Software Architecture

Lecture 3

Architectural Views and Styles

Rob Pettit

George Mason University

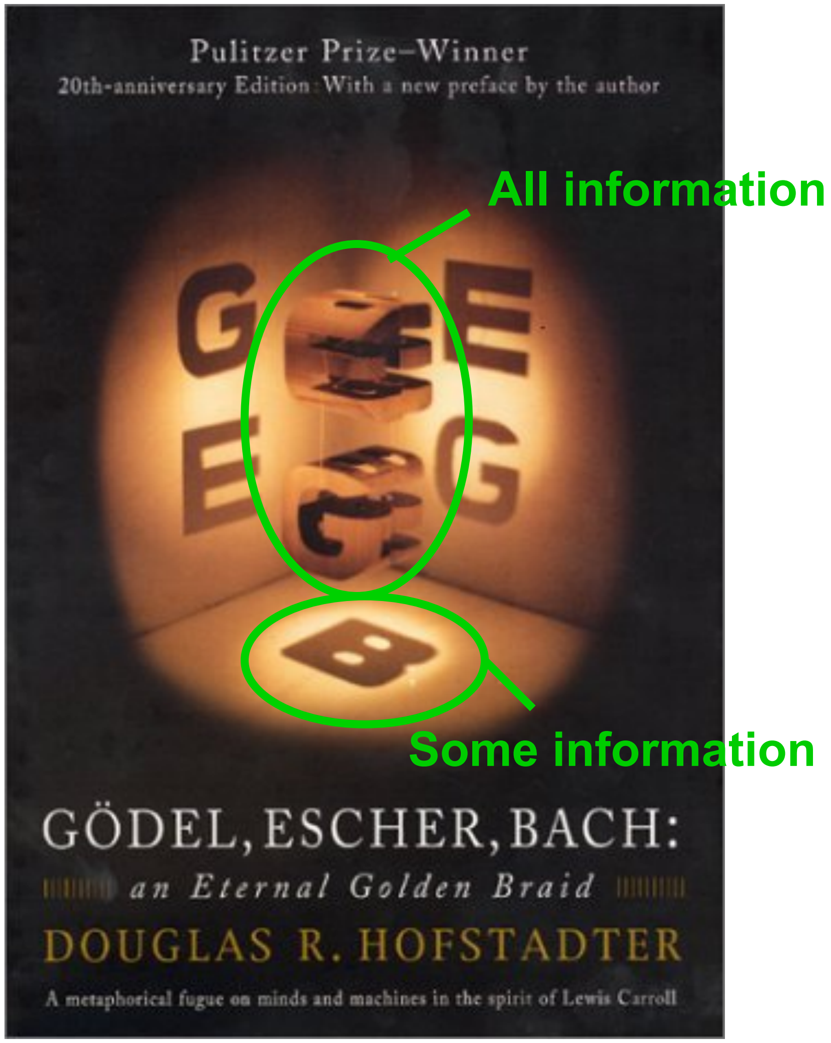
outline

- architectural views
  - module viewtype
  - component & connector viewtype
  - allocation viewtype
  - styles

one system, many views

- a view is a representation of a set of system elements and the relations among them
- not *all* system elements
- a view selects *element types* and *relation types* of interest, and shows only those

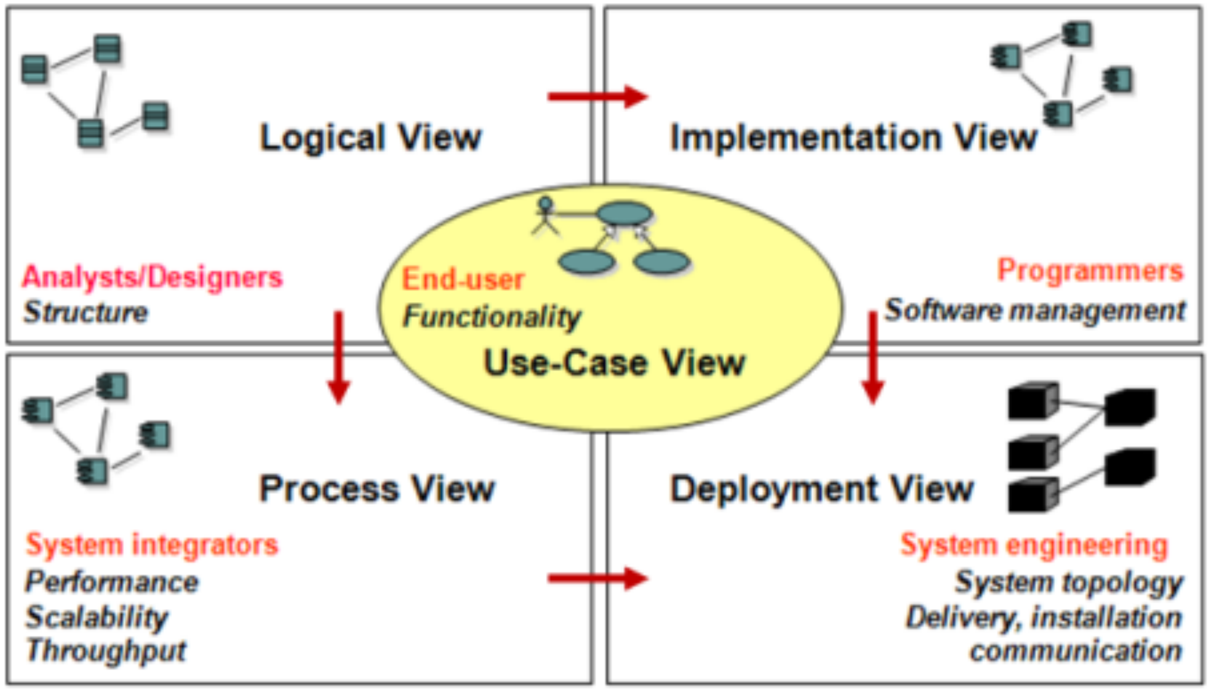
why?


