Module 2: Introduction to UML

- Background
- What is UML for?
- Building blocks of UML
- Appendix: Process for Using UML

UML History

- OO languages appear mid 70's to late 80's (cf. Budd: communication and complexity)

- Between '89 and '94, OO methods increased from 10 to 50.

- Unification of ideas began in mid 90's.
    - Rumbaugh joins Booch at Rational '94
  - v0.8 draft Unified Method '95
    - Jacobson joins Rational '95
  - UML v0.9 in June '96

pre-UML

  - UML 1.0 offered to OMG in January '97
  - UML 1.1 offered to OMG in July '97
    - Maintenance through OMG RTF
  - UML 1.2 in June '98
  - UML 1.3 in fall '99
  - UML 1.5 http://www.omg.org/technology/documents/formal/uml.htm

UML 1.x

  - UML 2.0 underway http://www.uml.org/

UML 2.0

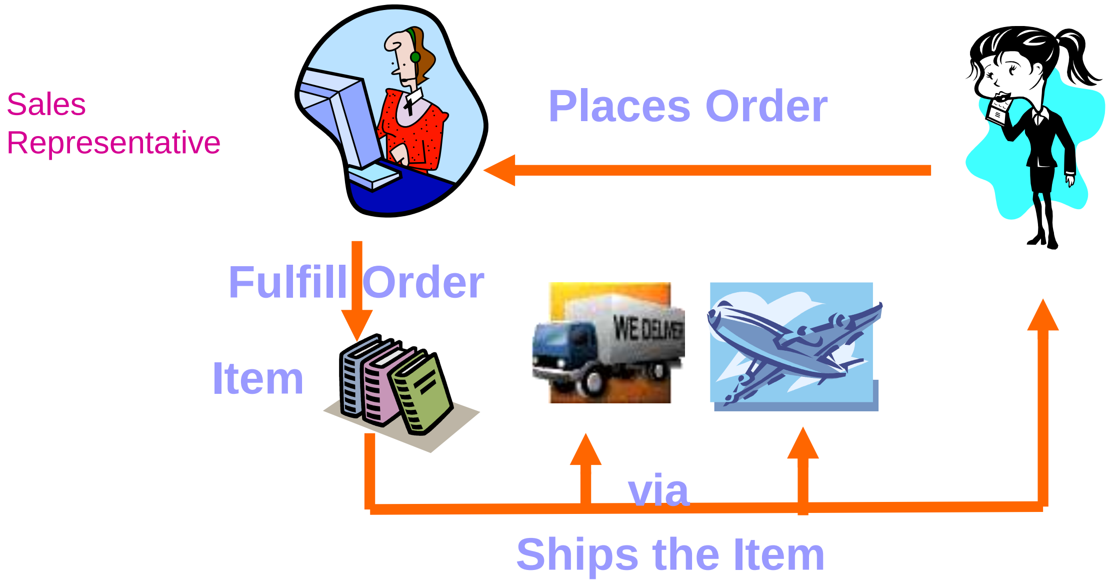
- IBM-Rational now has *Three Amigos*
  - Grady Booch - Fusion
  - James Rumbaugh – Object Modeling Technique (OMT)
  - Ivar Jacobson – Object-oriented Software Engineering: A Use Case Approach (Objectory)
  - (And David Harel - StateChart)

- Rational Rose http://www-306.ibm.com/software/rational/

UML is for Visual Modeling

A picture is worth a thousand words!

- standard graphical notations: Semi-formal
- for modeling enterprise info. systems, distributed Web-based applications, real time embedded systems, …



Sales Representative

Places Order

Customer

Fulfill Order

Item

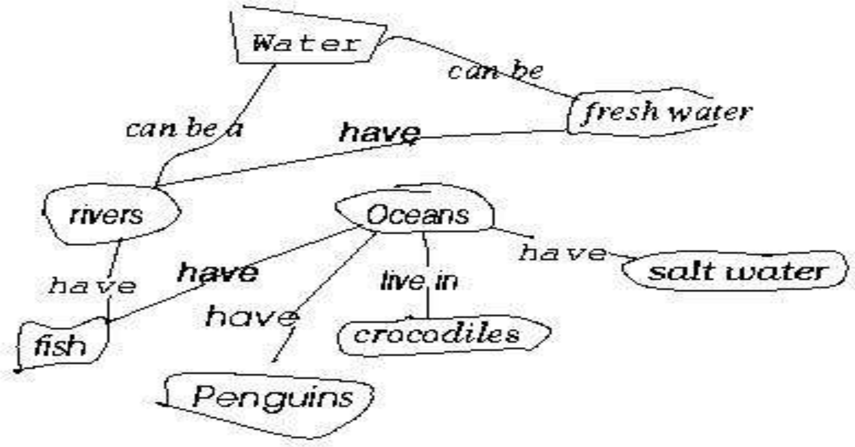
via

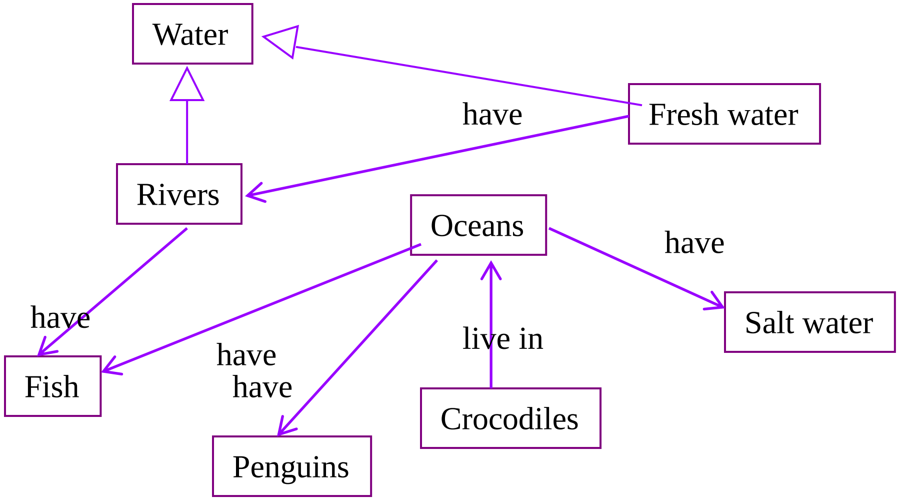
Ships the Item

Business Process

- ***Specifying & Documenting:*** models that are precise, unambiguous, complete
  - □ UML symbols are based on well-defined syntax and semantics.
  - □ analysis, architecture/design, implementation, testing decisions.
- ***Construction:*** mapping between a UML model and OOPL.

Three (3) basic ***building blocks*** of UML (cf. Harry)





Water

Fresh water

have

Rivers

Oceans

have

Salt water

have

Fish

have

have

live in

Crocodiles

Penguins

- □ Things - important modeling concepts
- □ Relationships - tying individual things

Just glance thru for now

- □ Diagrams - grouping interrelated collections of things and relationships

3 basic building blocks of UML - Things

- UML 1.x
  - □ Structural — nouns/static of UML models (irrespective of time).
  - □ Behavioral — verbs/dynamic parts of UML models.

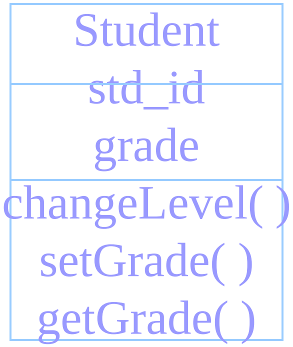
Main

  - □ Grouping — organizational parts of UML models.
  - □ Annotational — explanatory parts of UML models.

Structural Things in UML- *7 Kinds* *(Classifiers)*

- Nouns.
- Conceptual or physical elements.

Class



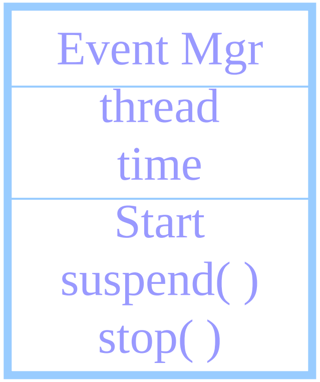
Student

std_id
grade

changeLevel( )
setGrade( )
getGrade( )

Active Class

(processes/threads)



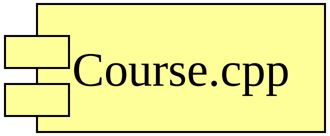
Event Mgr

thread
time

Start
suspend( )
stop( )

Component

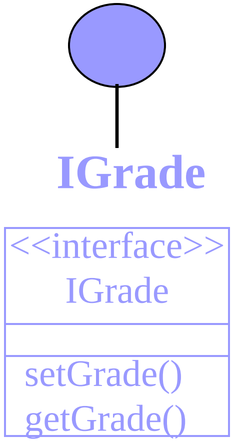
(replaceable part, realizes interfaces)



Course.cpp

Interface

(collection of externally Visible ops)



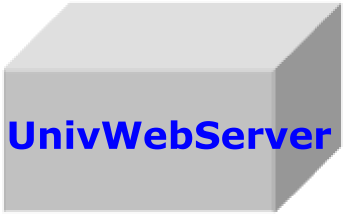
IGrade

<<interface>>
IGrade

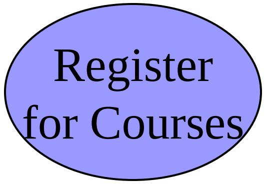
setGrade()
getGrade()

Node

(computational resource at run-time, processing power w. memory)



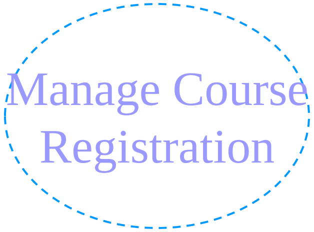
UnivWebServer



Register for Courses

Use Case

(a system service -sequence of Interactions w. actor)



Manage Course Registration

Collaboration

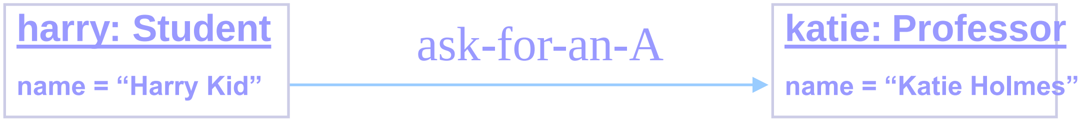
(chain of responsibility shared by a web of interacting objects, structural and behavioral)

Behavioral Things in UML

- Verbs.
- Dynamic parts of UML models: "behavior over time"
- Usually connected to structural things.

