Software Architecture

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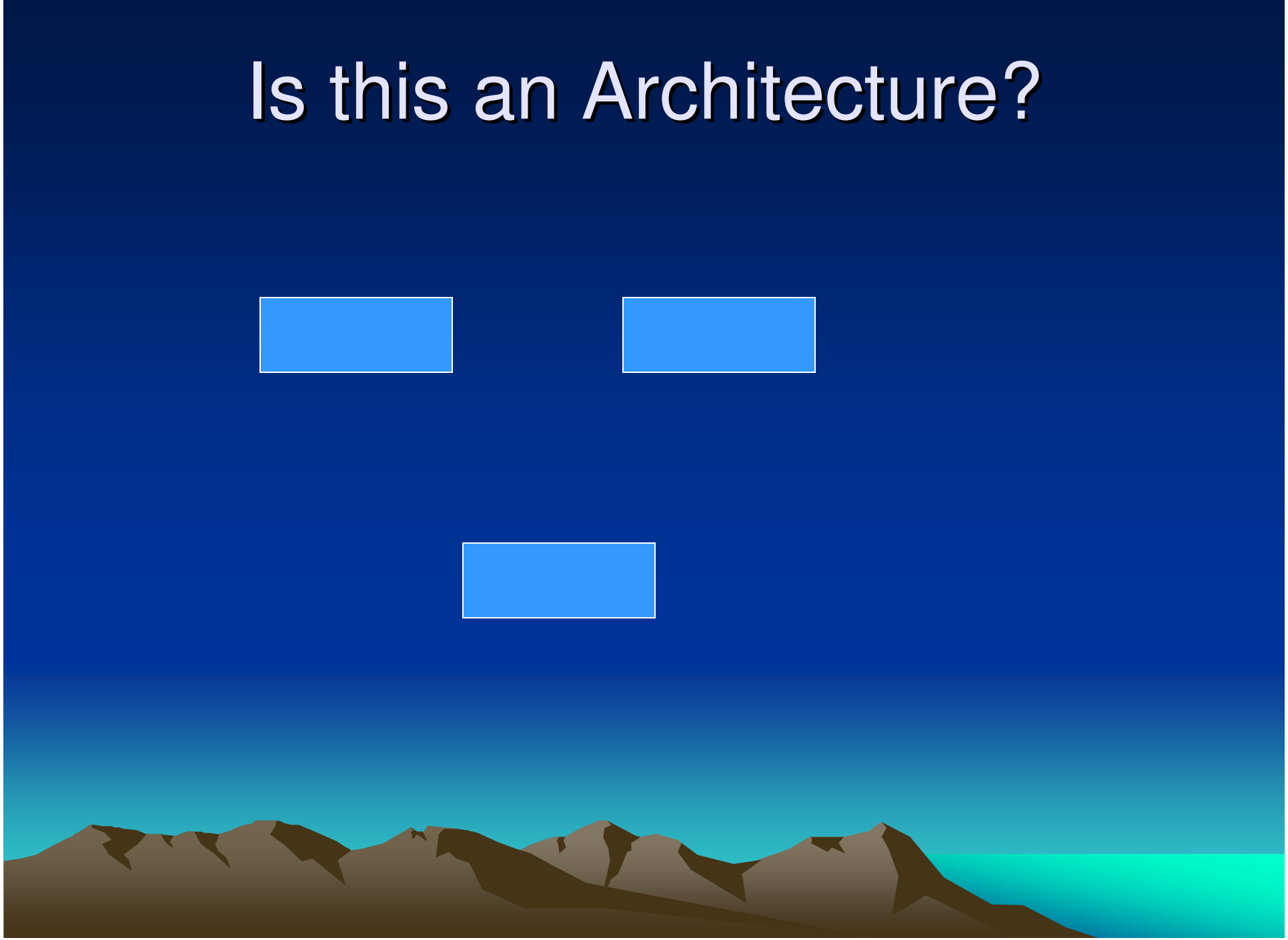
What is Architecture?
Software Architecture?

Is this an Architecture?