Pulitzer Prize–Winner
20th-anniversary Edition With a new preface by the author
All information
Some information
GÖDEL, ESCHER, BACH:
an Eternal Golden Braid
DOUGLAS R. HOFSTADTER
A metaphorical fugue on minds and machines in the spirit of Lewis Carroll

one system, many views

- an architect examines the system in three ways
  - how is it structured as a set of code units?
    - module viewtype
  - how is it structured as a set of elements that have run-time behavior and interactions?
    - component & connector viewtype
  - how does it relate to non-software structures, such as hardware and development teams?
    - allocation viewtype

more commonly – 4+1 views



- Adapted from Philippe Kruchen, IEEE Software 12(6)

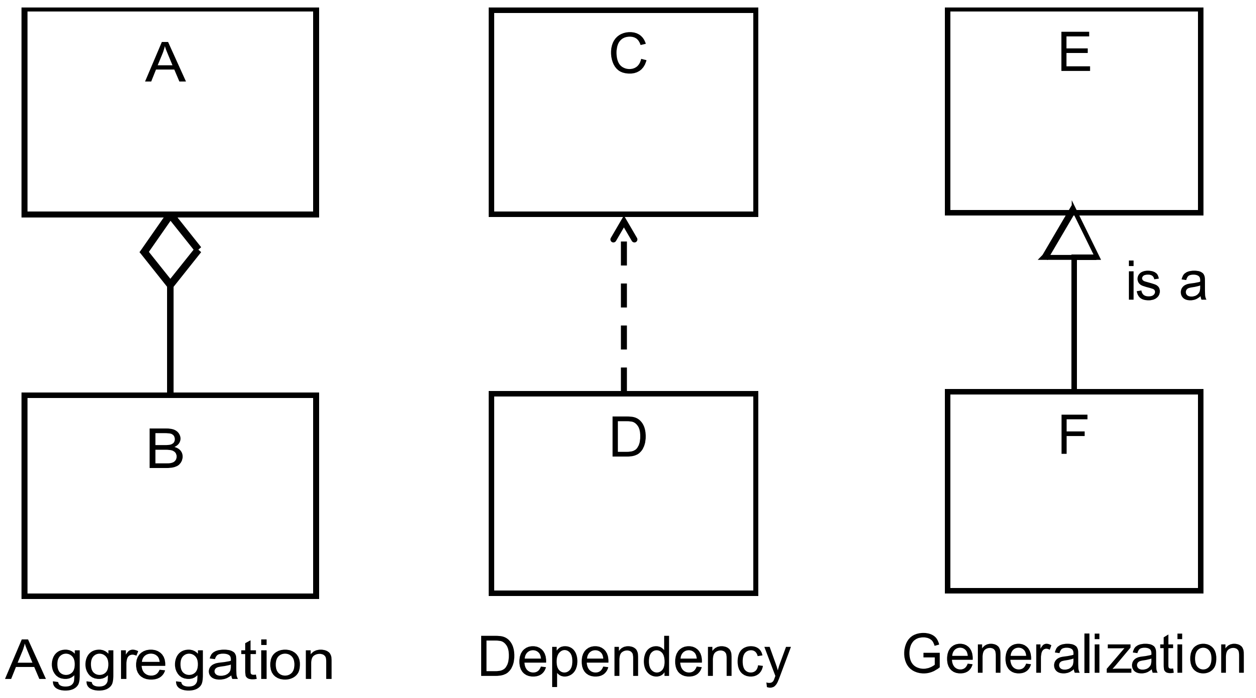
module viewtype
describes the code structure

- elements are modules
  code unit that implements a set of functionalities

- relations among modules include
  - A is part of B
    defines a part-whole relation
  - A depends on B
    defines a functional dependency relation
  - A is a B
    defines specialization and generalization

different notations exist for module views

- UML class diagrams:



- informal: stacked boxes, box-and-line...

