High-level Design

- Software Architecture
  - What is it?
  - Examples of common architectures
- Parnas' KWIK index example of information hiding
- Model view controller in high level layered design

What is software architecture?

"The architecture of a system is comprehensive framework that describes its form and structure -- its components and how they fit together" Jerrold Grochow, Pressman, Ch 10

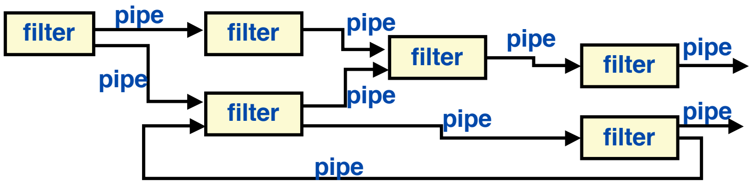
- Describes overall shape & structure of system
  - How components are integrated into cohesive whole
  - Their externally visible properties
  - Their relationships
- Goal: choose architecture to reduce risks in SW construction & meet requirements

SW Architectural Styles

- Architecture composed of
  - Set of components
  - Set of connectors between them
    - Communication, co-ordination, co-operation
  - Constraints on integration
  - Semantic models for understanding the overall properties from analysis of component known properties
- Architecture patterns for common organizational structures

Source: Adapted from Shaw & Garlan 1996, p21-2. See also van Vliet, 1999 Pp266-7 and p279

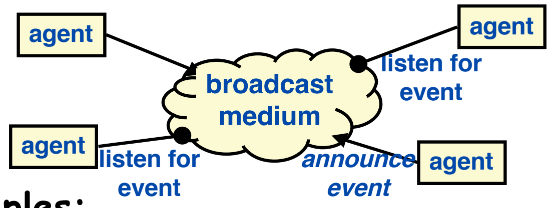
Pipe & Filter



- Examples:
  - UNIX pipes, compilers, signal processors
- Pros:
  - Filters oblivious of their neighbors, can be built in parallel
  - System behavior is compositional
- Cons:
  - Hard to handle errors
  - Often need encoding/decoding of input/output

Source: Adapted from Shaw & Garlan 1996, p23-4. See also van Vliet, 1999 Pp264-5 and p278

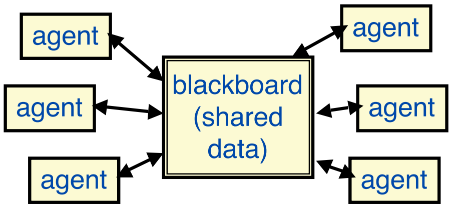
Event-based Architecture



- Examples:
  - GUIs, Breakpoint debuggers
- Pros:
  - Anonymous handlers of events
  - Supports re-use and evolution, new agents easy to add
- Cons:
  - Components have no control over order of execution

Source: Adapted from Shaw & Garlan 1996, p26-7. See also van Vliet, 1999, p280

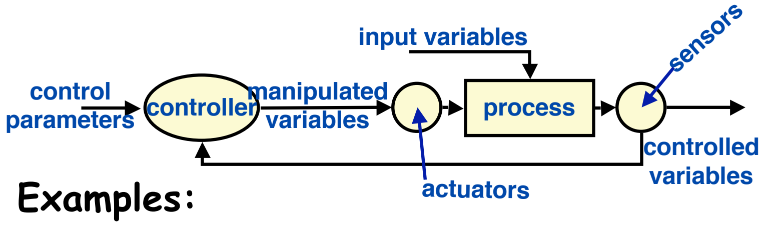
Data-centric Architecture



- Examples:
  - Databases, programming environments
- Pros:
  - Promotes integrability (ease of changing/adding clients)
  - Reduces need to replicate complex data
- Cons:
  - Blackboard can become a bottleneck

Source: Adapted from Shaw & Garlan 1996, p27-31.

