Object-Oriented Analysis and Modeling

Object-oriented analysis (OOA)

- What are the relevant objects? How do they relate to one another?
- How do we specify/model a problem so that we can create an effective design?
- OOA aims to model the problem domain, by developing an object-oriented (OO) system.

Elements of the Analysis Model

Object-oriented Analysis

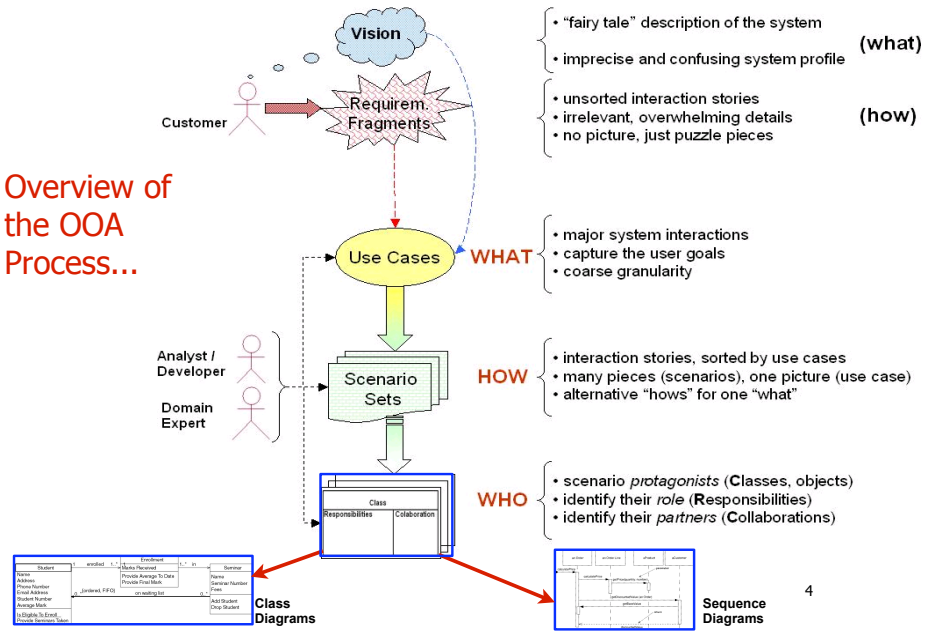
Scenario-based modeling	Class-based modeling
Use case text & diagrams Activity diagrams	CRC models Class diagrams

Structured Analysis

Flow-oriented modeling
Data structure diagrams Data flow diagrams Control-flow diagrams

Behavioral modeling
State diagrams Sequence diagrams

Overview of the OOA Process...



Class-Responsibility-Collaborator (CRC) Modeling

- Technique to identify candidate classes and indicate their responsibilities and collaborators
  - K.Beck&W.Cunningham (1989), R.Wirfs-Brock(1990,2002)
- Uses simple index cards

Class	
Responsibilities	Colaborators

Class name:	
Class type: (e.g., device, property, role, event)	
Class characteristic: (e.g., tangible, atomic, concurrent)	
responsibilities:	collaborations:

CRC Cards Session Scenario

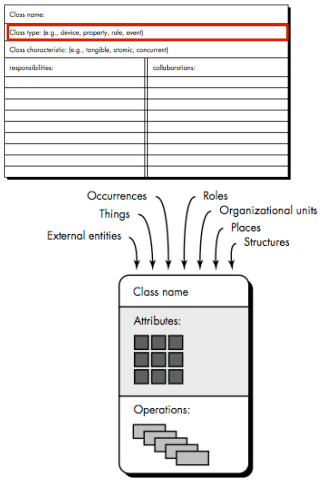
- Use-Case driven
  - a use-case is the token
- Goal: be able to go through the whole use-case description by using the responsibilities written on the CRC cards
  - ...and of course following the Collaborator links

