IMPORTANT NOTICE TO STUDENTS

These slides are **NOT** to be used as a replacement for student notes.
These **slides** are sometimes **vague and incomplete on purpose** to spark a class discussion

Architectural Blueprint

"The 4+1 View Model of Software Architecture"

by Philippe Kruchten

CS 446/646 ECE452
May 30th, 2011

WATERLOO
CHERITON SCHOOL OF COMPUTER SCIENCE

Architectural Model

Definition[1]

- Software architecture = {Elements, Forms, Constraints}

Definition [2]

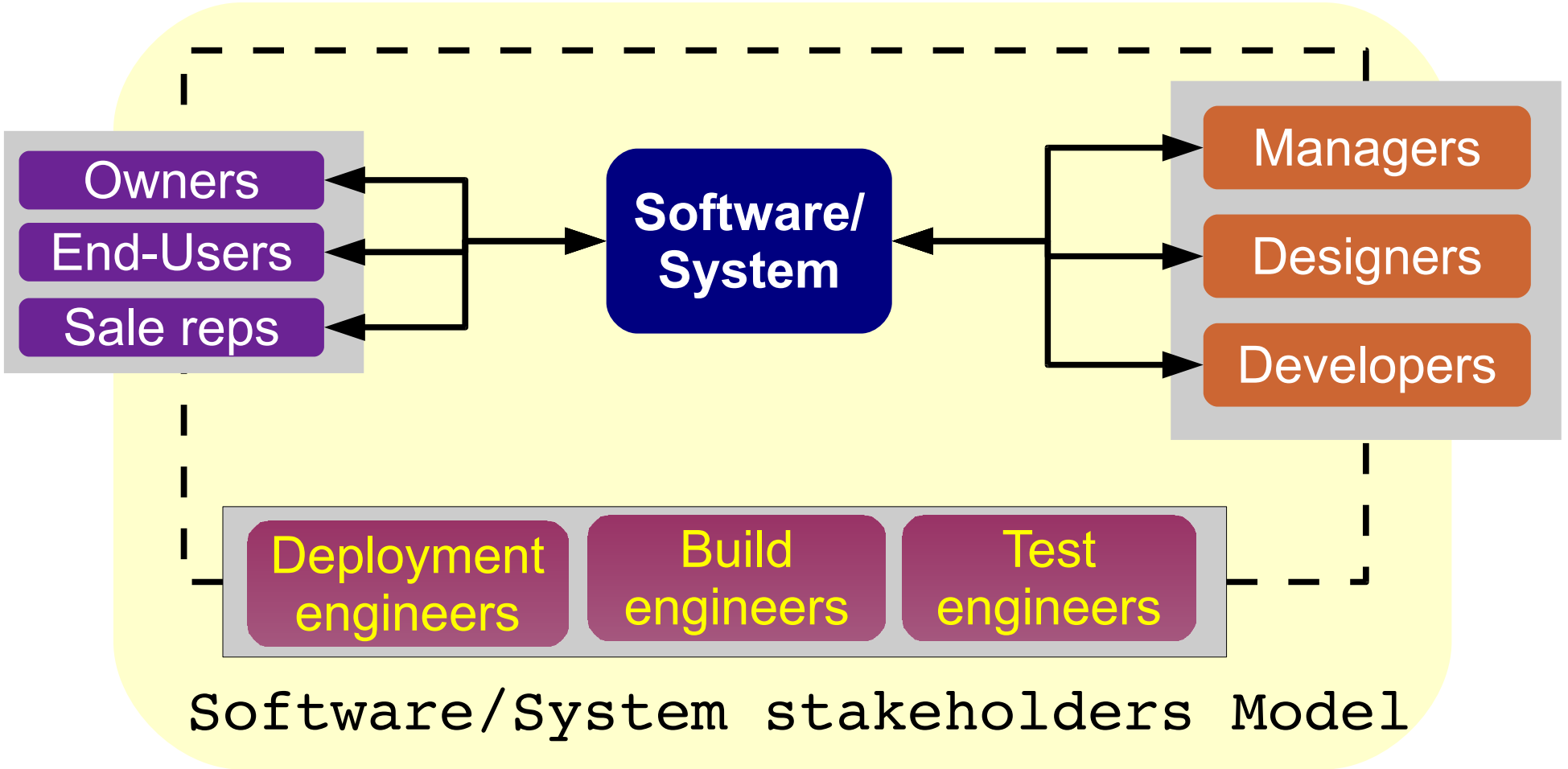
- *"deals with the **design and implementation** of the **high-level structure** of the software.*

  *It is the result of **assembling** a certain number of **architectural elements** in some well-chosen forms to **satisfy** the **major functionality** and .... **nonfunctional requirements**"*

[1] D. E. Perry & A. L. Wolf, "Foundations for the Study of Software Architecture," ACM Software Engineering Notes, 17, 4, October 1992, 40-52

[2] P. B. Kruchten. The 4+1 View Model of architecture. IEEE Software, 12(6), Nov. 1995, pp. 42–50.

Is this an Architectural Model?



What is going on here?