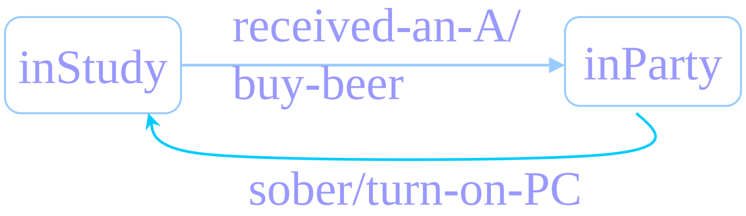
- Two primary kinds of behavioral things:
  - ***Interaction***

    a set of objects exchanging messages, to accomplish a specific purpose.



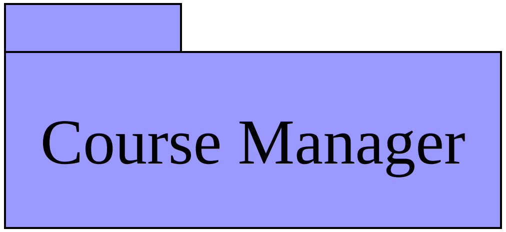
  - ***State Machine***

    specifies the sequence of states an object or an interaction goes through during its lifetime in response to events.

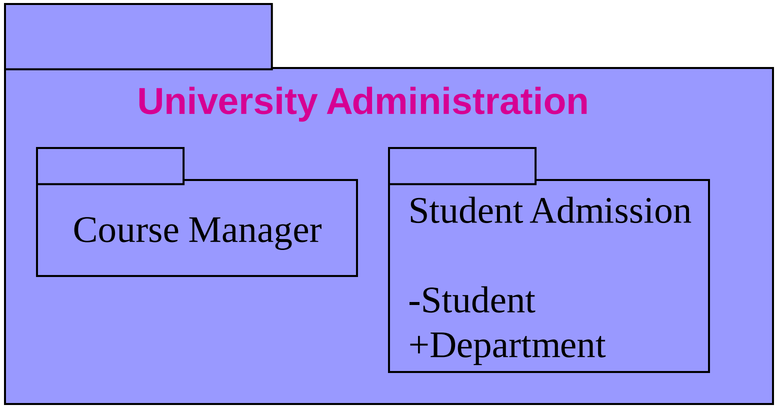


Grouping Things in UML: ***Packages***

- For organizing elements (structural/behavioral) into groups.
- Purely conceptual; only exists at development time.
- Can be nested.
- Variations of packages are: Frameworks, models, & subsystems.



Course Manager



University Administration

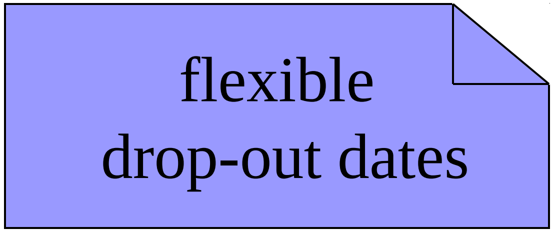
Course Manager

Student Admission

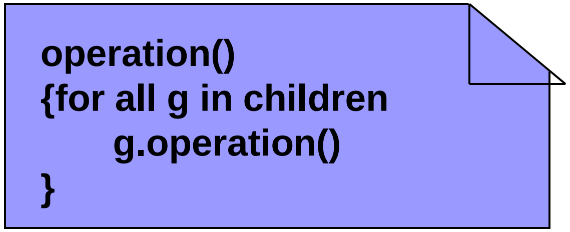
-Student
+Department

Annotational Things in UML: ***Note***

- Explanatory/Comment parts of UML models - usually called adornments
- Expressed in informal or formal text.

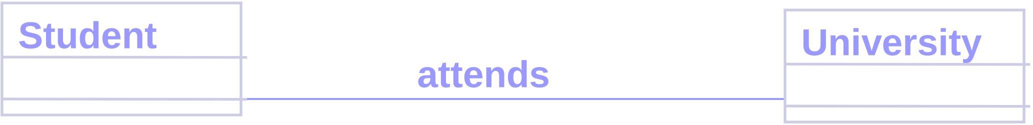


flexible
drop-out dates



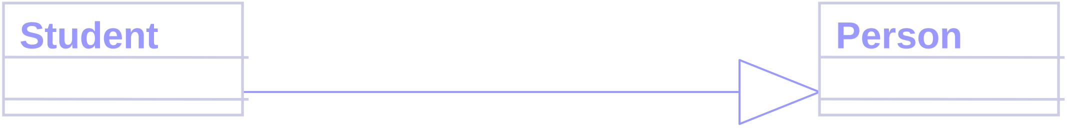
```
operation()
{for all g in children
      g.operation()
}
```

3 basic building blocks of UML - Relationships



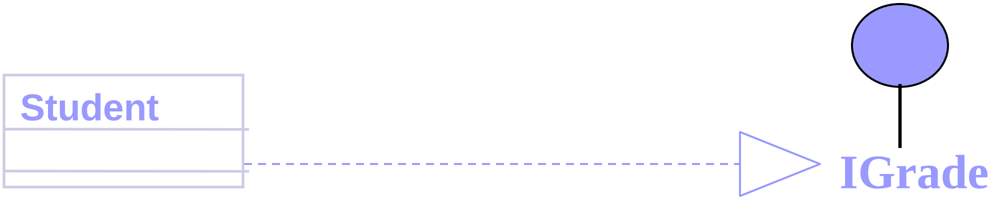
1. *Associations*

Structural relationship that describes a set of links, a link being a connection between objects. ***variants: aggregation & composition***



2. *Generalization*

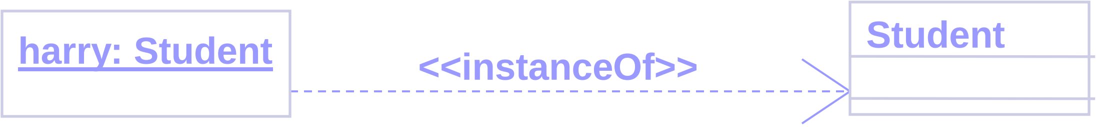
a specialized element (the child) is more specific the generalized element.



3. *Realization*

one element guarantees to carry out what is expected by the other element.

(e.g, interfaces and classes/components; use cases and collaborations)



4. *Dependency*

a change to one thing (independent) may affect the semantics of the other thing (dependent).

(direction, label are optional)

3 basic building blocks of UML - Diagrams

A connected graph: Vertices are things; Arcs are relationships/behaviors.

UML 1.x: 9 diagram types.

Structural Diagrams

Represent the static aspects of a system.

□ Class;
  Object

□ Component

□ Deployment

Behavioral Diagrams

Represent the dynamic aspects.

□ Use case

□ Sequence;
  Collaboration

□ Statechart

□ Activity

UML 2.0: 12 diagram types

Structural Diagrams

□ Class;
  Object

□ Component

□ Deployment

□ Composite Structure

□ *Package*

Behavioral Diagrams

□ Use case

□ Statechart

□ Activity

Interaction Diagrams

□ Sequence;
  Communication

□ Interaction Overvie

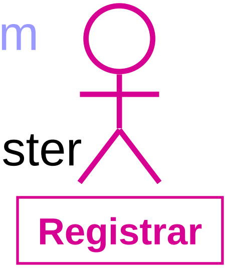
□ Timing

Diagrams in UML – Actors in Use Case Diagram

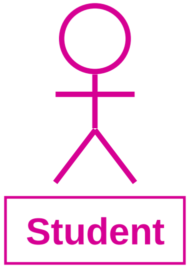
- An actor is someone or some thing that must interact with the system under development

The UTD wants to computerize its registration system

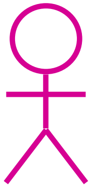
- The **Registrar** sets up the curriculum for a semester



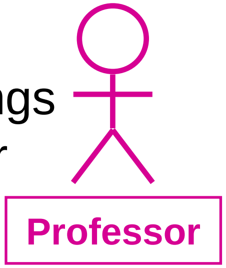
- **Students** select 3 core courses and 2 electives



- Once a student registers for a semester, the **billing system** is notified so the student may be billed for the semester



- Students may use the system to add/drop courses for a period of time after registration
- **Professors** use the system to set their preferred course offerings and receive their course offering rosters after students register



- Users of the registration system are assigned passwords which are used at logon validation

