# UML: Unified Modeling Language

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# Modeling

- Describing a system at a high level of abstraction
  - A model of the system
  - Used for requirements and specification

- Many notations over time
  - State machines
  - Entity-relationship diagrams
  - Dataflow diagrams

# History: 1980's

- The rise of object-oriented programming
- New class of OO modeling languages
- By early '90's, over 50 OO modeling languages

# History: 1990's

- Three leading OO notations decide to combine
  - Grady Booch (BOOCH)
  - Jim Rumbaugh (OML: Object Modeling Technique)
  - Ivar Jacobsen (OOSE: OO Soft. Eng)
- Why?
  - Natural evolution towards each other
  - Effort to set an industry standard

# UML

- UML stands for

  Unified Modeling Language

- Design by committee
  - Many interest groups participating
  - Everyone wants their favorite approach to be "in"

# UML (Cont.)

- Resulting design is huge
  - Many features
  - Many loosely unrelated styles under one roof

- Could also be called

  Union of all Modeling Languages

## This Lecture

- We discuss
  - Use Case Diagrams for functional models
  - Class Diagrams for structural models
  - Sequence Diagrams
  - Activity Diagrams
  - State Diagrams

  for dynamic models
- This is a subset of UML
  - But probably the most used subset

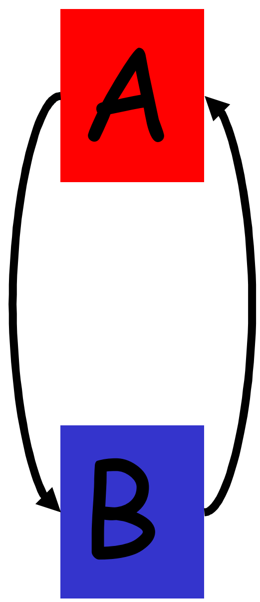
# Sources and more information

- Practical UML: A Hands-On Introduction for Developers – by Randy Miller
  - http://dn.codegear.com/article/31863
- UML 2 for Dummies – by Chonoles and Schardt
  - Available on books24x7 through home.nyu.edu
- Free UML tool
  - ArgoUML: http://argouml.tigris.org

## Running Example: Automatic Train

- Consider an unmanned people-mover
  - as in many airports
- Train
  - Moves on a circular track
  - Visits each of two stations (A and B) in turn
  - Each station has a “request” button
    - To stop at this station
  - Each train has two “request” buttons
    - To stop at a particular station

# Picture



## Use-Cases

- Describe functionality from the user's perspective

- One (or more) use-cases per kind of user
  - May be many kinds in a complex system

- Use-cases capture requirements

# An Example Use-Case in UML

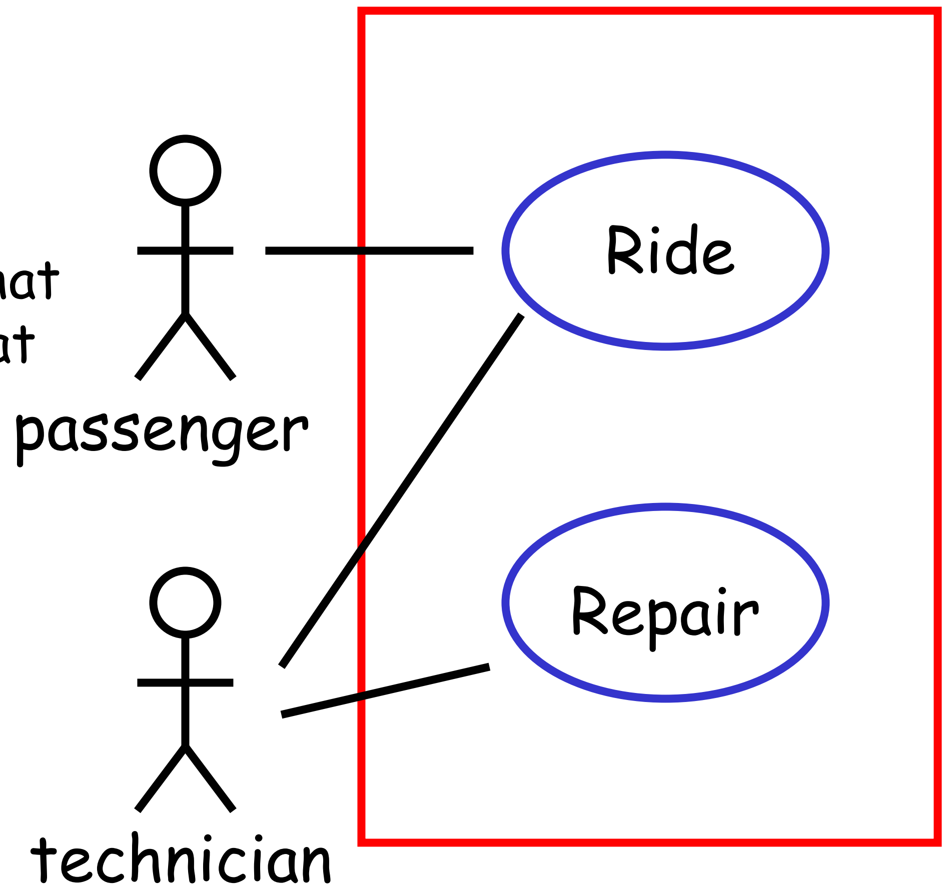
- Name
  - Normal Train Ride
- Actors
  - Passenger
- Entry Condition
  - Passenger at station
- Exit Condition
  - Passenger leaves station

## An Example Use-Case in UML

- Event-flow
  - Passenger presses request button
  - Train arrives and stops at platform
  - Doors open
  - Passenger steps into train
  - Doors close
  - Passenger presses request button for final stop
  - …
  - Doors open at final stop
  - Passenger exits train
- Nonfunctional requirements

# Use Case Diagram

- Graph showing
  - Actors
  - Use cases
  - Edges actor-case if that actor is involved in that case



