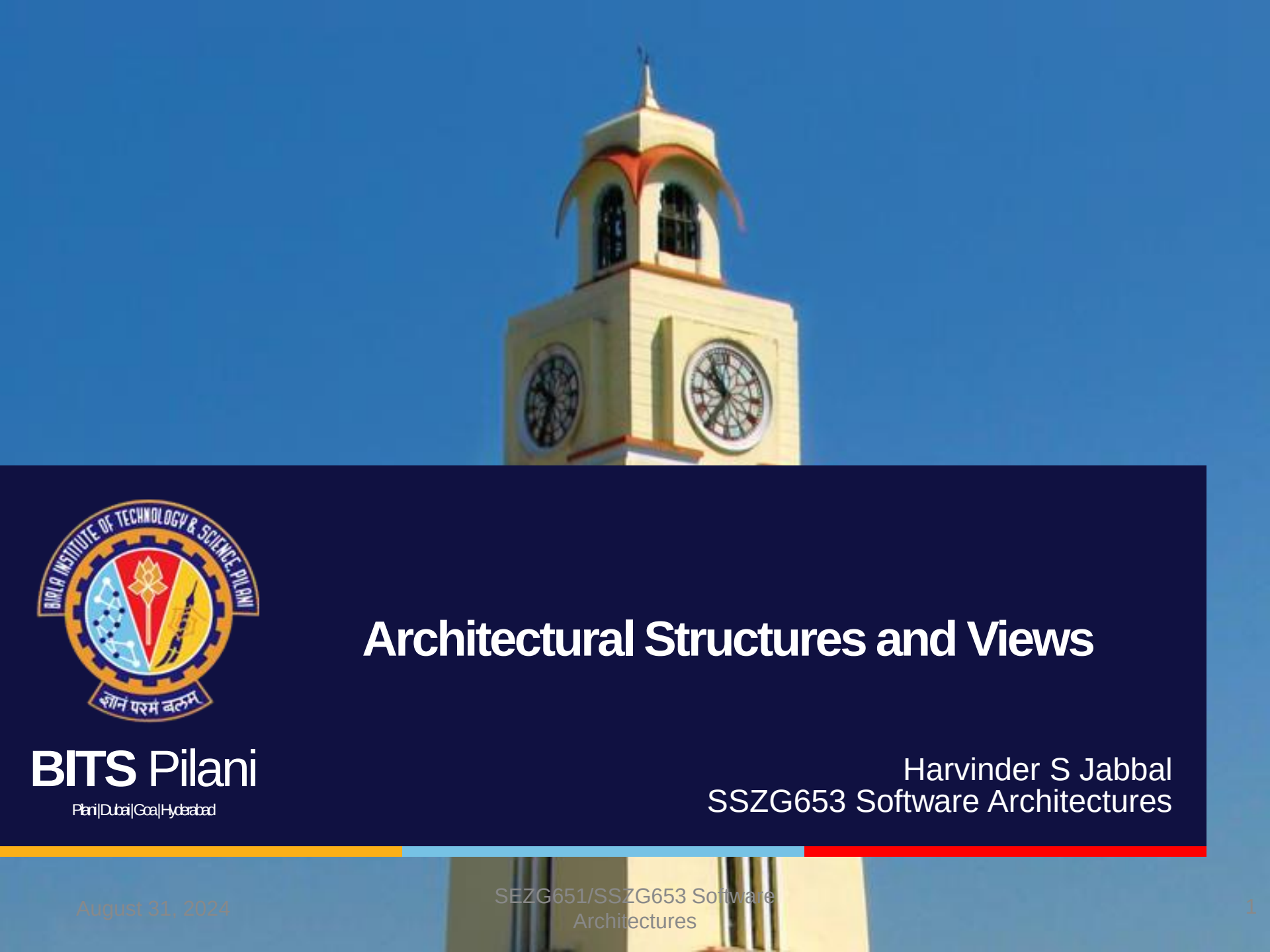


Architectural Structures and Views

Harvinder S Jabbal
SSZG653 Software Architectures

innovate achieve lead

BITS Pilani

Pilani|Dubai|Goa|Hyderabad

SEZG651/ SSZG653 Software Architectures Module 4-CS 05/1

innovate achieve lead

BITS Pilani

Pilani|Dubai|Goa|Hyderabad

Structure & View

Structure & View

- A **view** is a representation of a coherent set of architectural elements, as written by and read by system stakeholders.
  - It consists of a representation of a set of elements and the relations among them.
- A **structure** is the set of elements itself, as they exist in software or hardware.

example

- A **module structure** is the set of the system's modules and their organization.
- A **module view** is the representation of that structure, as documented by and used by some system stakeholders.
- These terms are often used interchangeably, but we will adhere to these definitions.

innovate achieve lead

BITS Pilani

Pilani|Dubai|Goa|Hyderabad

Architectural structures

Module structures.

