Software Engineering

CS305, Autumn 2020

Week 4

Class Progress…

- Last week:
  - Requirements Engineering Detailed Steps
    - Elicit, Analyze, Specify, Validate, Manage change
  - Requirements modeling
    - Goal-oriented, text-based methods, graphical based methods
  - Object Oriented Analysis and Design – overview
    - Object Modeling Technique
    - Unified Modeling Language (UML) and structural diagrams

Class Progress…

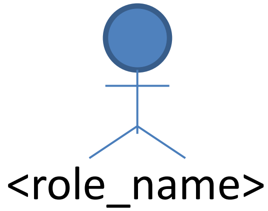
- This class: UML behavioral diagrams
  - Describe behavior or dynamic aspect of the system
  - E.g.

    Use Case diagram / user stories / scenarios

Use Case Diagrams

- Describes outside view of the system
  - Interaction of *outside entities* (Actors) with the system
  - System actions that result in observable actions of value to the actors
- Notation (important ones):

Use case



Actor

Connector between actor and use case (indicates “is the actor of”)

Actor

- Entity: human or device that interacts with the system
- Plays some role
  - Can play more than one role
    - E.g. customer of a bank can also be an employee of the bank (customer and employee are roles)
  - More than one entity can play the same role
    - E.g. an employee and a regular customer can both play the role of a *customer*
  - Can appear in more than one use case

Running Example

1. Registrar sets up the curriculum for a semester using a scheduling algorithm
2. One course may have multiple course offerings (think: sections)
3. Each course offering has a number, location, and time
4. Students register for courses using a registration form
5. Students may add/drop courses for a certain period after registration
6. Professors use the system to receive their course attendance sheets / course rosters
7. Users of the system are assigned passwords to validate at logon

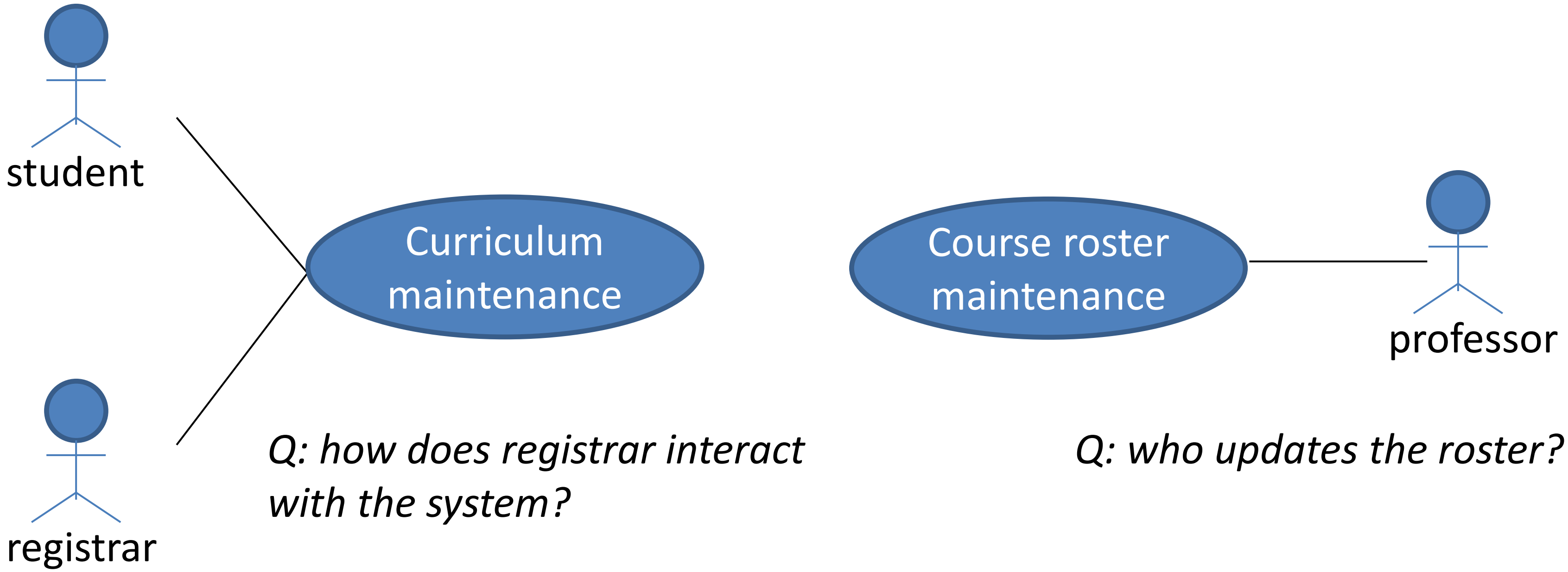
Exercise: Identify Actors

1. Registrar
2. curriculum
3. Semester
4. Scheduling algorithm
5. Course
6. Course offerings
7. Students
8. Registration form
9. Professors
10. Passwords

Exercise: Identify Actors

1. Registrar
2. Curriculum
3. Semester
4. Scheduling algorithm
5. Course
6. Course offerings
7. Students
8. Registration form
9. Professors
10. Passwords

Example Use Case Diagrams



Q: how does registrar interact with the system?

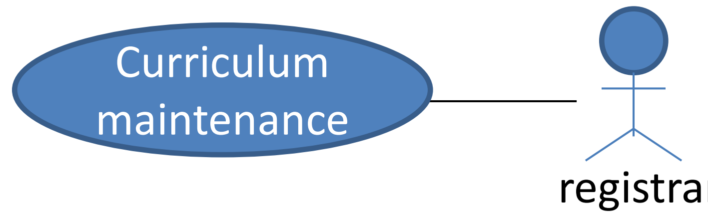
Q: who updates the roster?

Q: how to document the interactions?

Documenting use case - guidelines

- Describe flow of events either *formally or informally*
  - How the use case starts and ends
  - Normal flow of events
  - Alternative flow of events
  - Exceptional flow of events
- Formal way
  - Sequence diagrams, pseudocodes
- Informal way
  - Textual description

Documenting use case - example



- Registrar provides a password to log in to the system
- If the password is valid, the system asks to specify a semester
- Registrar enters the desired semester, and the system prompts the registrar to select an activity: ADD / DELETE / REVIEW / QUIT
- When selected ADD / DELETE, the system allows registrar to add / delete a course
  - When done, the system runs the scheduling algorithm
- When selected REVIEW, the system displays the curriculum for that semester
- When selected QUIT, the system logs out the registrar

Use cases - role

- Why important?
  - More effective requirements elicitation
  - Starting point for analyzing architecture (next topic)
  - Identify priority of users (e.g. Registrar. *If the registrar cannot perform his assigned role? How can a student use the system?*)
    - Help in better planning
  - Help in writing test cases even before the system is defined / coded