Rules for Identifying Classes

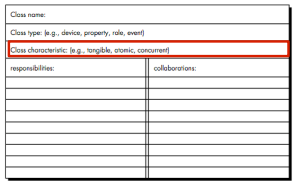
1. Retained Information
   - information about object must be remembered for the system to function
2. Needed Services
   - have a set of operations that change the value of its attributes
3. Multiple Attributes
   - focus on “major” information
   - object with single attribute is ok during design, but during analysis is just an attribute of another object
4. Essential Requirements objects
   - entities that produce or consume information of the system, in any solution

Class Types

- Thing or Device
  - e.g., report, screen display
  - e.g., sensor, vehicle, computer
- Role
  - e.g., manager, engineer, salesperson

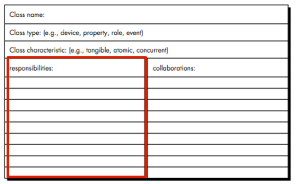


Class Characteristics



- Tangibility
  - tangible vs. abstract
- Inclusiveness
  - atomic or aggregate
- Sequentiality
  - sequential vs. multi-threaded
- Persistency
  - transient vs. temporary vs. permanent
- Integrity
  - does it protect its resources from outside influence?
    - corruptible vs. guarded

Identifying Responsibilities



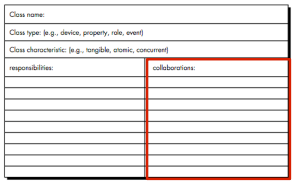
- attributes and operations of an identified class
- **Guidelines of Wirfs-Brock**:
  1. *System intelligence should be evenly distributed*
  2. *Information about one thing should be localized within a single class*
  3. *Information and its related behavior should stay in the same class*
  4. *Responsibilities should be shared among related classes*

Operations = Verbs

- **Computation**
- **Manipulation of data**
  - e.g., add, delete, modify attributes
- **Query**
  - about the state of an object
- **Monitor** an object
  - for the occurrence of a controlling event

- Has knowledge about the state of class and its associations

Collaborations



- Class can fulfill responsibilities by:
  1. using its own operations to manipulate its own attributes
  2. collaborating with others
- Three types of generic relationships:
  1. *has-knowledge-of (association)*
  2. *is-part-of (aggregation)*
  3. *composition*

Heuristics for Object-Oriented Modeling

Problema Proliferarii Claselor [Riel96]

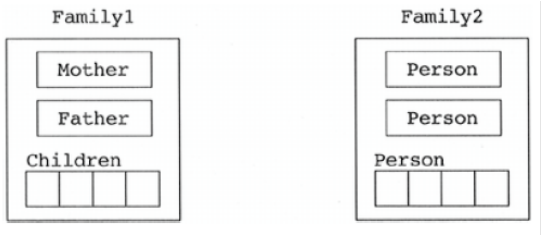
- Spaghetti Code vs. Ravioli Code
- Cum se manifesta "Codul Ravioli"
  - Vreau sa adaug o facilitate noua in sistem. Care 23 de clase din cele 4.200 de clase trebuie sa le modific?

Fiti retinuti in a modela ca si clase
entitati din afara sistemului de implementat!

- Exemplu: Clientul unui Bancomat
  - trimite un mesaj bancomatului

Clase sunt acelea care PRIMESC MESAJE (sunt apelate)
nu cele care TRANSMIT MESAJE (apeleaza)!