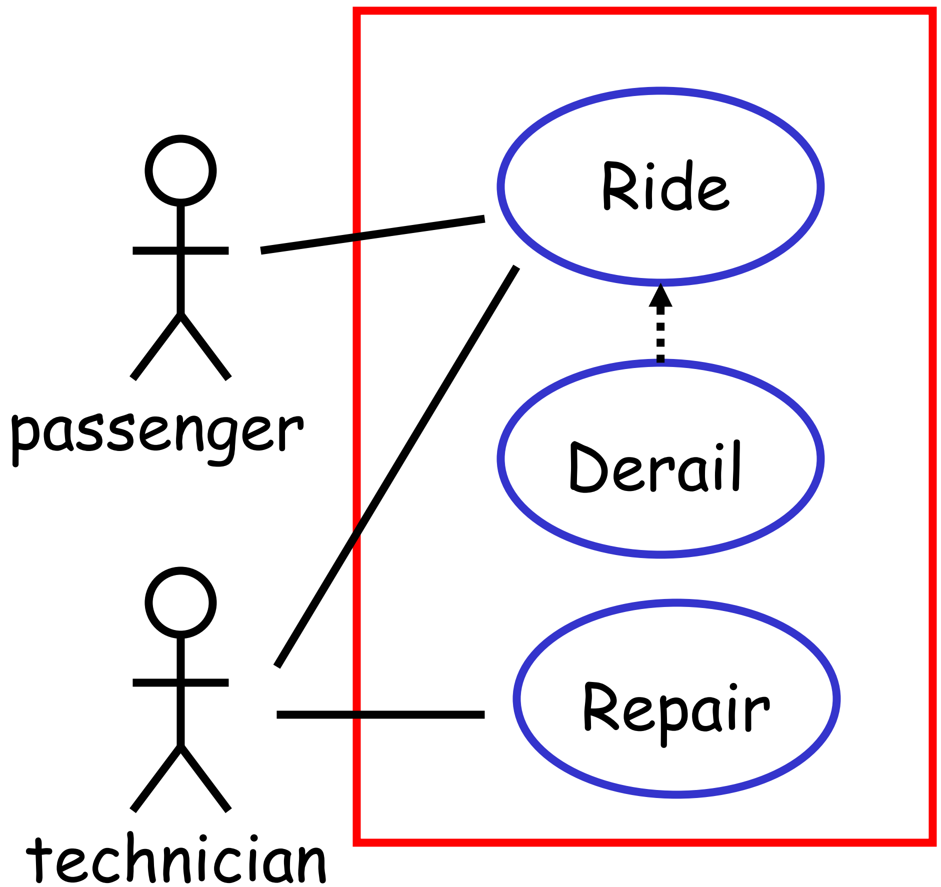

- Actors
  - Stick figures
- Use cases
  - Ovals

# Exceptional Situations

- Use cases have relationships
  - Inclusion (E.g., push button included in ride)
  - Variations

- UML has a special notation
  - The "extends" relationship to express a exceptional variation of a use case
  - Normally used to express errors

# Extension




*Dotted arrow pointing to "normal" case*

## Summary of Use Cases

- Use Case Diagram
  - Shows all actors, use cases, relationships
  - Actors are agents external to the system
    - E.g., users

- Supplemental information
  - Entry/Exit Conditions, Story, Main and Alternative flows, Nonfunctional requirements
  - Specified in a separate document
    - In English

# Class Diagrams

- Describe classes
  - In the OO sense
- Each box is a class
  - List fields
  - List methods
- The more detail, the more like a design it becomes

| Train |
|---|
| lastStop<br>nextStop<br>velocity<br>doorsOpen? |
| addStop(stop);<br>startTrain(velocity);<br>stopTrain();<br>openDoors(); |

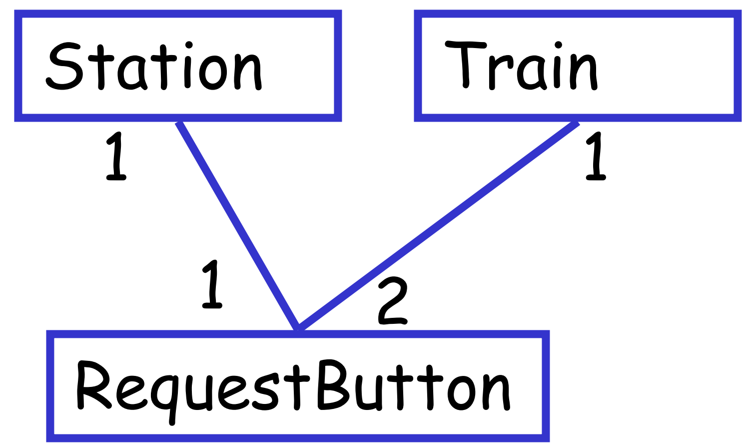
# Class Diagrams: Relationships

- Many different kinds of edges to show different relationships between classes

- Mention just a couple

# Associations

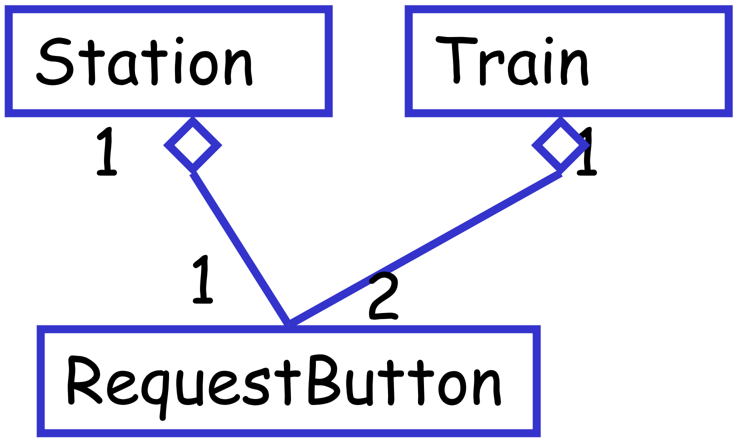
- Capture n-m relationships
  - Subsumes ER diagrams
- Label endpoints of edge with cardinalities
  - Use * for arbitrary
- Typically realized with embedded references
- Can be directional (use arrows in that case)




*One request button per station; each train has two request buttons*

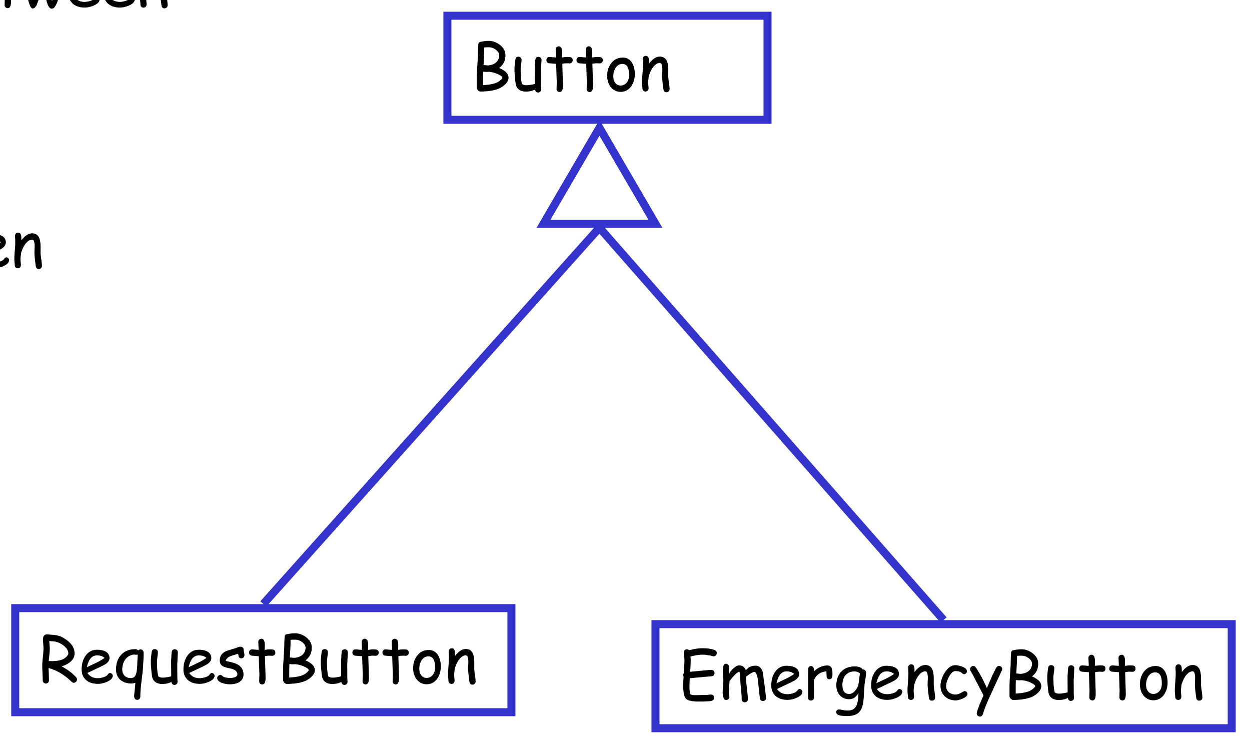
# Aggregation

- Show *contains a* relationships
- Station and Train classes can contain their respective buttons
- Denoted by open diamond on the "contains" side