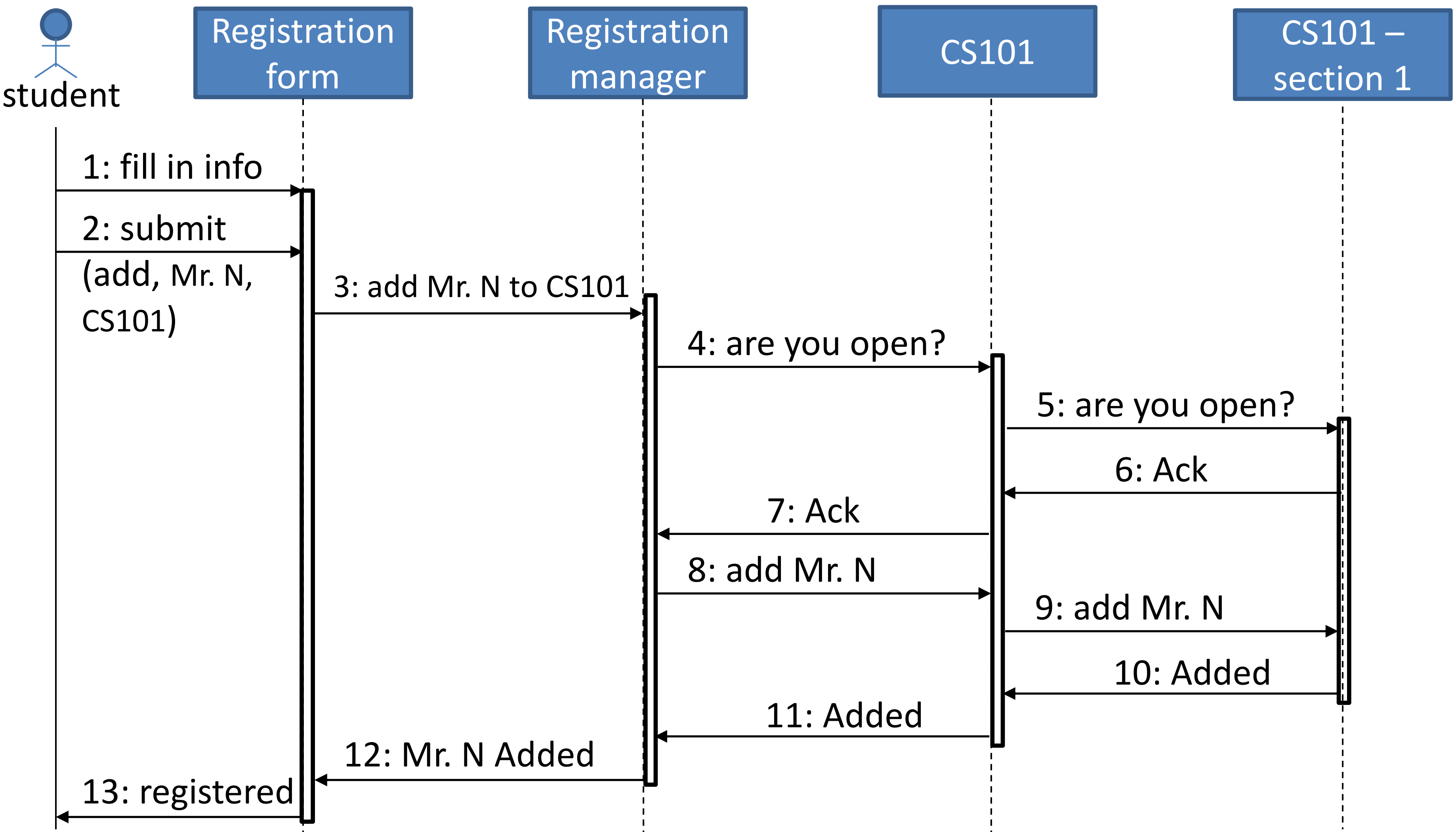
Use case diagram creation - guidelines

- Choose a name that conveys purpose
- Put a single scenario into a use case
- Define the flow of events clearly - helps understand how system works
- Omit irrelevant details
- Extract common flow of events among multiple user interactions to create new use cases i.e. refine e.g. Registrar, student, professors all log in to the system before performing their roles.

Sequence Diagrams

- Interaction diagram that describes how objects / components communicate and the ordered sequence of messages that are exchanged
- Can be used as a formal way to document a use case

Sequence Diagrams - Example



Sequence diagram creation - guidelines

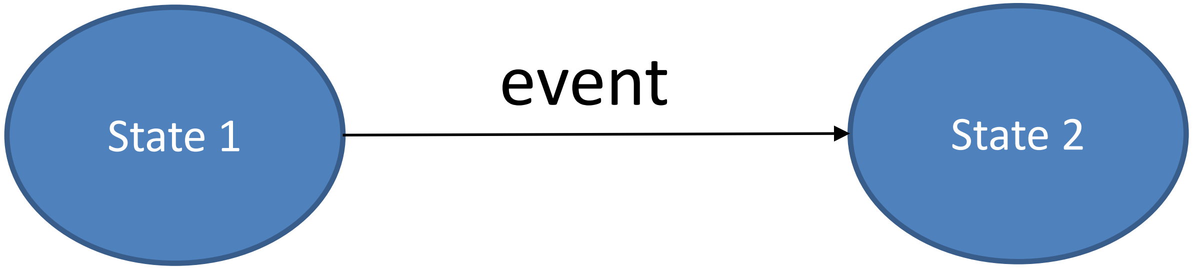
- Draw objects that participate in the interaction at the top along X-axis
  - Place objects that *initiate the interaction* towards the left
- Add object lifelines – lines that show the existence of an object over a period
  - Add dashed lines for all except the left-most object
- Place messages from top to bottom
  - Annotate messages with numbers for added clarity
- Add focus of control – thin rectangular boxes that indicate the period when the object is in action

State Transition Diagrams

- Shows possible life history of each object / class
- Defined for each relevant object / class
- Shows:
  - States of the class (attributes)
  - Events that cause transition from one state to another
  - Actions that result from state change

State Transition Diagrams - Notation

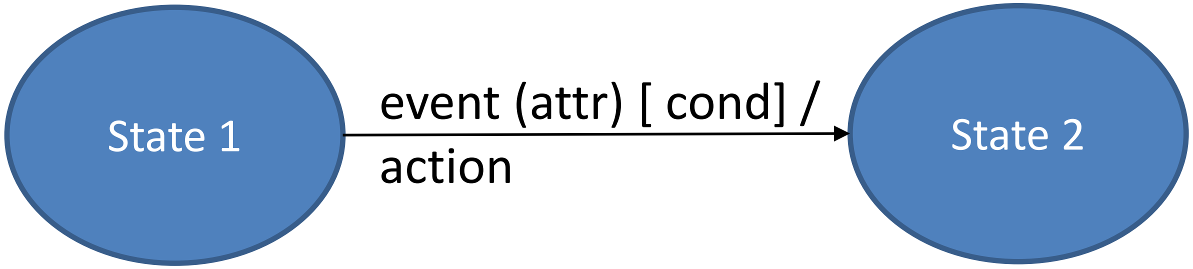
- States are indicated as ovals with names written inside