Diagrams in UML – Use Cases in Use Case Diagram

- A use case is a sequence of interactions between an actor and the system

The UTD wants to computerize its registration system

- The **Registrar** sets up the curriculum for a semester
- **Students** select 3 core courses and 2 electives
- Once a student registers for a semester, the **billing system** is notified so the student may be billed for the semester
- Students may use the system to add/drop courses for a period of time after registration
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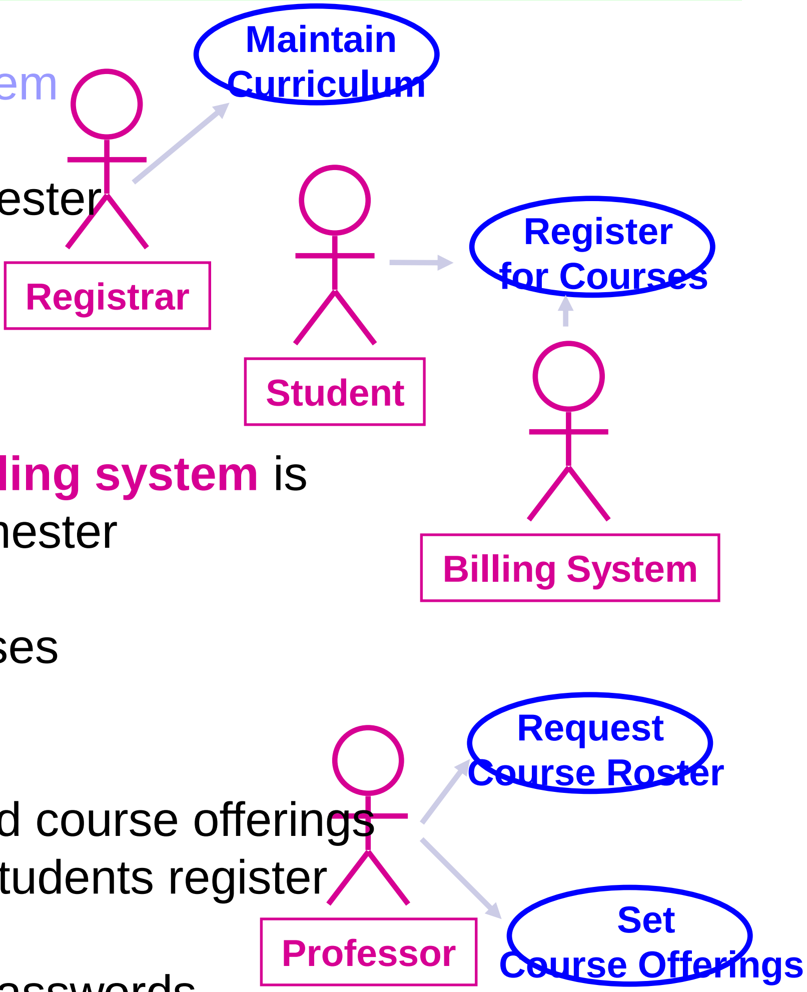
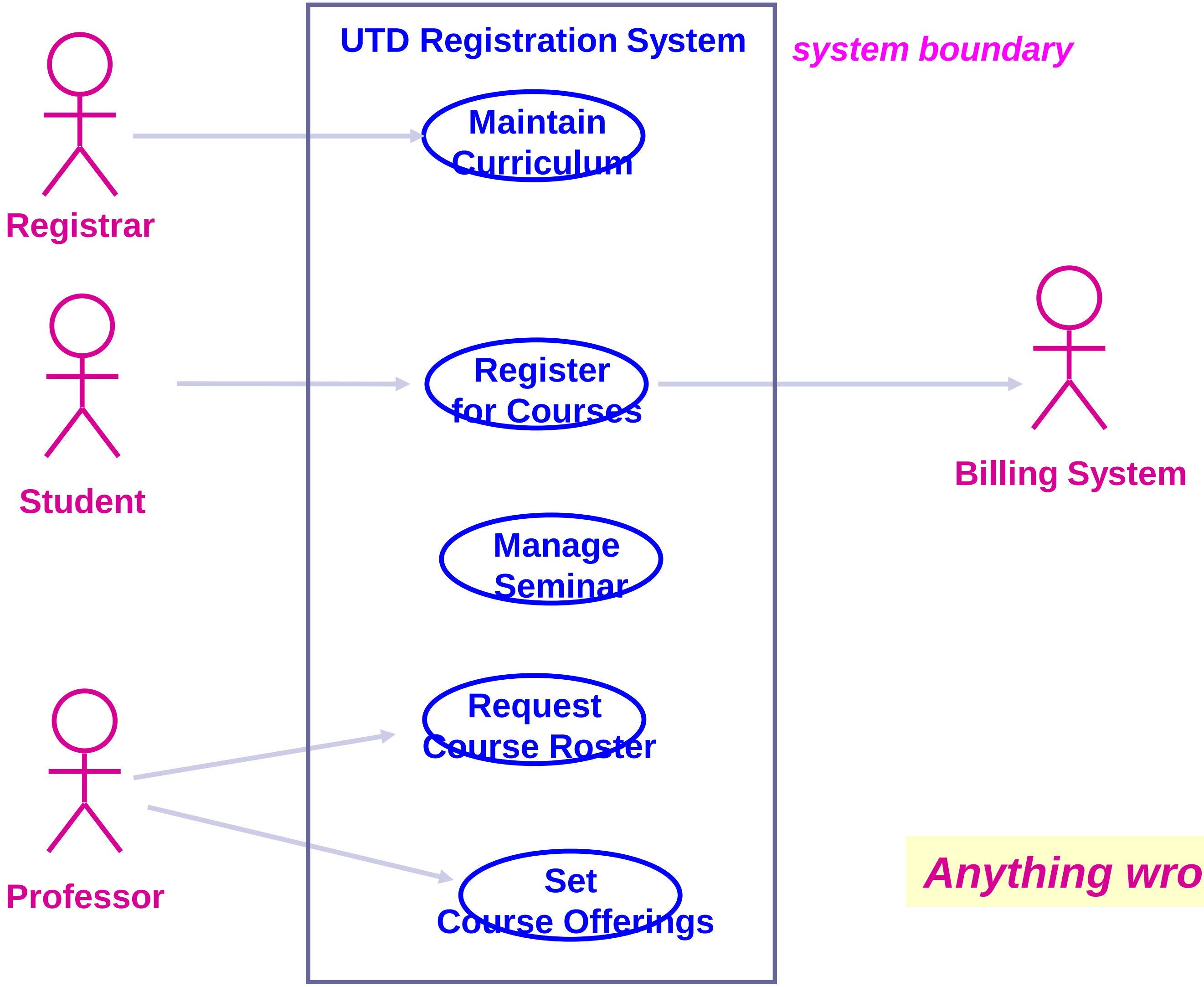


Diagrams in UML – Use Case Diagram

- Use case diagrams depict the relationships between actors and use cases

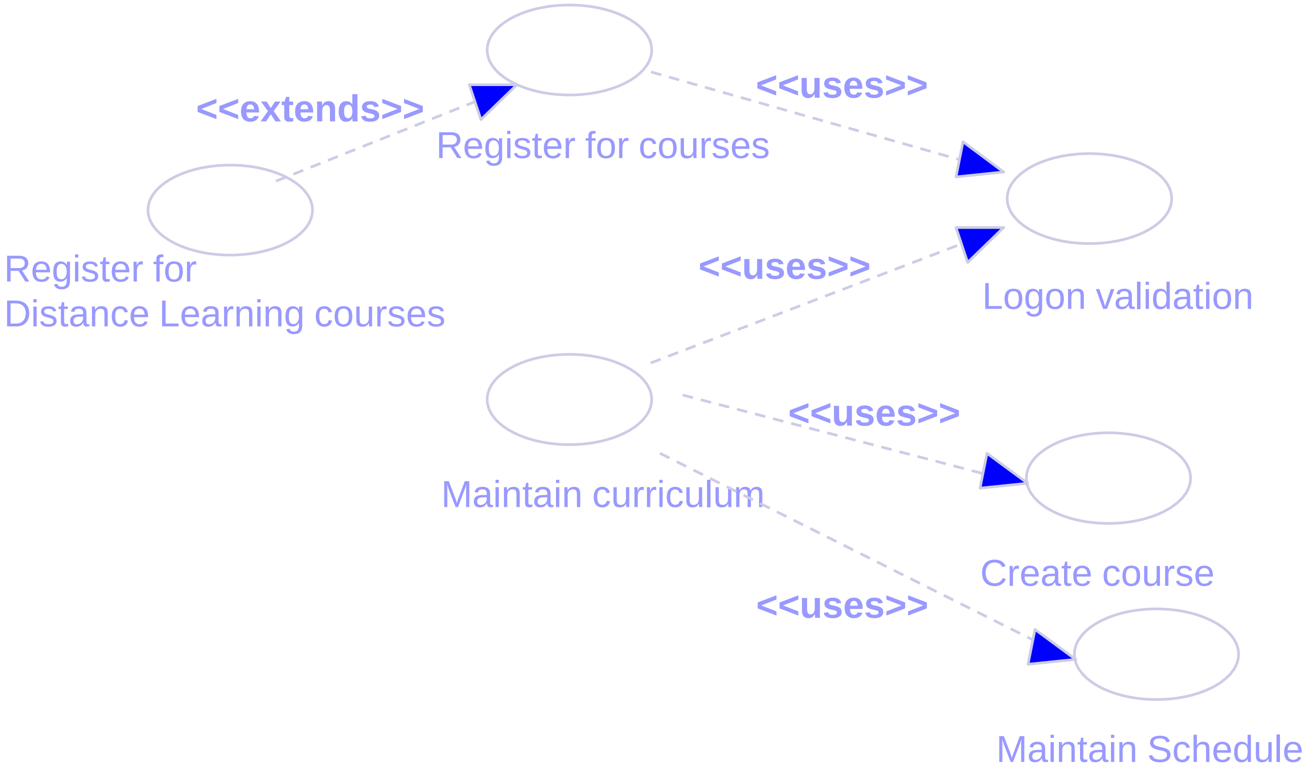


Anything wrong?

Diagrams in UML - Uses and Extends in Use Case Diagram

A uses relationship shows behavior common to one or more use cases

An extends relationship shows optional/exceptional behavior

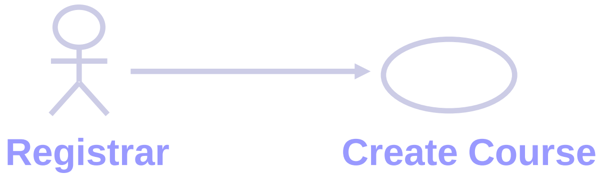


Diagrams in UML – Flow of Events for each use case:

Typical contents:

How the use case starts and ends
Normal flow of events (focus on the normal first!)
Alternate/Exceptional flow of events

Flow of Events for Creating a Course



- This use case begins after the Registrar logs onto the Registration System with a valid password.
- The registrar fills in the course form with the appropriate semester and course related info.
- The Registrar requests the system to process the course form.
- The system creates a new course, and this use case ends

Diagrams in UML – Interaction Diagrams

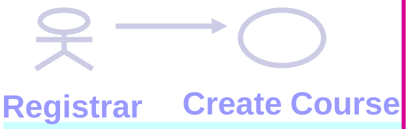
*A use case diagram presents an **outside** view of the system.*

*Then, how about the **inside** view of the system?*

- Interaction diagrams describe how use cases are ***realize***d in terms of interacting objects.
- Two types of interaction diagrams
  - □ Sequence diagrams
  - □ Collaboration *(Communication)* diagrams

Diagrams in UML - Sequence Diagram

- A sequence diagram displays object interactions arranged in a time sequence



This use case begins after the Registrar logs onto the Registration System with a valid password.

The registrar fills in the course form with the appropriate semester and course related info.