# Generalization

- Inheritance between classes
- Denoted by open triangle



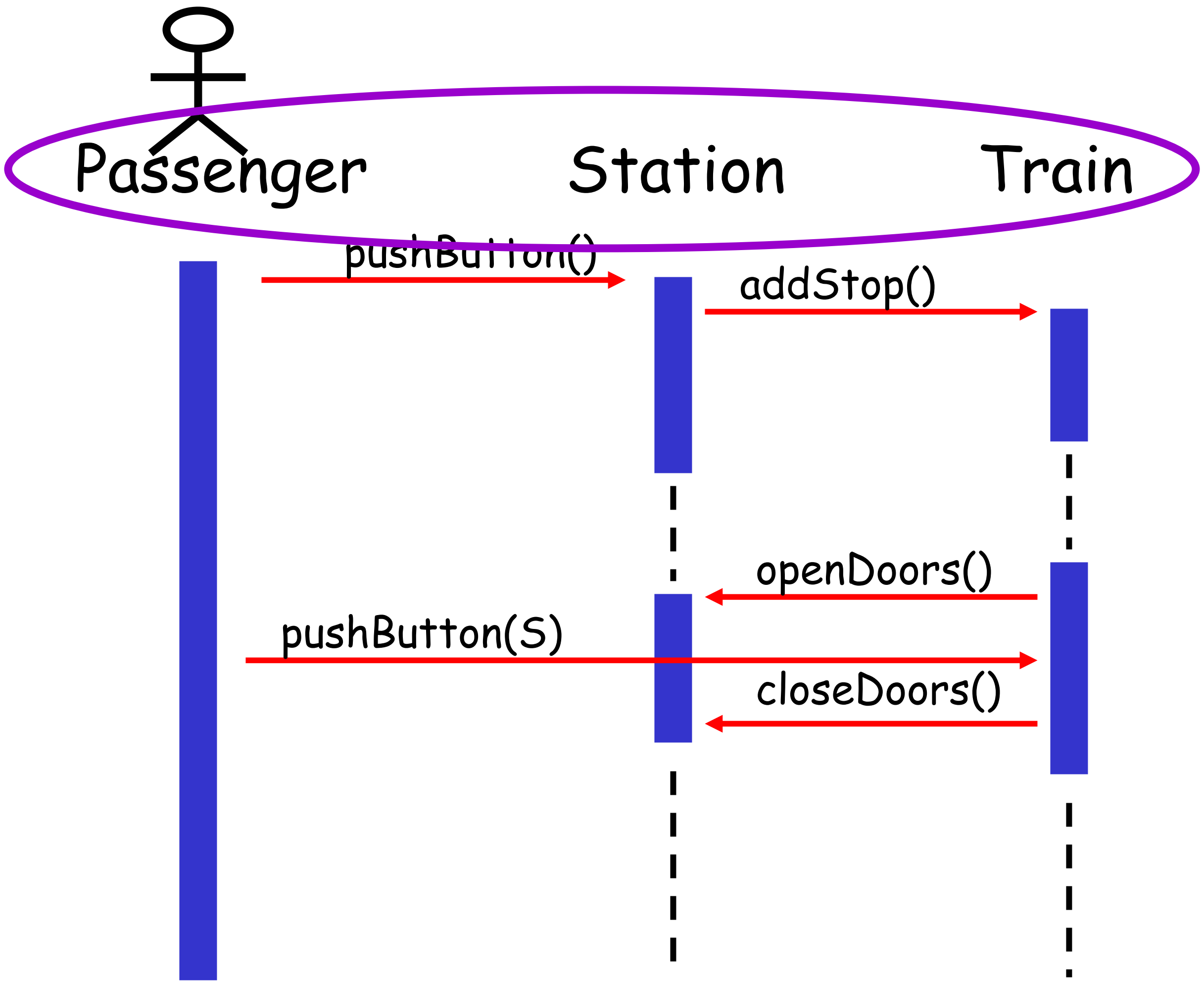
## More about Class Diagrams

- Classes vs Objects
  - Same diagrams can be used to specify relationships between instances of classes
- Roles and Association Classes
  - More detail on relationships between classes
- Hierarchical Diagrams

## Sequence Diagrams

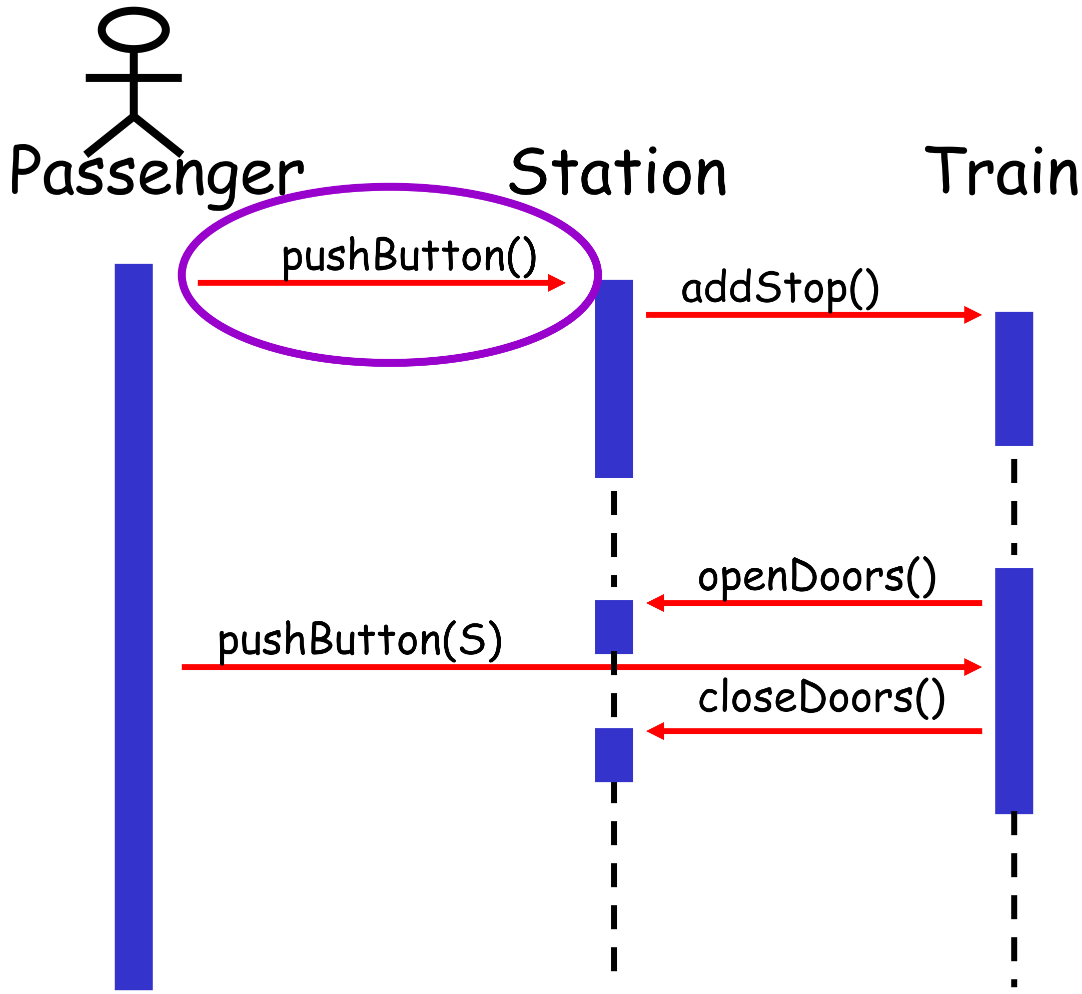
- A table
  - Columns are classes or actors
  - Rows are time steps
  - Entries show control/data flow
    - Method invocations
    - Important changes in state