- Transition is indicated as event that triggers the transition. Indicates passage from one state to another because of some external stimuli (some events may be consumed within the state itself)

State Transition Diagrams - Notation

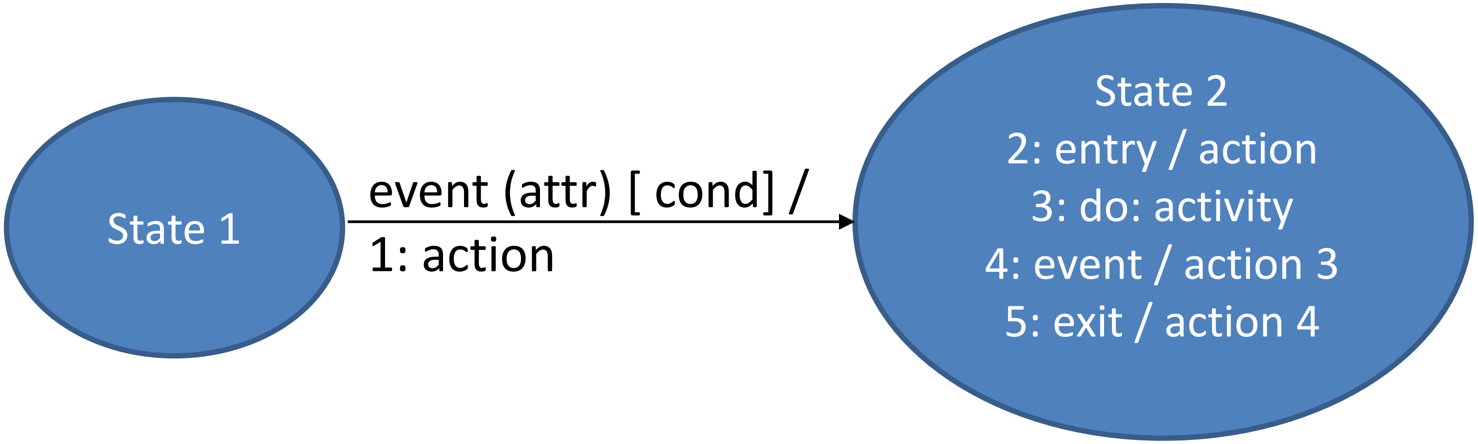
- events might also produce actions



- might also have attributes (analogous to method parameters) and Boolean conditions that indicate that the event is triggered only when the condition is true