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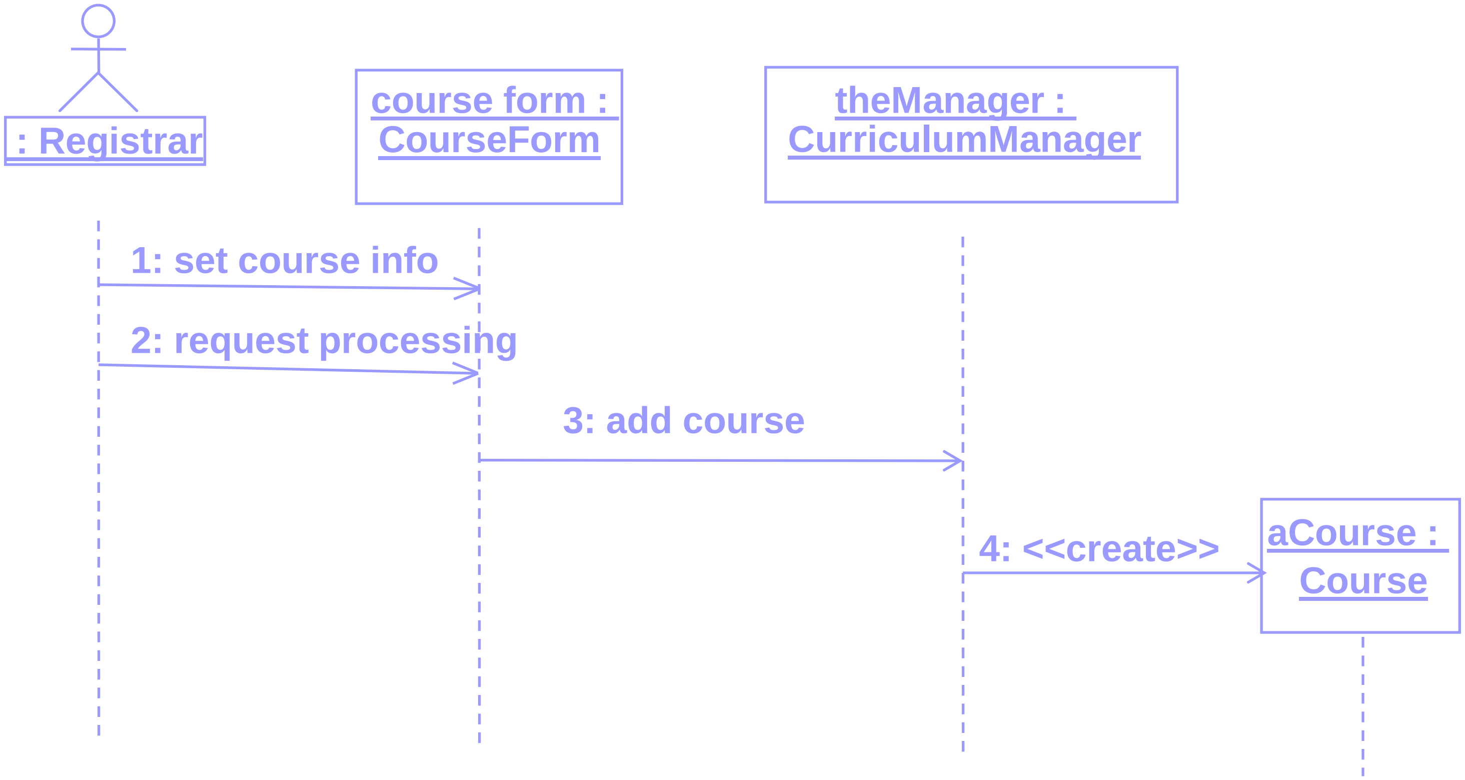
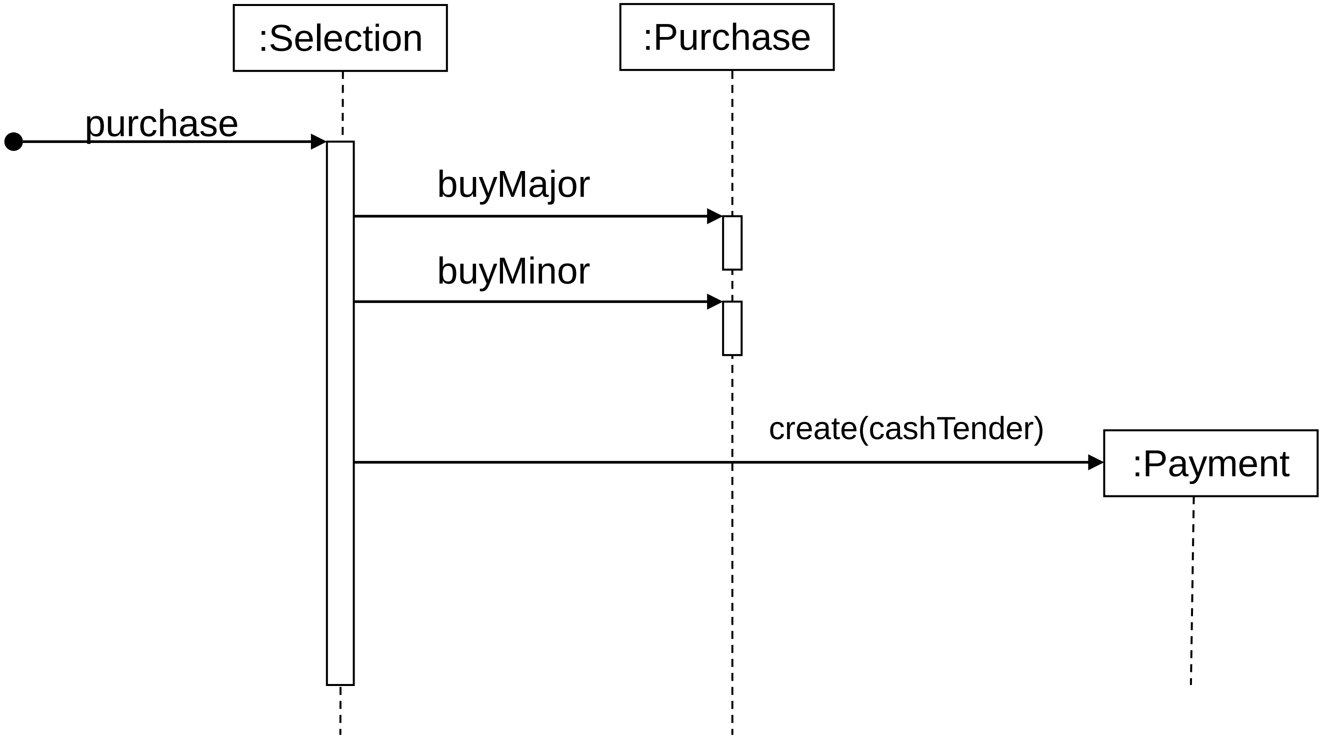
The system creates a new course, and this use case ends



Traceability!

Sequence Diagrams & Some Programming



```
public Class Selection
             { private Purchase myPurchase = new Purchase();
               private Payment myPayment;
                public void purchase()
                            { myPurchase.buyMajor();
                              myPurchase.buyMinor():
                              myPayment = new Payment( cashTender );
                              //. .
                            }
               // . .
             }
```

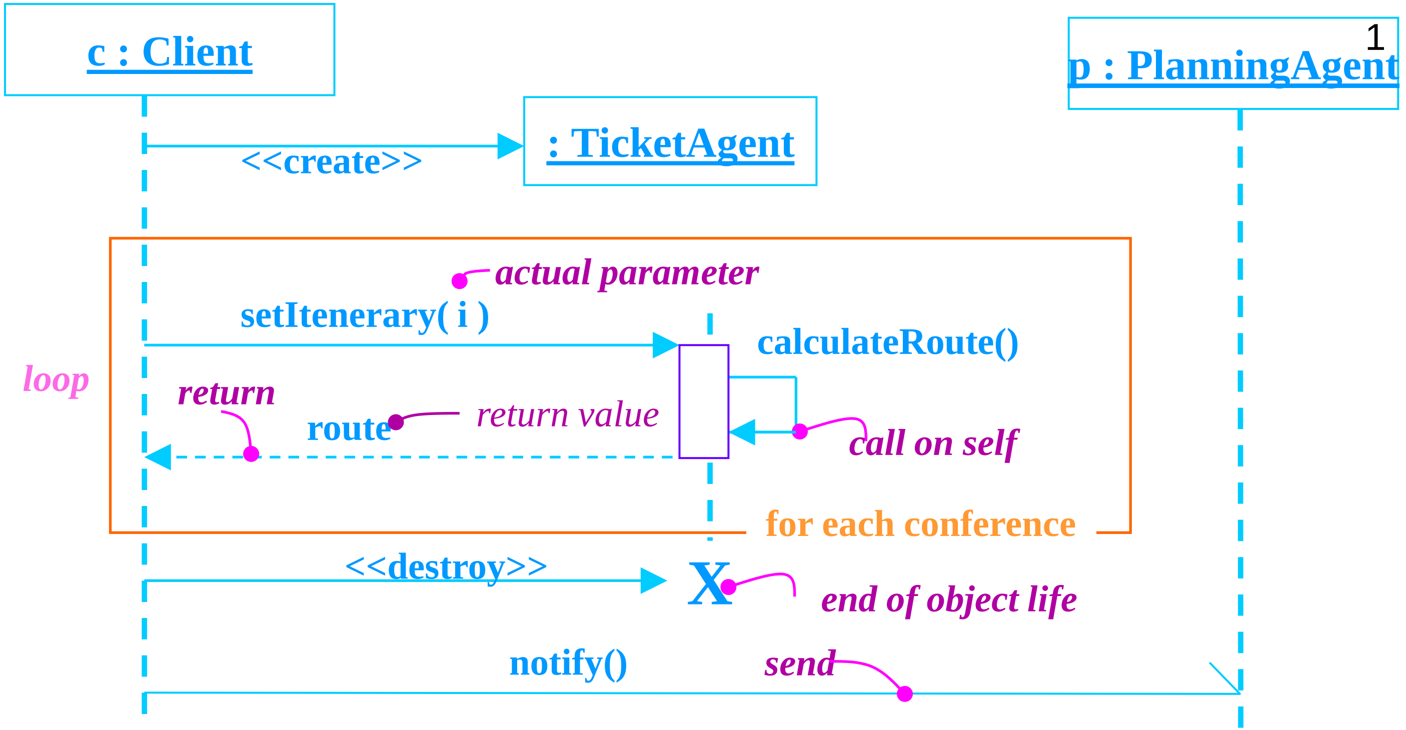
Interactions - Modeling Actions

- Simple
- Call
- Return
- Send

asynchronous in 2.0 (stick arrowhead) – no return value expected at end of callee activation