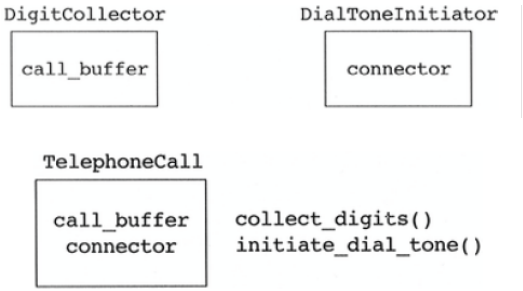
Roluri vs. Clase



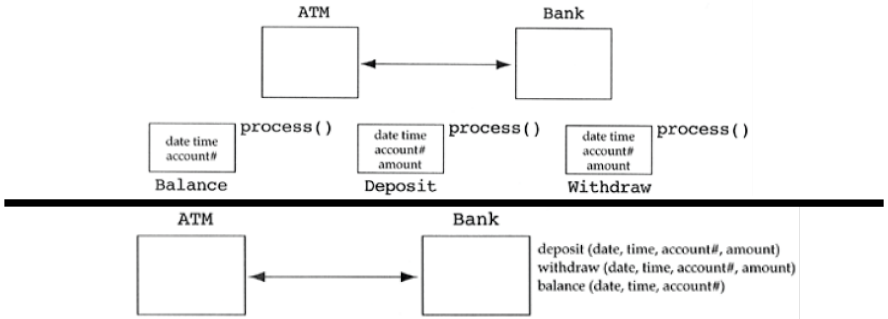
- Comportamentul este cel care decide!
  - daca comportamentul difera: **avem clase**;
  - daca nu: doar roluri ale aceleeasi clase
  - depinde de domeniul modelat de aplicatie
    - *naste()* vs. *schimbaScutece()*

Euristici pentru Eliminare Claselor Inutile

Nu transformati operatiile in clase



Cand Poate Fi Operatia o Clasa?



- cand cerintele sunt de asa natura incat operatiile reprezinta un "atom" adica "obiectiveaza" o anumita entitate intr-un context dat
  - ex. tiparirea tranzactiilor --> **operatii persistente**
  - tiparul Command

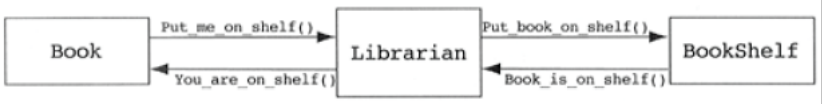
Clasele Agent

"*La o ferma orientata pe obiecta, exista o vaca orientata pe obiecte care produce lapte orientat pe obiecte.*

Dilema:
Vaca orientata pe obiecte ar trebui sa ceara laptelui orientat pe obiecte sa **se extraga pe sine** *din vaca*
... sau ar trebui ca laptele orientat pe obiecte sa trimita un mesaj vacii cerandu-i sa **se mulga pe sine** de lapte?"

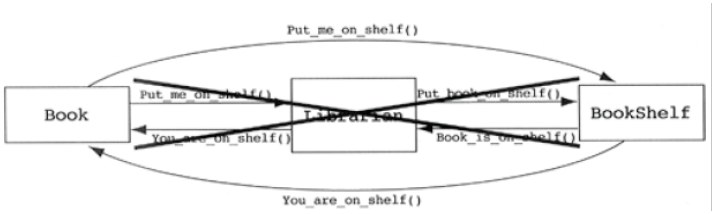
M.Pages-Jones, OOPSLA 1987

- ... la fel, considerand o carte si un raft dintr-o biblioteca, ar trebui cartea sa stie sa se puna pe raft? Sau raftul sa stie sa introduca in sine o carte?



Clasele Agent (continuare)

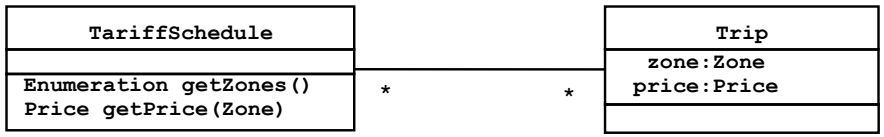
Clasele agent apar adeseori in faza de analiza si definire a modelului.
La implementare cele mai multe trebuie ELIMINATE!