Process Control Architecture



- Examples:
  - Control systems (e.g., airplanes, spacecraft, industrial production lines, power stations
- Pros:
  - Handles real-time, reactive systems
  - Separates control policy from controlled process
- Cons:
  - Hard to specify timing constraints or responses to disturbances

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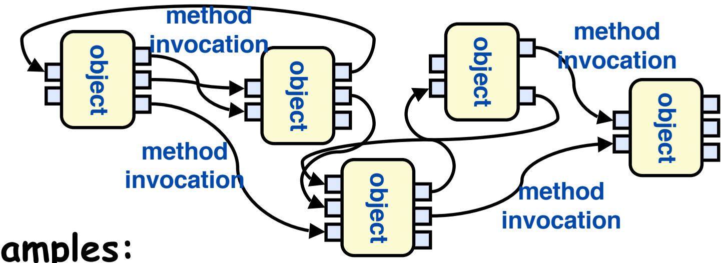
Source: Adapted from Shaw & Garlan 1996, p22-3.

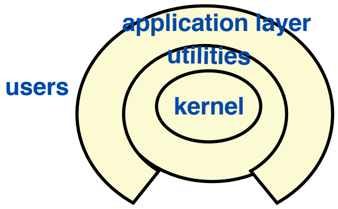
OO Architecture



- Examples:
  - Abstract datatypes and object broker systems (e.g., CORBA)
- Pros:
  - Offers data hiding
  - Problems expressed as set of interacting agents
- Cons:
  - Objects need to know with whom they need to interact (more later on patterns)

Source: Adapted from Shaw & Garlan 1996, p25. See also van Vliet, 1999, p281.

Layered Architecture



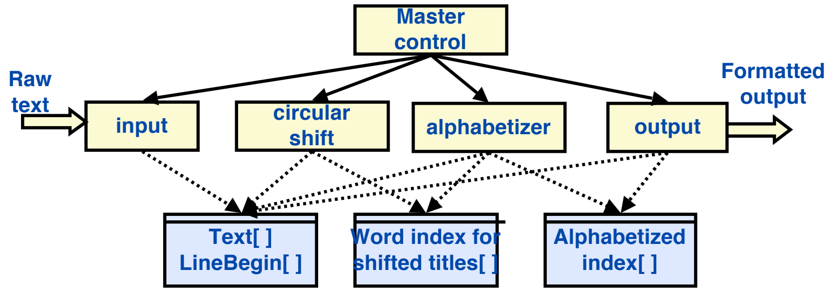
- Examples:
  - Operating systems, Communication protocols, E-commerce applications
- Pros:
  - Supports increasing levels of abstraction during design
  - Supports re-use and enhancement
  - Can have standard layer interfaces

D. Parnas,"On the criteria to be used in decomposing systems into modules", CACM 1971.

Key Principle: Information Hiding

- Design modules to hide design decisions
  - To accommodate possible change
  - Module as a responsibility assignment, not a subprogram
- Problem
  - KWIC = Key Word In Context
    - Task is to build a contextualized index for the text; Input is a set of lines of text; Output is the set of all circular shifts of all lines, in alphabetical order
- Two Designs
  - Shared data model
  - Data abstraction model

KWIK Index - Shared Data


Master control

Raw text

input

circular shift

alphabetizer

output

Formatted output

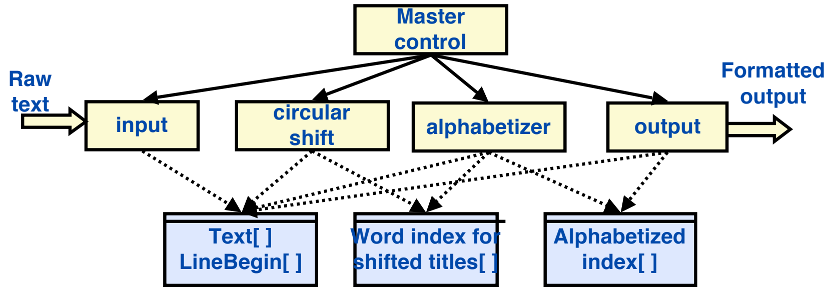
Text[ ] LineBegin[ ]

Word index for shifted titles[ ]

Alphabetized index[ ]

- Control-flow based design
  - Every module "knows" internal representation of data and addressing mechanism!
  - Good for adding another functionality