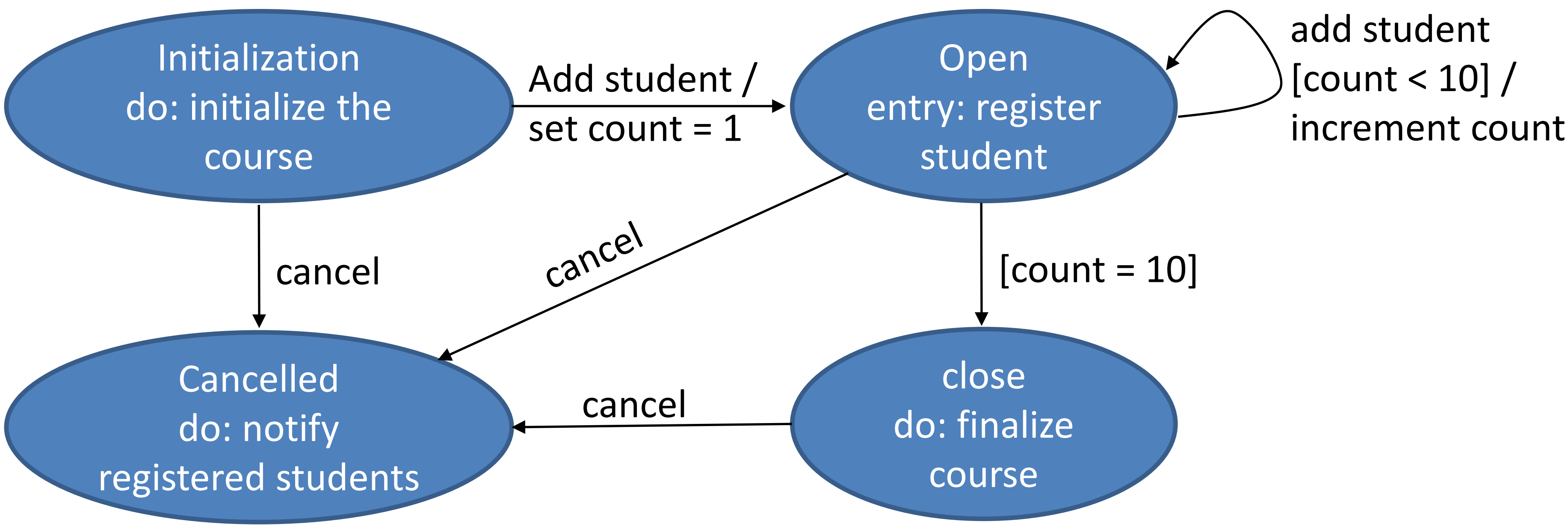
State Transition Diagrams - Notation

- States might also be associated with activities and actions

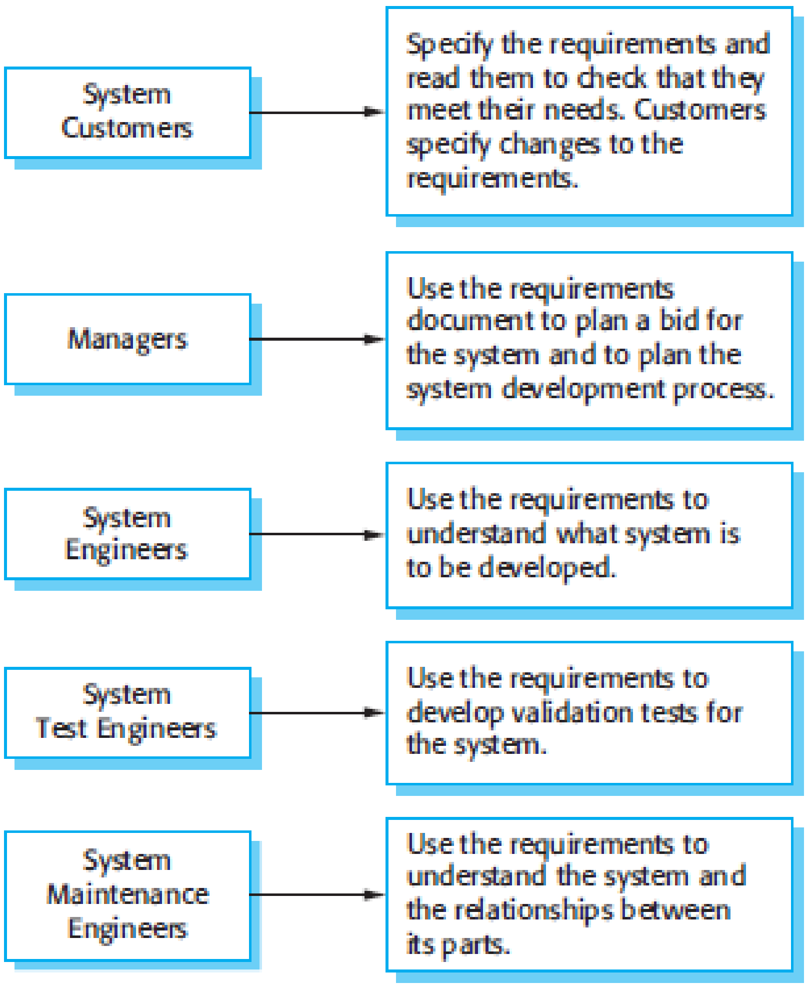


  - activities: operations performed by the object in a given state that take time to complete
  - actions: events that can be triggered upon entry or exit to that state or in response to specific event caused due to an activity performed
  - Numbers indicate the time ordering of actions / activities

State Transition Diagrams - example



Users of a Requirements Document



pic source: Software Engineering, Ian Sommerville

SRS Summary

- Way to communicate requirements to others
- Different projects require different SRSs depending upon the context e.g. small vs. large teams

Time to turn things around… a bit.

Write tests before you code and then code to make the tests pass

Testing

- Is a kind of verification technique
  - Recall: verification is checking against requirements
- Is executing the program on a *tiny sample* of the input domain
  - It is a dynamic technique: you need to execute the program
  - It is an approximation technique: for all other inputs, you expect the behavior of the program to be consistent with the samples tested

Testing

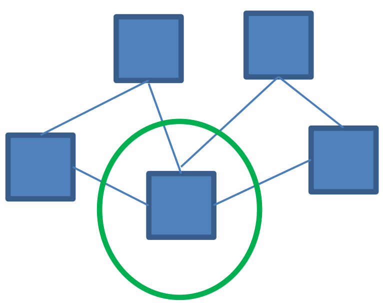
- Goal is to uncover bugs in the program

"A test is successful if the program fails" –

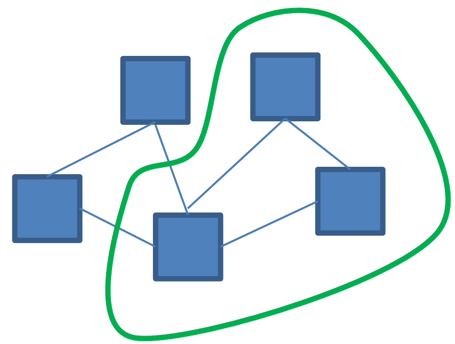
Goodenough and Gerhart

Testing Granularity Levels

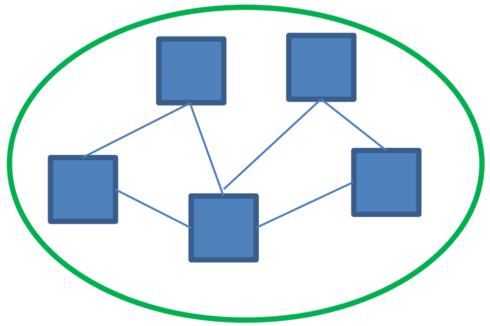
- View: software system as a bunch of interacting components



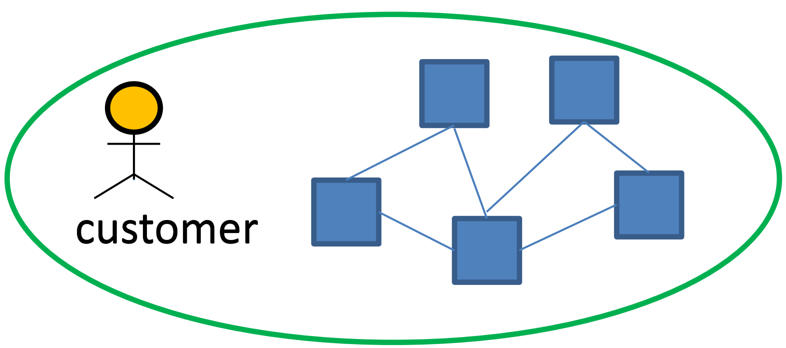
Unit testing



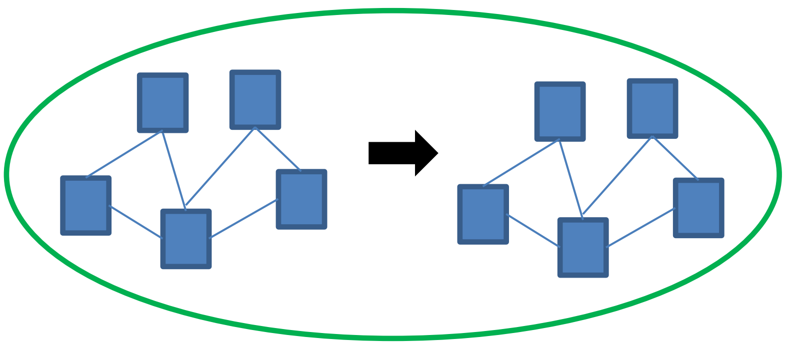
Integration testing



System testing



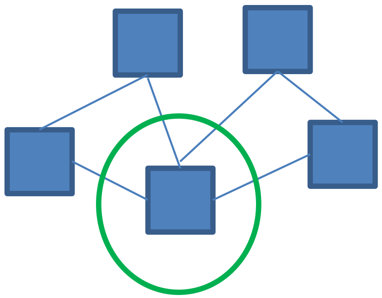
Acceptance testing



Regression testing

Testing Granularity Levels - Overview

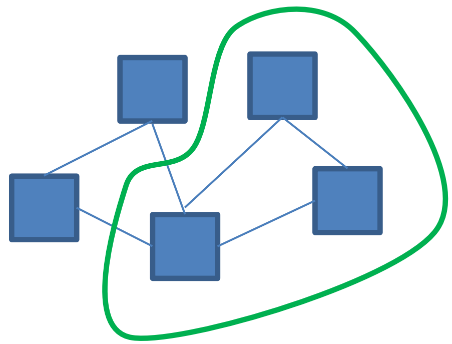
- Unit Testing



- Testing of individual modules in isolation

Testing Granularity Levels - Overview

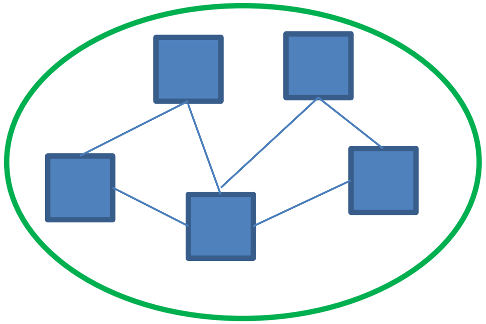
- Integration Testing



- Testing of a subset of modules taken together
  - Testing for interaction among the modules
  - Modules of the subset can be tested one at a time or all taken together (Big-bang)