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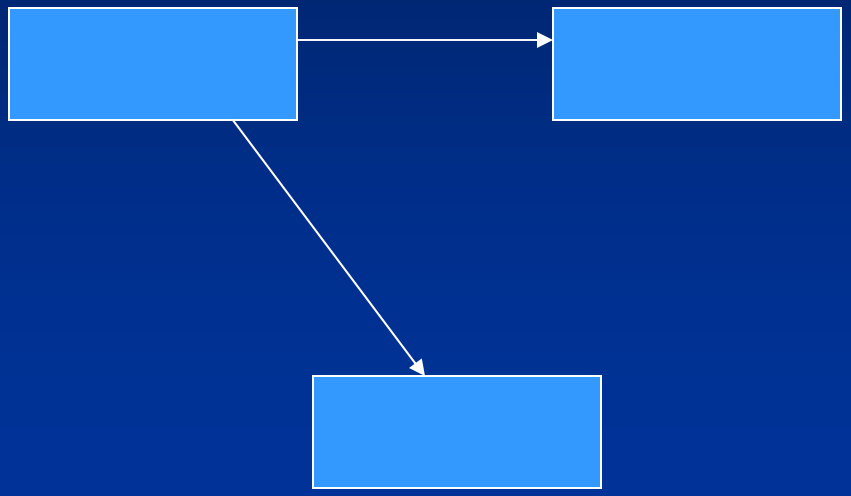
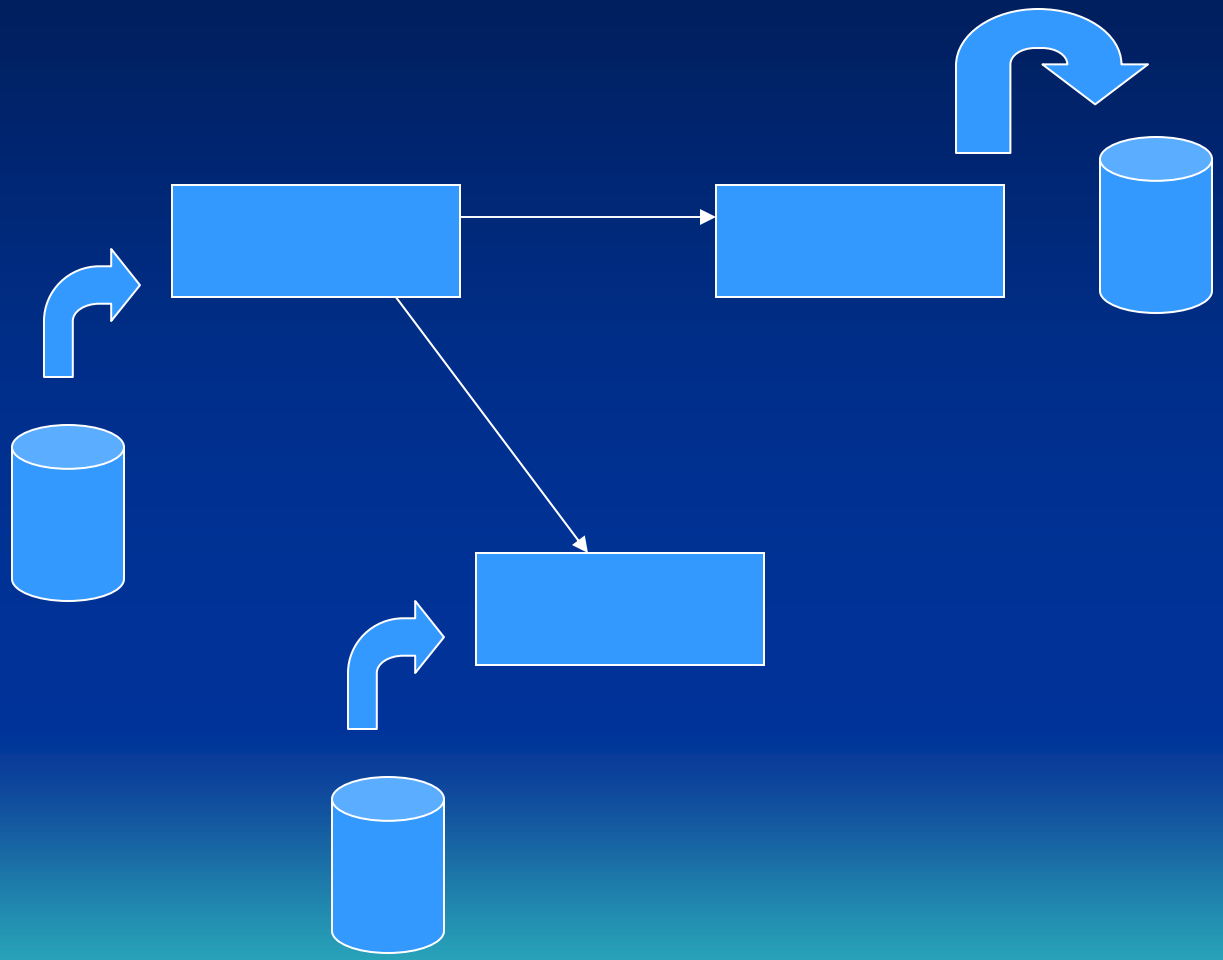


