

# Process Models: Specialized Process Models (Continue)

LECTURE # 9

# Advantages of CBD

- ▶ Faster development
- ▶ Easier to maintain
- ▶ Increase Quality
- ▶ Easier to create applications variants and upgrades
- ▶ Lower overall development cost

# Disadvantages of CBD

- ▶ Component trustworthiness - how can a component with no available source code be trusted?
- ▶ Component certification - who will certify the quality of components?
- ▶ Requirements trade-offs - how do we do trade-off analysis between the features of one component and another?
- ▶ Choosing Middleware - Incompatible technologies
- ▶ Testing is Harder - Unknown uses of components
- ▶ High initial cost - Training of developers

# Specialized Process model

- ▶ Special process models take many features from one or more conventional models.
- ▶ However these special models tend to be applied when a narrowly defined software engineering approach is chosen.
- ▶ Types in Specialized process models:
  - ▶ 1. Component based development (Promotes reusable components)
  - ▶ **2. The formal methods model (Mathematical formal methods are backbone here)**
  - ▶ 3. Aspect oriented software development (Uses crosscutting technology)
  - ▶ Unified Process ( use-case driven, architecture centric)

# What are Formal Methods?

- ▶ Broad View
  - ▶ application of discrete mathematics to software engineering
  - ▶ involves modeling and analysis
  - ▶ with an underlying mathematically-precise notation
- ▶ Narrow View
  - ▶ Use of a formal language
  - ▶ a set of strings over some well-defined alphabet, with rules for distinguishing which strings belong to the language
    - ▶ Formal reasoning about formulae in the language
- ▶ E.g. formal proofs: use axioms and proof rules to demonstrate that some formula is in the language



# Formal Methods in Software Engineering

## What to formalize?

- models of requirements knowledge (so we can reason about them)
- specifications of requirements (so we can document them precisely)
- Specifications of program design (so we can verify correctness)

## ▶ Why formalize?

- ▶ Removes ambiguity and improves precision
- ▶ To verify that the requirements have been met
- ▶ To reason about the requirements/designs
  - ▶ Properties can be checked automatically
  - ▶ Test for consistency, explore consequences, etc.
- ▶ To animate/execute specifications
  - ▶ Helps with visualization and validation
- ▶ ...because we have to formalize eventually anyway
- ▶ Need to bridge from the informal world to a formal machine domain

# Formal Methods Model

- ▶ The **formal methods model** is concerned with the application of a mathematical technique to design and implement the software.
- ▶ Formal methods are techniques used to model complex systems as mathematical entities. By building a mathematically rigorous model of a complex system, it is possible to verify the system's properties in a more thorough fashion than empirical testing.
- ▶ The formal methods used during the development process provide a mechanism for eliminating problems, which are difficult to overcome using other software process models.
- ▶ The software engineer creates formal specifications for this model. These methods minimize specification errors and this result in fewer errors when the user begins using the system.

# Formal Methods Model

- ▶ For requirements modeling...
  - ▶ A notation is formal if:
    - ▶ it comes with a formal set of rules which define its syntax and semantics.
- ▶ Formal specification is expressed in a language whose syntax and semantics are formally defined.
- ▶ This language comprises a syntax that defines specific notation used for specification representation; semantic, which uses objects to describe the system; and a set of relations, which uses rules to indicate the objects for satisfying the specification.



# Examples

1. **A>B and C>D**
2. *exists i, j, k in M...N:  $i^2 = j^2 + k^2$*
3. *for-all i in 1...10, exists j in 1...10: squares (i)=j<sup>2</sup>*

*string: seq CHAR* — Declaration  
*#string ≤ 64* — Invariant

Conditions	Rule 1	Rule 2	Rule 3	Rule 4
Username (T/F)	F	T	F	T
Password (T/F)	F	F	T	T
Output (E/H)	E	E	E	H

## Two Approaches: Property-Based Specification

- ▶ It describes the operations performed on the system.
- ▶ In addition, it describes the relationship that exists among these operations.
- ▶ A property-based specification consists of two parts:
  - ▶ signatures, which determine the syntax of operations and
  - ▶ an equation, which defines the semantics of the operations through a set of equations known as **axioms**.

```
AIRCRAFT_TABLE(AIRCRAFT_DETAILS)  
sort aircraft_table  
imports integer, aircraft_track, aircraft_details
```

## Two Approaches: Property-Based Specification

- ▶ For example, consider a simple Instant Messaging application for your cell phone. Then some operations might be:
  - ▶ Start up, Send message, Receive message, Display message, Shut down
- ▶ The relationships between these operations might include:
  - ▶ Startup must come before any other operation
  - ▶ Shut down must be the last operation performed
  - ▶ Display message comes during each send message and after each receive message

# Example

## SIGNATURE

`create(integer) → aircraft_table`  
`insert(aircraft_table, aircraft_track, aircraft_details) → aircraft_table`  
`remove(aircraft_table, aircraft_track) → aircraft_table`  
`size(aircraft_table) → integer`  
`eval(aircraft_table, aircraft_track) → aircraft_details`

```
size( create(i) ) = i
size( insert(x, n, y) ) = size( x ) + 1
size( remove(x, m) ) = size( x ) - 1
eval( create(i), n ) = Undefined
eval( insert(x, n, y), m ) =
    if m == n
    then y
    else
    then eval( x, m )
eval( remove(x,n), m ) =
    if m == n
    then Undefined
    else
    then eval( x, m )
```

where

x is an aircraft\_table  
n is an aircraft\_track  
m is an aircraft\_track  
y are aircraft\_details

AXIOM



# Two Approaches: Model-Based Specification

- ▶ It utilizes the tools of set theory, function theory, and logic to develop an abstract model of the system.
- ▶ In addition, it specifies the operations performed on the abstract model.
- ▶ A model-based specification comprises
  - ▶ a definition of the set of states of the system and
  - ▶ definitions of the legal operations performed on the system to indicate how these legal operations change the current state.

## Two Approaches: Model-Based Specification

- ▶ Consider the Instant Messaging application example mentioned above. States the system may be in might include:
  - ▶ Starting up, Sending message, Receiving message, Displaying message, Shutting down
- ▶ As for transitions, they might include:
  - ▶ Clicking the application icon to enter starting up
  - ▶ Or pressing the send button to leave the sending message state

Message\_connection:M system \_  
Connections  
Assigned to: instant\_connection:  
system\_connection

# Example

*INIT( )*

**ext**    **wr**    inflight : *Aircraft-set*  
         **wr**    onground : *Aircraft-set*  
**post**        inflight = { }  
              onground = { }

*ENTERSPACE(a : Aircraft)*

**ext**    **wr**    inflight : *Aircraft-set*  
         **rd**    onground : *Aircraft-set*  
**pre**         $a \notin \text{inflight} \wedge a \notin \text{onground}$   
**post**         $\text{inflight} = \text{inflight}' \cup \{a\}$