Testing Granularity Levels - Overview

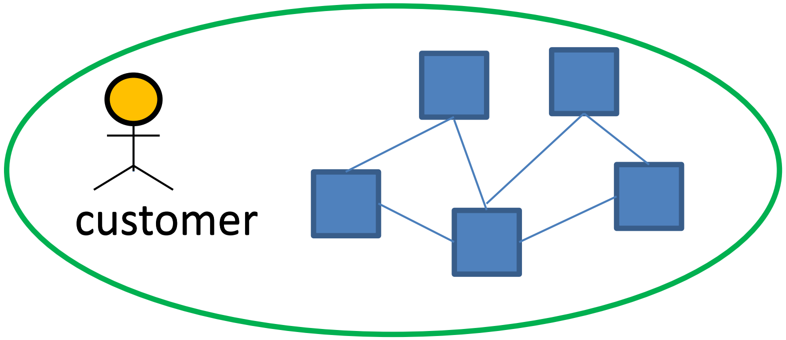
- System Testing



- Testing complete system as a whole: functional and non-functional requirements
  – Functional tests: test the functionality provided by the system
  – Non-functional tests: assess the "..ility" of the system – usability, reliability, maintainability etc.. e.g. load and stress tests

Testing Granularity Levels - Overview

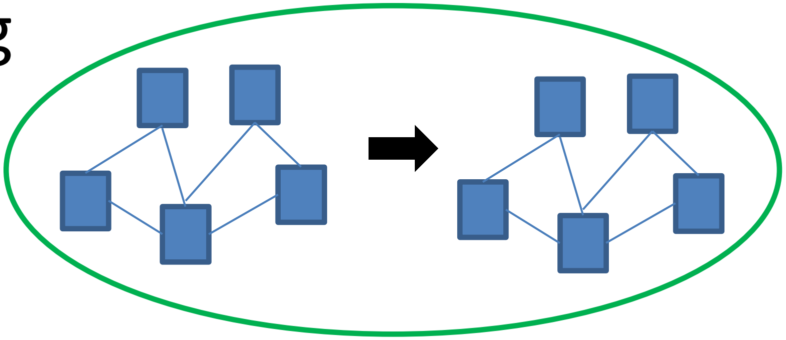
- Acceptance Testing



- Testing complete system as a whole: validation of software against customer requirements
  - System does what the customer expects it to do

Testing Granularity Levels - Overview

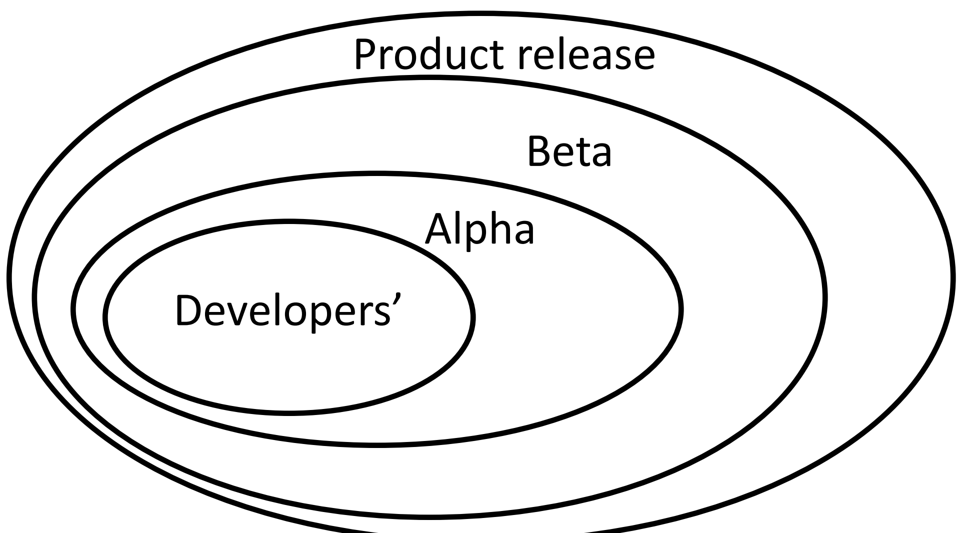
- Regression Testing



- Testing complete system as a whole: tests that check if some changes negatively affect the parts that have not changed
  - One of the causes why software maintenance is so expensive
  - Automation is an active research focus area

Alpha and Beta Testing

- Alpha Testing
  - Release the software to users within the organization for testing
  - Tolerance to bugs is fairly high
- Beta Testing
  - Release the software to a selected list of users outside org.



Black-box and White-box Testing

- Two families of test strategies
- Black-box testing: based on functionality
  - Do not look inside i.e. the code
  - Test against software description
  - Cannot reveal errors due to incorrect implementation
- White-box testing: based on code
  - test all control paths: sequence of code lines
  - Cannot reveal errors due to missing paths i.e. missing functionality

Black-box Testing Example

- Specification: `input an integer and print it`

```
void printNumBytes(int param)  {
  if ( param < 1024 )
      printf("%d",param);
  else
      printf("%d Kb",param/124)
}
```

- The implementation details are a grey-area
  - Cons: miss testing inputs that are > 1024
  - Pros: need not know the internal functionality to test

White-box testing would catch this typo.