KWIK Index - Shared Data


Master control

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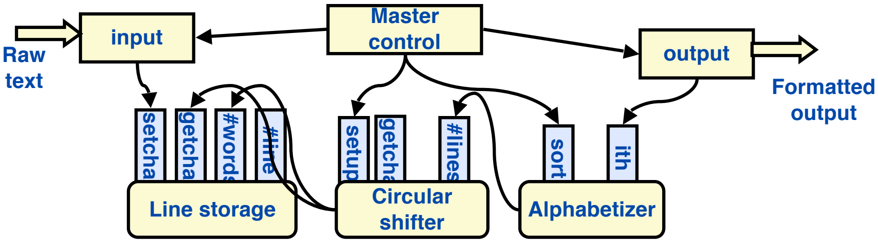
Text[ ] LineBegin[ ]

Word index for shifted titles[ ]

Alphabetized index[ ]

- Possible changes
  1. Input format
  2. Decision to store index in-core
  3. Packing of chars in words
  4. Use indexed notation or write out shifts

KWIK Index - Information hiding



- Based on hiding design decisions from other modules
  - Easier to change
    - #4 only affects the circular shifter here

D. Parnas," Designing software for ease of extension and contraction", IEEE Trans on SE, March 1979

Design for Extension & Contraction

- Idea of tailoring SW for specific apps
  - “family of programs w common aspects
- Idea (like a VM):
  - Identify minimal subset of reqs needed to be useful
  - Use information hiding
  - Don’t think of components as processing steps
  - Think about *uses* (not invokes) relation
    - Pgm A uses pgm B if sometimes the correct functioning of pgm A requires availability of a correct implementation of pgm B

Uses Relation

- Think about uses relation
    - Level 0 programs use no other
    - Level k programs use at least 1 program at level (k-1) but none at higher level
    - Then each level is a testable, usable subset of the system
- A should be allowed to use B if
    - A is simpler thereby
    - B is not more complex than A and doesn't use A (want acyclic relation)
    - There is a useful subset of the system containing B but not A
    - There's no useful subset of the system containing A but not B

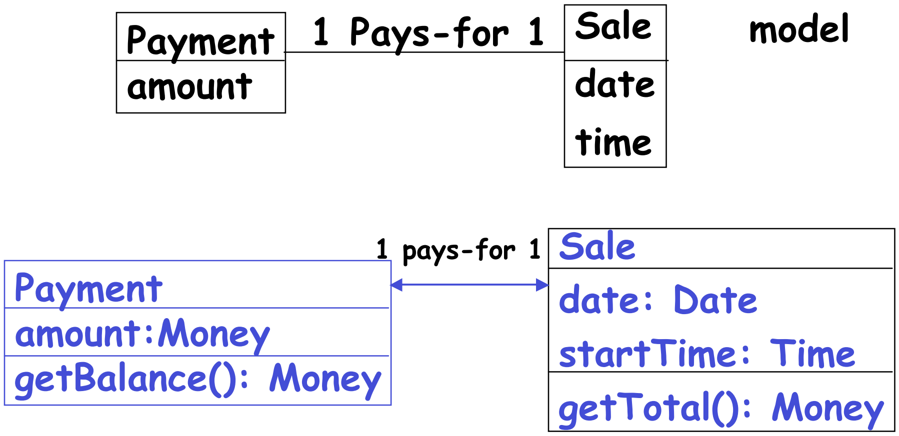
Layered Architecture

- Logical architecture
    - Large-scale organization of SW classes into packages (i.e., namespaces), subsystems and layers
- Layer - coarse-grained grouping of classes having responsibility for a major aspect of system
    - Strict - layer only calls layer directly below it
    - Relaxed - layer can call any layer below it
    - Responsibilities of objects in a layer are strongly related to each other
- UML package diagrams show logical architecture (LAR Ch 13.1)
    - Coupling between packages shown by UML dependency line, A- - - - -> B

Three Common Layers

- User interface
- Application logic and domain objects
  - E.g., Sale
  - Focus of OOA/D: Domain layer classes may represent domain model conceptual classes
- Technical services
  - E.g., interfacing with database, error logging
- Layer can be partitioned into horizontal slices
  - E.g., tech services: security & reporting