Desired Attributes

Addresses & captures

- concerns of various ***stakeholders***
  - stakeholders:
    - end-users, developers, system engineers, project management
    - testers, support teams
- requirements
  - functional
  - non-functional
    - performance, availability, concurrency, distribution, fault tolerance, security, testing, usability, configuration management, evolution, monitoring

Desired Attributes

An abstraction

- represents the high level view

Is robust

- adaptable
- scalable
- iterative

Meaningful & maintainable

- has to be a live document
  - changes with the system

Types of Architectural Styles

Box & line model

Architectural definition language (ADL)

View based models

- 4+1 view model (1995)

4+1 View Model

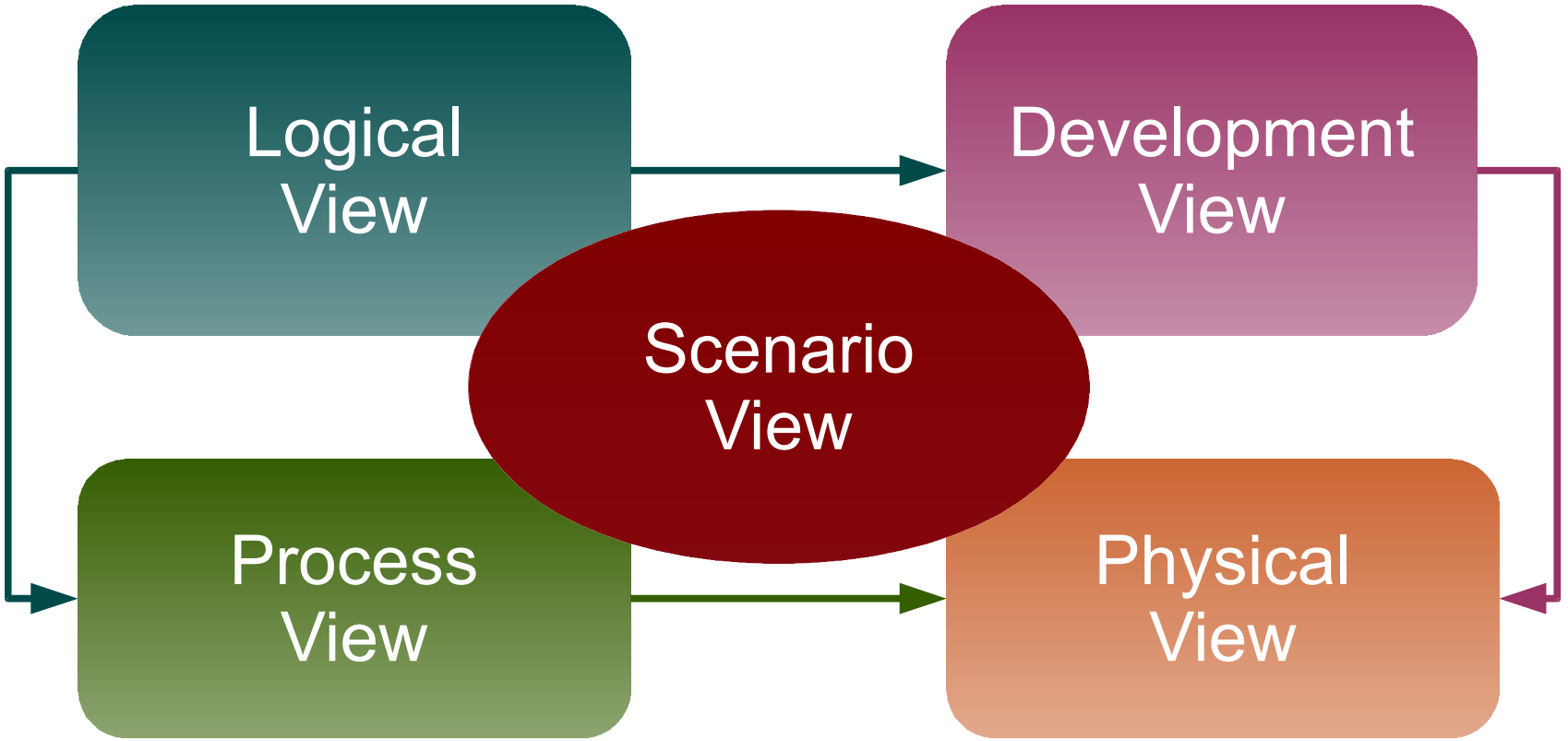
Model

- a model is ***composed*** of 5 ***views***
  - a single view is not enough

View

- is catered for a set of corresponding stakeholders
  - addresses the concerns of its stakeholders
- contains view elements
  - components, connectors, notation
- generic representation

4+1 View Model



Perhaps it should have been called **1+4 View Model**

Logical View

Intent

- ***'object model'*** of the design
- is generally the starting point
- **addresses** primarily **functional** requirements
- decomposition into ***'architectural entities'***