- Here the elements are modules, which are units of implementation.
- Modules represent a code-based way of considering the system.
- They are assigned areas of functional responsibility.
- There is less emphasis on how the resulting software manifests itself at runtime.
- Module structures allow us to answer questions such as
  - What is the primary functional responsibility assigned to each module?
  - What other software elements is a module allowed to use?
  - What other software does it actually use?
  - What modules are related to other modules by generalization or specialization (i.e., inheritance) relationships?

Component-and-connector structures.

innovate achieve lead

- Here the elements are
  - runtime components (which are the principal units of computation) and
  - connectors (which are the communication vehicles among components).
- Component-and-connector structures help answer questions such as
  - What are the major executing components and how do they interact?
  - What are the major shared data stores?
  - Which parts of the system are replicated?
  - How does data progress through the system?
  - What parts of the system can run in parallel?
  - How can the system's structure change as it executes?

Allocation structures.

- Allocation structures show the relationship between
  - the software elements and
  - the elements in one or more external environments in which the software is created and executed.
- They answer questions such as
  - What processor does each software element execute on?
  - In what files is each element stored during development, testing, and system building?
  - What is the assignment of software elements to development teams?

innovate achieve lead

BITS Pilani

Pilani|Dubai|Goa|Hyderabad

architectural design

3 structures
3 broad decision types

- How is the system to be structured as a set of code units (modules)?
- How is the system to be structured as a set of elements that have
  - runtime behavior (components) and
  - interactions (connectors)?
- How is the system to relate to nonsoftware structures in its environment
  - (i.e., CPUs, file systems, networks, development teams, etc.)?