activation of caller may end before callee's

half arrow in 1.x



loop

actual parameter

return

return value

call on self

for each conference

end of object life

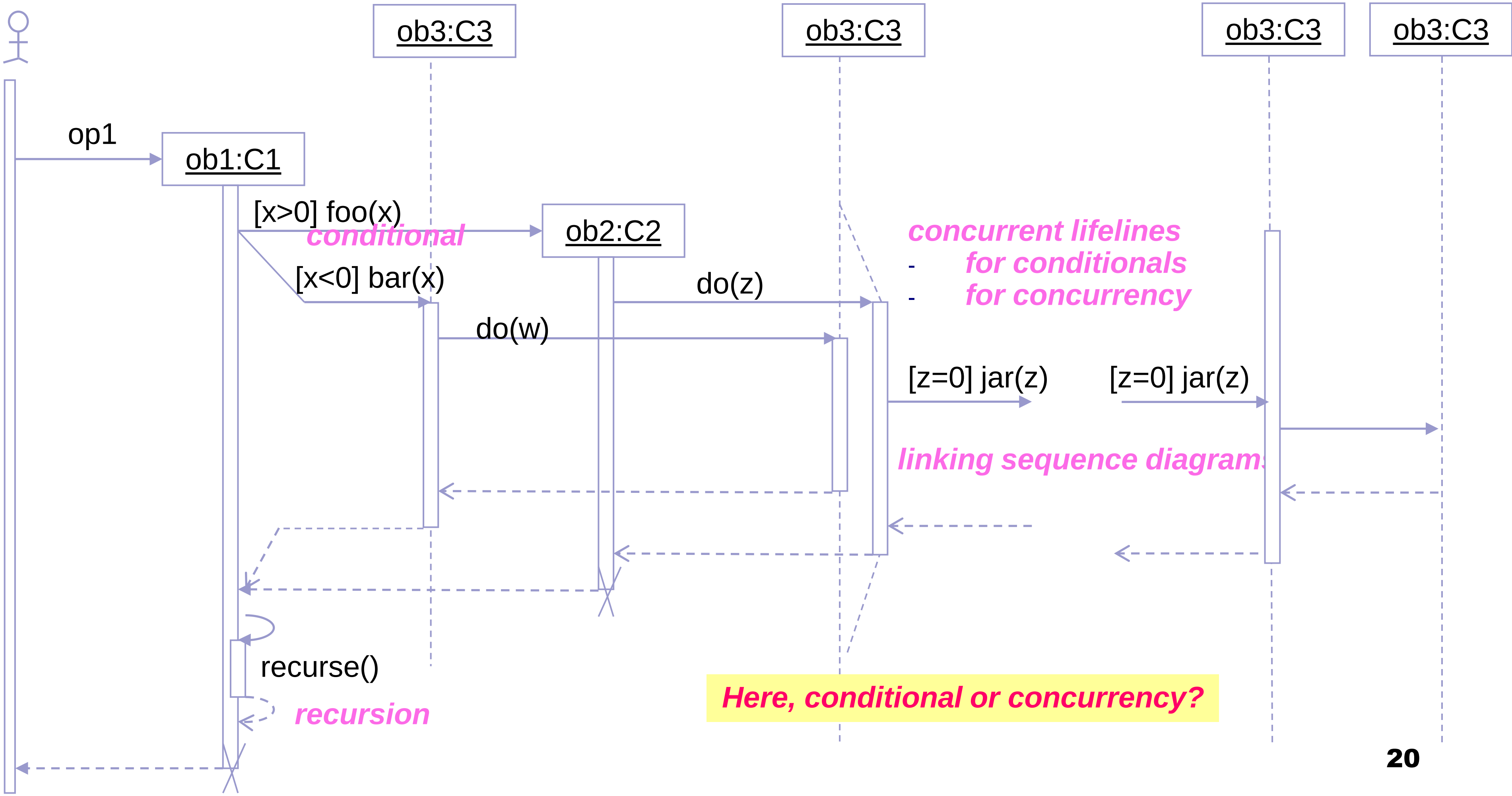
send

destroy: e.g., in C++ manual garbage collection; in Java/C#, unnecessary

natural death/
self destruction

Sequence Diagrams – Generic vs. Instance

- 2 forms of sd:
  - **Instance** sd: describes a specific scenario in detail; no conditions, branches or loops.
  - **Generic** sd: a use case description with alternative courses.



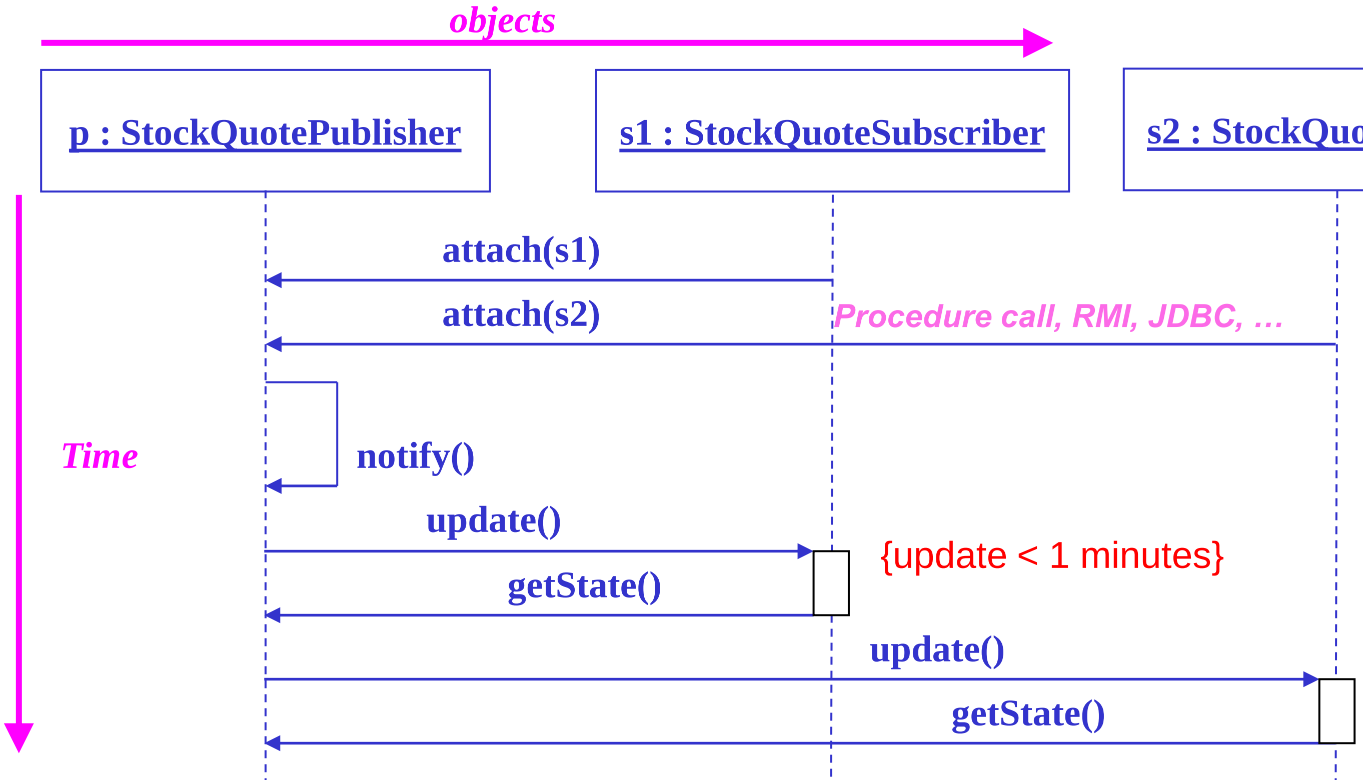
concurrent lifelines

- *for conditionals*
- *for concurrency*

linking sequence diagrams

Here, conditional or concurrency?

Interaction Diagram: sequence vs communication



objects

p : StockQuotePublisher

s1 : StockQuoteSubscriber

s2 : StockQuoteSubscriber

attach(s1)

attach(s2)

Procedure call, RMI, JDBC, …

Time

notify()

update()

getState()

{update < 1 minutes}

update()

getState()

object

role:ClassName

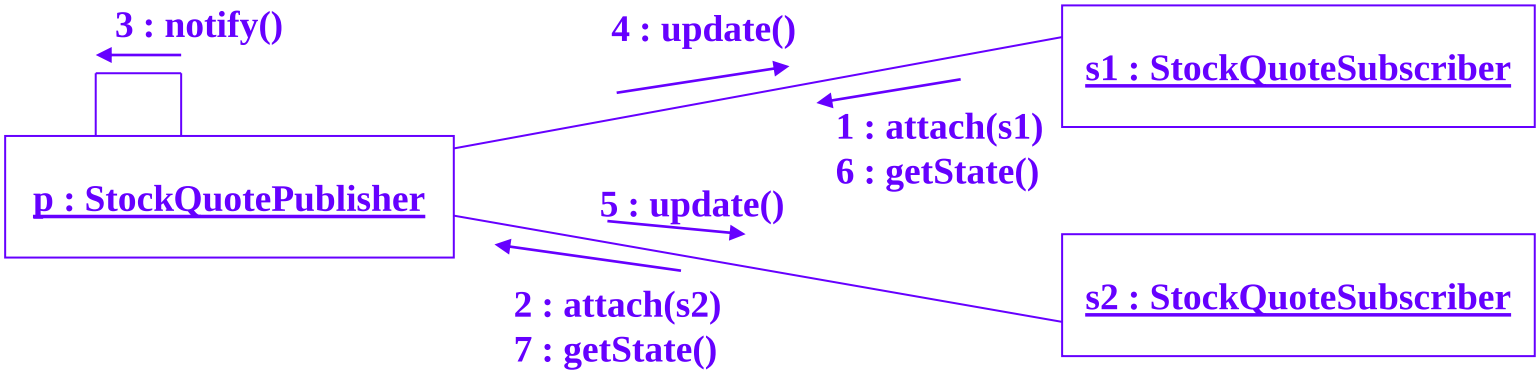
classifiers or their i

use cases or actors

Observer design pattern

Activations

- Show duration of execution
- Shows call stack
- Return message
  - Implicit at end of activation
  - Explicit with a dashed arrow



3 : notify()

4 : update()

s1 : StockQuoteSubscriber

p : StockQuotePublisher

1 : attach(s1)

6 : getState()

5 : update()

2 : attach(s2)