# Example Sequence Diagram




*Classes & Actors*

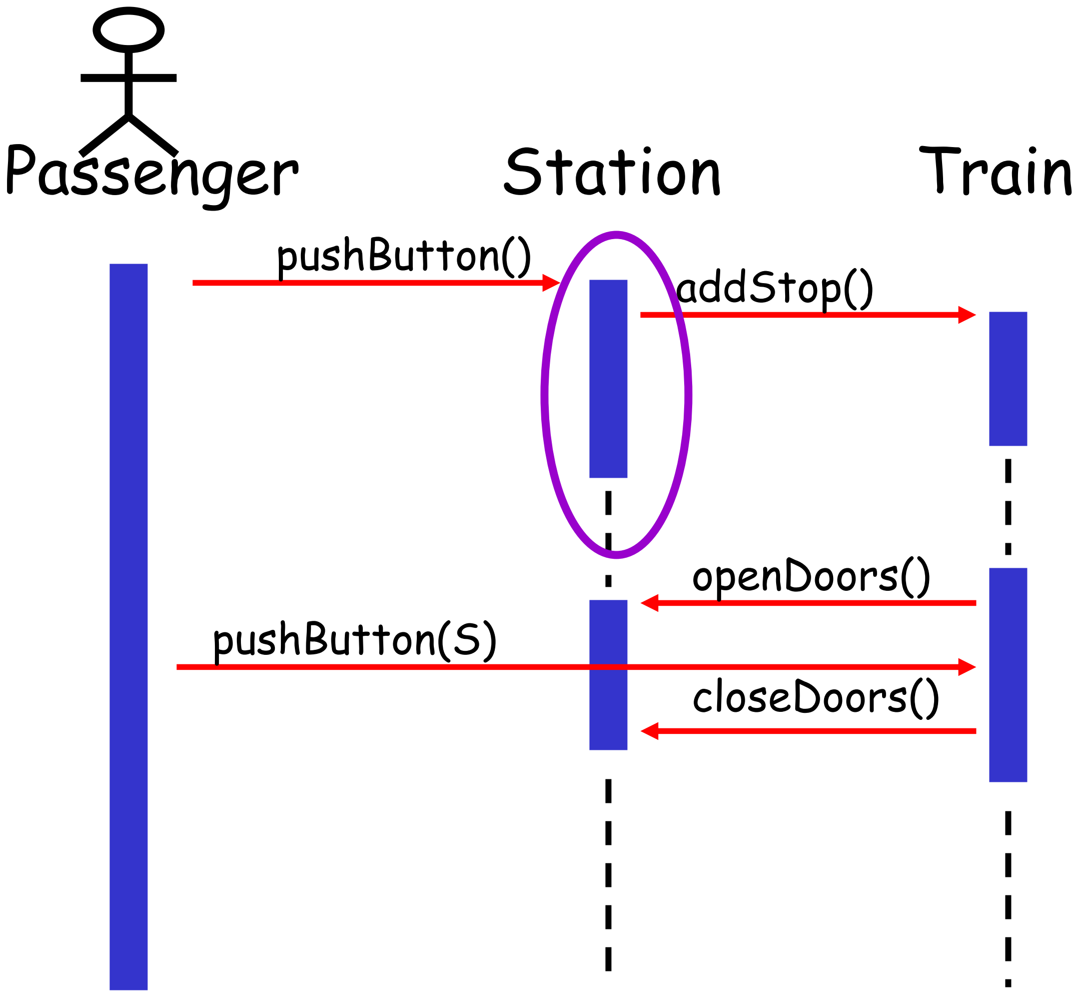
# Example Sequence Diagram




*Method invocation*

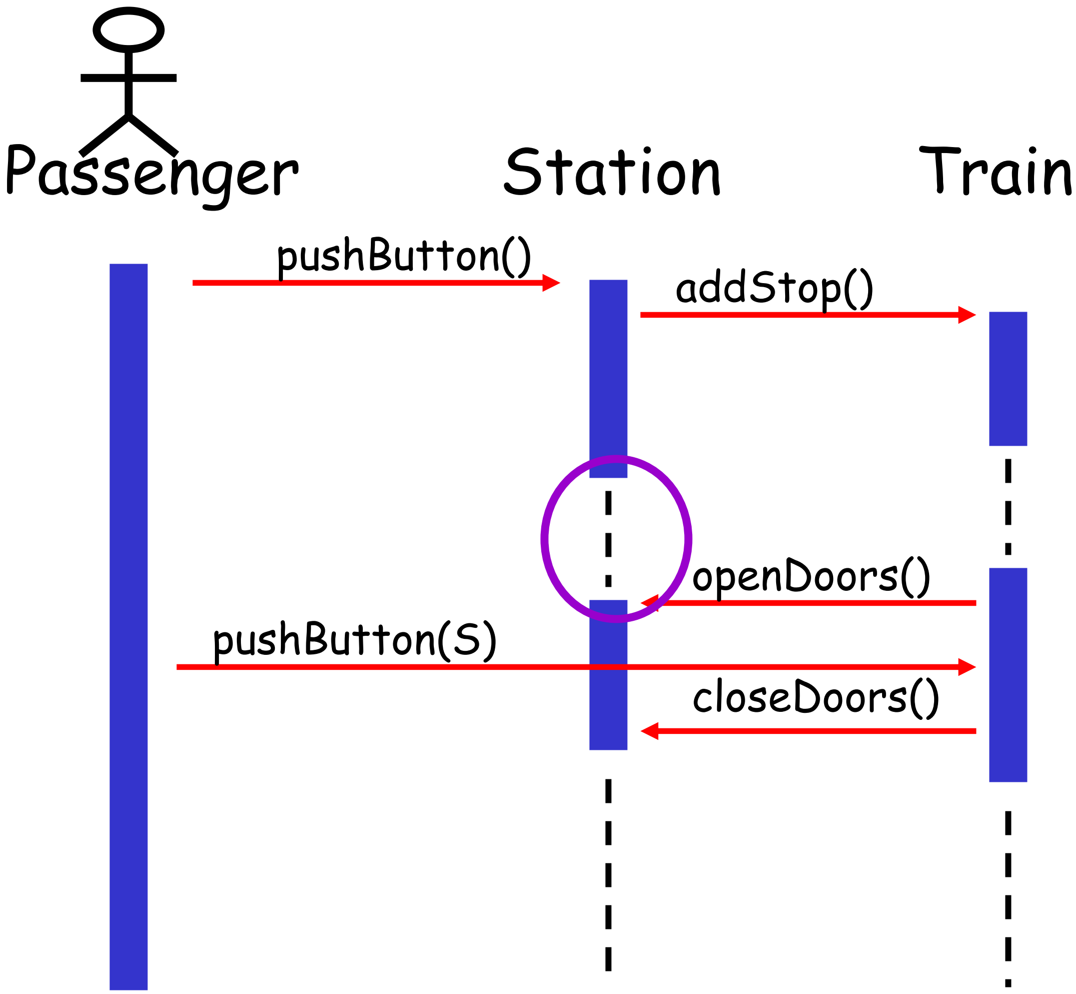
*Note: These are all synchronous method calls. There are other kinds of invocations.*