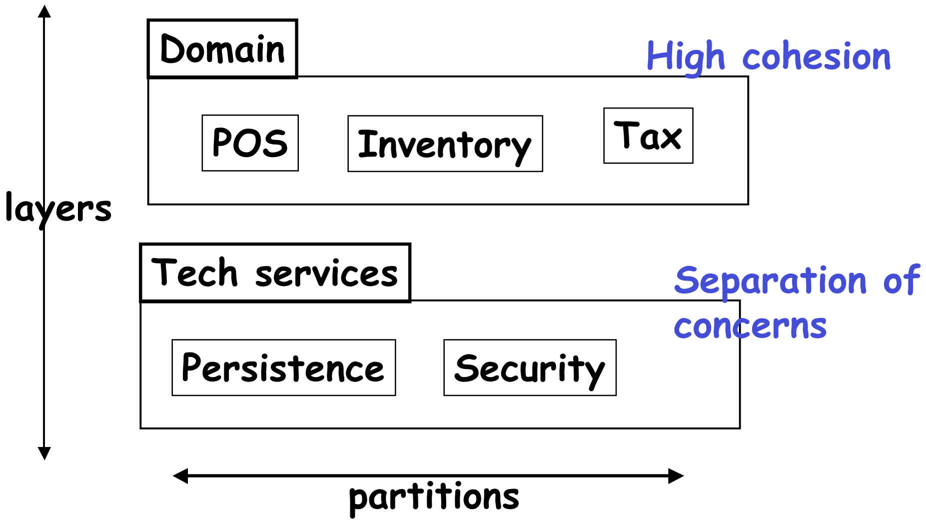
Example



Domain model

Domain layer, Design model

Domain Layer in UP Model



Domain

High cohesion

POS

Inventory

Tax

layers

Tech services

Separation of concerns

Persistence

Security

partitions

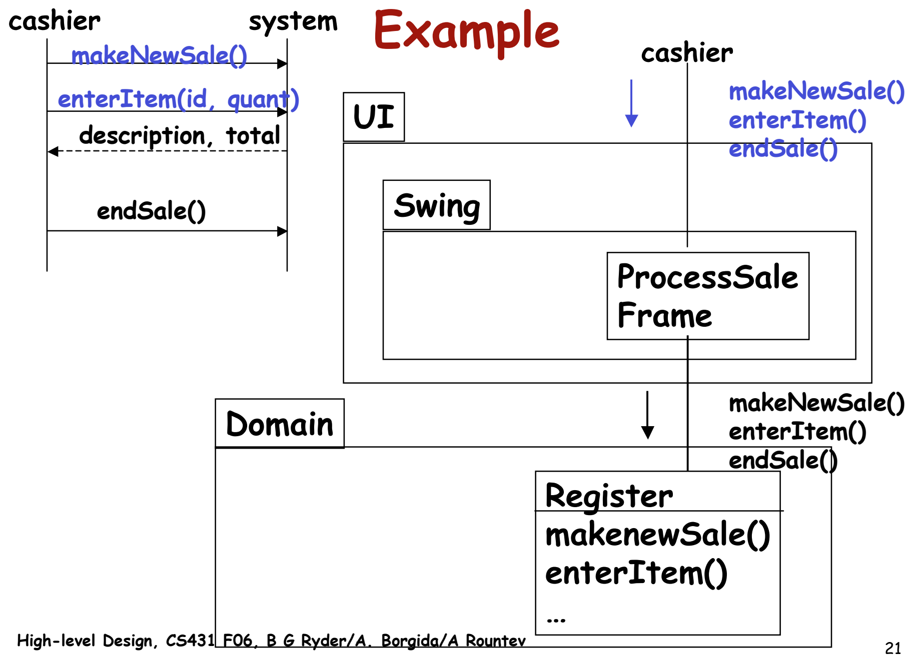
Model-View Separation Principle

1. Do not connect non-UI objects directly to UI objects
    - Sale object should not refer to a Java Swing JFrame object

- Do not put application logic in UI object methods
    - UI objects initialize UI elements; receive UI events (e.g., mouse click); delegate requests for application logic to non-UI objects

- Messages from UI to domain layer will be messages in corresponding sequence diagram