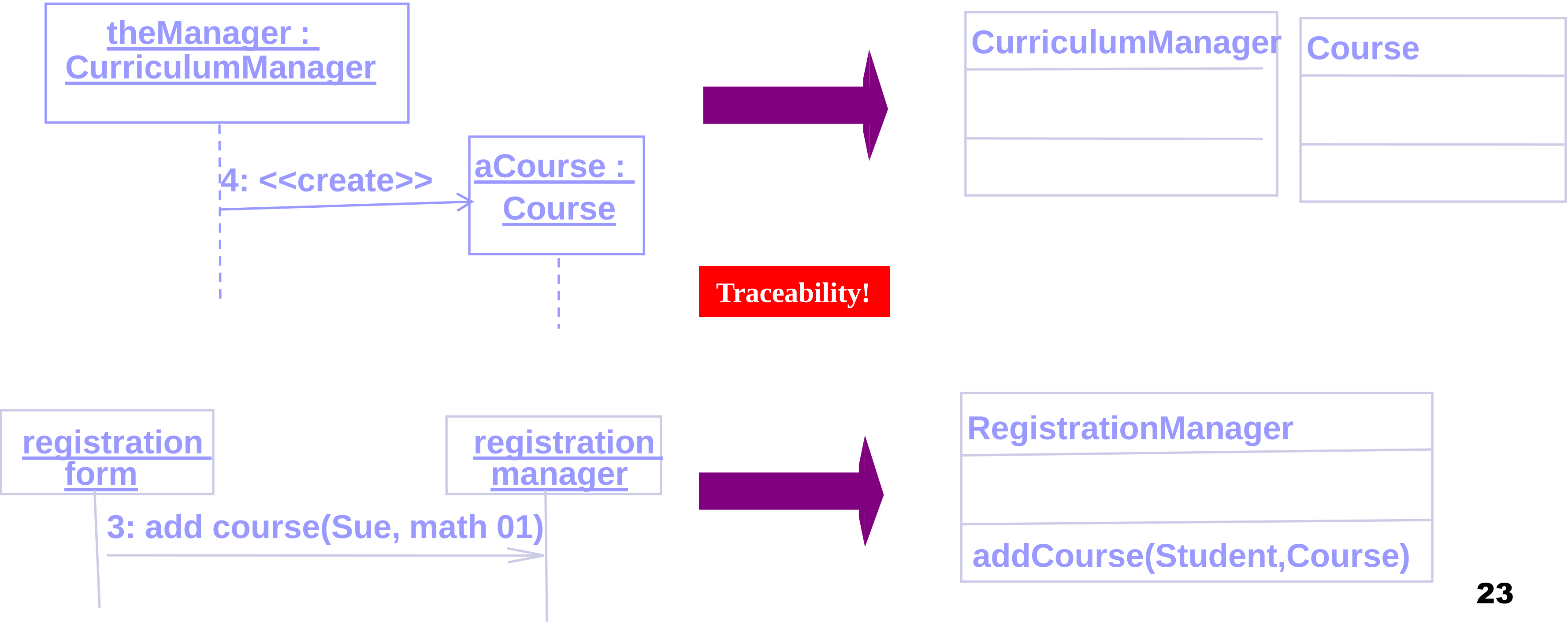
7 : getState()

s2 : StockQuoteSubscriber

Skip end: resume

Diagrams in UML - Class Diagrams

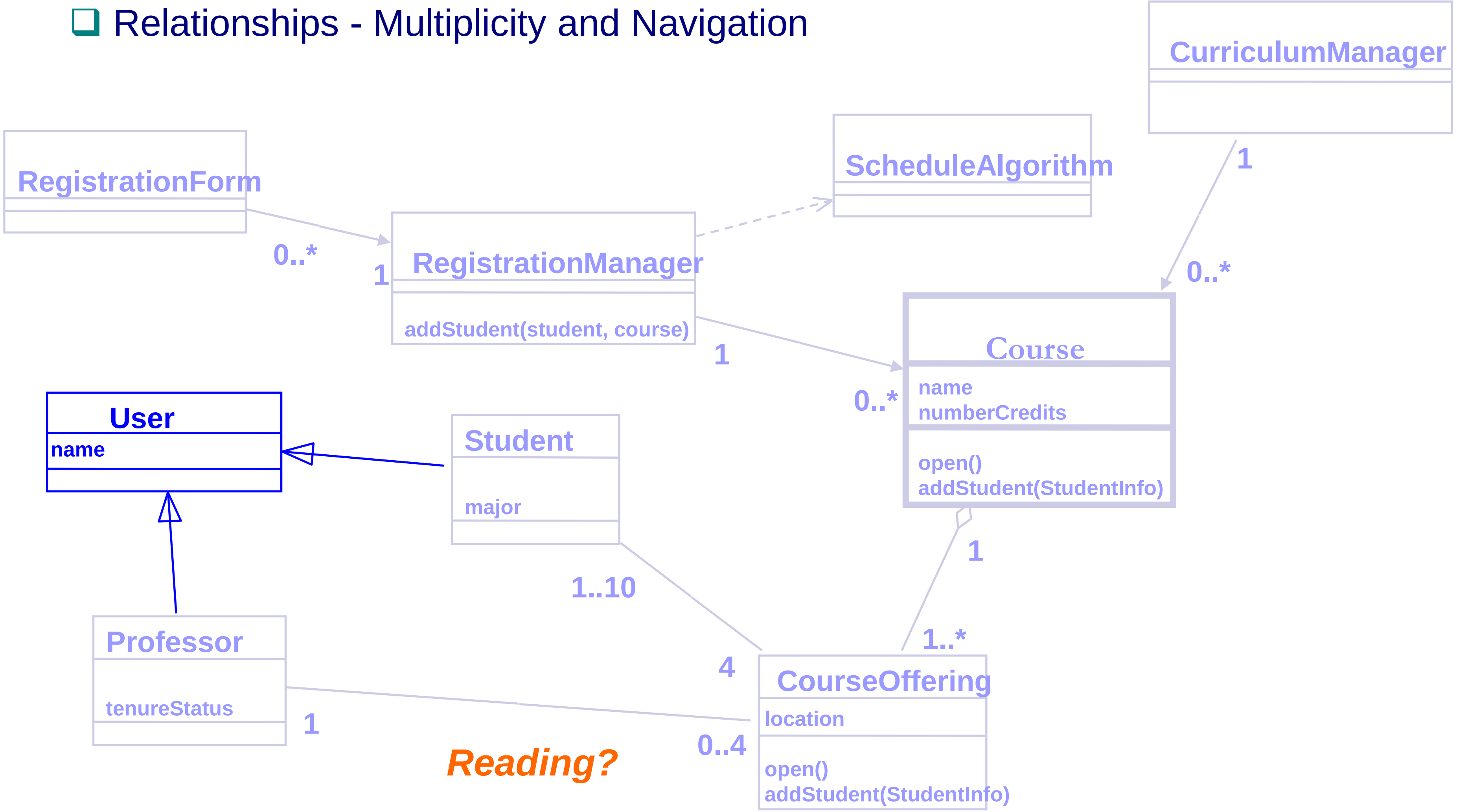
- A class diagram shows the existence of classes and their relationships
- Recall: A class is a collection of objects with common structure, common behavior, common relationships and common semantics
- Some classes are shown through the objects in sequence/collaboration diagram



Traceability!

Diagrams in UML - Class Diagrams: static structure in the system

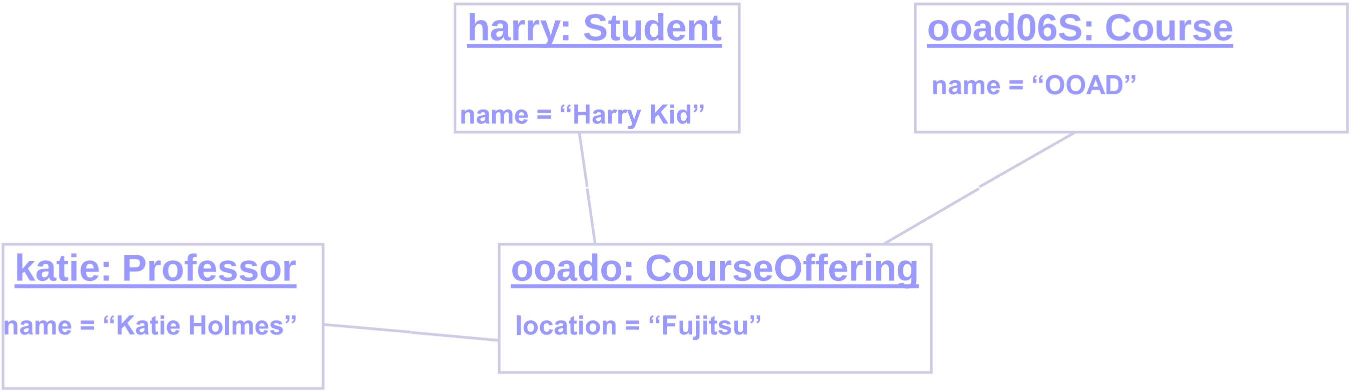
- Naming & (often) 3 Sections;
- Inheritance (as before);
- Relationships - Multiplicity and Navigation



Reading?

Diagrams in UML – Object Diagrams

- Shows a set of objects and their relationships.
- As a static snapshot.



harry: Student

name = “Harry Kid”

ooad06S: Course

name = “OOAD”

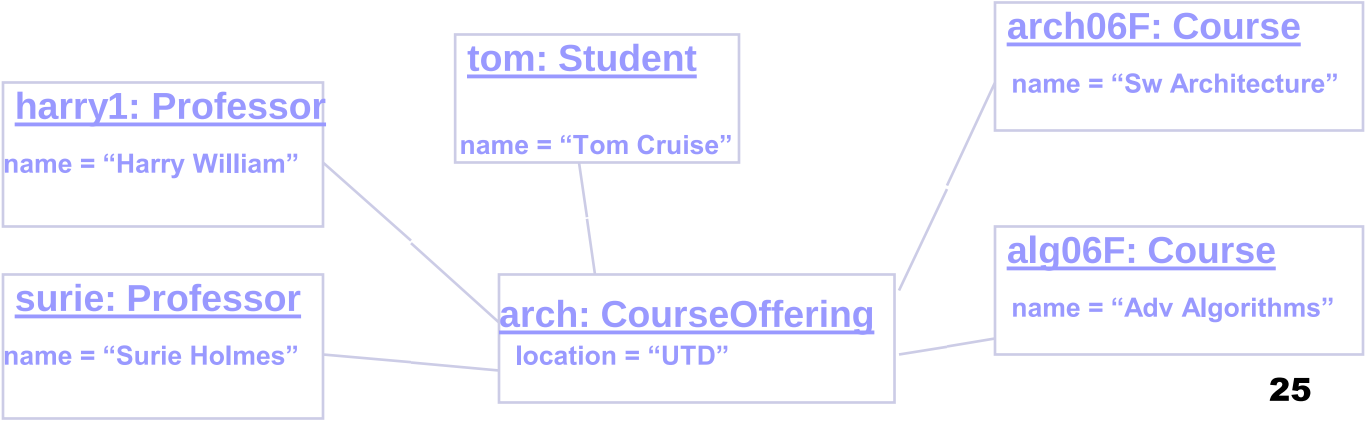
katie: Professor

name = “Katie Holmes”

ooado: CourseOffering

location = “Fujitsu”

Anything wrong?