- Dezavantajul: raftul bibliotecii devine mai putin reutilizabil
  - logica de asezare a cartilor intra in raftul bibliotecii...
- Trebuie gasit un echilibru intre un cuplaj moderat si a nu lasa clasele fara comportament

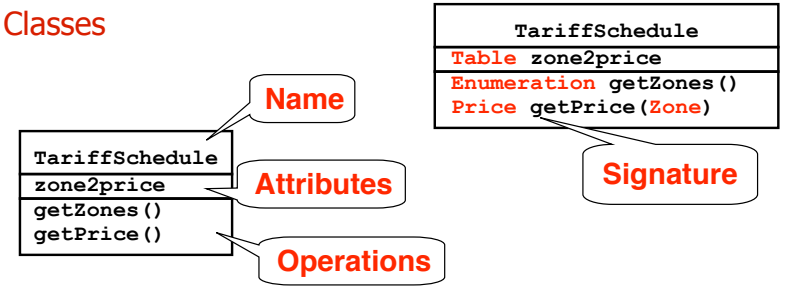
Class Diagrams

Class Diagrams

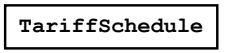


- Class diagrams represent the structure of the system.
- Class diagrams are used
  - during requirements analysis to model problem domain concepts
  - during system design to model subsystems and interfaces
  - during object design to model classes.

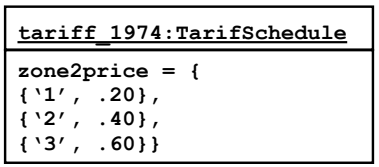
Classes



- A class represent a concept.
- A class encapsulates state (attributes) and behavior (operations).
- Each attribute has a type.
- Each operation has a signature.
- The class name is the only mandatory information.



Instances

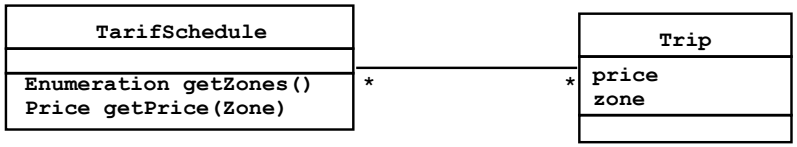


- An **instance** represents a phenomenon.
- The name of an instance is underlined and can contain the class of the instance.
- The attributes are represented with their **values**.

Instance vs. Class

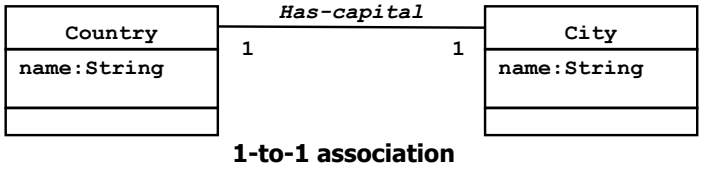
Rene Magritte, Treachery of Images - 1929

Associations

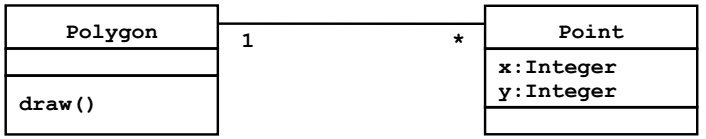


- Associations denote relationships between classes.
- The multiplicity of an association end denotes how many objects the source object can legitimately reference.

1-to-1 and 1-to-Many Associations



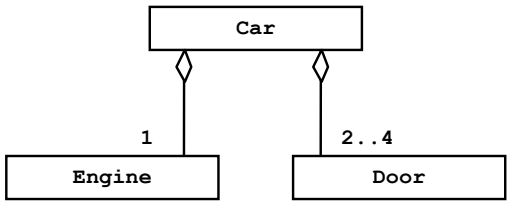
1-to-1 association



1-to-many association

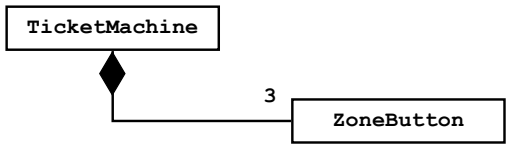
Aggregation

- An **aggregation** is a special case of association denoting a "*consists of*" (HAS-A) hierarchy.
- The aggregate is the parent class, the components are the children class.