Example



cashier

system

makeNewSale()

enterItem(id, quant)

description, total

endSale()

cashier

UI

makeNewSale()
enterItem()
endSale()

Swing

ProcessSale
Frame

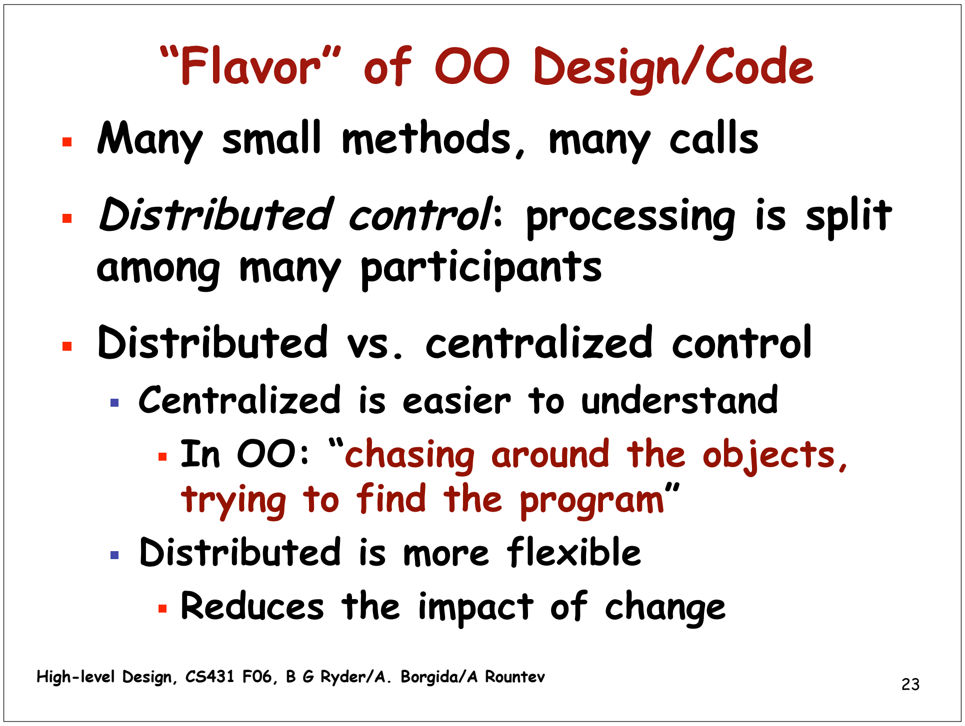
makeNewSale()
enterItem()
endSale()

Domain

Register
makenewSale()
enterItem()
...