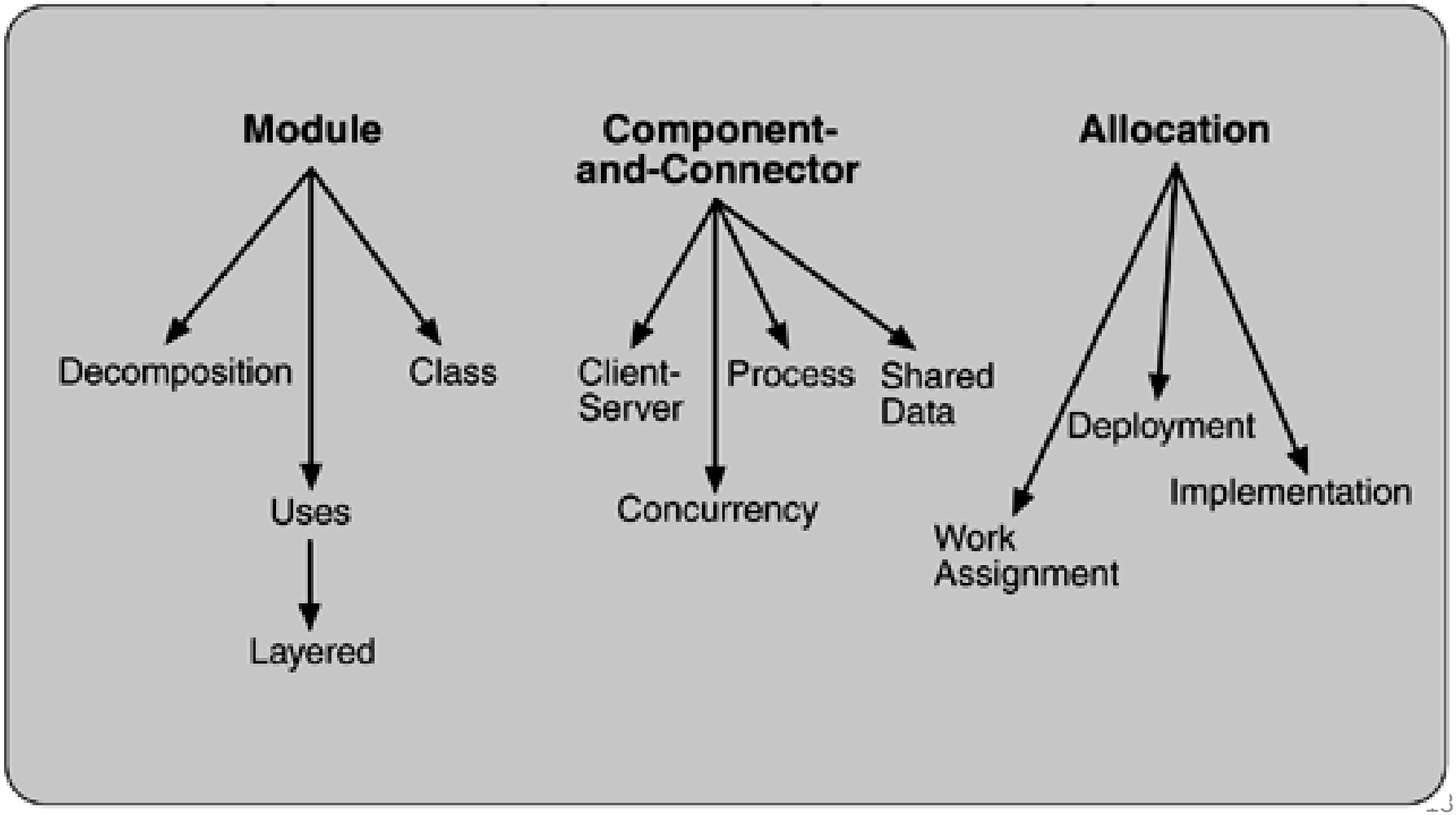
innovate achieve lead

BITS Pilani

Pilani|Dubai|Goa|Hyderabad

SOFTWARE STRUCTURES

SOFTWARE STRUCTURES



innovate achieve lead

BITS Pilani

Pilani|Dubai|Goa|Hyderabad

Module

Decomposition.

- The units are modules related to each other by the "is a submodule of " relation, showing how larger modules are decomposed into smaller ones recursively until they are small enough to be easily understood.
- Modules in this structure represent a common starting point for design, as the architect enumerates what the units of software will have to do and assigns each item to a module for subsequent (more detailed) design and eventual implementation.
- Modules often have associated products (i.e., interface specifications, code, test plans, etc.).
- The decomposition structure provides a large part of the system's modifiability, by ensuring that likely changes fall within the purview of at most a few small modules.
- It is often used as the basis for the development project's organization, including the structure of the documentation, and its integration and test plans. The units in this structure often have organization-specific names.
- Certain U.S. Department of Defense standards, for instance, define Computer Software Configuration Items (CSCIs) and Computer Software Components (CSCs), which are units of modular decomposition.

Uses.

- The units of this important but overlooked structure are also modules, or (in circumstances where a finer grain is warranted) procedures or resources on the interfaces of modules.
- The units are related by the uses relation.
- One unit uses another if the correctness of the first requires the presence of a correct version (as opposed to a stub) of the second.
- The uses structure is used to engineer systems that can be easily extended to add functionality or from which useful functional subsets can be easily extracted.
- The ability to easily subset a working system allows for incremental development.

Layered.

- When the uses relations in this structure are carefully controlled in a particular way, a system of layers emerges, in which a layer is a coherent set of related functionality.
- In a strictly layered structure, layer n may only use the services of layer n - 1.
- Many variations of this (and a lessening of this structural restriction) occur in practice, however.
- Layers are often designed as abstractions (virtual machines) that hide implementation specifics below from the layers above, engendering portability.

Class, or generalization.

- The module units in this structure are called classes.
- The relation is "inherits-from" or "is-an-instance-of."
- This view supports reasoning about collections of similar behavior or capability (i.e., the classes that other classes inherit from) and parameterized differences which are captured by subclassing.
- The class structure allows us to reason about re-use and the incremental addition of functionality.

Component and Connector

Process, or communicating processes.

