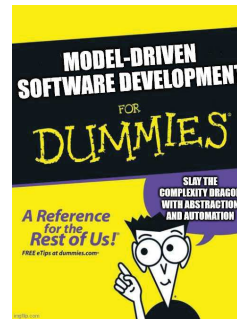


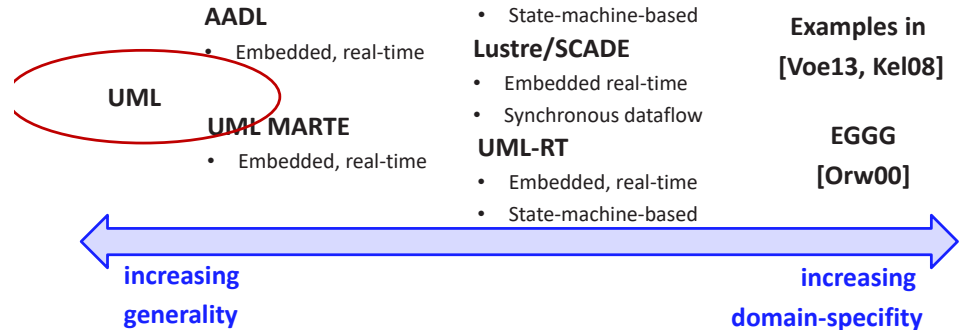
Beyond Code: An Introduction to Model-Driven Software Development (CISC 844)

Languages: UML

Juergen Dingel
Jan 2025



Modeling Languages



CISC844, Winter 2025

UML

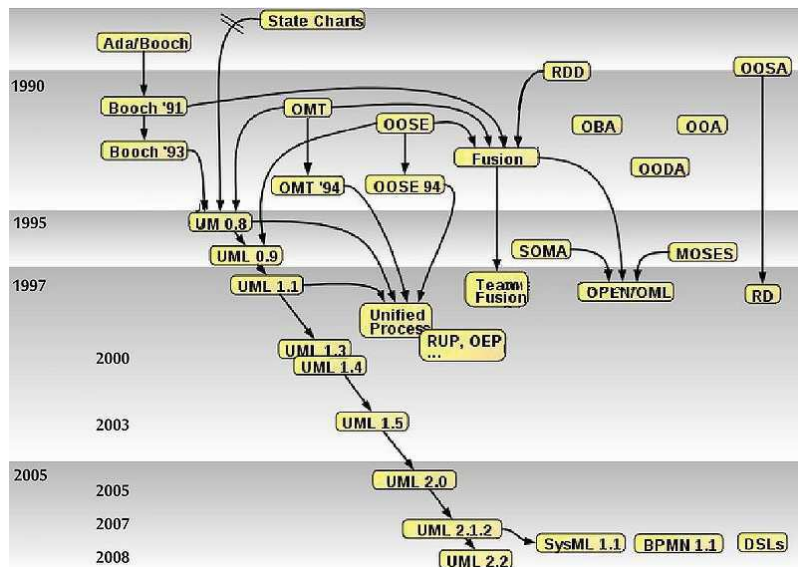
1

CISC844, Winter 2025

UML

2

UML: History



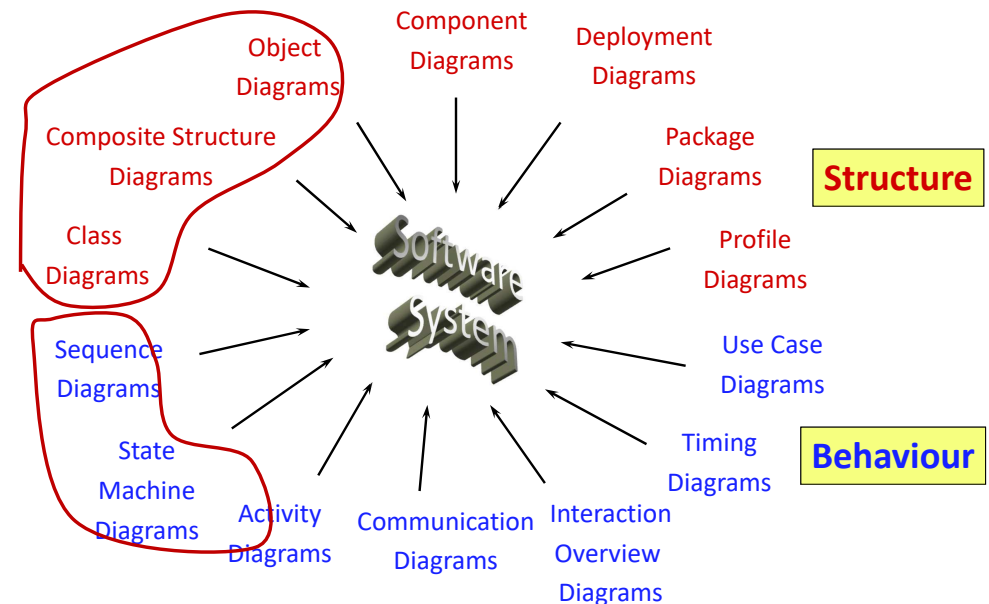
http://en.wikipedia.org/wiki/Unified_Modeling_Language