examples in a moment

module viewtype
used for code construction and budgeting

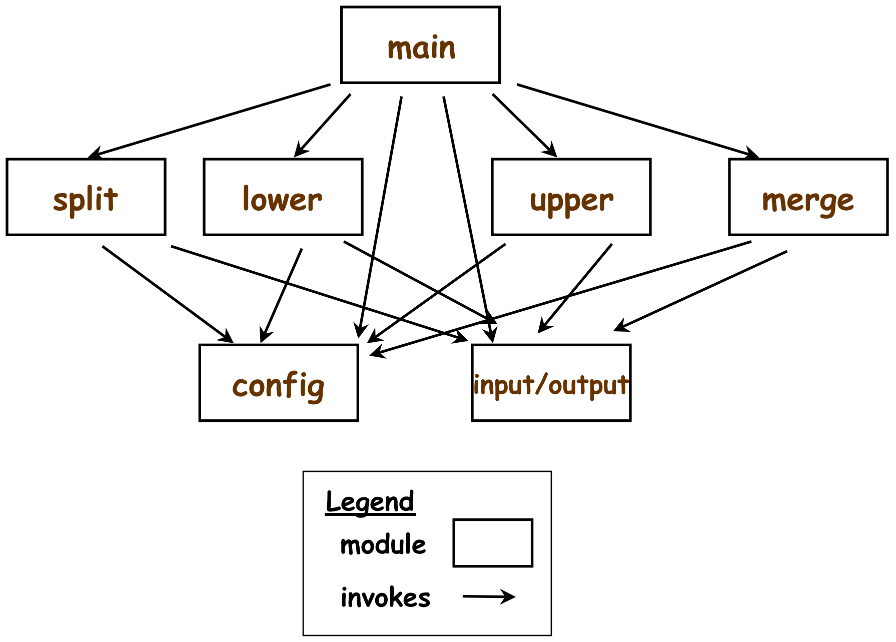
- construction
  - module views are the blueprints for the code
  - modules are assigned to teams for implementation
  - modules are often the unit for refining the design (e.g., module interfaces)
- analysis
  - traceability and impact analysis
  - budgeting, project management: planning and tracking

module and C&C show different aspects

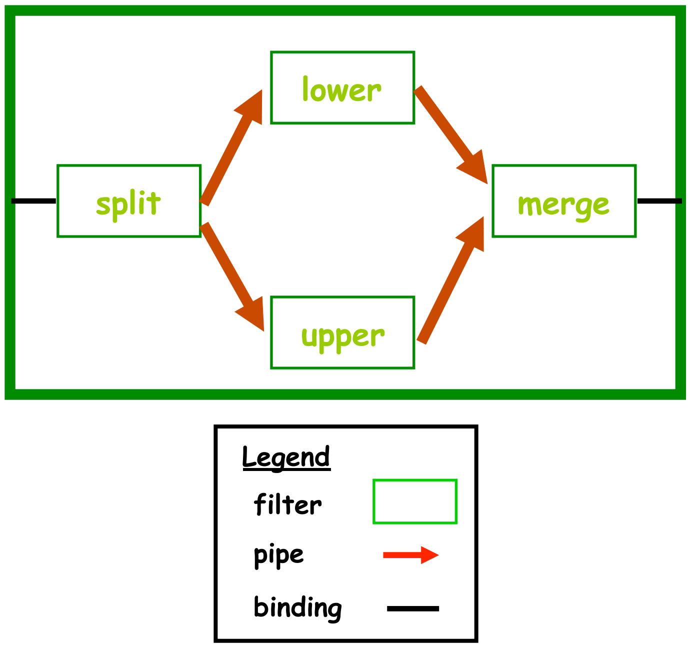
example program:

- produce alternating case of characters in a stream

module view



C&C view

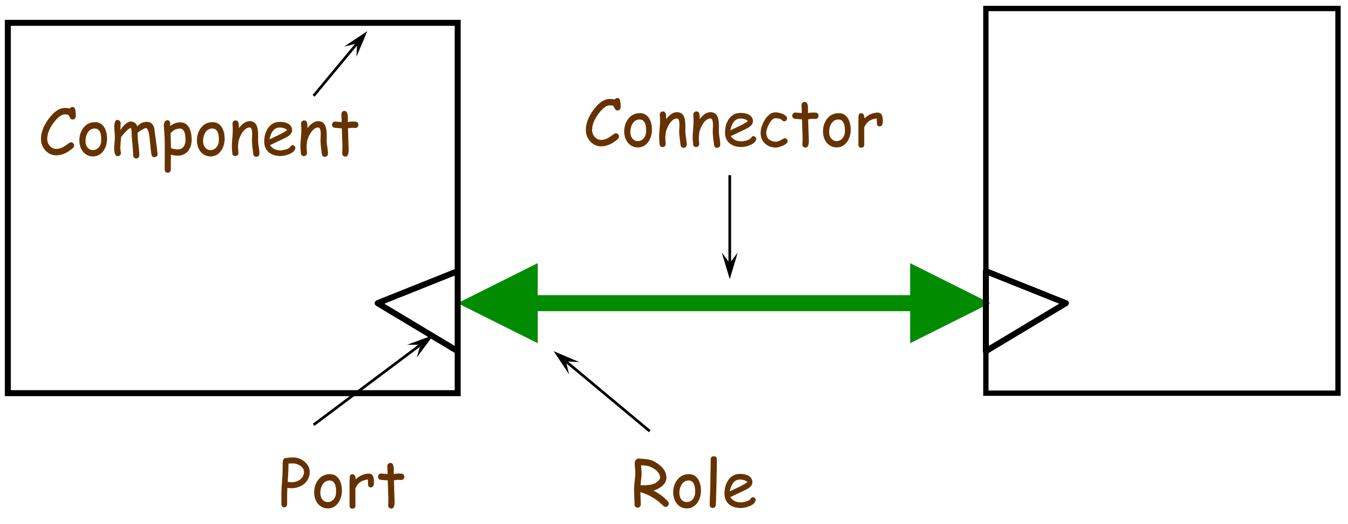


C&C viewtype
describes how the system works

- elements
  - components (boxes)
    principal units of run-time computation and data stores
  - connectors (lines)
    interaction mechanisms – identity and behavior of their own
- relations
  - attachment of components to connectors
- properties
  information for construction & analysis
  - quality attributes
  - others, depending on *style* (more in a moment)

different notations exist
for C&C views

- ACME diagrams:



