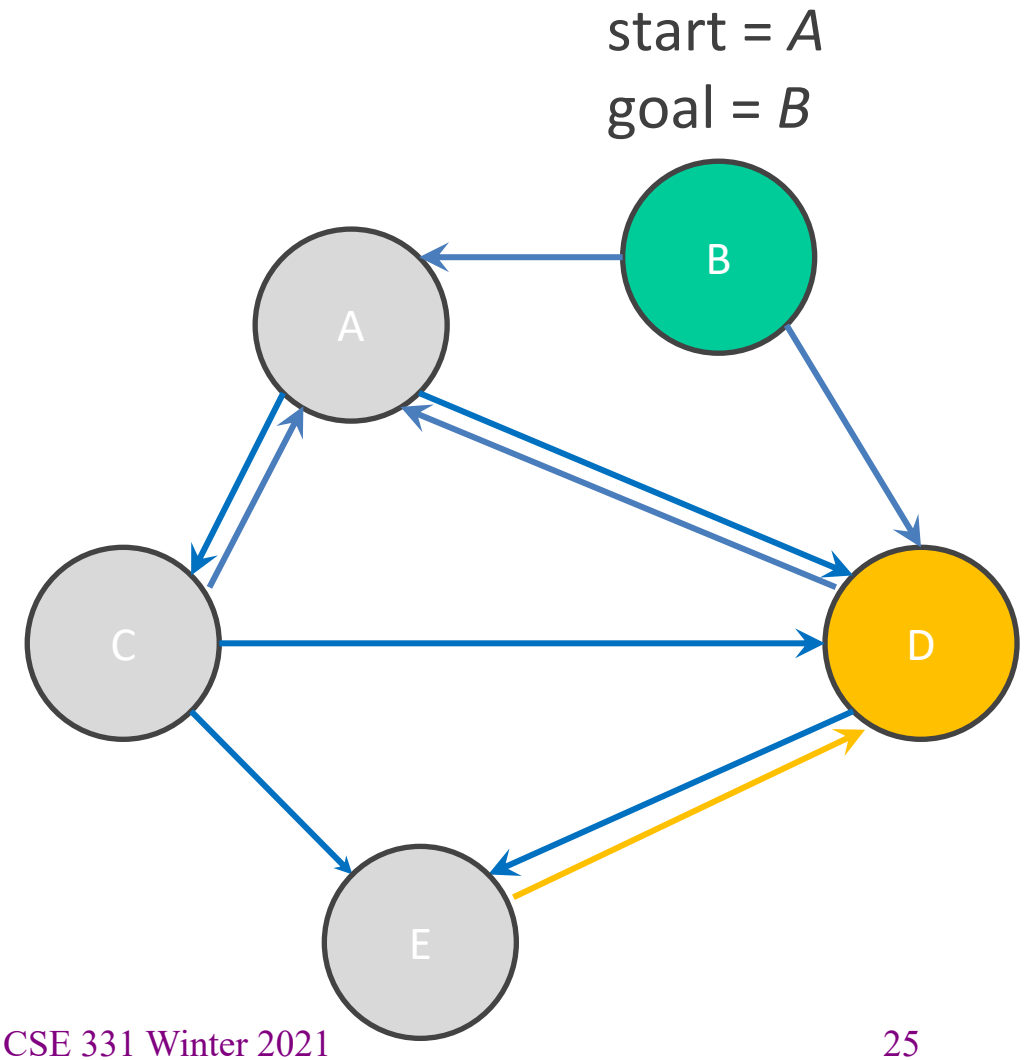

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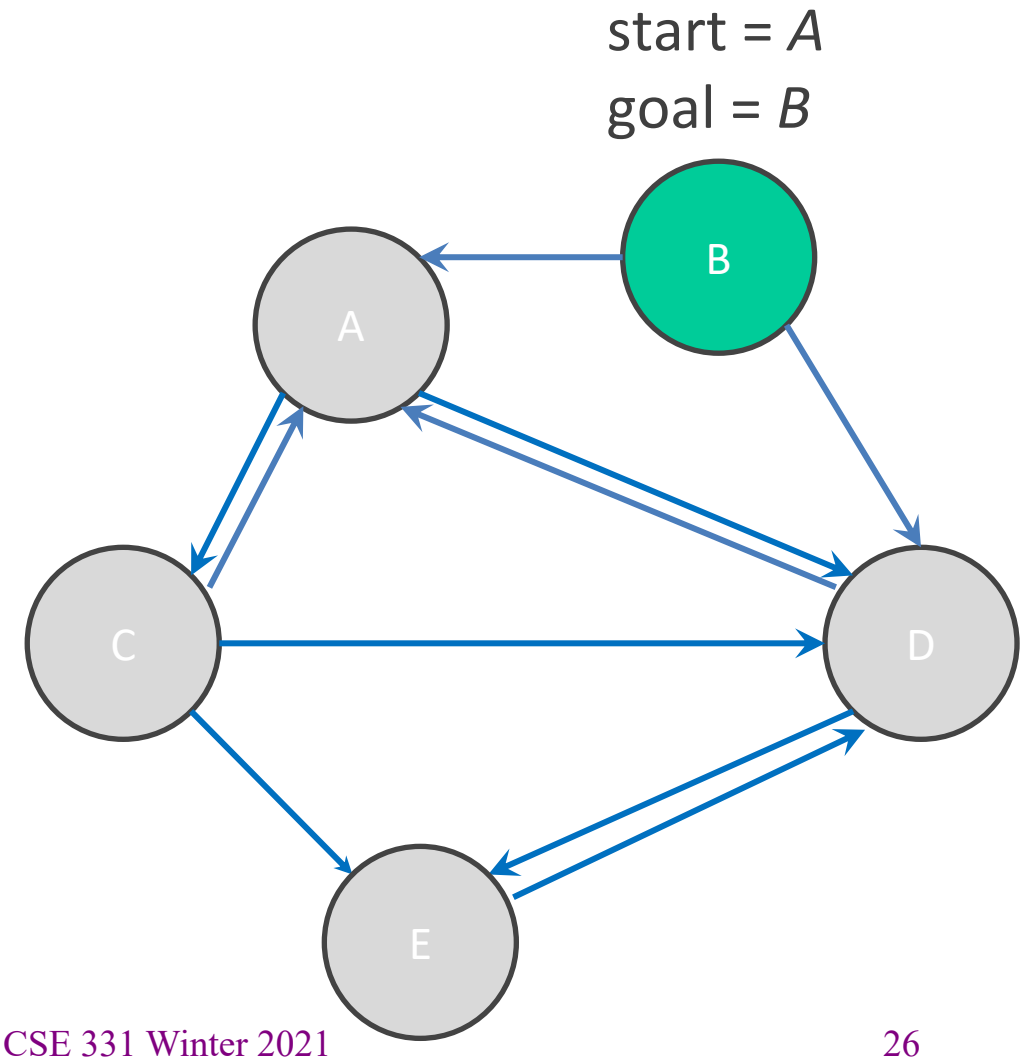
pop *D*	Q = [*E*]
pop *E*	Q = [ ]
return false	



Your turn!

Try running through the BFS algorithm on the worksheet.

BFS Reminders

- BFS is done on a graph, not by (inside) the graph
  - This is why we have you create a **`MarvelPaths`** class!

- We will eventually want to allow other kinds of searches to be done on the graph, so BFS should not be hard-wired into the core Graph ADT

- Extensive/expensive **`checkRep`** can be very helpful during debugging
  - Use the debug flag to turn off expensive parts of **`checkRep`** for testing/grading

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Reading in data

- Datasets are easily organized like a table or spreadsheet.
  - Each line is a row (*i.e.*, entry) in the dataset