CISC844, Winter 2025

UML

3

UML: 14 Different Diagram Types

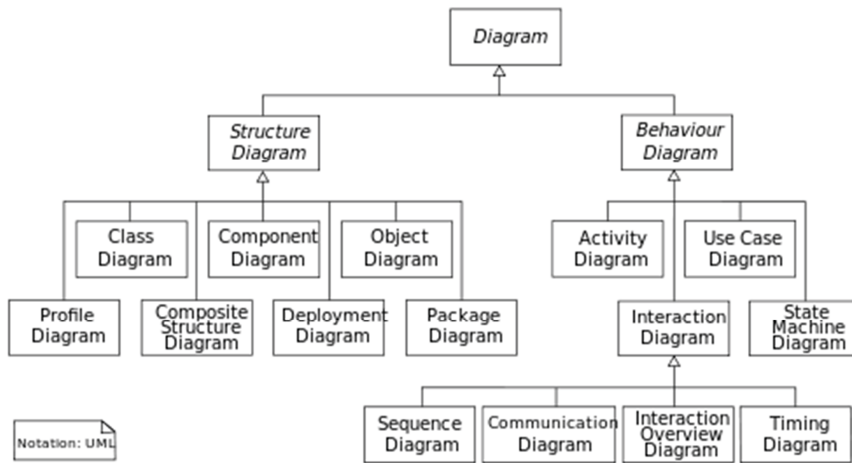


CISC844, Winter 2025

UML

4

UML: 14 Different Diagram Types (Cont'd)



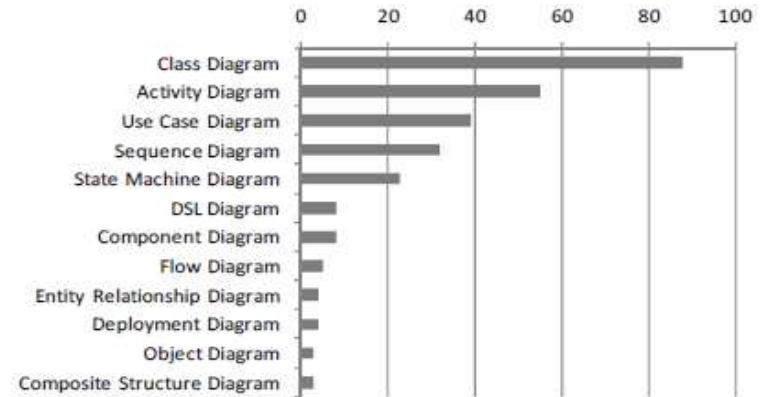
CISC844, Winter 2025

UML

5

UML: Class Diagrams

- Capture structure and relationships of objects
- Widely considered most important and most useful [ES07, Whi11a]
- Forms basis of many language specification techniques (MOF, Ecore)



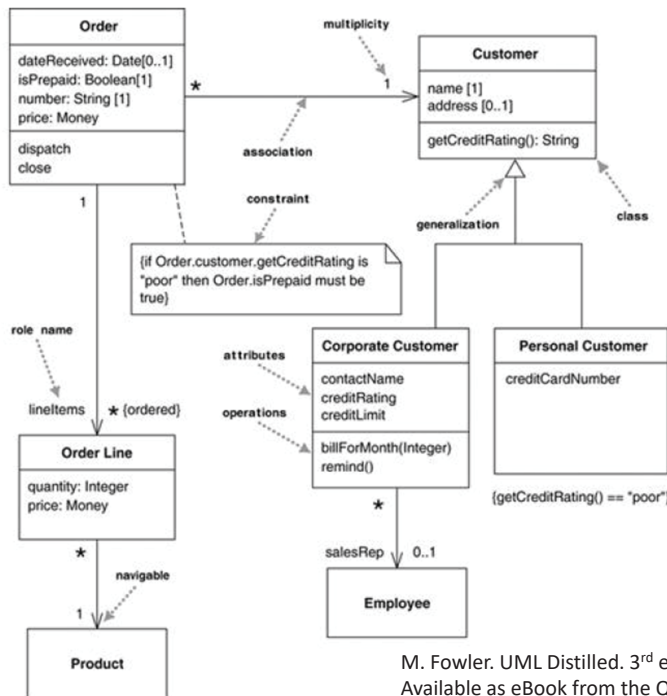
[Whi11a] Hutchinson, Whittle, Rouncefield, Kristoffersen. Empirical assessment of MDE in industry. ICSE'11. 2011