Is this an Architecture?



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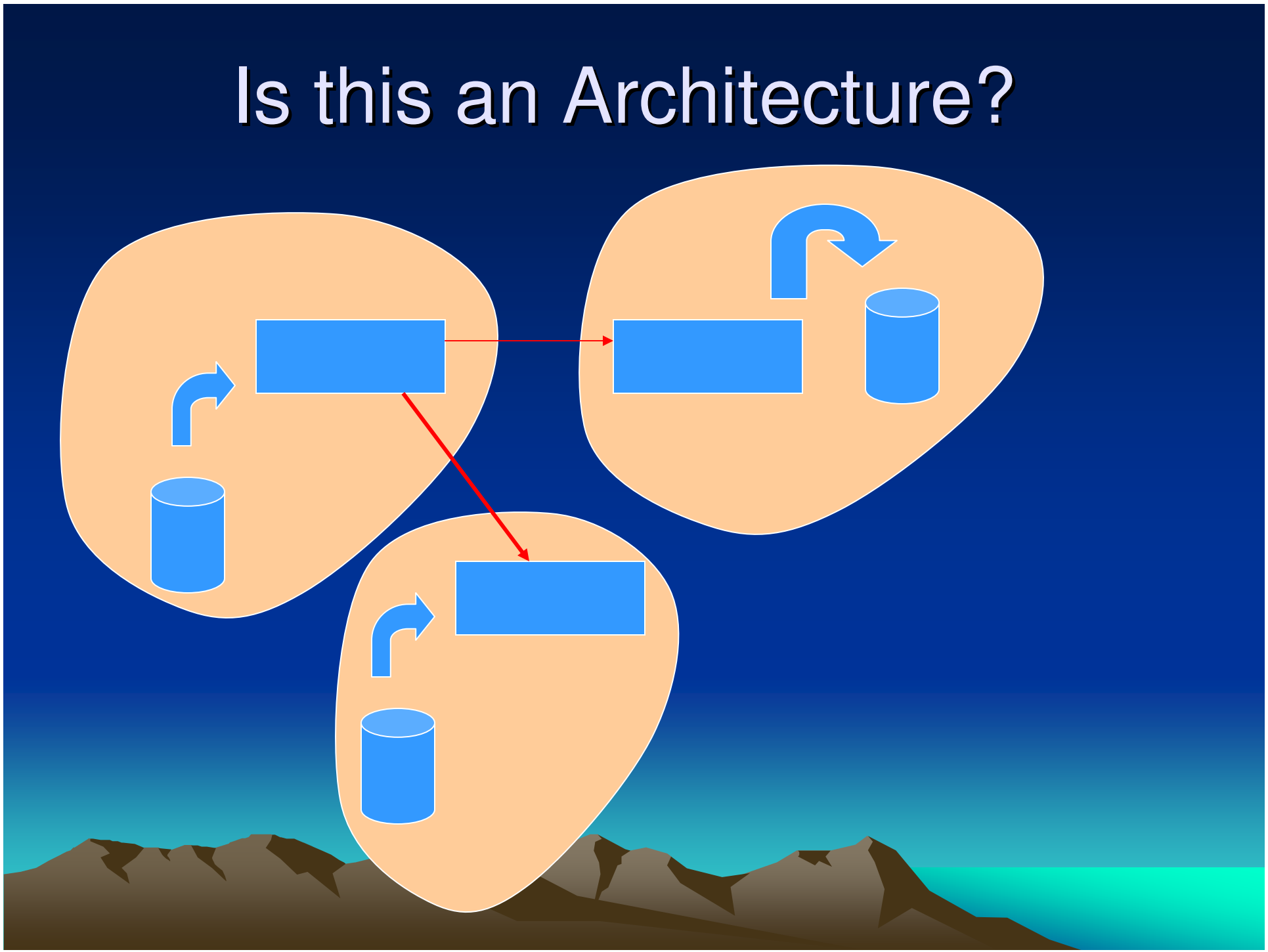