Style

- abstract data types / OO

Stakeholders

- end-users, architects, designers

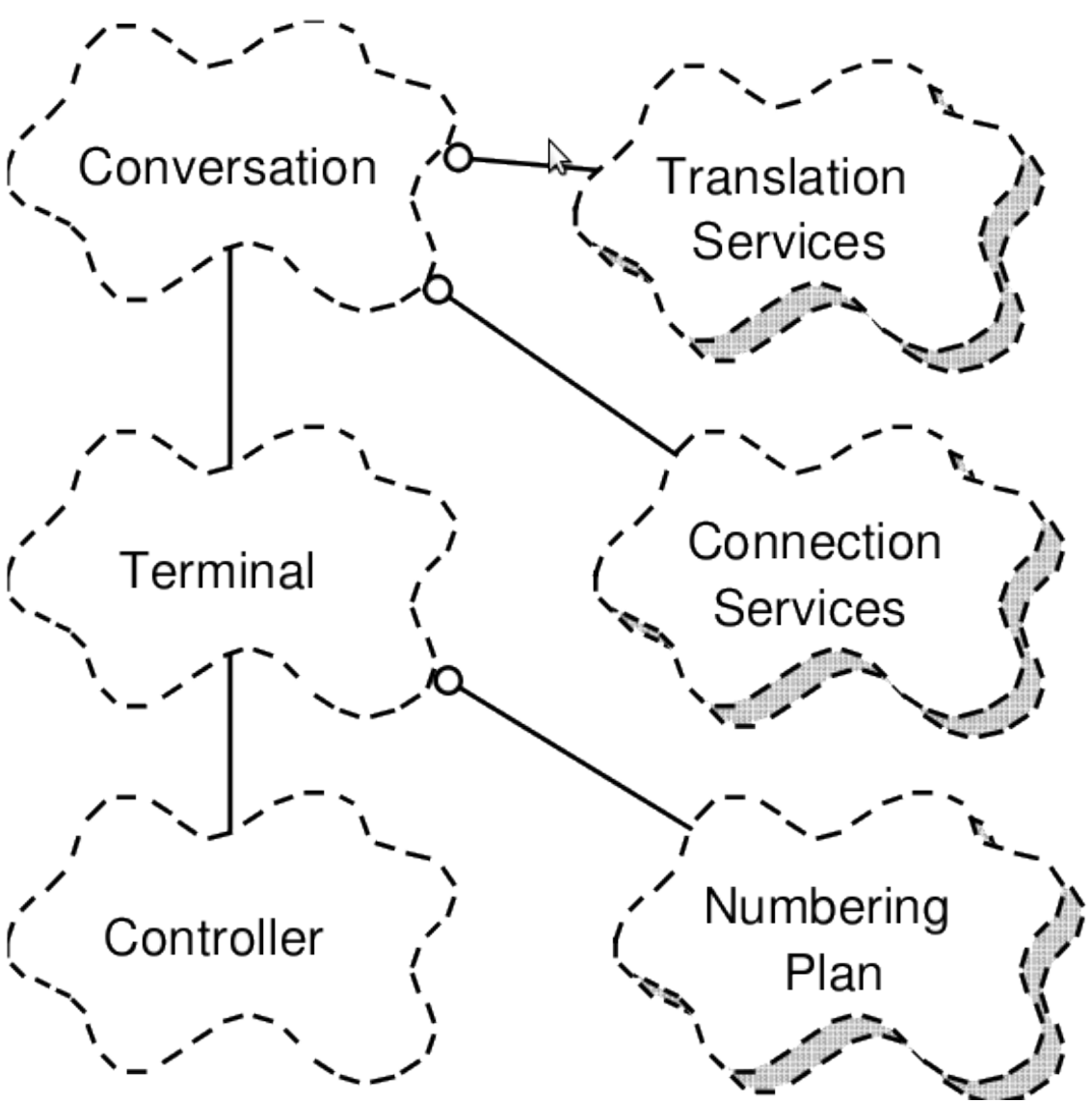
Logical View

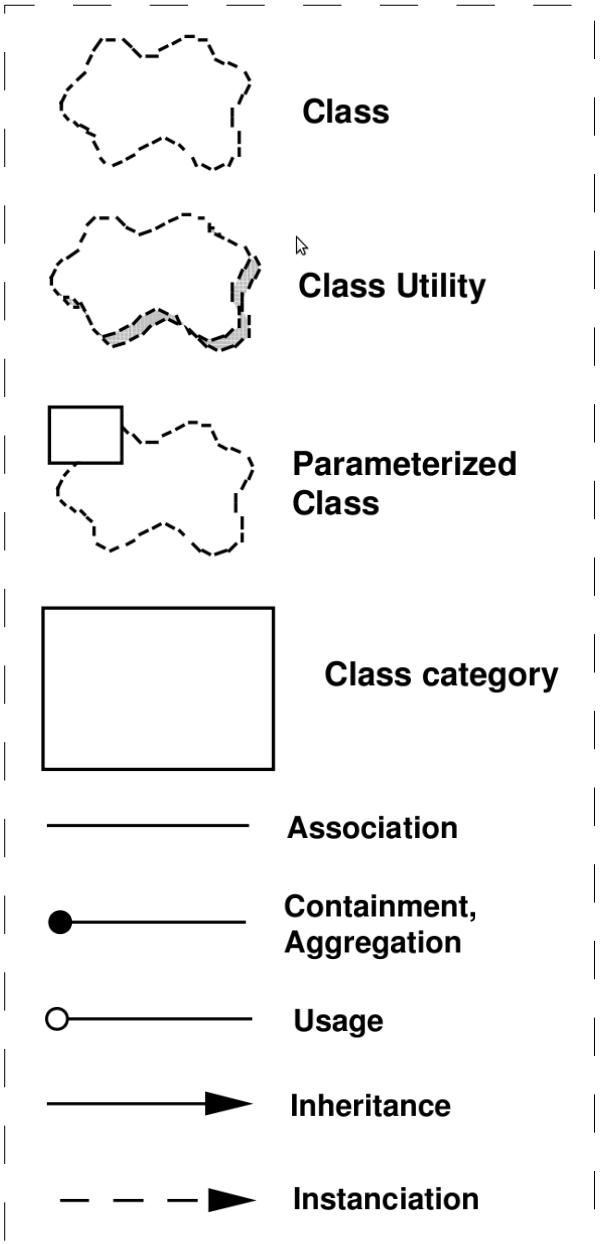
View representations

- 1. OOA (object oriented analysis)
  - entities are analysis classes
  - application of OOA principles
    - abstraction, encapsulation. inheritance
    - association (aggregation, composition)
  - class diagrams, state diagrams
- 2. data centric analysis
  - entity relationship (ER) diagrams

which is the correct view representation?