CISC844, Winter 2025

UML

6

UML: Class Diagrams (Cont'd)

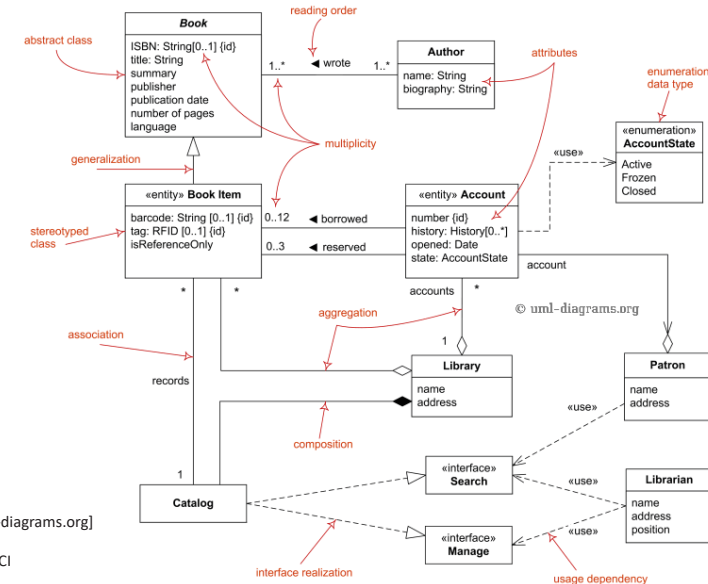


M. Fowler. UML Distilled. 3rd ed. Addison Wesley. 2003.
Available as eBook from the Queen's library.

7

UML: Class Diagrams (Cont'd)

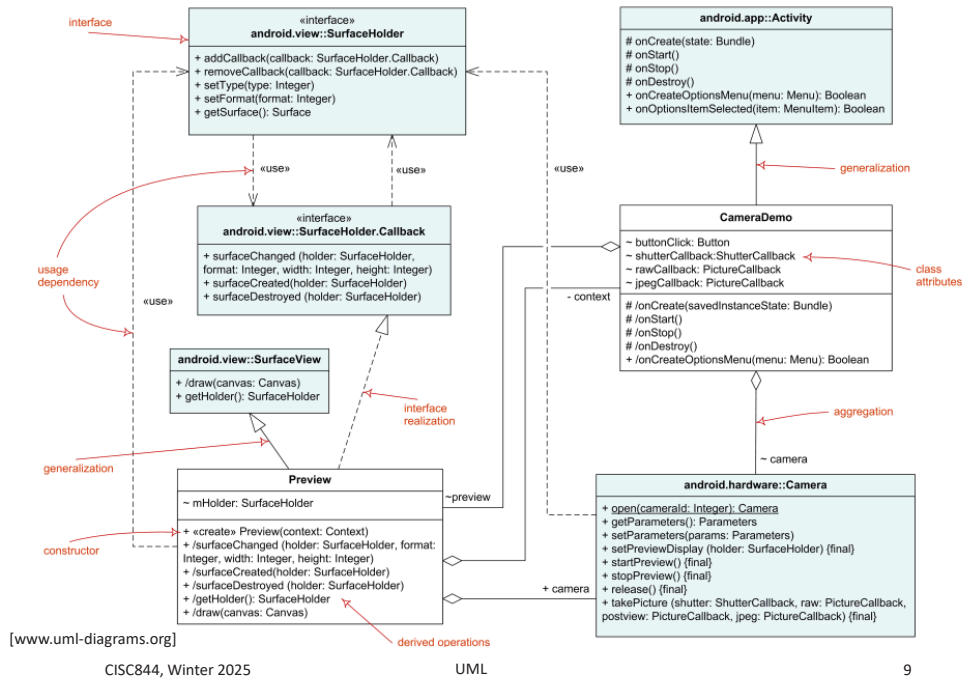
Shows classes/concepts, their attributes, operations & relationships