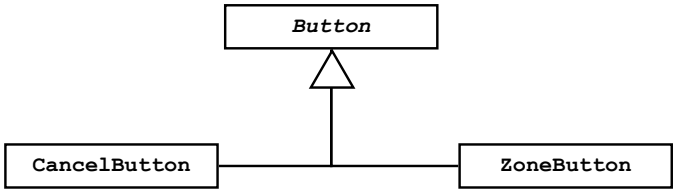


Composition

- A solid diamond denote **composition**, a strong form of aggregation where components cannot exist without the aggregate.



Generalization



- Generalization relationships denote inheritance between classes.
- The children classes inherit the attributes and operations of the parent class.
- Generalization simplifies the model by eliminating redundancy.

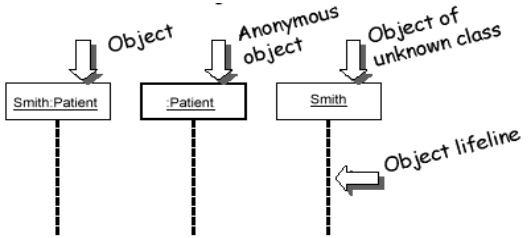
Sequence Diagrams

UML Sequence Diagrams

- Sequence Diagram: an "interaction diagram" that models a single scenario executing in the system
  - perhaps 2nd most used UML diagram (behind class diagram)
- Participant: an object or entity that acts in the sequence diagram
  - sequence diagram starts with an unattached "found message" arrow
- Message: communication between participant objects
- Axes in a sequence diagram:
  - horizontal: which object/participant is acting
  - vertical: time (down -> forward in time)

Representing Objects

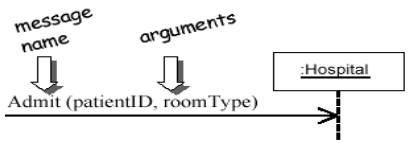
- squares with object type, optionally preceded by object name and colon
  - write object's name if it clarifies the diagram
  - object's "life line" represented by dashed vert. line



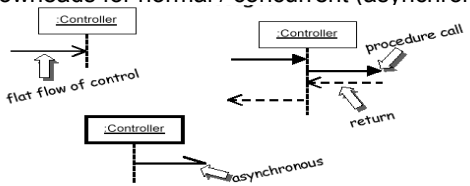
Name syntax: <objectname>:<classname>

Messages between objects

- message (method call) indicated by horizontal arrow to other object
  - write message name and arguments above arrow

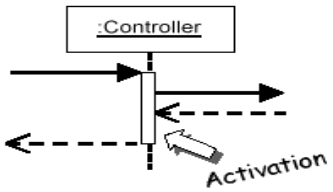


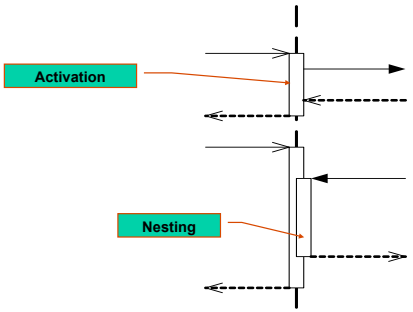
  - dashed arrow back indicates return
  - different arrowheads for normal / concurrent (asynchronous) methods



Indicating method calls

- Activation: shows when object's method is on the stack
  - either that object is running its code, or it is on the stack waiting for another object's method to finish
  - nest to indicate recursion