# Example Sequence Diagram




*Invocation lifetime spans lifetimes of all nested invocations*

# Example Sequence Diagram




*"Lifelines" fill in time between invocations*

# Sequence Diagrams Notes

- Sequence diagrams
  - Refine use cases
  - Gives view of dynamic behavior of classes
    - Class diagrams give the static class structure

- Not orthogonal to other diagrams
  - Overlapping functionality
  - True of all UML diagrams

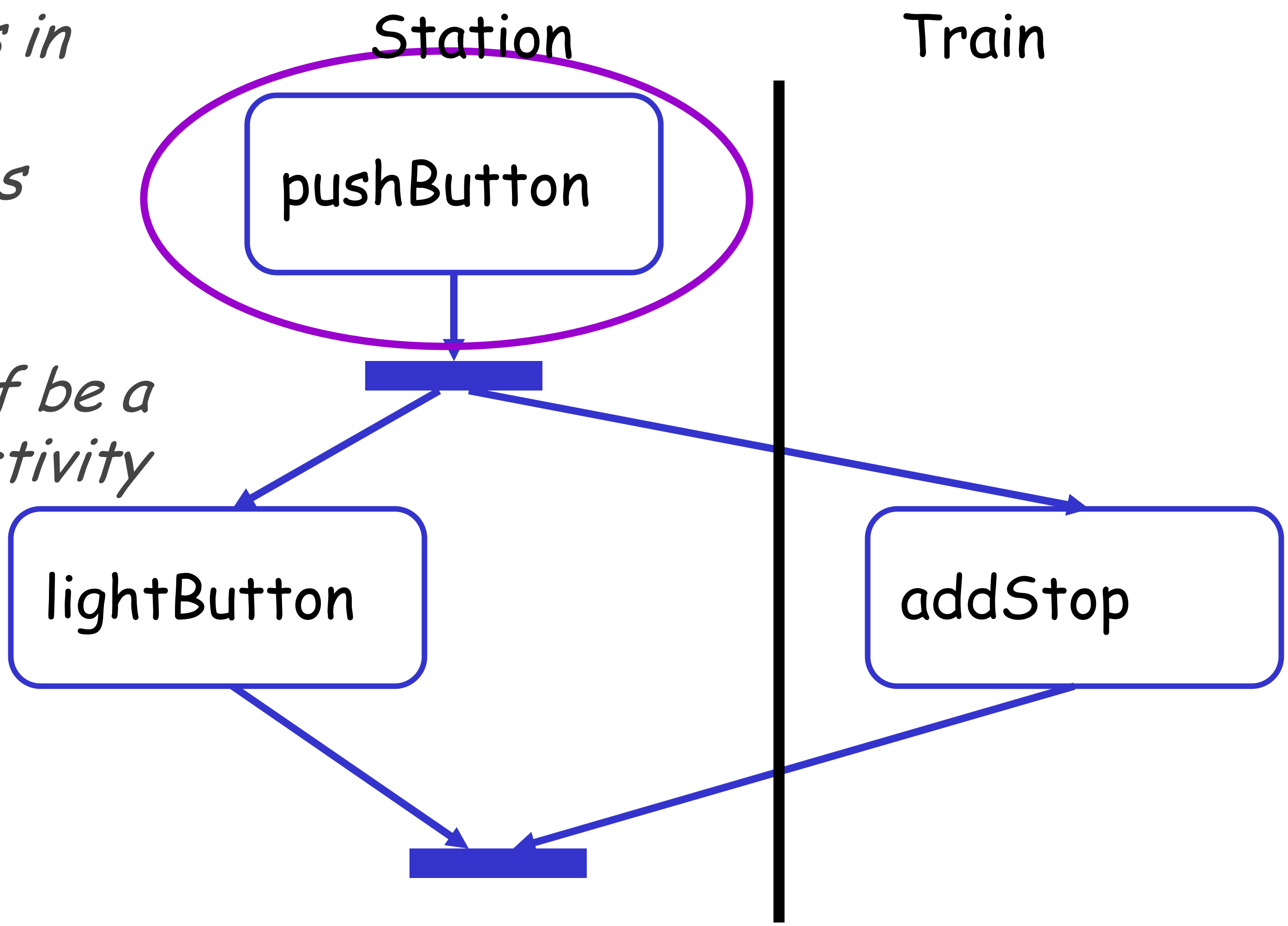
# Activity Diagrams

- Reincarnation of flow charts
  - Uses flowchart symbols
- Emphasis on control-flow
- Two useful flowchart extensions
  - Hierarchy
    - A node may be an activity diagram
  - Swim lanes