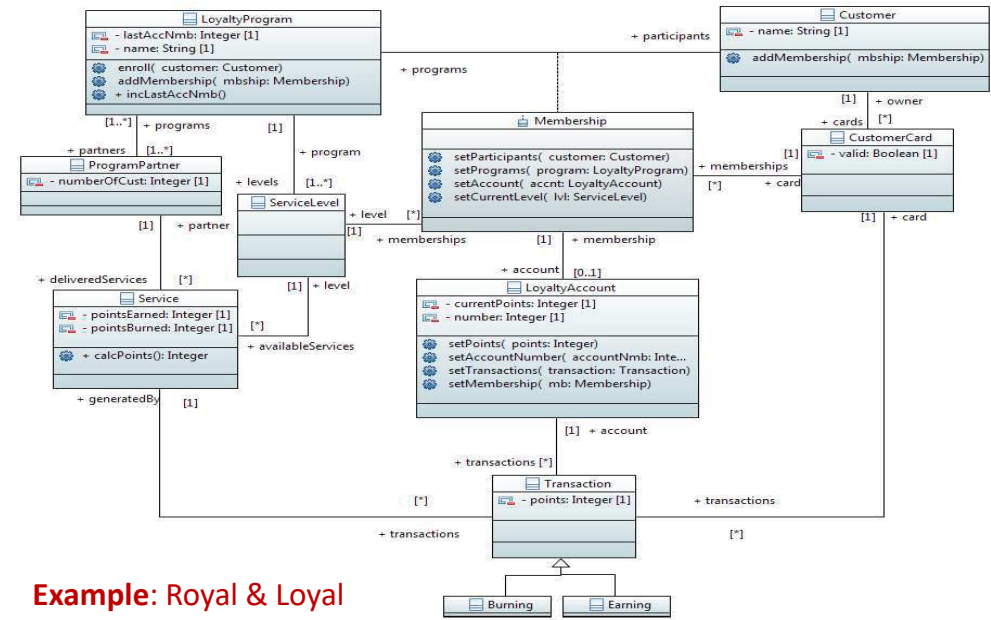
[www.uml-diagrams.org]

CI

8



UML: Class Diagrams (Cont'd)



Example: Royal & Loyal

UML: Class Diagrams (Cont'd)

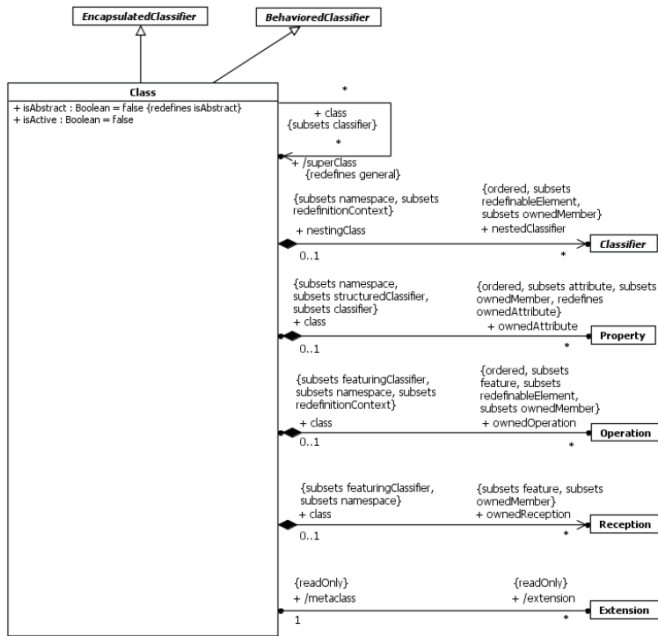
More material

- Examples (software design patterns)
 - http://en.wikipedia.org/wiki/Software_design_pattern (e.g., Factory, Composite, Proxy, Observer, Visitor)
 - refactoring.guru/design-patterns
- Books
 - M. Fowler. UML Distilled: A Brief Guide to the Standard Object Modeling Language (3rd Edition). Addison Wesley. 2004. Available as ebook (search [Queen's University Library](#) for book title)
 - G. Booch, J. Rumbaugh, I. Jacobson. UML User Guide. 2nd Edition. Addison Wesley. 2005. Available as ebook (search [Queen's University Library](#) for book title)
 - [SSH+16] Supporting material for 'UML @ Classroom' book by Seidl, Scholz, Huemer, and Kappel.
- Cheat sheets
 - [Cab24] J. Cabot. Best UML cheatsheet and UML reference guides. modeling-languages.com/best-uml-cheatsheets-and-reference-guides/
- Tutorial
 - [Amb25a] S. Ambler. Online UML Class Diagram tutorial by Scott Ambler (Agile Modeling). agilemodeling.com/artifacts/classDiagram.htm

UML: Class Diagrams (Cont'd)

- But what really is a class diagram?
- Can we use a **class diagram** to describe the concepts that make up a class diagram?