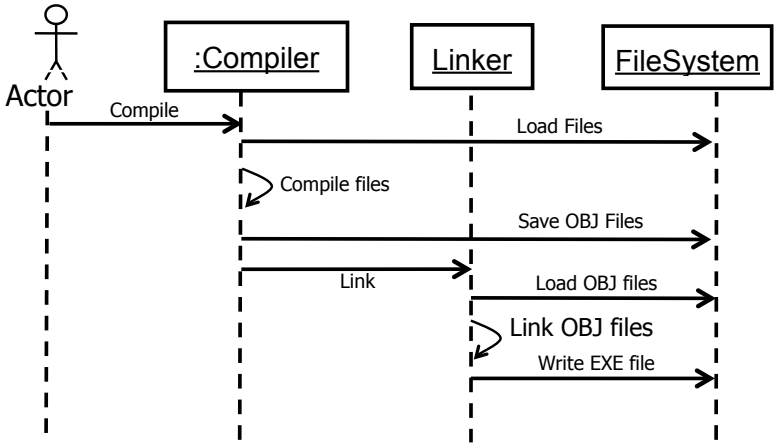




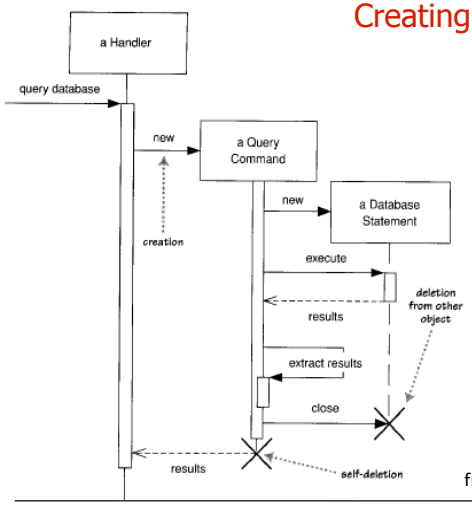
Example 1:

- Building an executable from sources
  - load source files and compile them
  - load resulting object files and link them
  - write executable file