# Example Activity Diagram

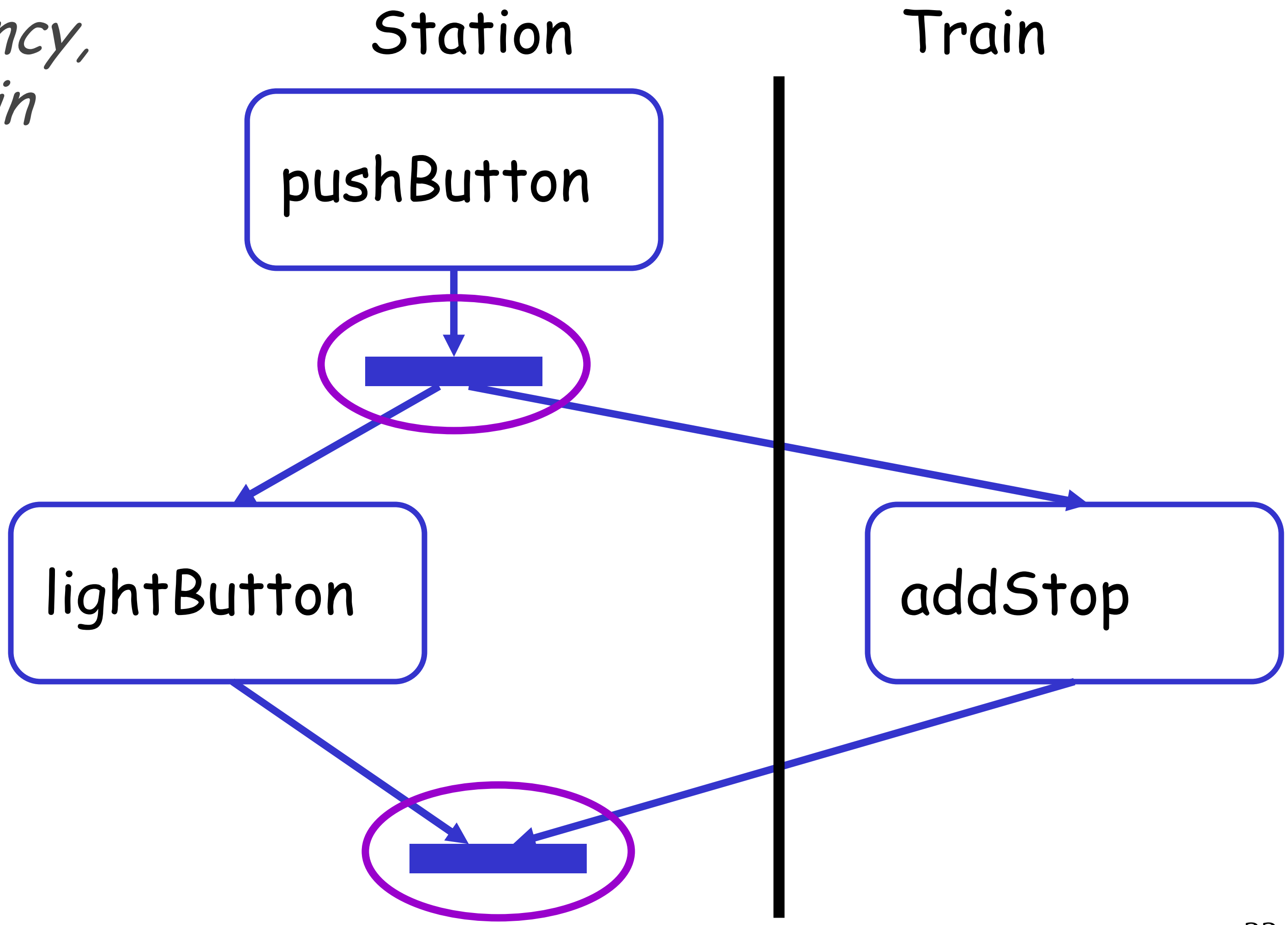
*Activities in rounded rectangles*

*May itself be a nested activity diagram*



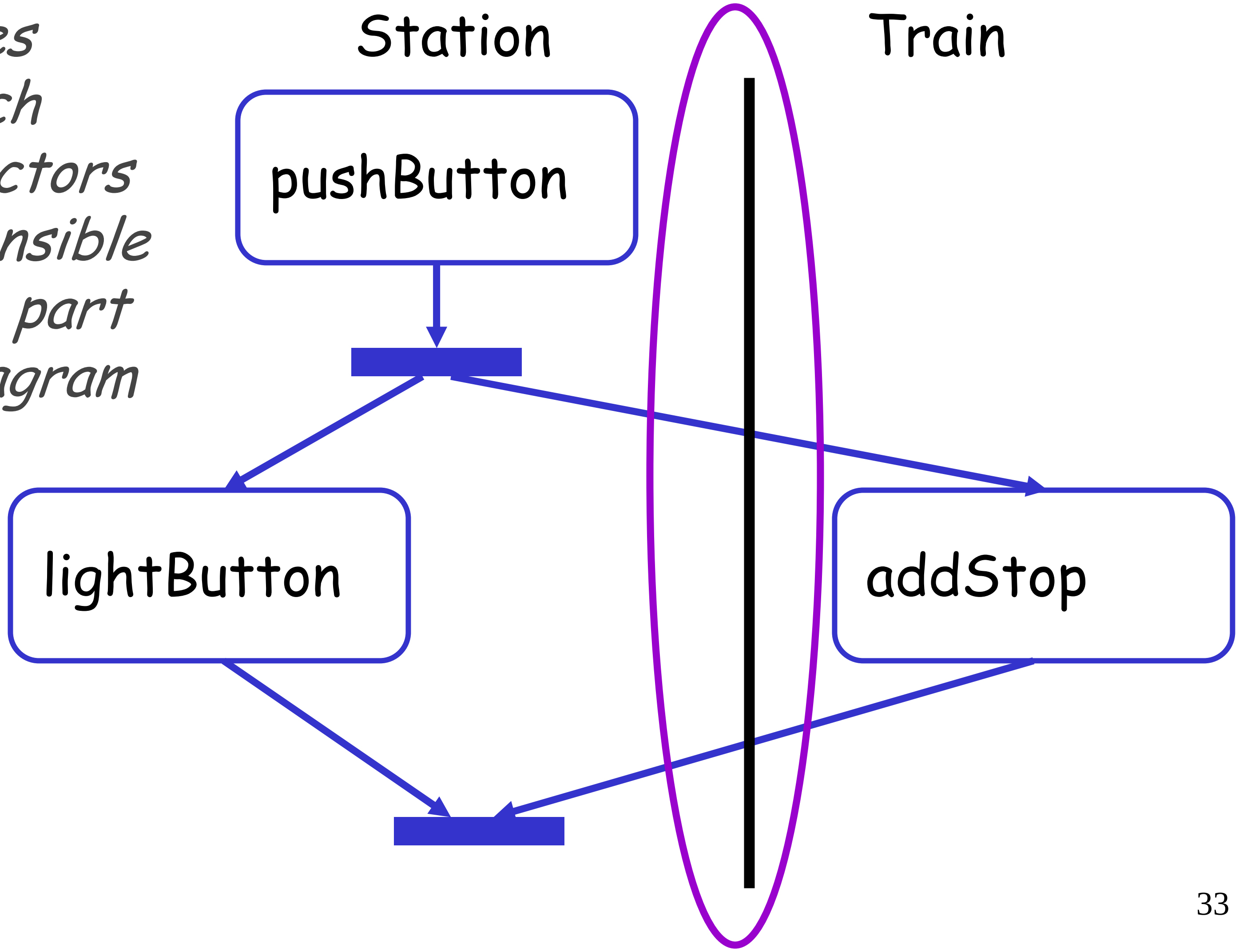
# Example Activity Diagram

*Concurrency, fork & join*



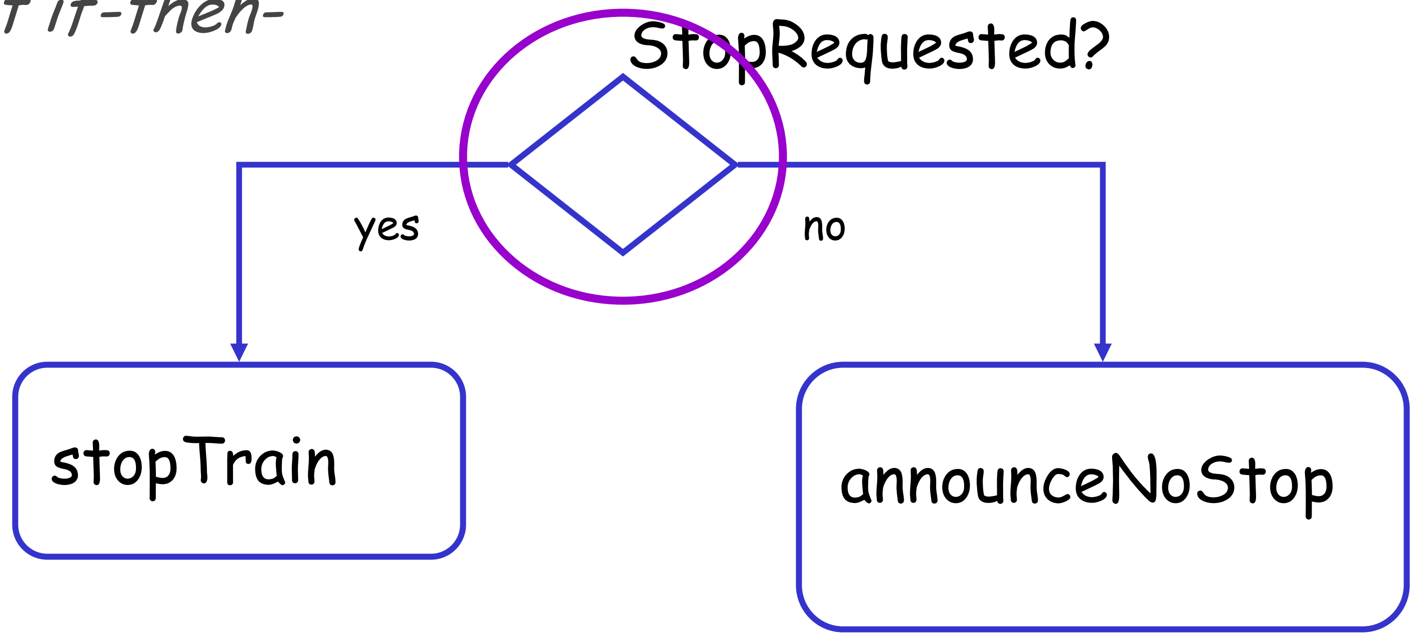
# Example Activity Diagram

*Swim lanes show which classes/actors are responsible for which part of the diagram*



# Another Example Activity Diagram

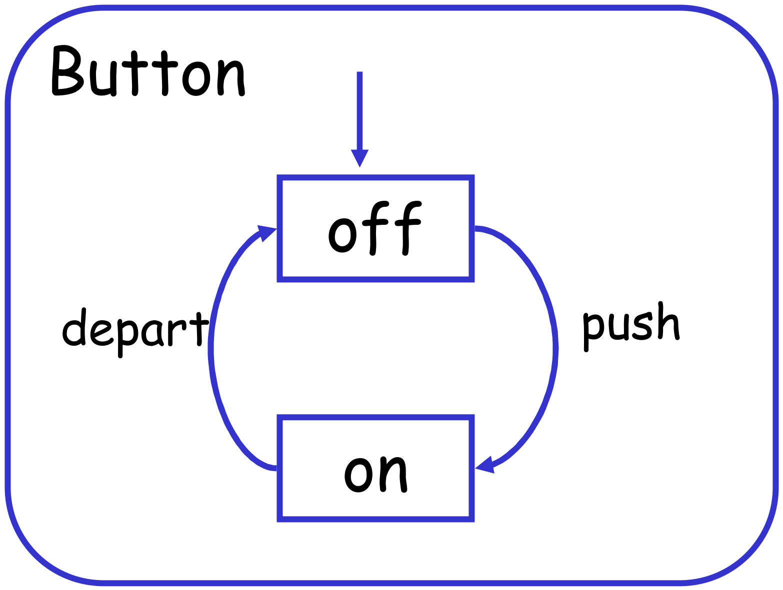