  - Special characters usually separate the columns (*i.e.*, fields) of an entry
  - **Note:** fields can contain spaces

- One common data format: CSV (Comma-Separated Values)
  - Columns are separated by commas (‘,’)

- For HW6, we will be using data formatted as TSV (Tab-Separated Values)
  - Columns are separated by tabs (‘\t’)

Structure of a CSV dataset

- First line of the CSV just names the fields of dataset entries.
- An example dataset in CSV format:

```
name,email
Kevin Zatloukal,kevinz@cs.uw.edu
Hal Perkins,perkins@cs.uw.edu
Mike Ernst,mernst@cs.uw.edu
Zachary Tatlock,ztatlock@cs.uw.edu
Dan Grossman,djg@cs.uw.edu
```

Parsing datasets

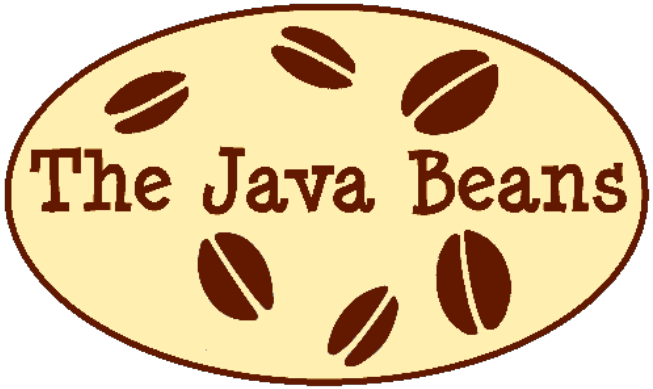
- Since datasets are structured, **we can interpret and parse the dataset programmatically**.
- Existing Java libraries already do this! No need to reinvent the wheel.
- For this class, we will be using the library OpenCSV as a parser.