Sequence Diagram – Compilation

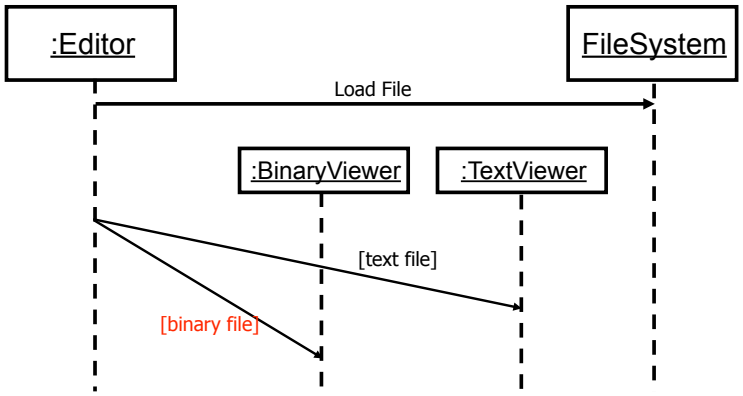


Creating and Deleting objects

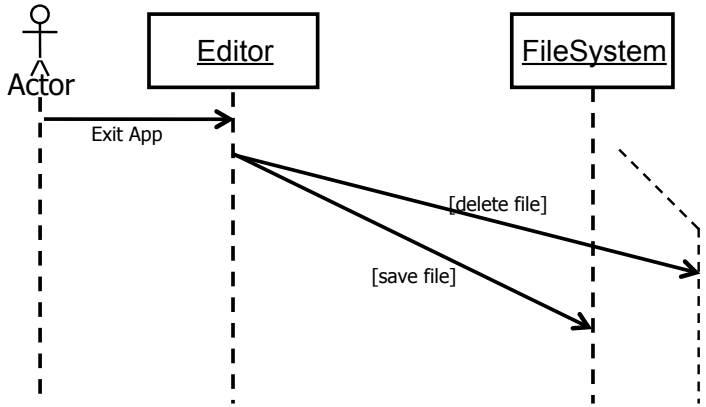


from **M.Fowler–UML Distilled, 2004**

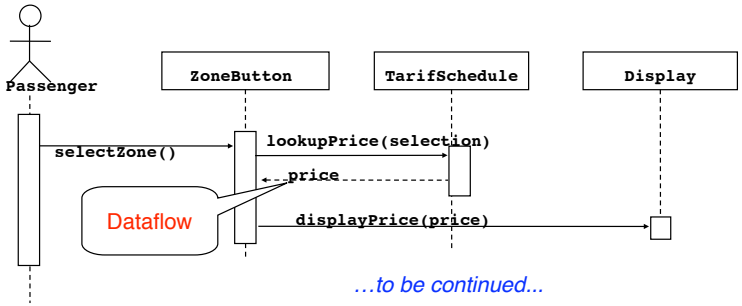
Branching Flow: flow goes to different objects [if condition is met]



Alternative Flow: flow changes to alternative lifeline branch of the same object



Flow of messages

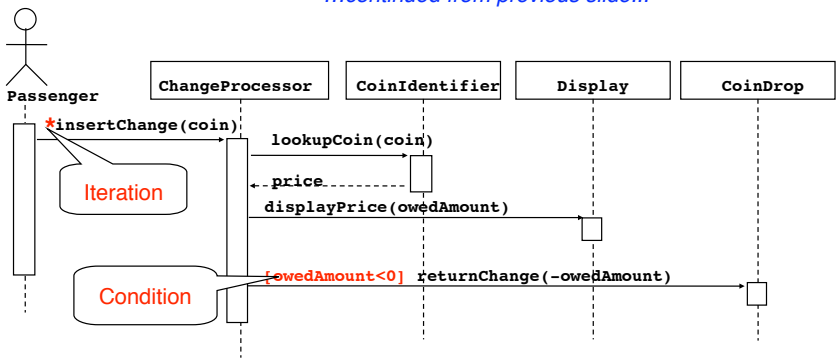


…to be continued...

- The source of an arrow indicates the activation which sent the message
- An activation is as long as all nested activations
- Horizontal dashed arrows indicate data flow
- Vertical dashed lines indicate lifelines

Iteration & condition

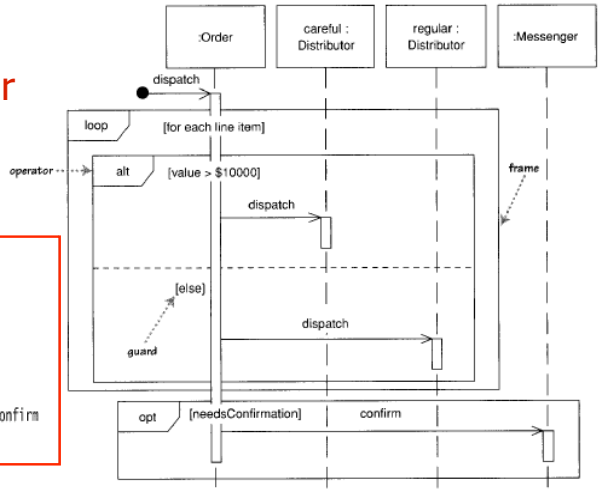
…continued from previous slide…



- Iteration is denoted by a * preceding the message name
- Condition is denoted by boolean expression in [ ] before the message name

Alternative Notation for Condition and Loops

```
procedure dispatch
  foreach (lineitem)
    if (product.value > $10K)
      careful.dispatch
    else
      regular.dispatch
    end if
  end for
  if (needsConfirmation) messenger.confirm
end procedure
```



from **M.Fowler–UML Distilled, 2004**

Sequence Diagram Summary

- UML sequence diagram represent behavior in terms of interactions.
- Useful to find missing objects.
- Time consuming to build but worth the investment.
- Complement the class diagrams (which represent structure).