*Classic flow-chart if-then-else*



# StateCharts

- Hierarchical finite automata
  - Invented by David Harel, 1983
- Specify automata with many states compactly
- Complications in meaning of transitions
  - What it means to enter/exit a compound state

# Example Simple StateChart



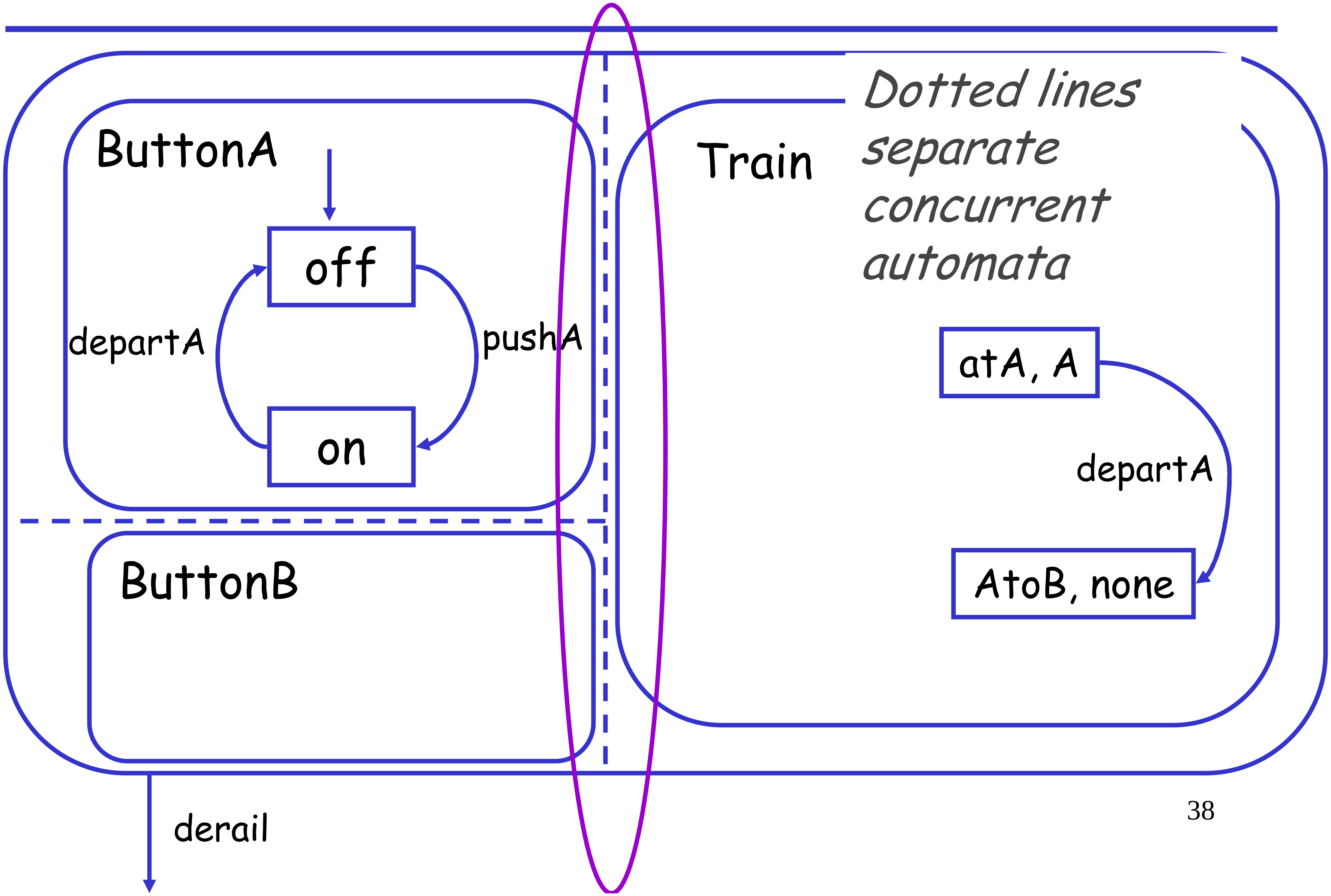
## StateChart for the Train

- A train can be
  - At a station (atA, atB)
  - Between stations (AtoB, BtoA)