UML: Class Diagrams (Cont'd)



Example:

[Classes in UML 2.5 Specification \[Section 11.4, page 202\]](#)

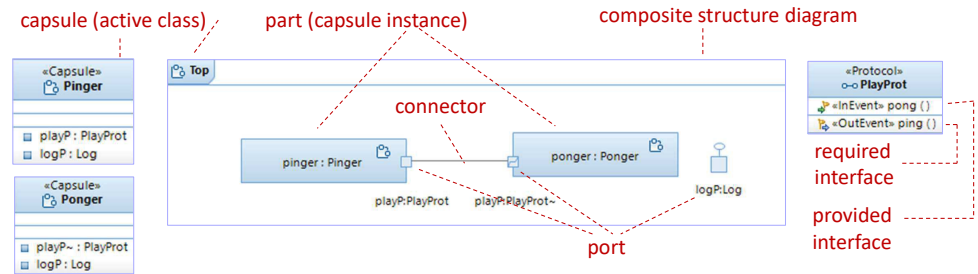
CISC844, Winter 2025

UML

13

UML: Composite Structure Diagrams

- Shows internal structure of object, including interaction points to other objects
- Key concepts**
 - Part:** Properties specifying instances that object owns
 - Port:** typed element defining interaction between object and environment; may specify provided and required services (via **interfaces**)
 - Connector:** represents possibility to communicate



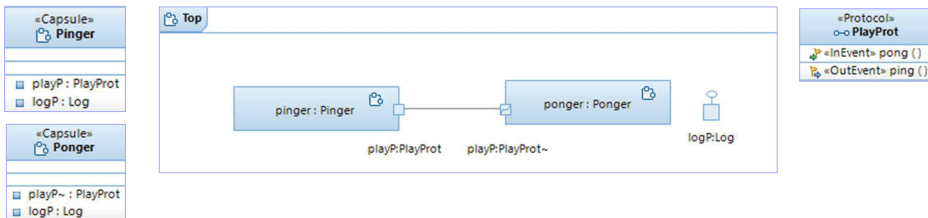
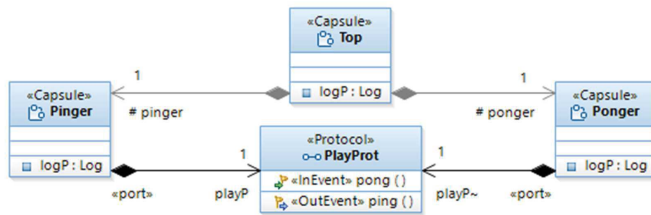
CISC844, Winter 2025

UML

14

UML: Composite Structure Diagrams (Cont'd)

- Similar, but not showing connector



CISC844, Winter 2025

UML

15

UML: Object Diagrams

- Shows **objects/instances** and their relationships at particular point in time (a.k.a., "snapshot" or "state")
- Must be **conforming** to class diagram

Figure 6.1. Class diagram of Party composition structure

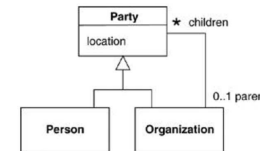
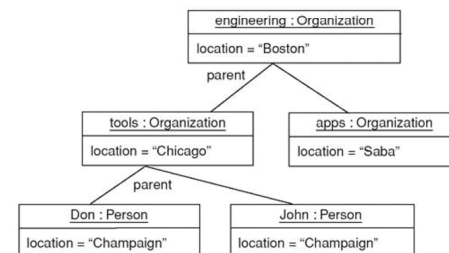


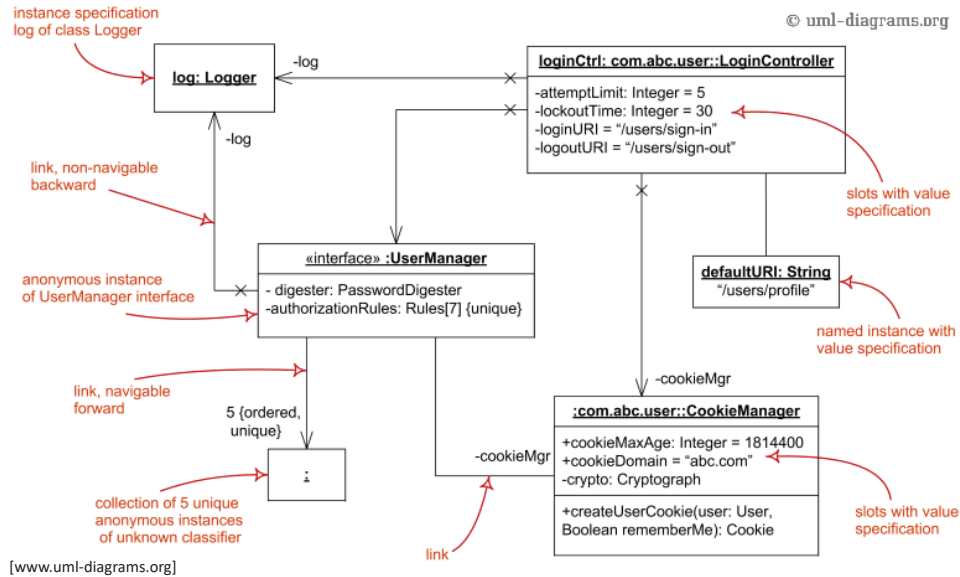
Figure 6.2. Object diagram showing example instances of Party