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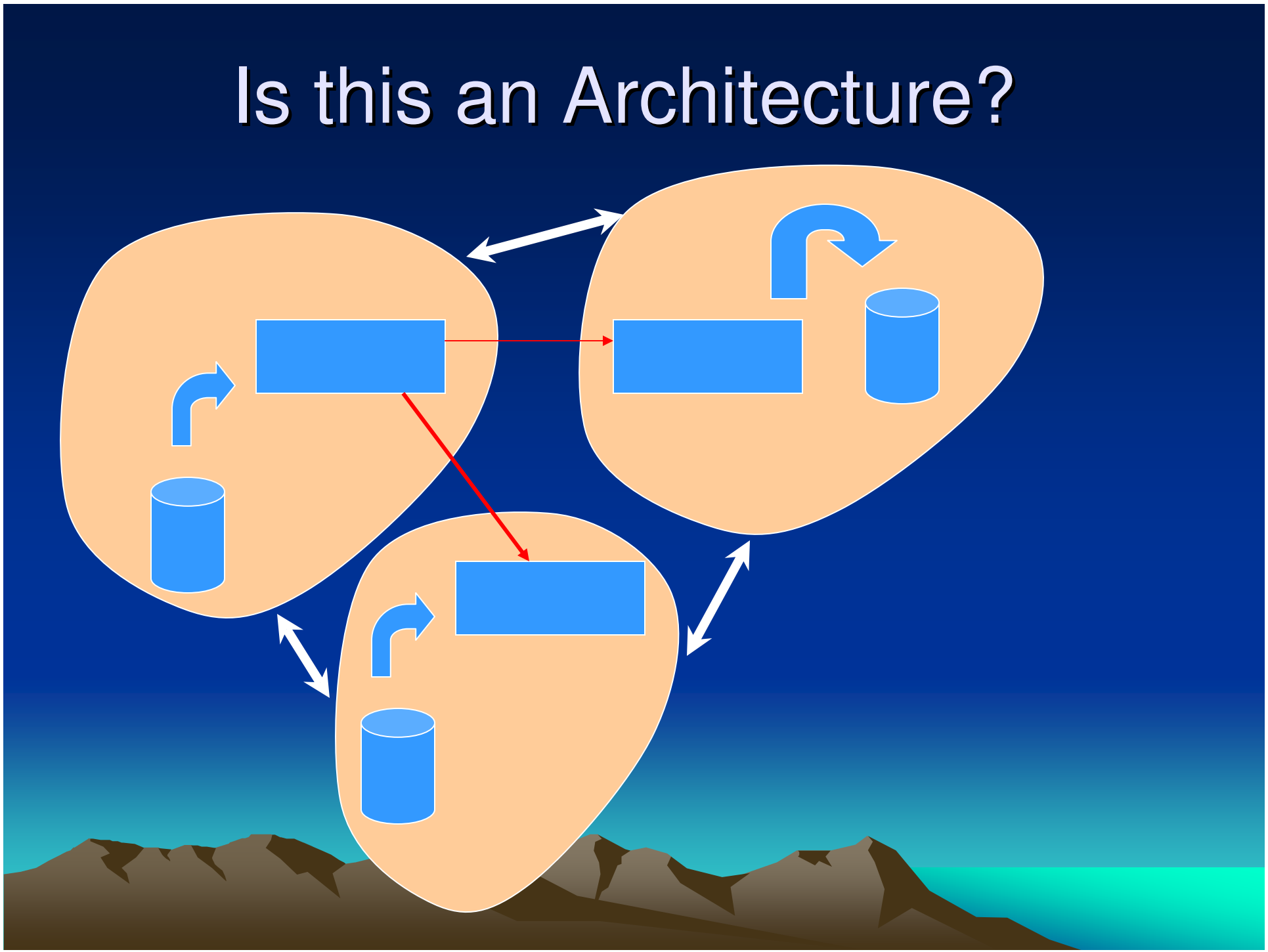