- other notations (normally box-and-line)

examples in a moment

C&C viewtype
used for behavior and QoS analysis

- construction
  - how the system will appear at run time
  - what kind of behavior must be built in
  - pathways of interaction and communication mechanisms
- analysis of runtime properties
  - availability
  - performance
  - security
  - reliability…

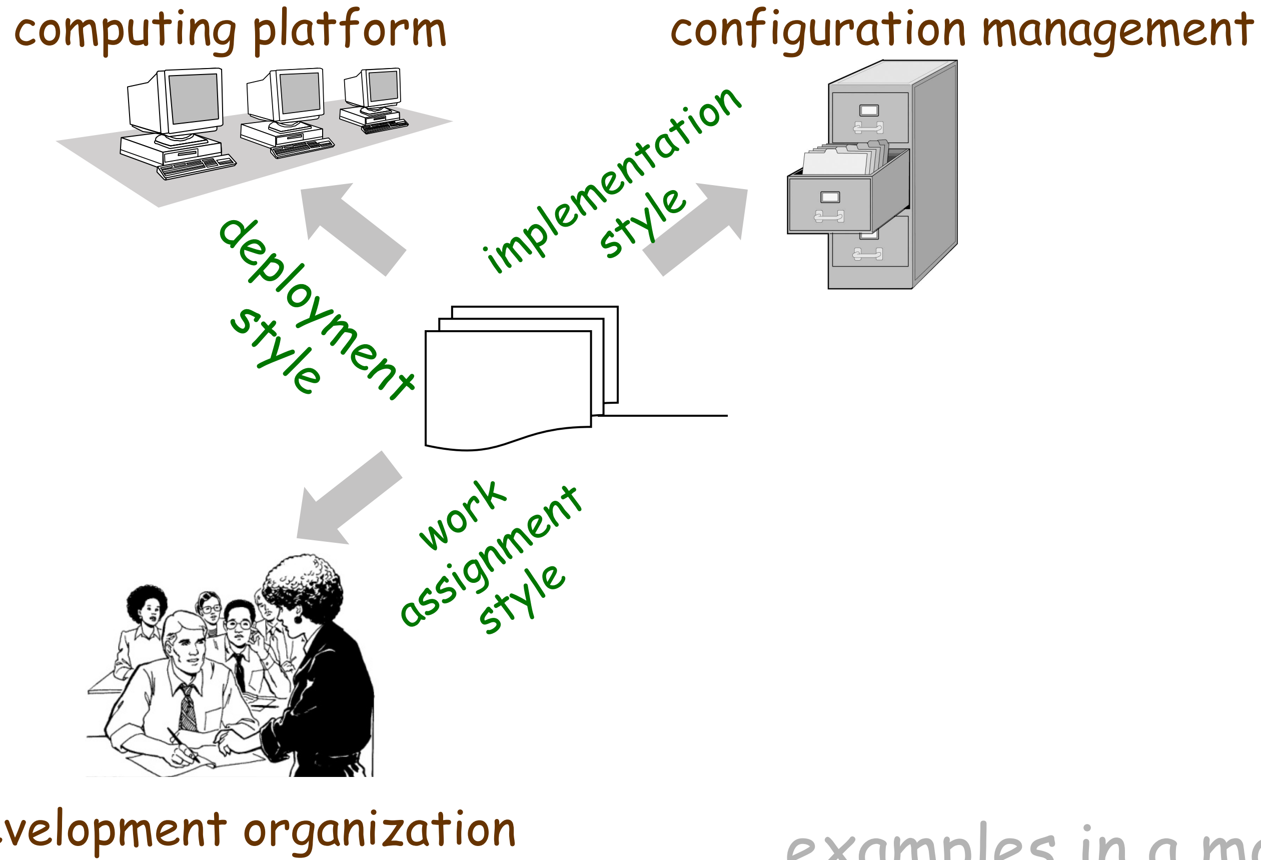
allocation viewtype

- elements
  - software elements
    as defined in module or C&C views
  - environment elements
    such as hardware and development teams

- relations
  - allocated-to

notations for allocation views depend on the *style*

- normally informal, style-specific notations



examples in a moment

outline

- architectural views

  overview of the first half semester

  - module viewtype
  - component & connector viewtype
  - allocation viewtype
  - styles

architectural styles:
specialization of element and relation types

- within each viewtype, recurring forms have been widely observed in different systems
- these forms are worth capturing because they have known properties and can be re-used:
  "tools" in the architect's "bag of tricks"

an architectural style
is a specialization of element and relation types
together with a set of constraints on how they can be used

- styles exist independently of any system
- two different systems can use the same style
- different parts of the same system may use different styles

remember

- *viewtypes* reflect the three broad ways an architect looks at a system:
  - units of implementation (module viewtype)
  - run-time units (C&C viewtype)
  - relation to non-software structures (allocation viewtype)
- within a viewtype, many choices remain:
  - what kinds of elements are allowed
  - how they relate to each other
  - how are they used or configured

  different styles result from making different choices

three major styles in the module viewtype

- decomposition style
  - hierarchical decomposition of modules
  - supports concurrent development
- generalization style
  - specialization hierarchy
  - supports reuse; managing large numbers of definitions
- layered style
  - virtual machines
  - supports portability, reuse