Example Logical View





Logical View

Design guidelines

- a **single (object) model** across the system (**why?**)
- avoid premature specialization (**of what?**)
- UML diagrams
  - class, communication, sequence diagrams

Process View

Intent

- handles the **non-functional requirements**
- abstraction of architectural processes

Process View

Architectural Process

- grouping of **tasks** into executable units
  - **task:** thread of control
- **task hierarchy**: major & minor tasks
  - reflects task scope
- **types**: atomic & distributed
- can be replicated
  - to improve performance, availability etc.
- execute on ***'process nodes'*** ***(what is a process node?)***

Process View

Communication

- messaging (synchronous, asynchronous, RPC, broadcast)
  - usually for major tasks
- shared memory
  - for minor tasks
- can we estimate the ***system load*** form the inter-process communication?

Process View

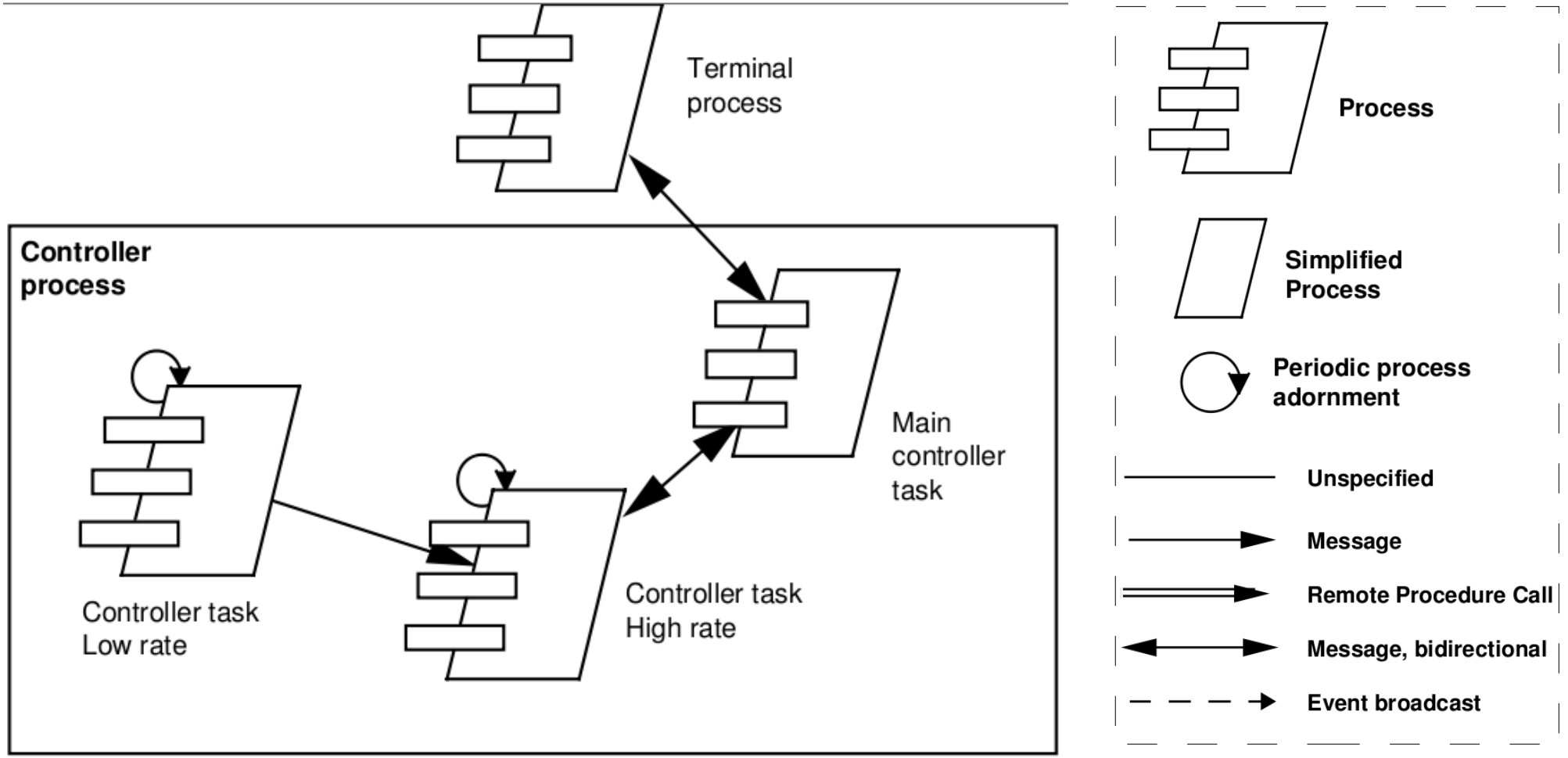
Style

- several styles are applicable
  - pipes & filters
  - layered
    - client / server

Stakeholders

- integrators, architects

Example Process View



Development View

Intent

- software/system decomposition into ***software modules***
- software modules
  - name space, packages, libraries, subsystems
  - modules are scoped for small (development) teams