White-box Testing Example

- Note: test without a specification

```
int fun(int param)  {
  int result;
  result = param / 2;
  return result;
}
```

  - Execute all statements in the function
  - Cons: miss catching an obvious error for a specification: `input an integer and return half the value if even. Unchanged otherwise.`

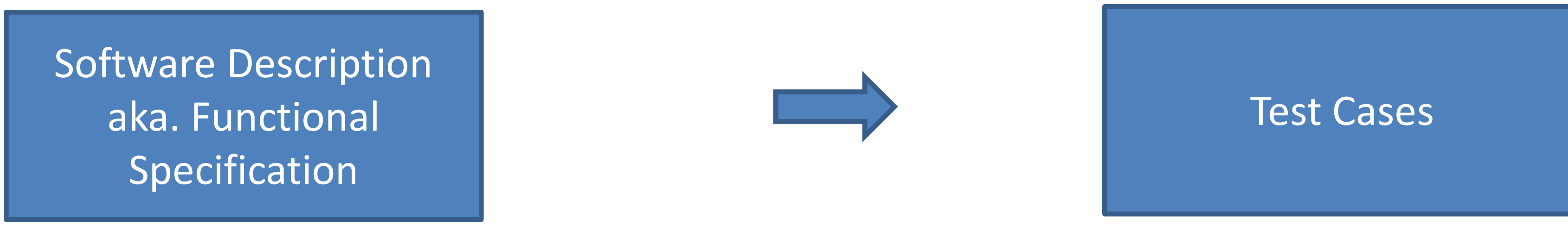
Focus: Black-box Testing

Black-box Testing

- Advantages:
  - Focuses on the domain
  - Does not need code. Helps you start early. Real advantage in real-life software development
  - Catches logic errors
  - Applicable at all granularity levels

We will focus on system testing at this point

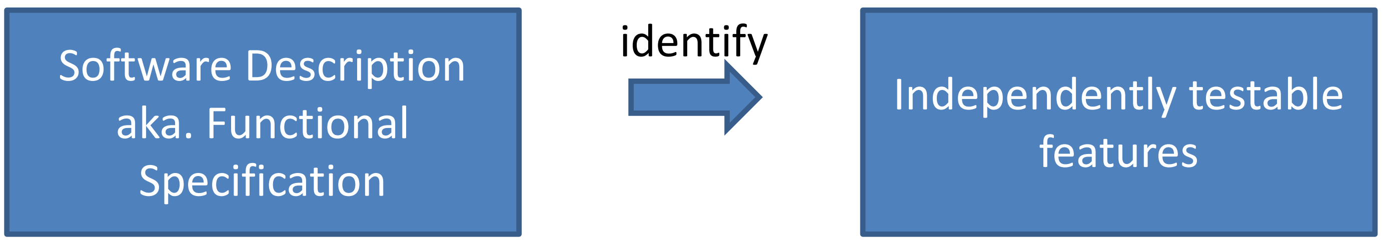
Black-box Testing – From Spec. to Test Cases



- **Input:** Function Spec.
- **Output:** Test Cases – <u>set of inputs</u> and <u>corresponding outputs</u> that we use to exercise our code to uncover bugs
- *Problem: How do we go from input to output?*
  - *Can be extremely complex*
- Solution: break the complexity
  - 4 main steps

From Spec. to Test Cases

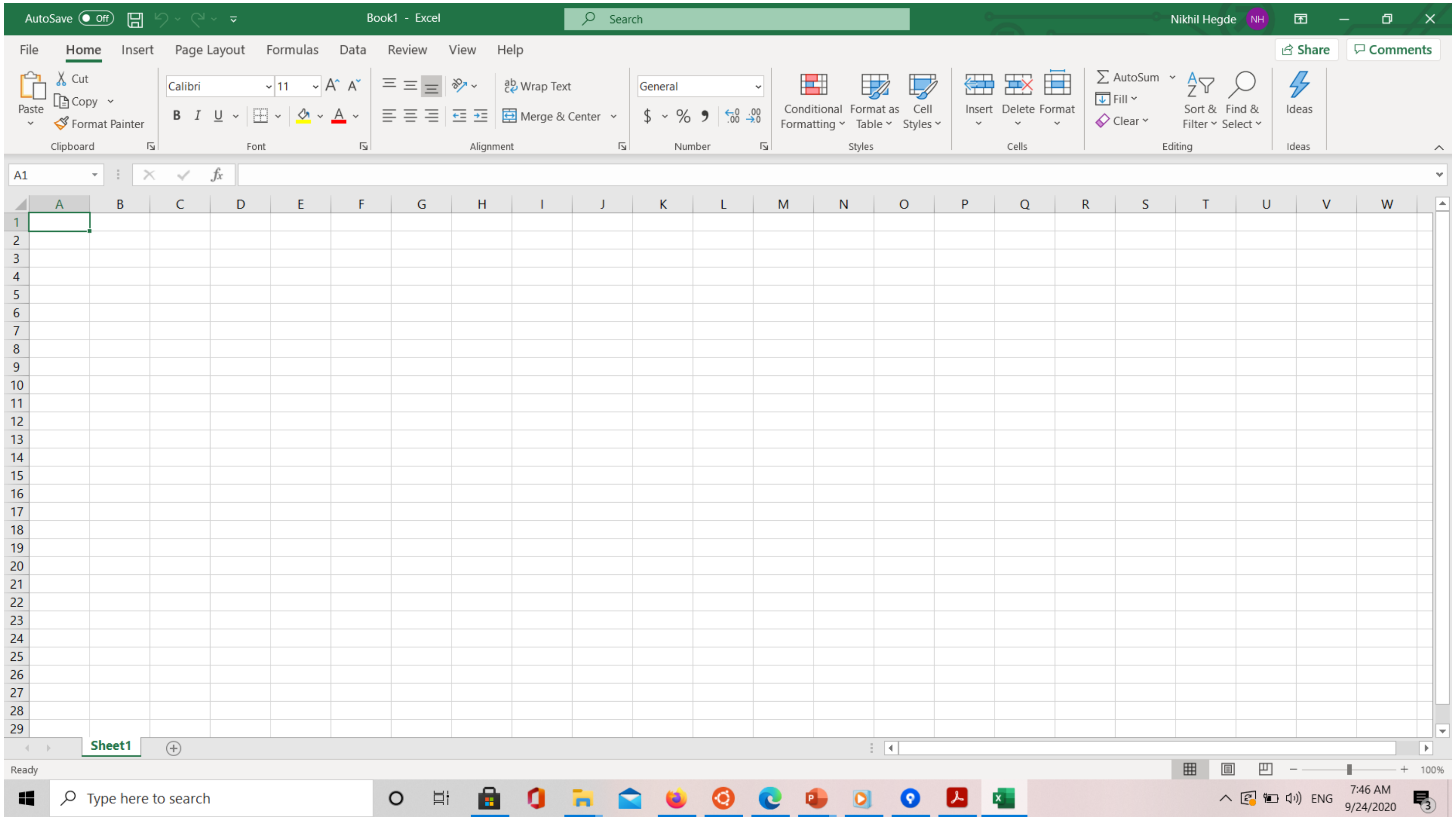
- **Step 1:** identify independently testable features



  - May not be possible to test all possible features at once
    - e.g. printing receipt after successful ATM transaction
  - How many features here?