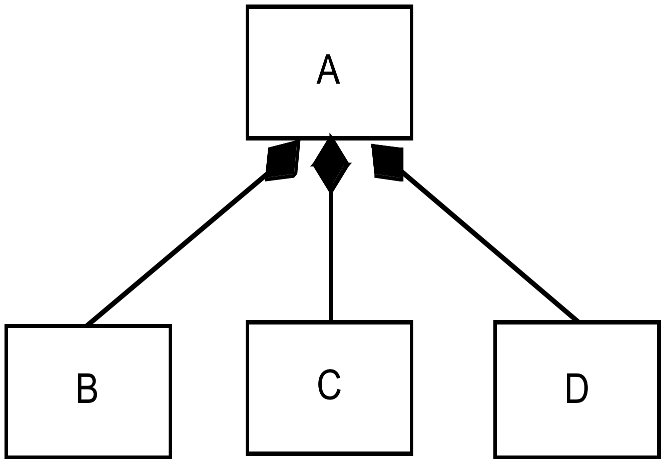
decomposition style in the module viewtype

- elements are modules
- relations restricted to A is part of B

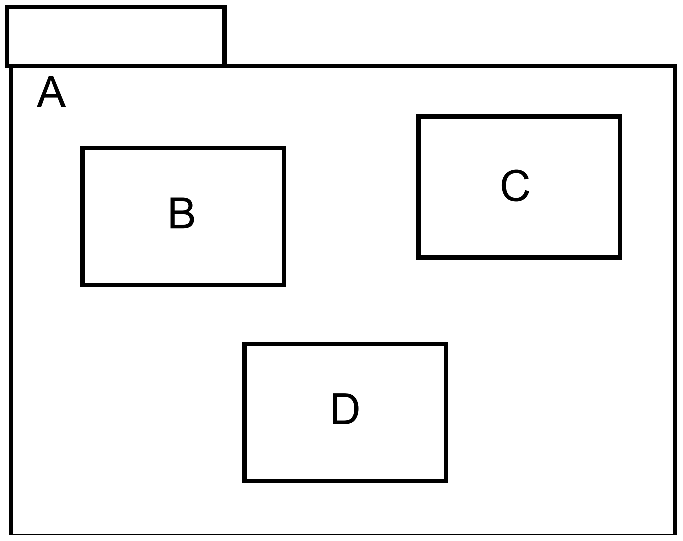
- what it is for
  - a starting point
    frequently, assigning functions to modules
    is a prelude to detailed design
  - change/impact analysis
  - basis for work assignments
    provides elements in the allocation view

decomposition style in the module viewtype

- examples in UML



(classes)



(packages)

decomposition style in the module viewtype

- outline/tree examples

- Software Decision Module
  - Application Data Type Module
    - Numeric Data Type Module
    - State Transition Event Mod.
  - Data Banker Module
    - Singular Values Module
    - Complex Event Module
  - Filter Behavior Module
  - Physical Models Module
    - Aircraft Motion Module
    - Earth Characteristics Module
    - Human Factors Module
    - Target Behavior Module
    - Weapon Behavior Module
  - Software Utility Module
    - Power-Up Initialization Module
    - Numerical Algorithms Module
  - System Generation Module
    - System Generation Parameter Mod.
    - Support Software Module

- Behavior-Hiding Module
  - Function Driver Module
    - Air Data Computer Module
    - Audible Signal Module
    - Computer Fail Signal Module
    - Doppler Radar Module
    - Flight Information Display Module
    - Forward Looking Radar Module
    - Head-Up Display Module
    - Inertial Measurement Set Module
    - Panel Module
    - Projected Map Display Set Module
    - Shipboard Inertial Nav. Sys. Mod.
    - Visual Indicator Module
    - Weapon Release Module
    - Ground Test Module
  - Shared Services Module
    - Mode Determination Module
    - Panel I/O Support Module
    - Shared Subroutine Module
    - Stage Director Module
    - System Value Module

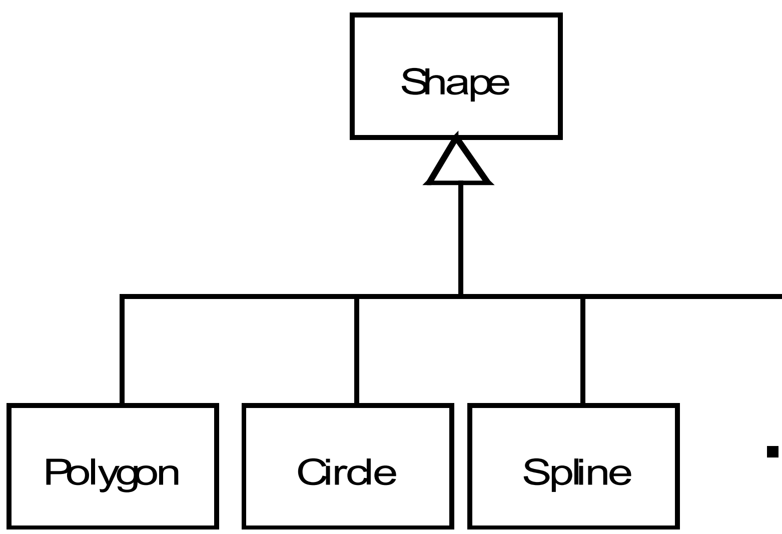
generalization style
in the module viewtype