Driven by internal requirements

Development View

Intent

- software/system decomposition into ***software modules***
- software modules
  - name space, packages, libraries, subsystems
  - modules are scoped for small (development) teams

Driven by internal requirements

management	technology	resources
cost evaluation	requirement allocation	progress monitoring
management	reuse	<from class>

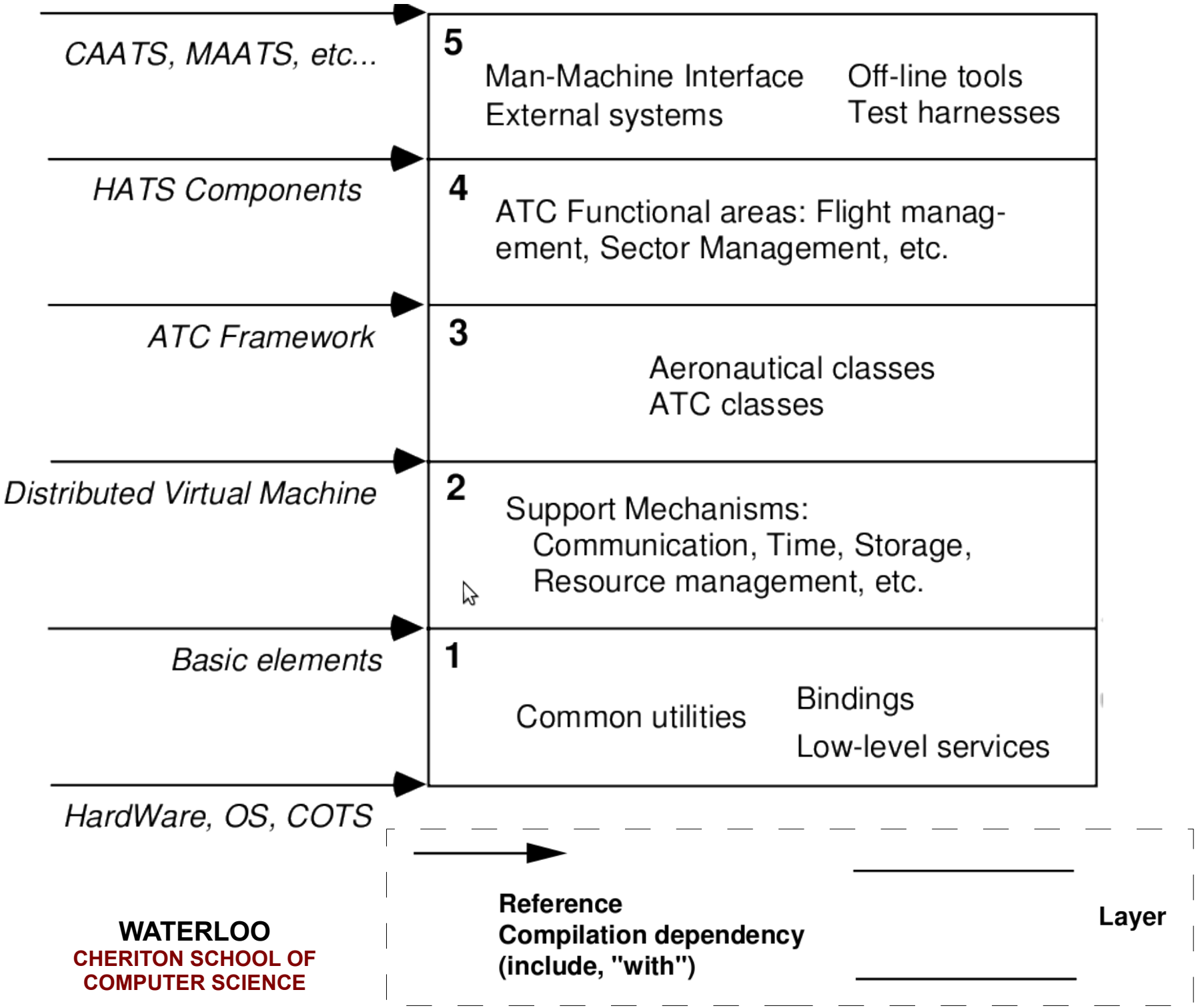
Development View

Style

- layered style
  - each layer with **well defined** interface
  - subsystem dependencies on other subsystems
    - in the same layer or lower
  - each layer provides a development abstraction (**responsibility**)

Stakeholders

- managers, architects, designers, developers, testers


CAATS, MAATS, etc...
5
Man-Machine Interface
External systems
Off-line tools
Test harnesses
HATS Components
4
ATC Functional areas: Flight manag-
ement, Sector Management, etc.
ATC Framework
3
Aeronautical classes
ATC classes
Distributed Virtual Machine
2
Support Mechanisms:
Communication, Time, Storage,
Resource management, etc.
Basic elements
1
Common utilities
Bindings
Low-level services
HardWare, OS, COTS
Reference
Compilation dependency
(include, "with")
Layer

Development View

Observations

- "***complete development architecture*** *can* ***only be described*** *when* ***all the elements*** *of the software have been* ***identified***." [1]
- So what things can we define here?

[1] P. B. Kruchten. The 4+1 View Model of architecture. IEEE Software, 12(6), Nov. 1995, pp. 42–50.