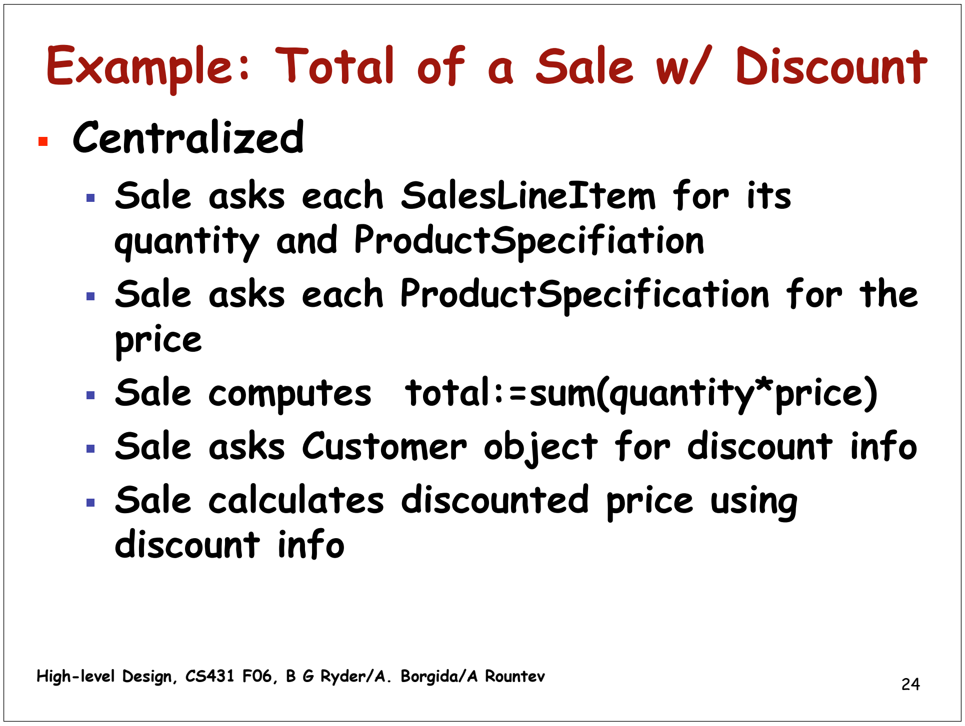
Object-Oriented Design

- Objects, with attributes and operations
- Classes define the blueprint for objects
  - Objects are instances of classes
- Messages between objects
  - Object x sends message to object y to activate one of m's operations
- Operation in design -> method in code
- Message in design -> method call in code



"Flavor" of OO Design/Code

- Many small methods, many calls
- *Distributed control*: processing is split among many participants
- Distributed vs. centralized control
  - Centralized is easier to understand
    - In OO: "chasing around the objects, trying to find the program"
  - Distributed is more flexible
    - Reduces the impact of change



Example: Total of a Sale w/ Discount

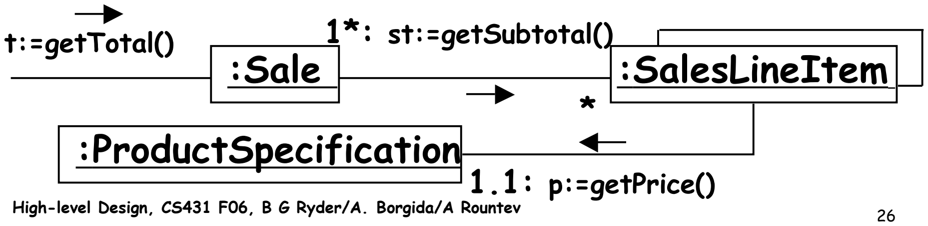
- Centralized
  - Sale asks each SalesLineItem for its quantity and ProductSpecifiation
  - Sale asks each ProductSpecification for the price
  - Sale computes total:=sum(quantity*price)
  - Sale asks Customer object for discount info
  - Sale calculates discounted price using discount info

Example, cont.

- Distributed
  - Sale asks each SalesLineItem to compute its subtotal
  - Sale computes total := sum(subtotals)
  - Sale gives the total to the Customer object and asks it to compute the discounted price
- More delegation of responsibility, less coupling

Core Principles of OO Design

- Identify the responsibilities that are needed to satisfy the requirements
- Assign these responsibilities to objects
  - Add the appropriate operations (i.e., methods)
- Design the interactions among objects
  - Add the appropriate messages (i.e., calls)



UP Artifacts

Artifact	Incep	Elab	Const	Trans
Use-Case Model	X	X		
Supplem. Spec	X	X		
Domain Model		X		
Design Model		X	X	
Implem. Model		X	X	X

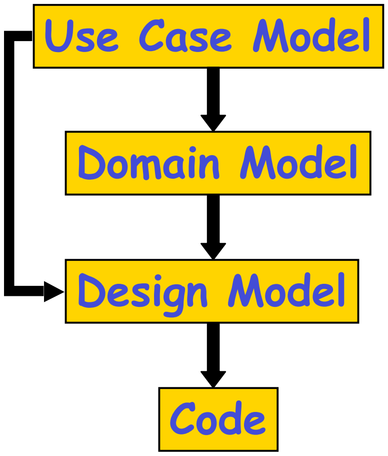
Requirements analysis: Use-Case Model + Supplementary Specification

Domain analysis: Domain Model

Design: Design Model

Coding: Implementation Model

Relationships Among Models



Use Case Model

Domain Model

Design Model

Code

Design in the Unified Process

- At the end of elaboration
  - Almost all requirements are clarified
  - High-risk design aspects are stabilized
- Construction: iterative design and coding for the remaining requirements
- Interaction diagrams: sequence diagrams, communication diagrams
- Design class diagrams