harry1: Professor

name = “Harry William”

tom: Student

name = “Tom Cruise”

arch06F: Course

name = “Sw Architecture”

surie: Professor

name = “Surie Holmes”

arch: CourseOffering

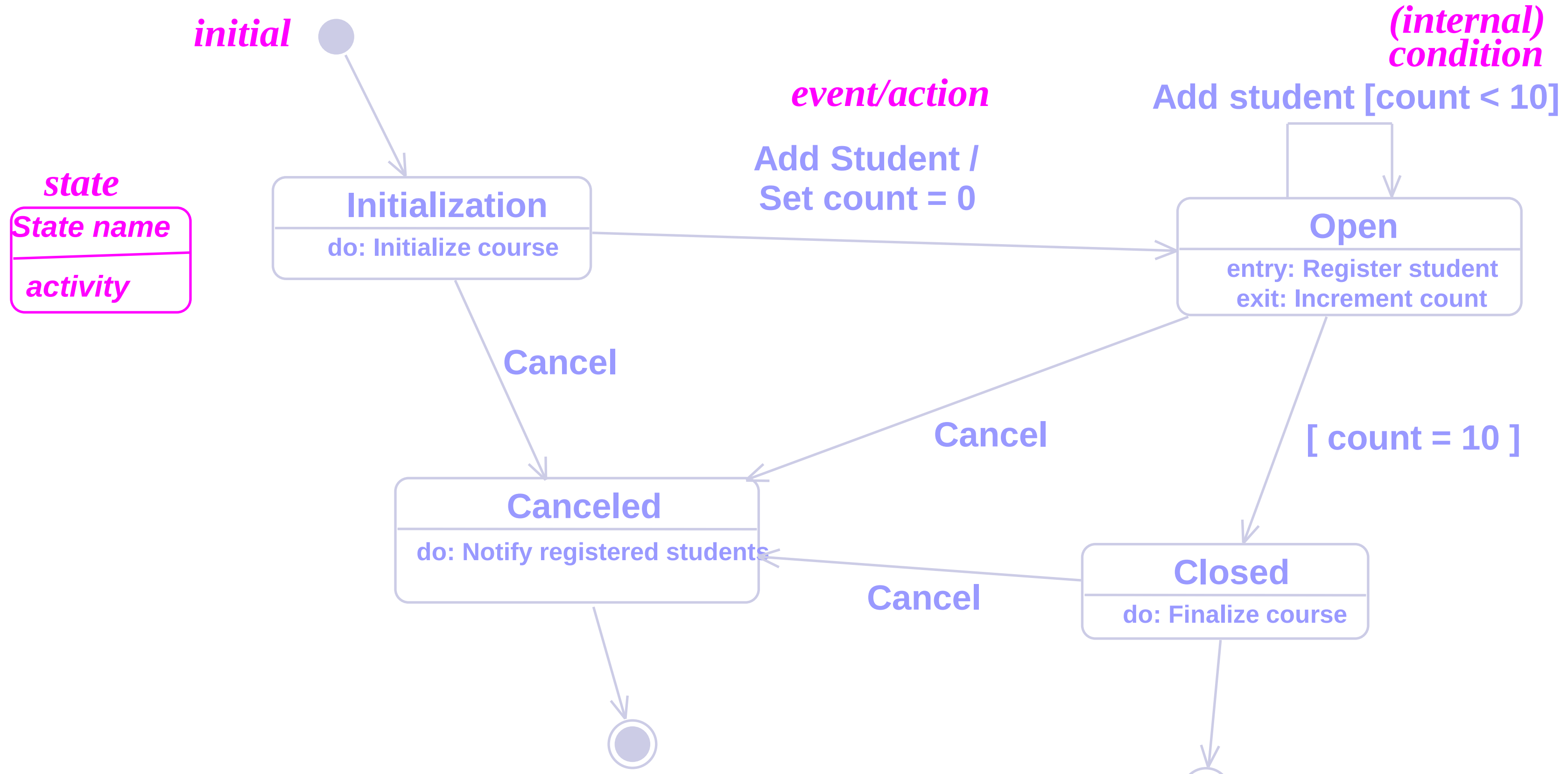
location = “UTD”

alg06F: Course

name = “Adv Algorithms”

Diagrams in UML – State Transition Diagram (Statechart Diagram)

- The life history (often of a given class: from class to object behavior)
- States, transitions, events that cause a transition from one state to another
- Actions that result from a state change

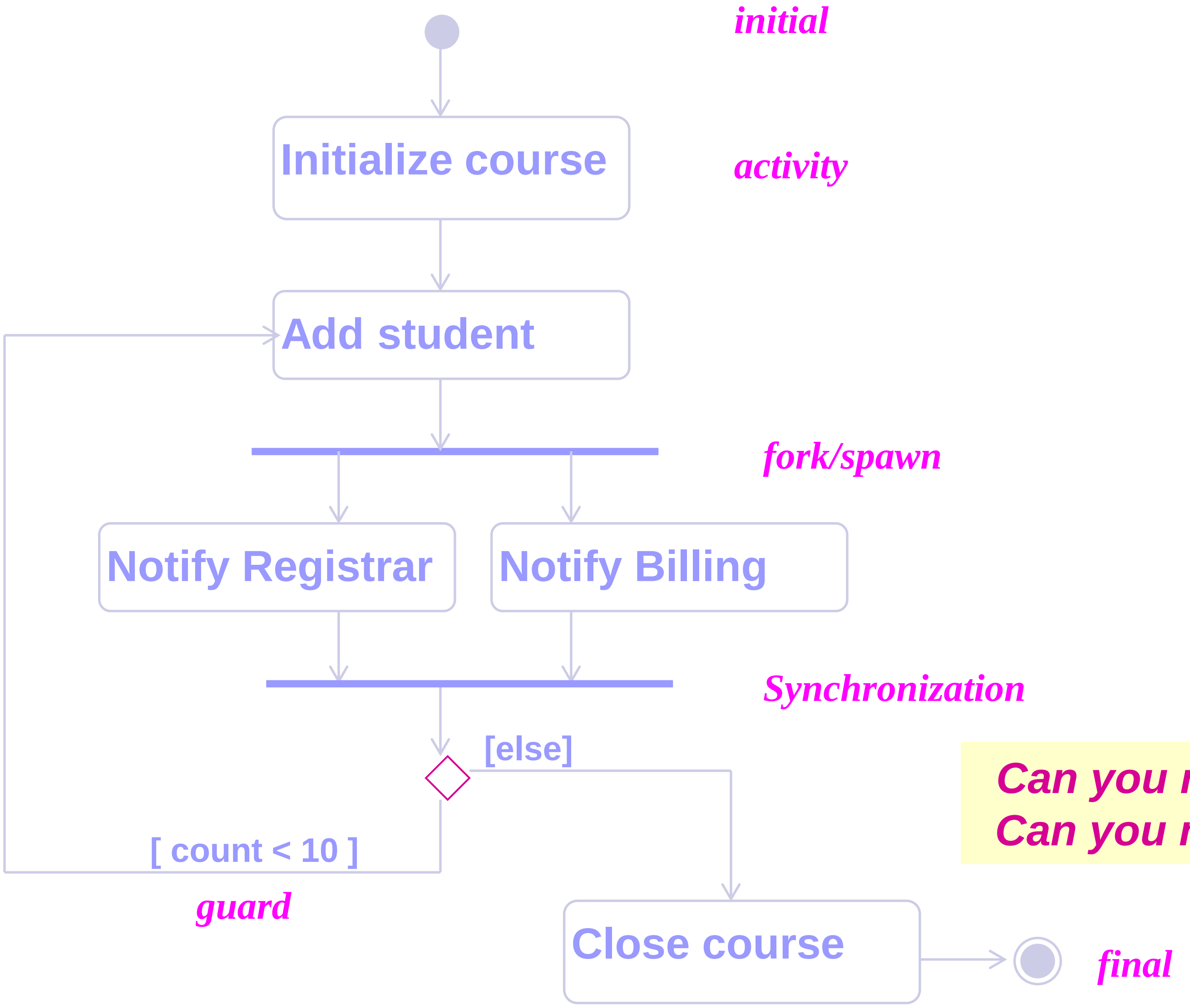


What life history/class is this for? Anything wrong?

…until the drop date?

Diagrams in UML – Activity Diagrams

- A special kind of statechart diagram that shows the flow ***from activity to activity***.



What is this for? Traceability???

Can you model this using SD? Can you model this using CD?

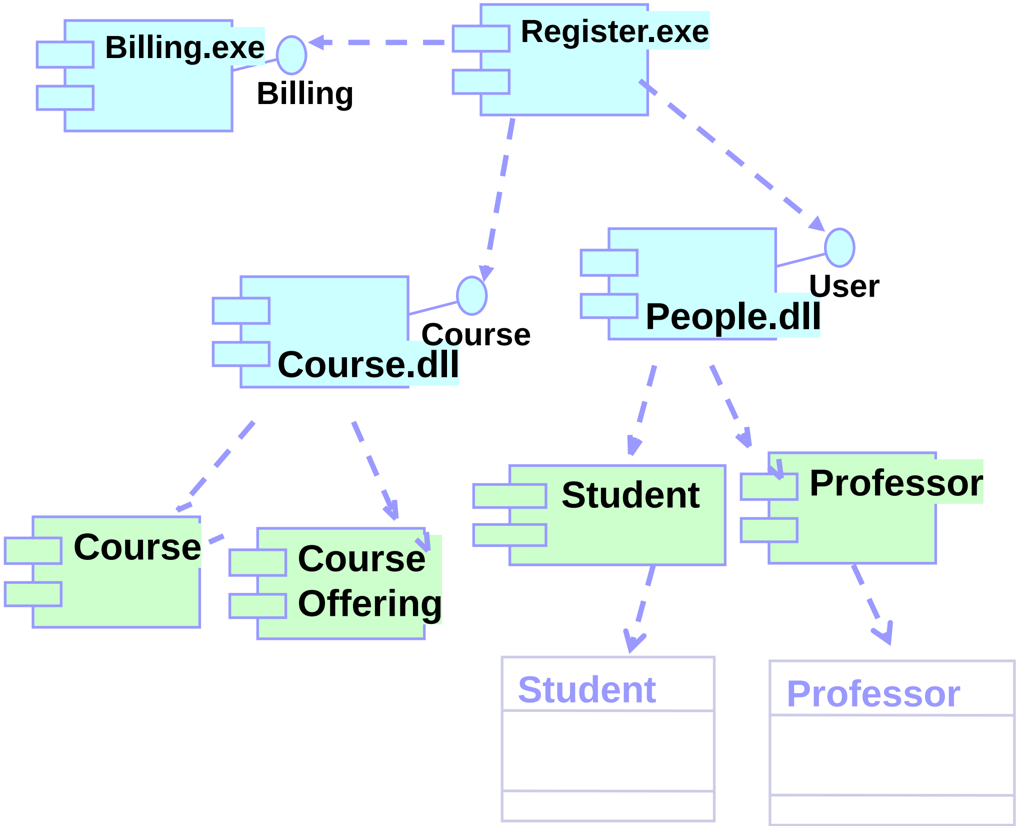
Diagrams in UML – Component Diagram

shows the organizations and dependencies among a set of components *(mostly <<uses>>).*