Development View

Observations

- "***complete development architecture*** *can* ***only be described*** *when* ***all the elements*** *of the software have been* ***identified***." [1]
- So what things can we define here?

code partitioning	module visibility	work allocation
inter-partition dependencies	development methodology	

[1] P. B. Kruchten. The 4+1 View Model of architecture. IEEE Software, 12(6), Nov. 1995, pp. 42–50.

Physical View

Intent

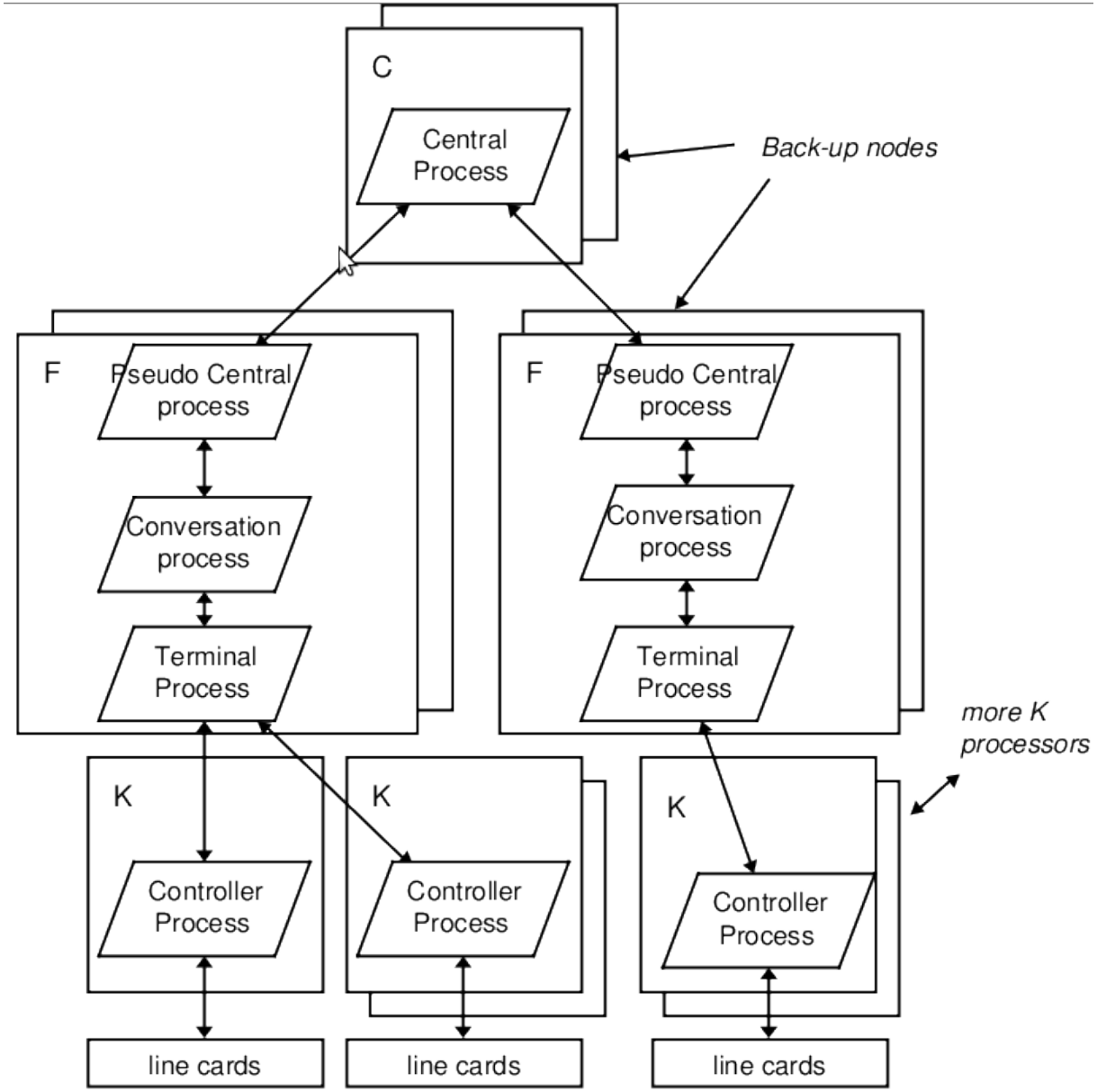
- physical manifestation of process view
  - processes are mapped to processing nodes

Concerns

- installation, configuration, deployment & delivery, networking, messaging protocols

Stakeholders

- system engineers, installers, architects, operators



Components

Processor

Connectors

Communication line

Communication (non permanent)

Uni-directional communication

High bandwidth communication, Bus

Physical View

Design guidelines

- mapping to be flexible
- minimal impact on source code
- same concerns as process view
- UML deployment diagram