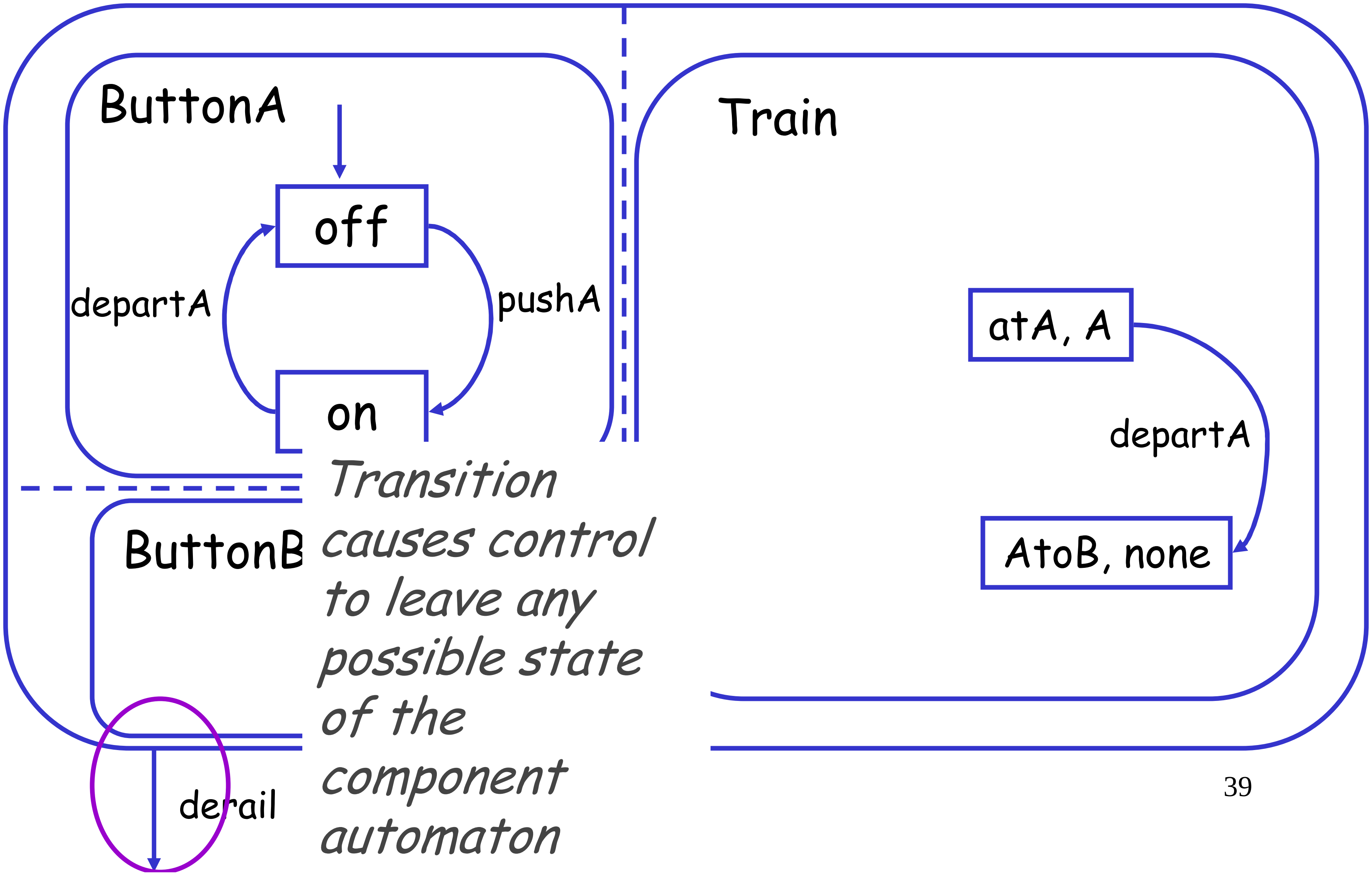
- Pending requests are subset of {A,B}

- 16 possible states
  - Transitions: pushA, pushB, departA, departB, …

# StateChart for Buttons + Train



# StateChart for Buttons + Train




*Transition causes control to leave any possible state of the component automaton*

# Opinions about UML: What's Good

- A common language
  - Makes it easier to share requirements, specs, designs
- Visual syntax is useful, to a point
  - A picture is worth 1000 words
  - For the non-technical, easier to grasp simple diagrams than simple pseudo-code
- To the extent UML is precise, forces clarity
  - Much better than natural language
- Commercial tool support
  - Something natural language could never have

# Opinions On UML: What's Bad

- Hodge-podge of ideas
  - Union of most popular modeling languages
  - Sublanguages remain largely unintegrated
- Visual syntax does not scale well
  - Many details are hard to depict visually
    - Ad hoc text attached to diagrams
  - No visualization advantage for large diagrams
    - 1000 pictures are very hard to understand
- Semantics is not completely clear
  - Some parts of UML underspecified, inconsistent
  - Plans to fix

## UML is Happening

- UML is being widely adopted
  - By users
  - By tool vendors
  - By programmers
- A step forward
  - Seems useful
  - First standard for high-levels of software process
  - Expect further evolution, development of UML

# Suggestions on using UML

- Requirements
  - Use Case Diagrams to illustrate use cases
  - Activity or Sequence Diagrams to illustrate typical flow within a use case (scenarios)

- Design
  - Class Diagram for system architecture

# Presentations (Requirements)

- 20 minutes/presentation
  - Enough time to give some details
- Format
  - 15 minute presentation
  - 5 minutes Q&A
- Try to make your presentation useful
  - It is a plus to share negative experiences, perhaps with solutions

# Presentation 1: Requirements: ~10 slides

1. Project name and name of speaker
2. What does it do?
   - Brief description of what project will do
3. Who are the customers?
   - List of customers you have contacted
   - Comments on each
4. What are the requirements?
   - Bulleted list, use cases
5. What are the problems?
   - What don't you know how to solve yet?

- HTML, PDF, or PowerPoint
- Email to barrett@cs by 10am on the day of presentations.

# Presentation 2: Design: ~10 slides, 20 min.

1. Project name and name of speaker
    - Different speaker than last time
2. How has the spec. changed
    - If nothing, say "none"
3. Design
4. Plan
    - Implementation and testing plan
5. What are the problems?
    - What don't you know how to solve yet?

- HTML, PDF, or Powerpoint
- Email to barrett@*cs* by 10 a.m. on the day of the presentation

# Presentations 3&4: Testing, Final Report

1. Different speakers (so everyone gets a chance)
2. More information on these coming later