Dataset Parsers

- OpenCSV needs to understand how your columns are structured to translate to Java code.
- Because rows have fixed columns, Java classes can be used to represent each row.
  - Each column is a field in the Java class
- This class is known as a JavaBean!

What is a JavaBean?

- A JavaBean is any class that…
  - has a public, zero-argument constructor
  - has several *properties, i.e.*, private fields each with getter and setter



Example bean

```
public class UserModel {

  private String name;


  private String email;

  public String getName() { return this.name; }
  public void setName(String v) { this.name = v; }

  public String getEmail() { return this.email; }
  public void setEmail(String v) { this.email = v; }
}
```

```
name,email
Kevin Zatloukal,kevinz@cs.uw.edu
Hal Perkins,perkins@cs.uw.edu
Mike Ernst,mernst@cs.uw.edu
Zachary Tatlock,ztatlock@cs.uw.edu
```

Example bean (OpenCSV)

```
public class UserModel {
  @CsvBindByName
  private String name;

  @CsvBindByName
  private String email;

  public String getName() { return this.name; }
  public void setName(String v) { this.name = v; }

  public String getEmail() { return this.email; }
  public void setEmail(String v) { this.email = v; }
}
```

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Kevin Zatloukal,kevinz@cs.uw.edu
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Mike Ernst,mernst@cs.uw.edu
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  public String getEmail() { return this.email; }
  public void setEmail(String v) { this.email = v; }
}
```

Helps OpenCSV identify field names that match data column names

From dataset to beans via OpenCSV

- OpenCSV converts each entry into an object of a chosen JavaBean class

- Returns an iterator to loop through each row of CSV!

```
// see hw spec for details on getting the BufferedReader
Reader reader = new BufferedReader(...);

Iterator<UserModel> csvUserIterator =
     new CsvToBeanBuilder<UserModel>(reader) // set input
               .withType(UserModel.class) // set entry type
               .withSeparator(',') // , for CSV
               .withIgnoreLeadingWhiteSpace(true)
               .build() // returns a CsvToBean<UserModel>
               .iterator();
```

Demo

A quick walkthrough of the parser code for HW6.

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Script testing in HW6

- **Same test-script mechanism from HW5, but 2 new commands!**
  - New command **`LoadGraph`** to read and initialize graph from TSV
  - New command **`FindPath`** to find shortest path in graph using BFS

- Must write the test driver (**`MarvelTestDriver`**) yourself
  - But you can copy most of it from **`GraphTestDriver`** in HW5

Command (in *`foo`*`.test`)	Output (in *`foo`*`.expected`)
`LoadGraph` *name file.tsv*	**`loaded graph`** *name*
`FindPath` *graph* $node_1$ $node_n$	**`path from`** $node_1$ **`to`** $node_n$**`:`** $node_1$ **`to`** $node_2$ **`via`** $edge_{1,2}$ $node_2$ **`to`** $node_3$ **`via`** $edge_{2,3}$ `...` $node_{n-1}$ **`to`** $node_n$ **`via`** $edge_{n-1,n}$
`...`	`...`

`LoadGraph` and `FindPath`

- **`LoadGraph`** creates a *new* graph variable, much like **`CreateGraph`**
  - **`LoadGraph`** populates a graph with nodes and edges from dataset
  - **Note:** Other script commands (*e.g.*, **`AddNode`**, **`AddEdge`**) can still mutate the graph once it has been loaded!

- **`FindPath`** breaks ties by lexicographic (alphabetic) order
  - Necessary when there are multiple shortest paths so the test output will be deterministic
  - **Sorting should not be implemented in your Graph ADT.** Lexicographic order should be done in BFS algorithm.

- **All this specified in detail on the homework's webpage**
  - **You will need to read it to get things right :-)**

Demo

A quick walkthrough of the TestDriver code for HW6.

HW6 notes

- Read the assignment spec carefully!
  - Ensure that you are using the right file path in the right place to read the data file
    - Most common reason for failures during grading is incorrect file paths

- Helpful to test and debug using smaller datasets
  - Faster and easier to understand what's going on

- To run MarvelPaths or any program that does console I/O, use gradlew to run the desired gradle target *using the IntelliJ terminal window* (console I/O doesn't work right otherwise )

- When you are done, you will be able to find the shortest path from your command line!