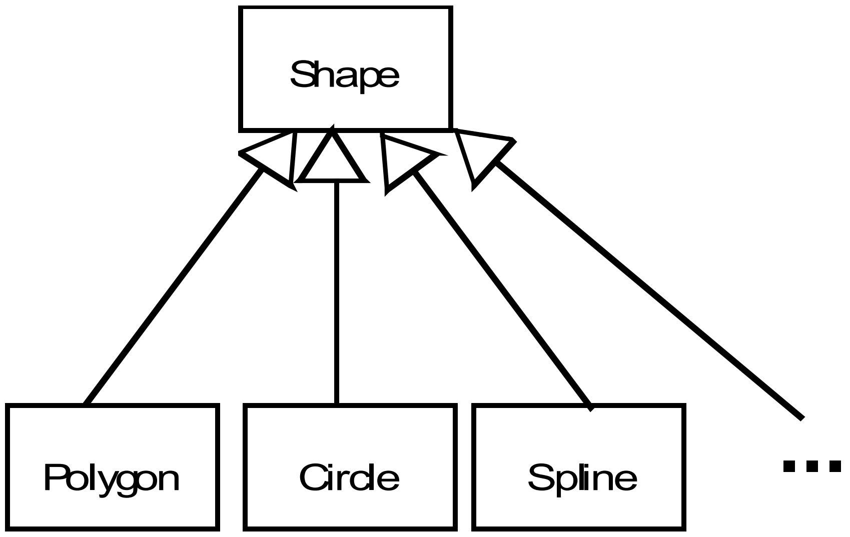
- elements are modules
- relations restricted to *A* is a B
- properties
  inheritance semantics: interface vs. implementation

- what it is for
  - basis for object-oriented designs
  - supports evolution and extension
  - reuse

generalization style in the module viewtype

- examples in UML





- reflected in programming languages
  - Circle extends Shape

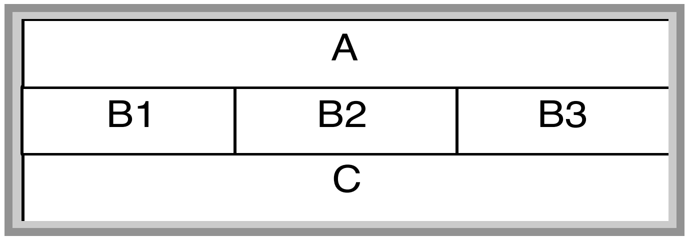
layered style in the module viewtype

- elements are layer modules
- relations restricted to A allowed to use B
  a special case of A depends on B
- stylistic rules
  - every piece of software is assigned to exactly one layer
  - software in a layer is allowed to use software in {any lower layer, next lower layer}
  - software in a layer {is, is not} allowed to use other software in same layer
- what it is for
  - separation of concerns/incremental development
  - portability

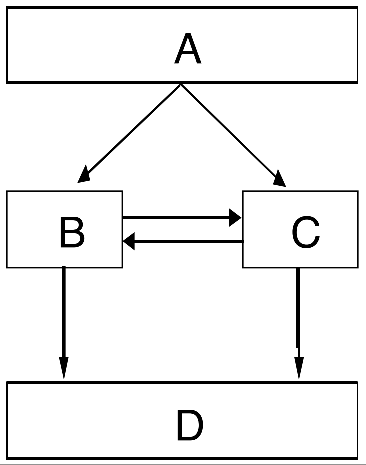
style variations:

layered style in the module viewtype

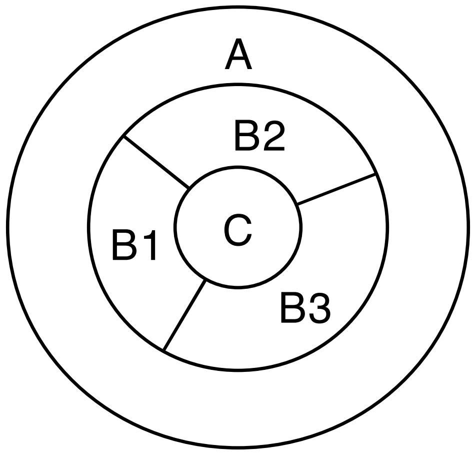
- examples (interpret each one)
- stack of boxes