Scenario View

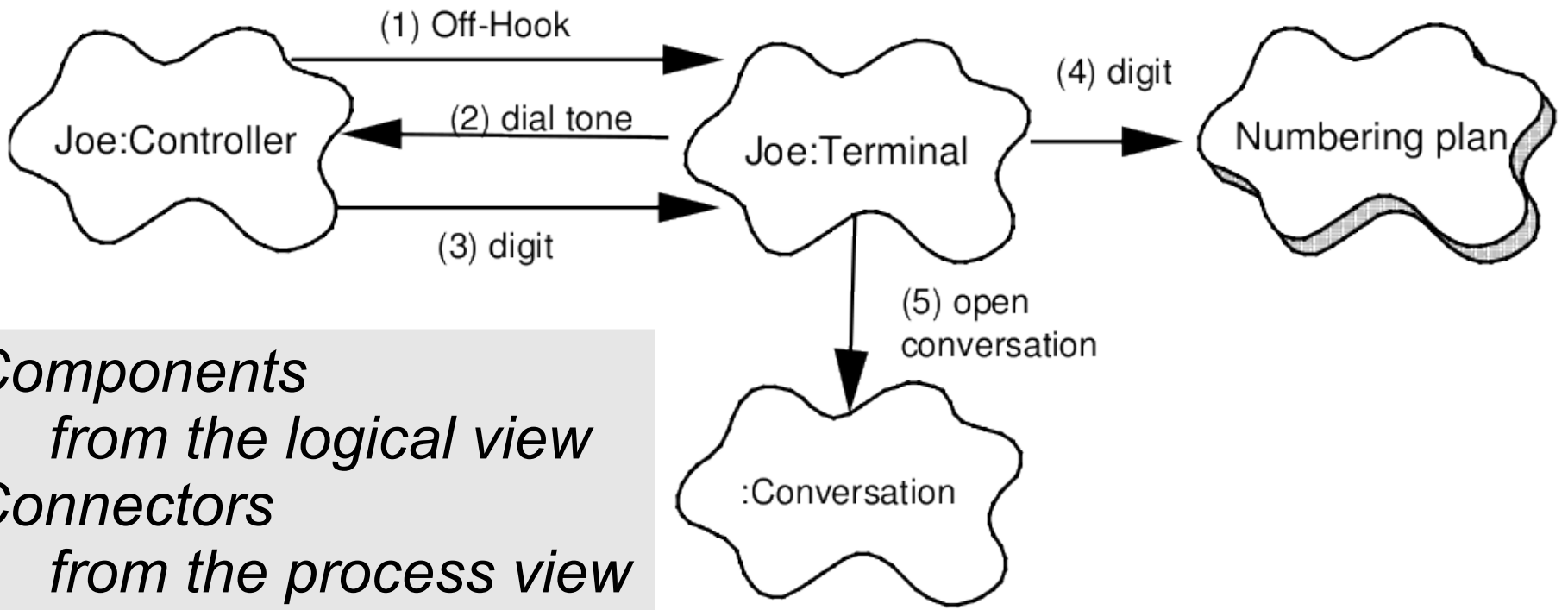
Intent

- **"one view to rule them all"**
- capture system functionality in scenarios
  - interaction of objects & processes
  - driven by important scenarios
- provides architecture validation

Stakeholders

- all stakeholders from the other views

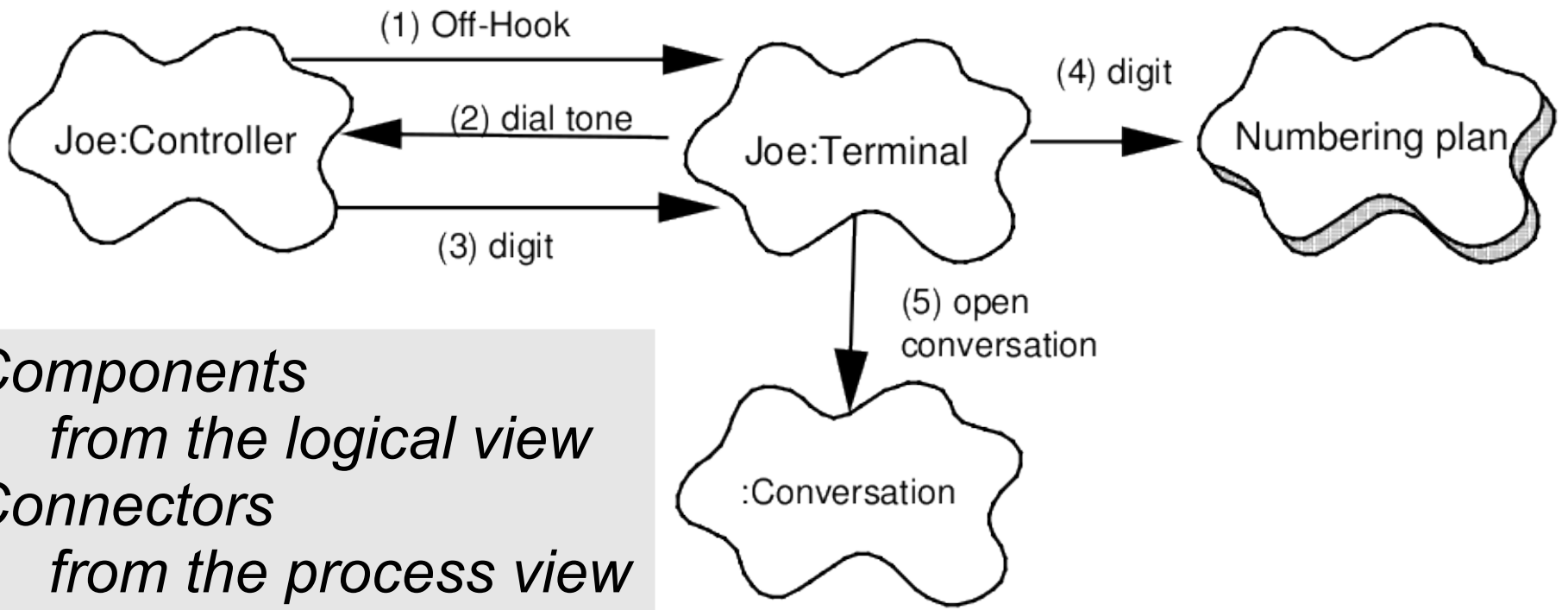
Example Scenario View



Components
from the logical view
Connectors
from the process view

looks like a collaboration diagrams.
what happened to use case diagram?