In UML 1.1, a component represented implementation items, such as files and executables;

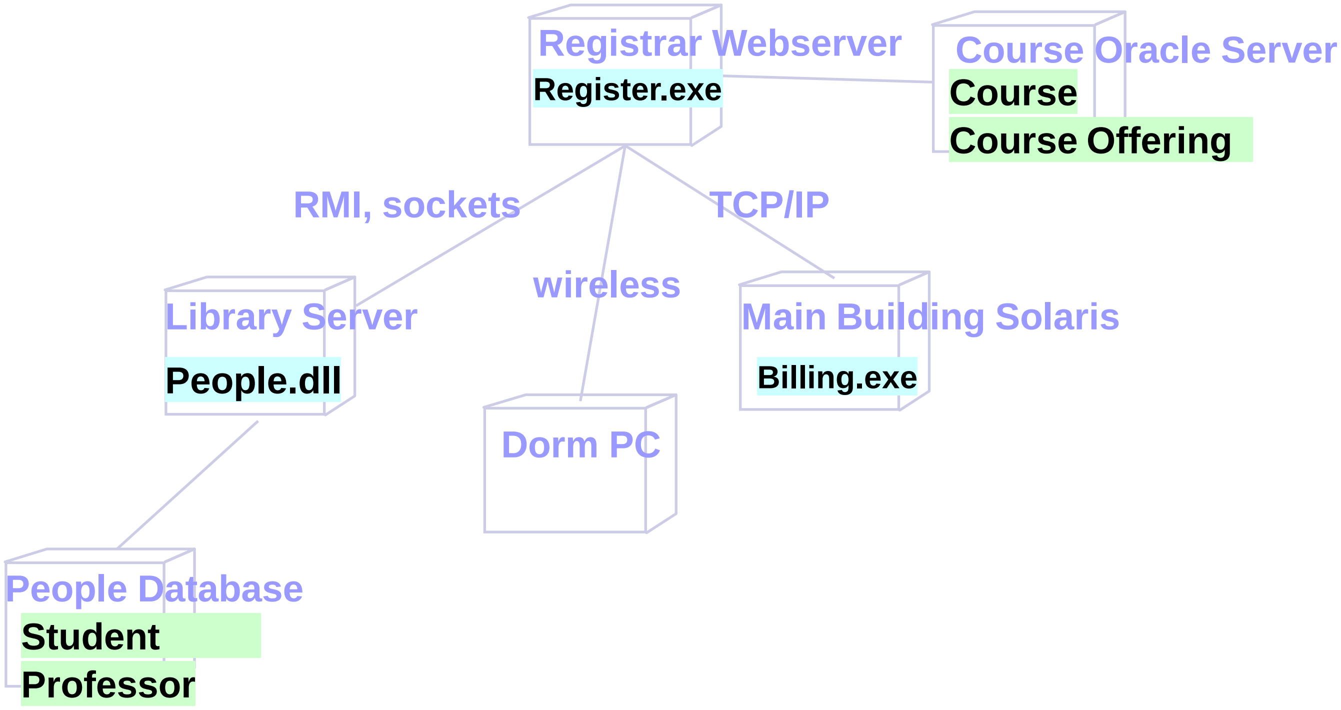
…

In ***UML 2.0***, a component is a replaceable/reusable, ***architecture***/design-time construct w. interfaces



Diagrams in UML – Deployment Diagram

- shows the configuration of run-time processing elements and the software processes living on them.
- visualizes the distribution of components across the enterprise.



Registrar Webserver

Register.exe

Course Oracle Server

Course

Course Offering

RMI, sockets

TCP/IP

wireless

Library Server

People.dll

Main Building Solaris

Billing.exe

Dorm PC

People Database

Student

Professor

3 basic building blocks of UML - Diagrams

Here, UML 1.x first (UML 2.0 later)	***Using UML Concepts in a Nutshell***
Use case	Display the boundary of a system & its major functions using use cases and actors
Sequence; Collaboration (Communication)	Illustrate use case realizations with interaction diagrams
Class; Object	Represent a static structure of a system using class diagrams
Statechart Activity	Model the behavior of objects with state transition diagrams
Component Deployment	Reveal the physical implementation architecture with component & deployment diagrams
	Extend your functionality with stereotypes

Module 2: Introduction to UML - Appendix

Extensibility of UML

- Stereotypes (<< >>) can be used to extend the UML notational elements
- Stereotypes may be used to classify and extend associations, inheritance relationships, classes, and components
- Examples:
  - Class stereotypes: boundary, control, entity, utility, exception
  - Inheritance stereotypes: uses and extends
  - Component stereotypes: subsystem

***Stereotypes** — extends vocabulary (metaclass in UML metamodel)*
***Tagged values** — extends properties of UML building blocks (i.e., metamodel)*
***Constraints** — extend the semantics of UML building blocks.*

More on this later

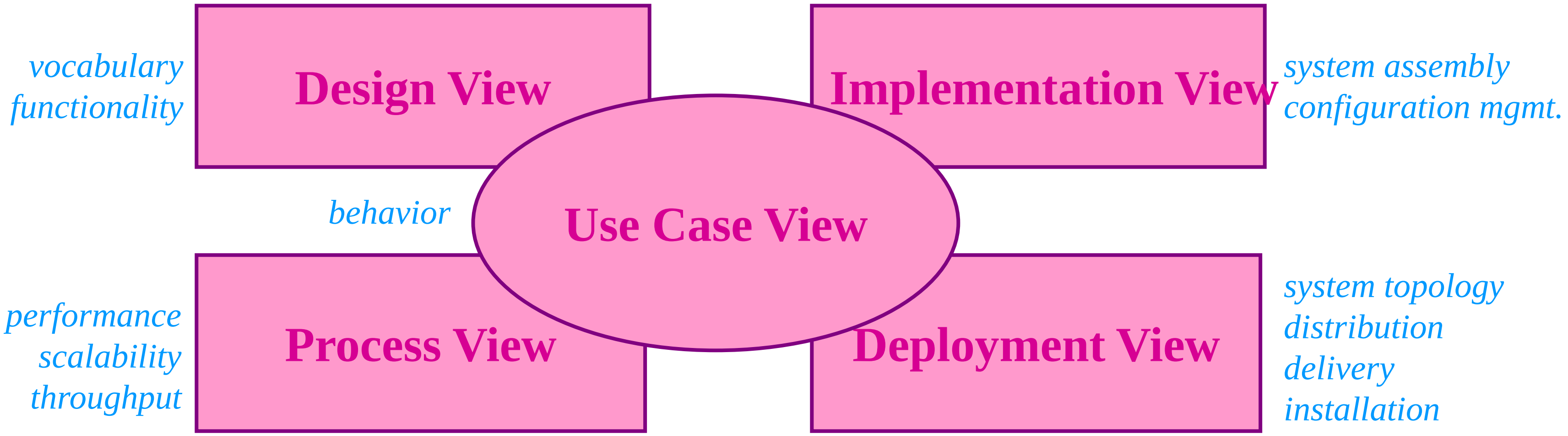
Architecture & Views

(You can skip this part on the first reading)

UML is for visualizing, specifying, constructing, and documenting with emphasis on system architectures (things in the system and relationships among the things) from five different views

Architecture - set of significant decisions regarding:

- □ Organization of a software system.
- □ Selection of structural elements & interfaces from which a system is composed.
- □ Behavior or collaboration of elements.
- □ Composition of structural and behavioral elements.
- □ Architectural style guiding the system.



Views

Use Case View

- Use Case Analysis is a technique to capture business process from user's perspective.
- Encompasses the behavior as seen by users, analysts and testers.
- Specifies forces that shape the architecture.
- Static aspects in use case diagrams; Dynamic aspects in interaction (statechart and activity) diagrams.

Design View

- Encompasses classes, interfaces, and collaborations that define the vocabulary of a system.
- Supports functional requirements of the system.
- Static aspects in class and object diagrams; Dynamic aspects in interaction diagrams.

Process View

- Encompasses the threads and processes defining concurrency and synchronization.
- Addresses performance, scalability, and throughput.
- Static and dynamic aspects captured as in design view; emphasis on active classes.

Implementation View

- Encompasses components and files used to assemble and release a physical system.
- Addresses configuration management.
- Static aspects in component diagrams; Dynamic aspects in interaction diagrams.

Deployment View

- Encompasses the nodes that form the system hardware topology.
- Addresses distribution, delivery, and installation.
- Static aspects in deployment diagrams; Dynamic aspects in interaction diagrams.

Rules of UML

- Well formed models — *semantically self-consistent and in harmony with all its related models*.
- Semantic rules for:
  - □ Names — what you can call things.
  - □ Scope — context that gives meaning to a name.
  - □ Visibility — how names can be seen and used.
  - □ Integrity — how things properly and consistently relate to one another.
  - □ Execution — what it means to run or simulate a dynamic model.
- Avoid models that are

Elided — certain elements are hidden for simplicity.

Incomplete — certain elements may be missing.

Inconsistent — no guarantee of integrity.

Process for Using UML

How do we use UML as a notation to construct a good model?

- Use case driven — use cases are primary artifact for defining behavior of the system.
- Architecture-centric — the system’s architecture is primary artifact for conceptualizing, constructing, managing, and evolving the system.
- Iterative and incremental — managing streams of executable releases with increasing parts of the architecture included.

The Rational Unified Process (RUP)

Process for Using UML - Iterative Life Cycle

- It is planned, managed and predictable …almost
- It accommodates changes to requirements with less disruption
- It is based on evolving executable prototypes, not documentation
- It involves the user/customer throughout the process
- It is risk driven

Primary phases

- □ Inception — seed idea is brought up to point of being a viable project.
- □ Elaboration — product vision and architecture are defined.

  (http://www.utdallas.edu/~chung/OOAD_SUMMER04/HACS_vision_12.doc)
- □ Construction — brought from architectural baseline to point of deployment into user community.
- □ Transition — turned over to the user community.

Process for Using UML - Iterative Approach

Three Important Features

- Continuous integration - Not done in one lump near the delivery date
- Frequent, executable releases - Some internal; some delivered
- Attack risks through demonstrable progress - Progress measured in products, not documentation or engineering estimates

Resulting Benefits

- Releases are a forcing function that drives the development team to closure at regular intervals - Cannot have the “90% done with 90% remaining” phenomenon
- Can incorporate problems/issues/changes into future iterations rather than disrupting ongoing production
- The project’s supporting elements (testers, writers, toolsmiths, QA, etc.) can better schedule their work