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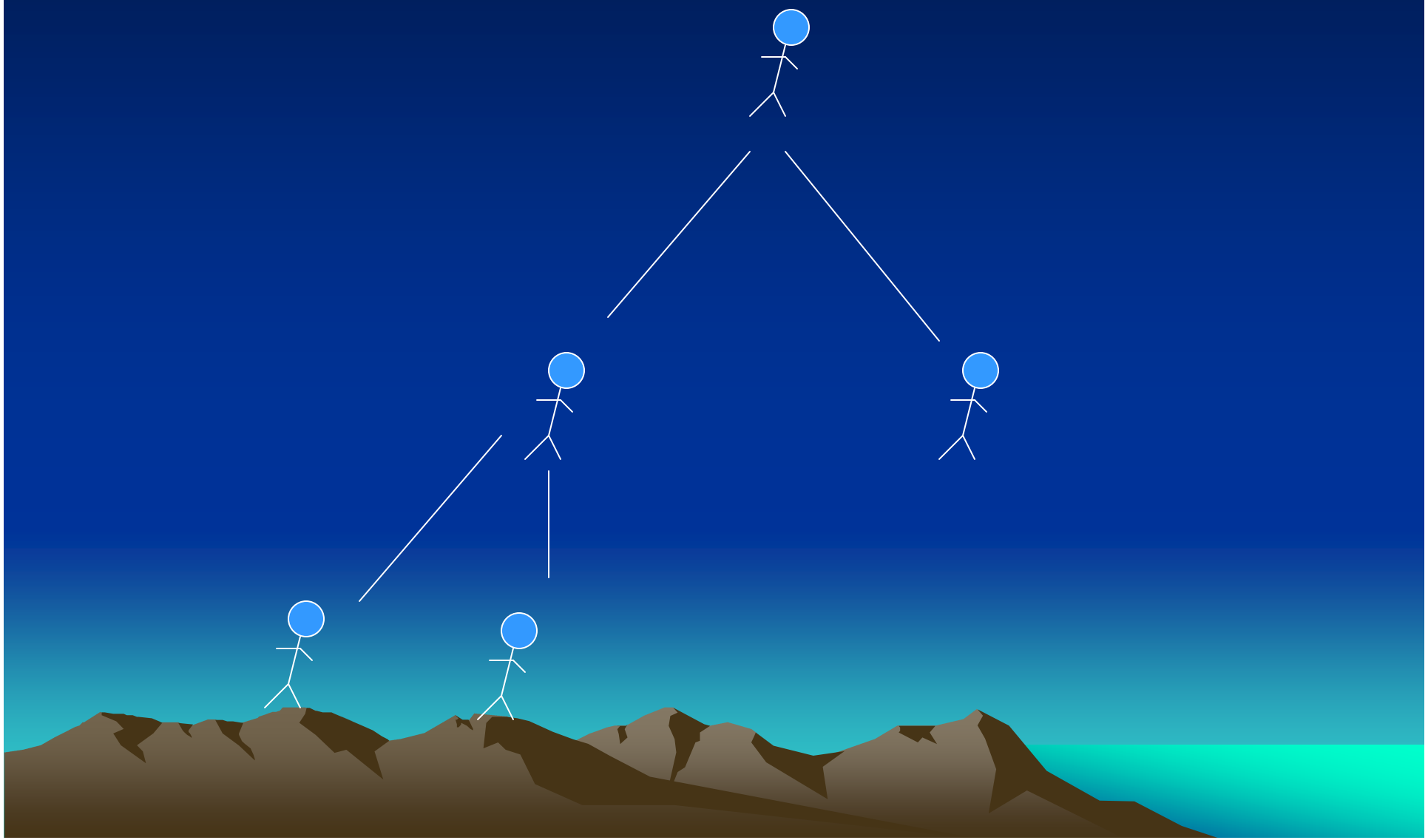