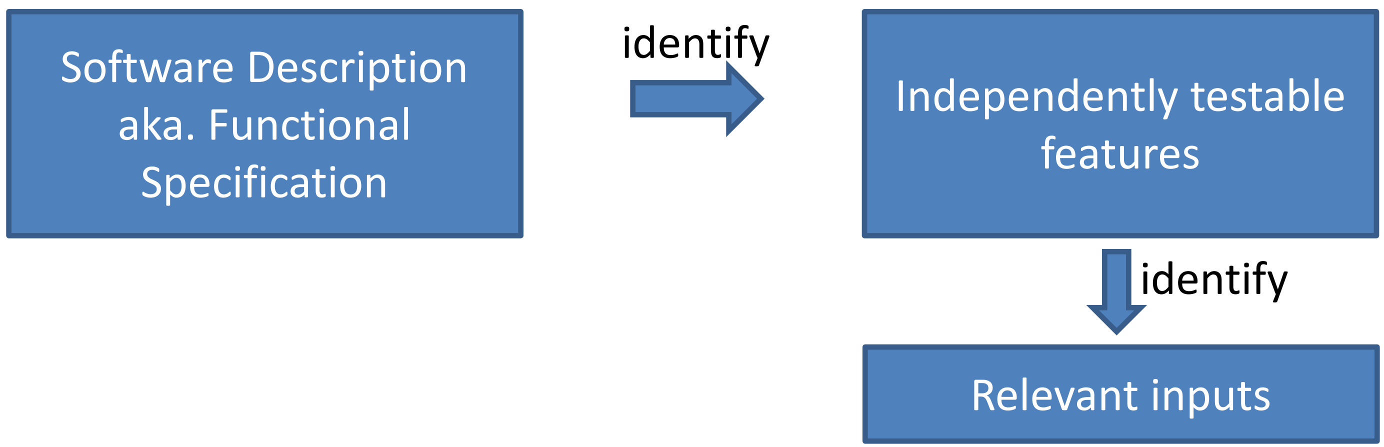
```
int sum(int a, int b)  {
   return a + b;
}
```

- How many features here (MS-Excel)?

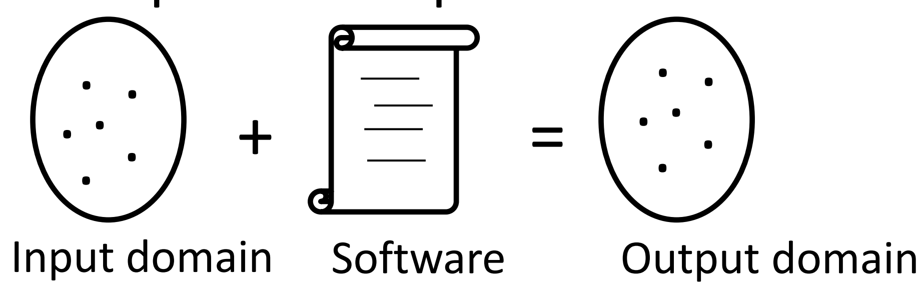


From Spec. to Test Cases

- **Step 2:** identify relevant inputs. Also called test data selection



- test cases = inputs + expected outputs



Test Data Selection – Naïve approach

- Test-them all !
  - Consider all inputs from the input domain (exhaustive testing)
  - Lay-man approach
- E.g. How long would it take to test the `sum` function exhaustively:

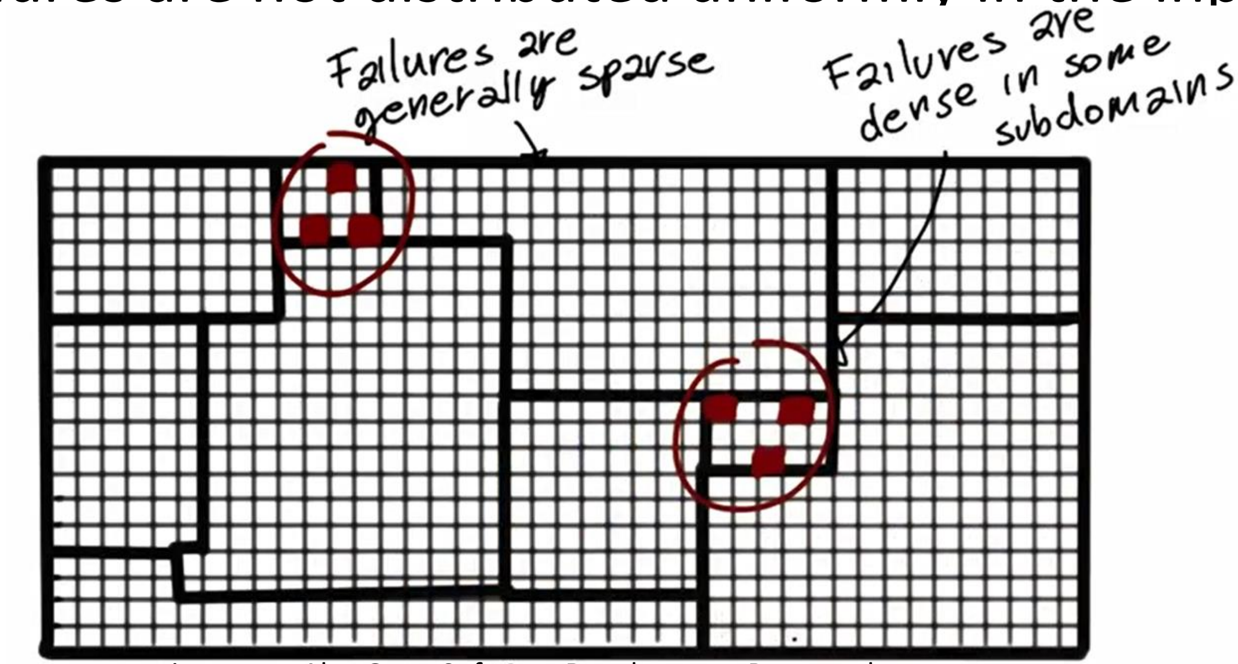
```
1. int sum(int a, int b)  {
2.    return a + b;
3.  }
```

~ *600 years!*

- *How can we select interesting inputs?*

Test Data Selection - partitioning

- Insight: failures are not distributed uniformly in the input domain!