- Like all component-and-connector structures, this one is orthogonal to the module-based structures and deals with the dynamic aspects of a running system.
- The units here are processes or threads that are connected with each other by communication, synchronization, and/or exclusion operations.
- The relation in this (and in all component-and-connector structures) is attachment, showing how the components and connectors are hooked together.
- The process structure is important in helping to engineer a system's execution performance and availability.

Concurrency.

- This component-and-connector structure allows the architect to determine opportunities for parallelism and the locations where resource contention may occur.
- The units are components and the connectors are "logical threads."
- A logical thread is a sequence of computation that can be allocated to a separate physical thread later in the design process.
- The concurrency structure is used early in design to identify the requirements for managing the issues associated with concurrent execution.

Shared data, or repository.

- This structure comprises components and connectors that create, store, and access persistent data.
- If the system is in fact structured around one or more shared data repositories, this structure is a good one to illuminate.
- It shows how data is produced and consumed by runtime software elements, and it can be used to ensure good performance and data integrity.

Client-server.

- If the system is built as a group of cooperating clients and servers, this is a good component-and-connector structure to illuminate.
- The components are the clients and servers, and the connectors are protocols and messages they share to carry out the system's work.
- This is useful for separation of concerns (supporting modifiability), for physical distribution, and for load balancing (supporting runtime performance).

innovate achieve lead

BITS Pilani

Pilani|Dubai|Goa|Hyderabad

Allocation

Deployment.

- The deployment structure shows how software is assigned to hardware-processing and communication elements.
- The elements are software (usually a process from a component-and-connector view), hardware entities (processors), and communication pathways.
- Relations are "allocated-to," showing on which physical units the software elements reside, and "migrates-to," if the allocation is dynamic.
- This view allows an engineer to reason about performance, data integrity, availability, and security.
- It is of particular interest in distributed or parallel systems.

Implementation.

- This structure shows how software elements (usually modules) are mapped to the file structure(s) in the system's development, integration, or configuration control environments.
- This is critical for the management of development activities and build processes.

Work assignment.

- This structure assigns responsibility for implementing and integrating the modules to the appropriate development teams.
- Having a work assignment structure as part of the architecture makes it clear that the decision about who does the work has architectural as well as management implications.
- The architect will know the expertise required on each team.
- Also, on large multi-sourced distributed development projects, the work assignment structure is the means for calling out units of functional commonality and assigning them to a single team, rather than having them implemented by everyone who needs them.

elements and relations in each structure

Software Structure	Relations	Useful for
Decomposition	Is a submodule of; shares secret with	Resource allocation and project structuring and planning; information hiding, encapsulation; configuration control
Uses	Requires the correct presence of	Engineering subsets; engineering extensions
Layered	Requires the correct presence of; uses the services of; provides abstraction to	Incremental development; implementing systems on top of "virtual machines" portability
Class	Is an instance of; shares access methods of	In object-oriented design systems, producing rapid almost-alike implementations from a common template

elements and relations in each structure

Software Structure	Relations	Useful for
Client-Server	Communicates with; depends on	Distributed operation; separation of concerns; performance analysis; load balancing
Process	Runs concurrently with; may run concurrently with; excludes; precedes; etc.	Scheduling analysis; performance analysis
Concurrency	Runs on the same logical thread	Identifying locations where resource contention exists, where threads may fork, join, be created or be killed
Shared Data	Produces data; consumes data	Performance; data integrity; modifiability

elements and relations in each structure

Software Structure	Relations	Useful for
Deployment	Allocated to; migrates to	Performance, availability, security analysis
Implementation	Stored in	Configuration control, integration, test activities
Work Assignment	Assigned to	Project management, best use of expertise, management of commonality

innovate achieve lead

BITS Pilani

Pilani|Dubai|Goa|Hyderabad

Kruchten's four views

WHICH STRUCTURES TO CHOOSE?

innovate achieve lead

Logical.

The elements are "key abstractions," which are manifested in the object-oriented world as objects or object classes. This is a module view.

Process.

This view addresses concurrency and distribution of functionality. It is a component-and-connector view.

Development.

This view shows the organization of software modules, libraries, subsystems, and units of development. It is an allocation view, mapping software to the development environment.

Physical.

This view maps other elements onto processing and communication nodes and is also an allocation view (which others call the deployment view).

Thank you

innovate achieve lead

Ref. Text Book