M. Fowler. UML Distilled. 3rd ed. Addison Wesley. 2003. Available as eBook from the Queen's library.

16

UML: Object Diagrams (Cont'd)



[www.uml-diagrams.org]

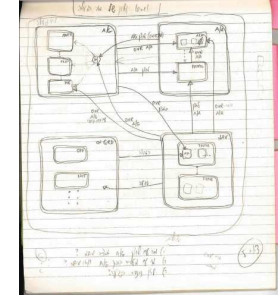
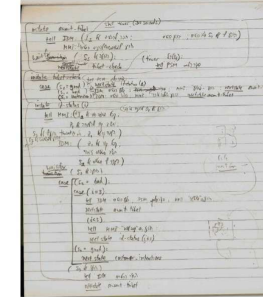
CISC844, Winter 2025

UML

17

UML: State Machines

David Harel



"The pictures were simply doing a much better job of setting down on paper the system's behavior, as understood by the engineers, and we found ourselves discussing the avionics and arguing about them over the diagrams, not the statocols."
[Har07]

[Har07] D. Harel. Statecharts in the Making: A Personal Account. 3rd ACM SIGPLAN Conference on History of Programming Languages. 2007.

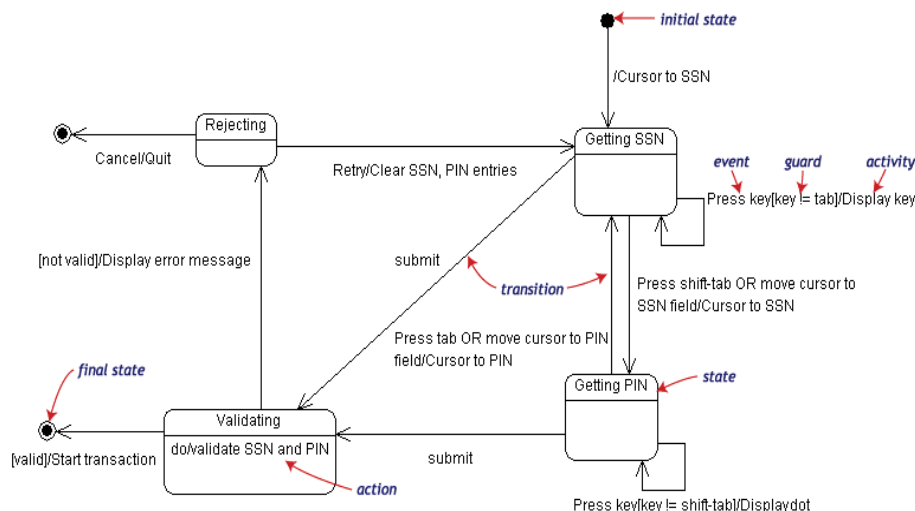
CISC844, Winter 2025

UML

18

UML: State Machine Diagrams

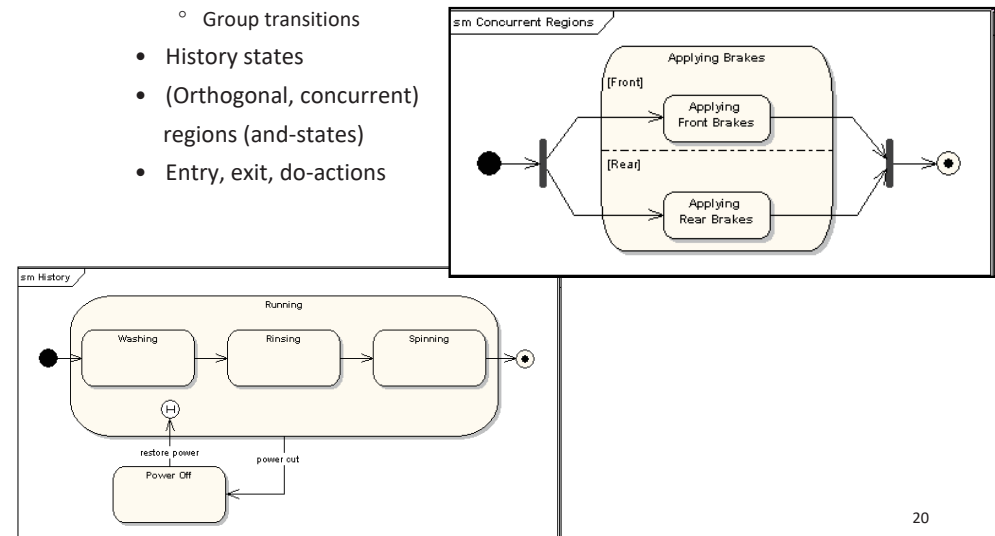
Show behaviour as sequences of state changes caused by transitions triggered by events