pic source: Alex Orso, Software Development Process class notes

- Identify partitions and select inputs from each partition

Example – test data selection

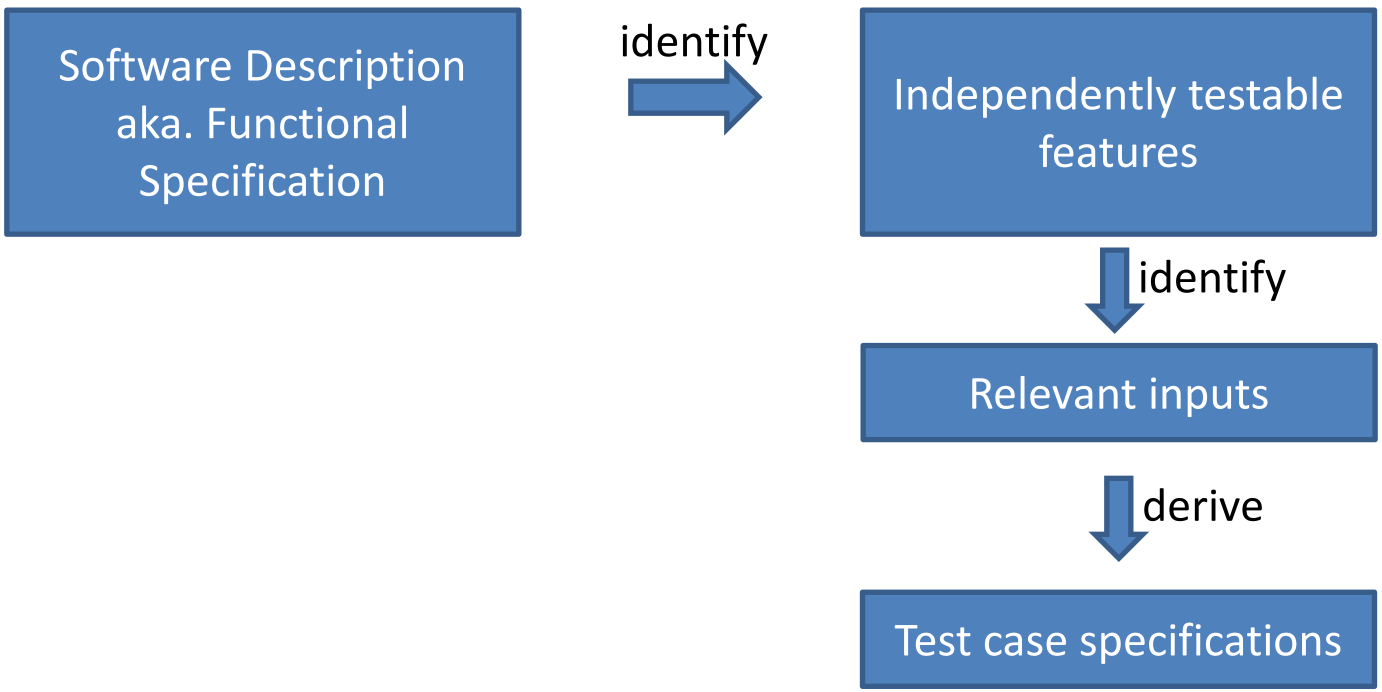
```
1. int Split(string str, int size)  {
2.    //split the input string str into chunks of
      //length size
3. }
```

- Some possible partitions:
  - `size < 0, size > 0, size = 0`
  - Note that testing for `size < 0` overcomes developer bias
  - `str` with length `< size`
  - `str` with length `= size` (boundary case)

Key: adapt based on domain and type of data

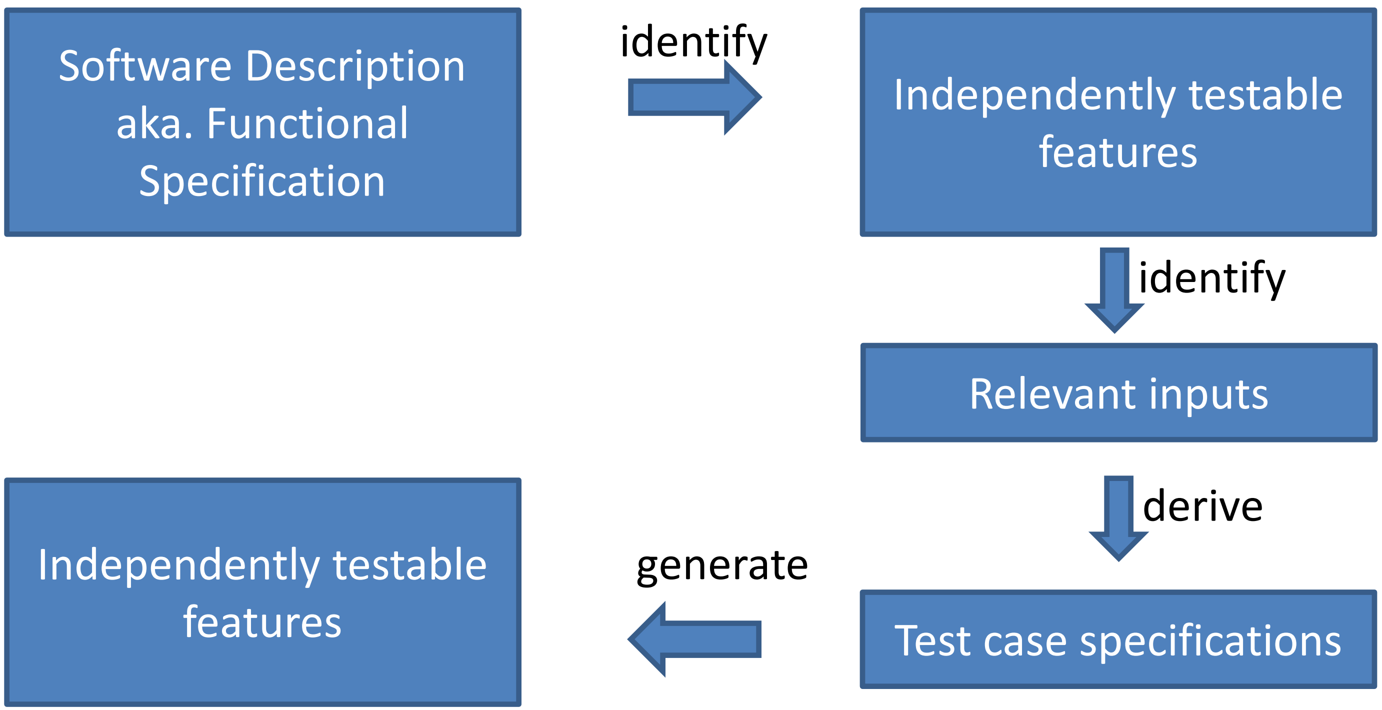
From Spec. to Test Cases

- **Step 3**: derive test case specifications



From Spec. to Test Cases

- **Step 4**: generate test cases from specifications



From Spec. to Test Cases

- The previously outlined approach is systematic:
  - Decoupling different activities
  - Separating analytical-intensive tasks from those that are not
  - Monitoring testing process e.g. not generating too many test cases