- boxes and arrows

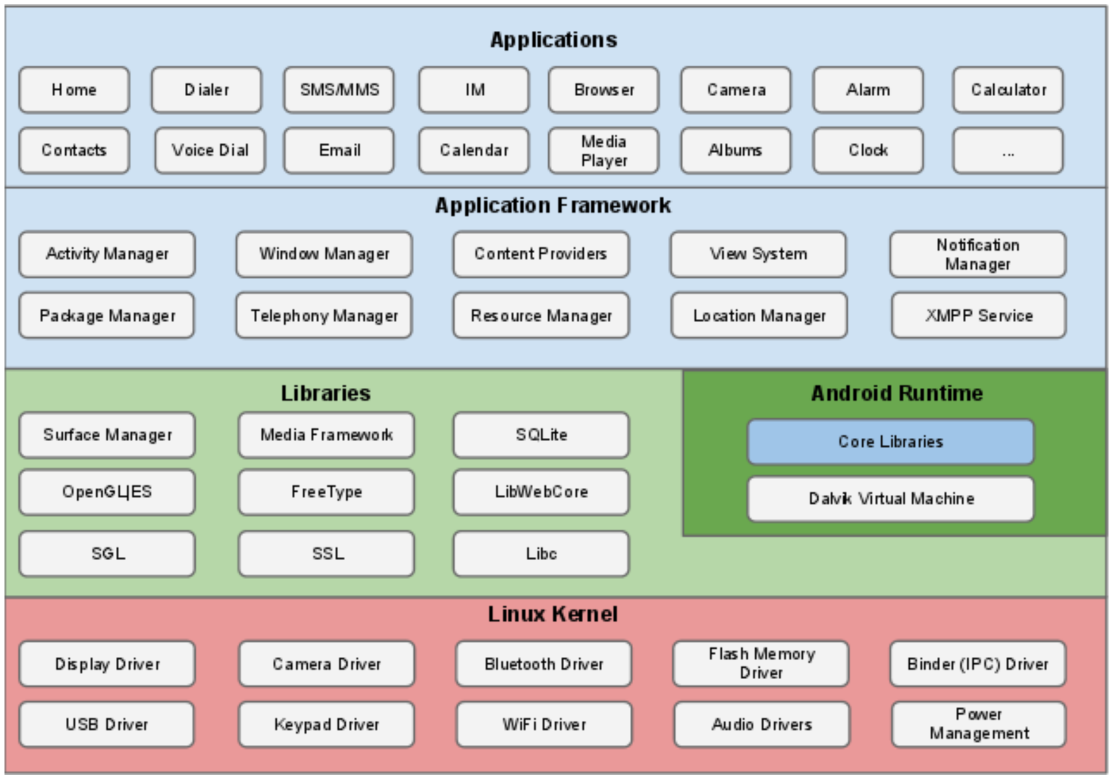


- concentric rings



layered style
in the module viewtype

- example: Google Android's Architecture



- is this a good description?
  (interpret it according to the style variations)

many styles in the C&C viewtype

data flow
- batch sequential
- dataflow network (pipe & filter)
  - acyclic, fan-out, pipeline, Unix
- closed loop control

call-and-return
- main program/subroutines
- information hiding – objects
- stateless client-server
- SOA

interacting processes
- communicating processes
- event systems
  - implicit invocation
  - publish-subscribe

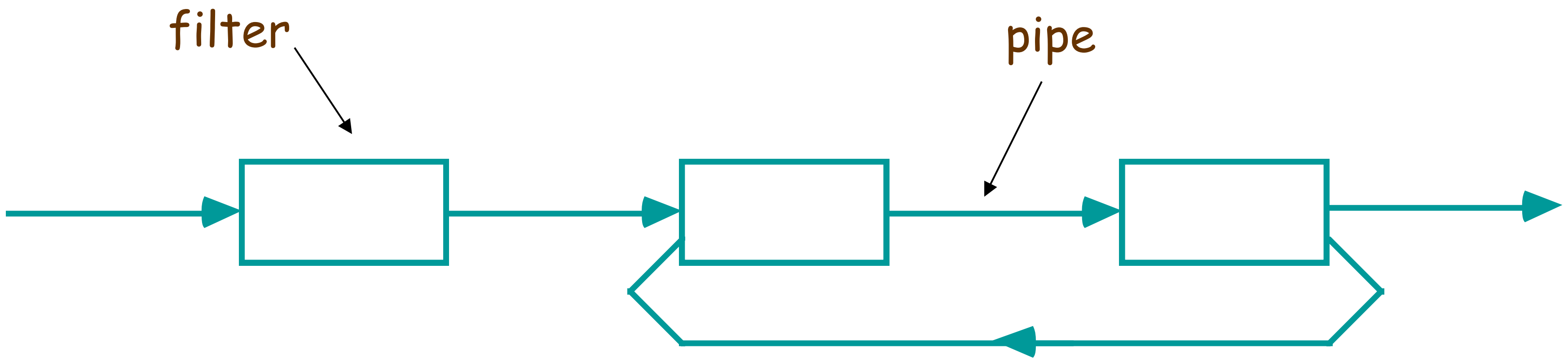
data-oriented repository
- transactional databases
  - stateful client-server
- blackboard
- modern compiler

data-sharing
- compound documents
- hypertext
- Fortran COMMON
- LW processes

hierarchical
- tiers
  - interpreter
  - N-tiered client-server

pipe & filter style in the C&C viewtype

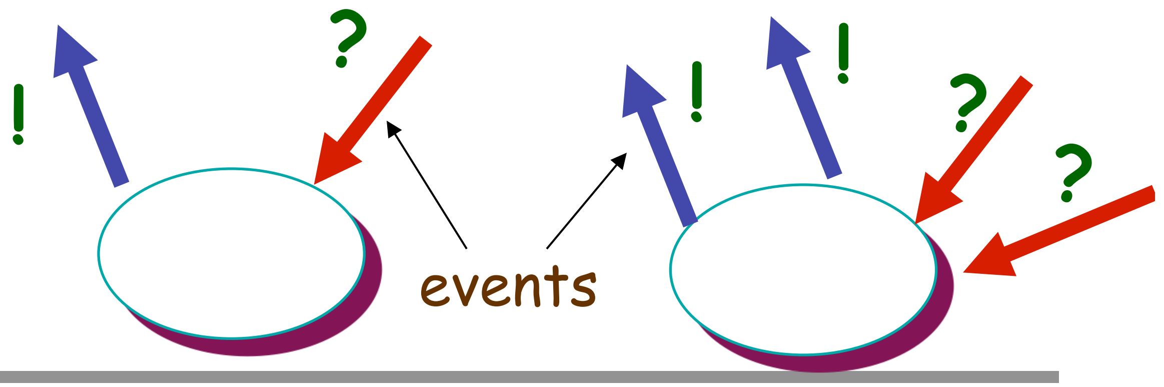
- elements are pipes (data flow) and filters (computation)
- relations restricted to P.in/out attached to F.port
- what it is for
  - functionality related to data streaming and transformation
    e.g. media streaming, image processing,…