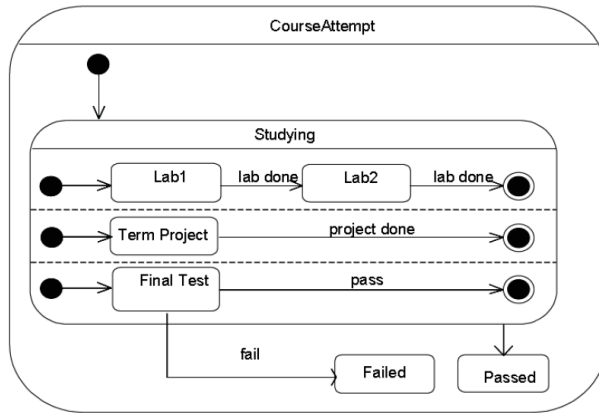
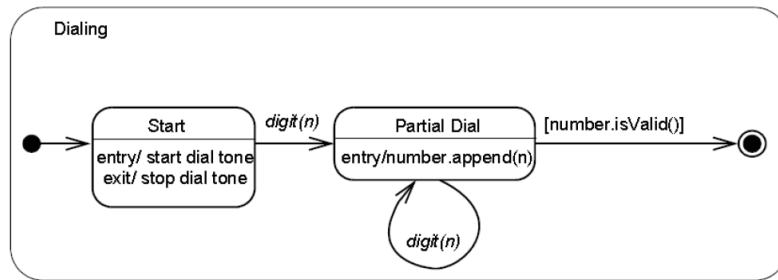
UML: State Machine Diagrams (Cont'd)

Features

- Composite states (hierarchical, or-states)
 - Group transitions
- History states
- (Orthogonal, concurrent) regions (and-states)
- Entry, exit, do-actions



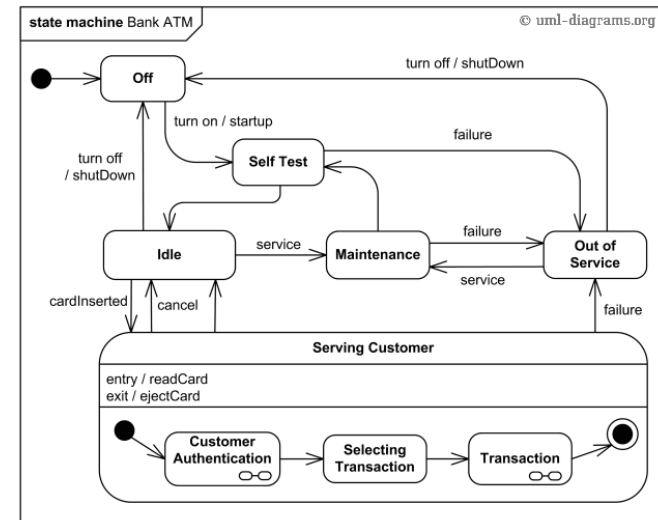
20



UML: State Machine Diagrams (Cont'd)

21

UML: State Machines (Cont'd)



[www.uml-diagrams.org]

CISC844, Winter 2025

UML

22

UML: State Machines (Cont'd)

More material

Books

- M. Fowler. UML Distilled: A Brief Guide to the Standard Object Modeling Language (3rd Edition). Addison Wesley. 2004. Available as ebook (search Queen's University Library for book title)
- G. Booch, J. Rumbaugh, I. Jacobson. UML User Guide. 2nd Edition. Addison Wesley. 2005. Available as ebook (search Queen's University Library for book title)

Cheat sheets

- [Cab24] J. Cabot. Best UML cheatsheet and UML reference guides. modeling-languages.com/best-uml-cheatsheets-and-reference-guides/