Example Scenario View

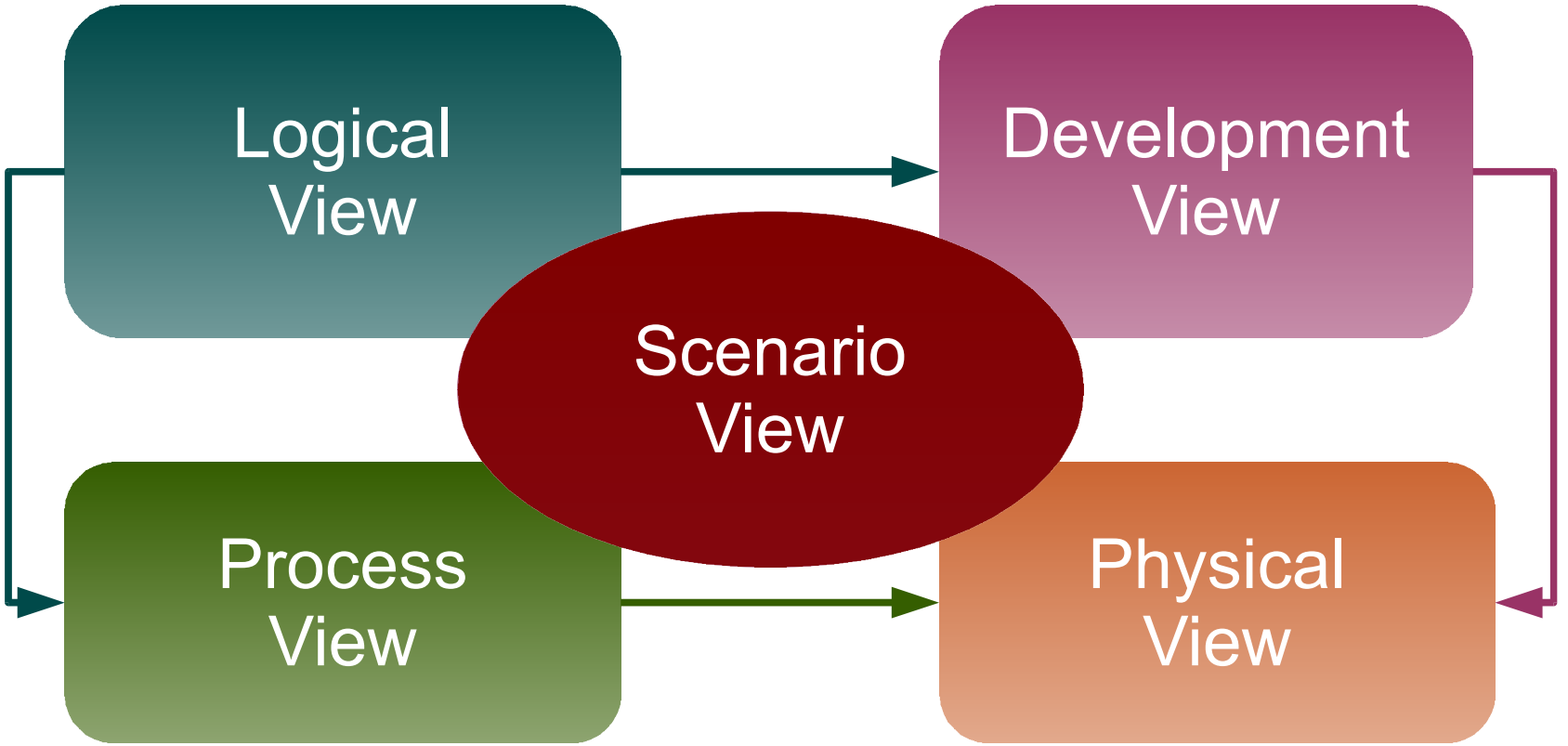


Components
from the logical view
Connectors
from the process view

looks like a collaboration diagrams.
what happened to use case diagram?

use cases & use case realization

View Mappings



Logical to Process View

Objects are mapped to processes

- considerations
  - autonomy
  - persistence
  - subordination
  - distribution

Strategy

- inside-out: identify processes for objects
- outside-in: identify processes (based on system requests) and then allocate objects to these processes

Logical to Development View

Architectural component decomposition

- architectural entities are broken down into design components
  - packages, modules
  - classes
- mapping is governed by development concerns
- ***'distance'*** between logical and design view
  - an indication of the size of the system

Process to Physical View

Processes assignment to hardware

- major and minor tasks are assigned to physical machines
- various configurations
  - development
  - testing
  - deployment

Model an Iterative Process

Start with **a** model

In each iteration the architecture is

- prototyped
- tested: under load if possible
- measured & analyzed
- refined
  - add more scenarios
  - detect abstractions and optimizations
- goal:
  - each iteration should takes us a step closer to a stable architecture

Comments

Lacks some fundamental views

- security, user interface, testing
- upgrade, disaster recovery

Are the views ever complete?

Change in architectural style?

- data centric to OO architecture