event publish-subscribe style in the C&C viewtype

- elements are objects/threads and events
- relations restricted to A publishes E, A subscribes E
- two style variants
  - implicit invocation: one responder will be passed the event
  - publish-subscribe: zero or many subscribers (no guaranties)
- what it is for
  - high degree of separation between functional units

    e.g. Google Android

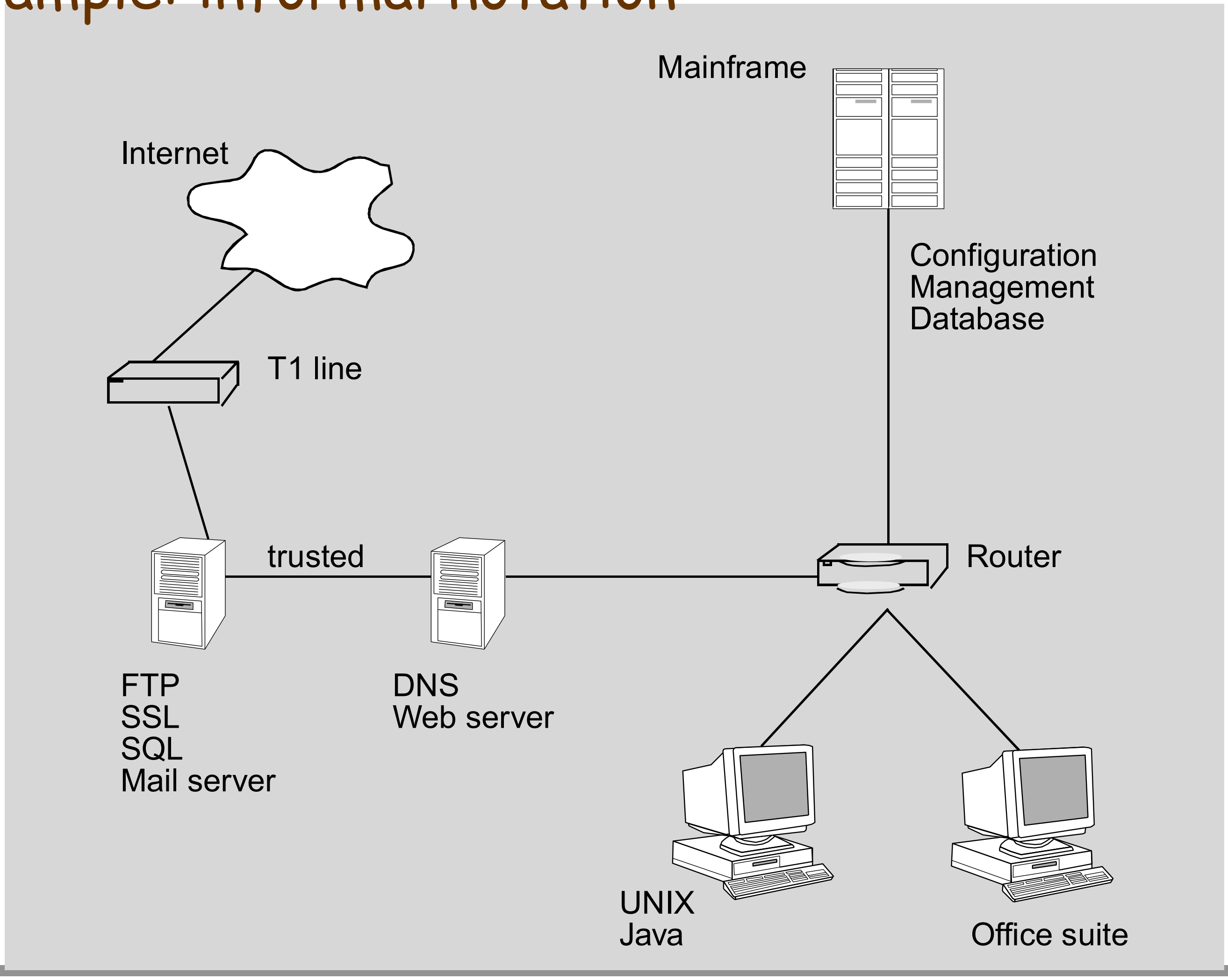


three major styles in the allocation viewtype

- deployment style
  - allocates software elements, i.e. code, to processing and communication nodes
  - properties include those necessary to calculate (and achieve) performance, availability
- implementation style
  - allocates software elements to structures in the development environment's file systems
  - properties include files and capacities
- work assignment style
  - allocates software elements to organizational work units
  - properties include skill sets

deployment style in the allocation viewtype

- example: informal notation



in Summary

- views help manage the complexity of describing an architecture
- viewtypes
  determine the kinds of things a view talks about
  - three primary viewtypes: module, C&C, allocation
- each viewtype has many styles
  - module: decomposition, generalization, layered, …
  - C&C: pipe & filter, client-server, pub-sub…
  - allocation: deployment, work assignment…