Tutorial

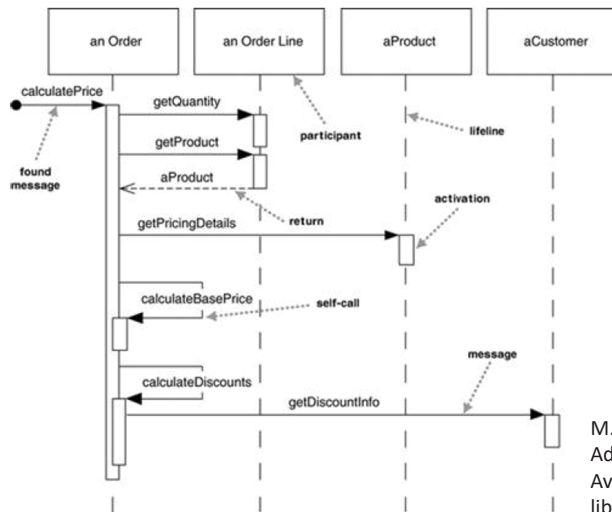
- [Amb25b] S. Amber. Online UML State Machine tutorial. agilemodeling.com/artifacts/stateMachineDiagram.htm

State Machine UML: Class Diagram (Cont'd)

- But what really is a ~~class diagram~~ state machine?
- Can we use a **class diagram** to describe the concepts that make up a **class diagram** state machine?

UML: Sequence Diagrams

- Show behaviours as sequences of messages b/w objects



M. Fowler. UML Distilled. 3rd ed. Addison Wesley. 2003. Available as eBook from the Queen's library.

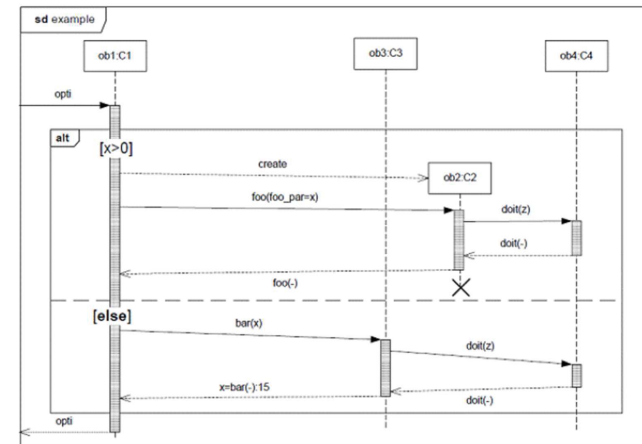
CISC844, Winter 2025

UML

25

Sequence Diagrams (Cont'd)

- Expressing alternatives (i.e., branching control flow)



OMG. UML 2.5.1 Specification.

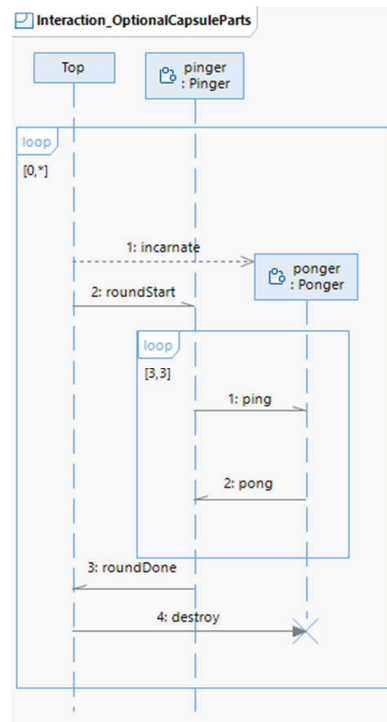
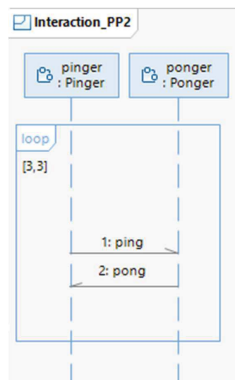
CISC844, Winter 2025

UML

26

Sequence Diagrams (Cont'd)

- Expressing iteration



agilemodeling.com/artifacts/sequenceDiagram.htm

CISC844, Winter 2025

UML

UML: Tools

- Commercial**
 - RSA, RSARTE, Rhapsody (IBM)
 - HCL Model RealTime (Rtist, RoseRT), HCL Code RealTime
 - MapleMBSE (Maplesoft)
 - MagicDraw, Cameo (No Magic)
- Open source**
 - Papyrus
 - eclipse.org/papyrus
 - Mentor Graphics xtUML
 - <http://www.xtuml.org/>
 - USE (for OCL)
 - sourceforge.net/apps/mediawiki/useocl
- Web-based**
 - Draw.io

CISC844, Winter 2025

UML

28

UML: Summary

- De facto standard in software modeling
- Rich “dictionary” of model concepts
 - UML 2.5.1 Spec has 796 pages
 - “*UML was designed to be used selectively*” Bran Selic in [Pet14]
⇒ best to approach study of UML with particular purpose, need
- Tool support
 - Still a problem, but getting better
 - Increasingly open source