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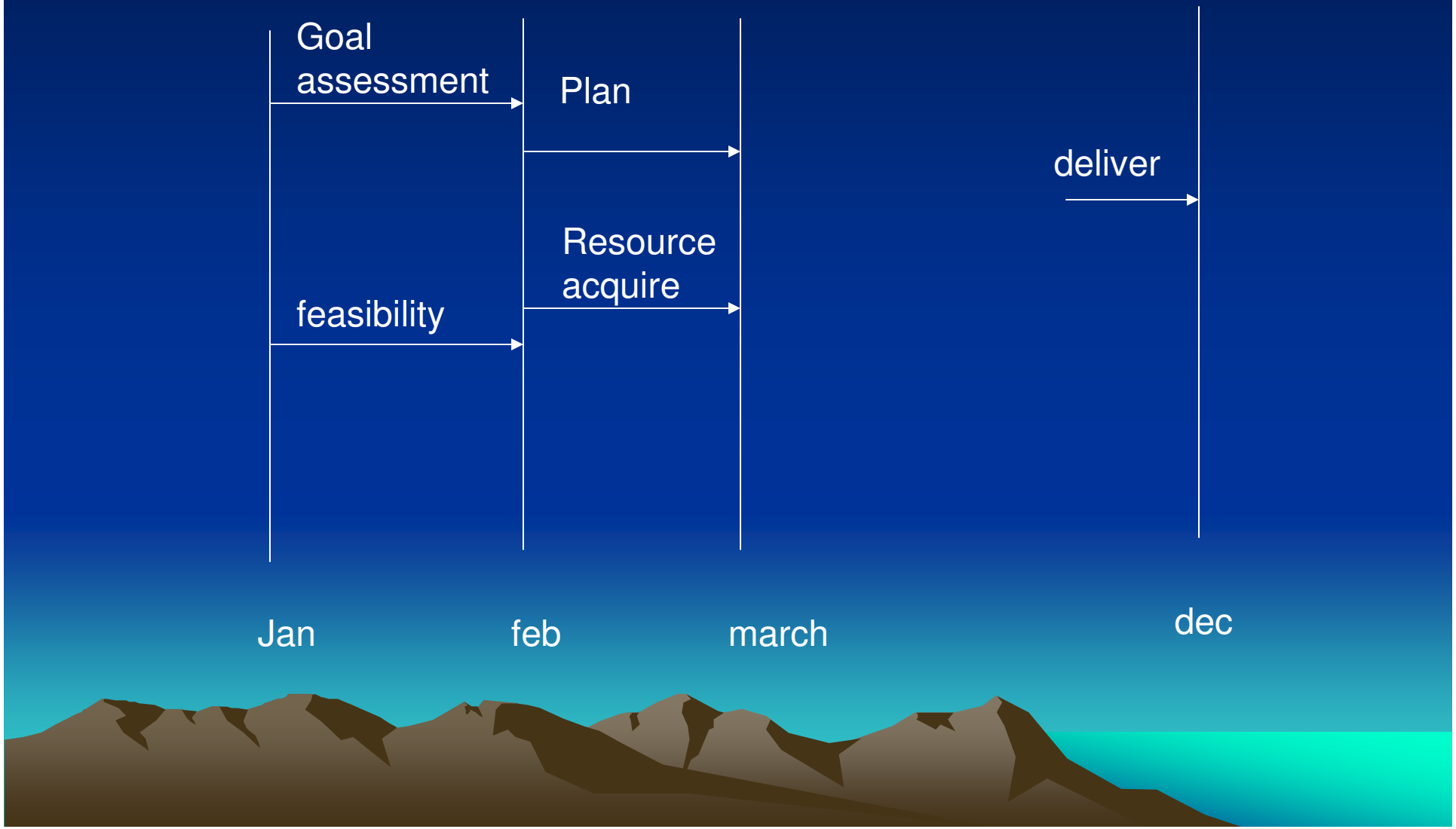


Why Do We need Architecture?

- Understand the system
  - Complex systems
- Organize the development
  - According to architectural partitioning
- Reuse
  - Componentization
- Evolution
  - Changes and dependencies

Processes and Products

- Process Architecture
  - About the process of software development
- Product Architecture
  - About the product under development

Several Approaches to Architecture

[e.g. see in Malveau & Moubray 2001]

- Zachman Framework (IBM)
  - 30 architectural viewpoints
- Open Distributed Processing (ISO standard)
  - 5 viewpoint reference model
- Domain Analysis
- 4+1 View Model (Unified Process-Rational)
- Academic Software Architecture

The Zachman Framework

[Zachman institute of framework advancement]

- "To keep the business from disintegrating, the concept of information systems architecture is becoming less of an option and more of a necessity" – Zachman in 1987
- Developed by Zachman from observing how architectures in engineering, construction and manufacturing managed *change*
- Intersection between roles in the design process and product abstractions
- Roles (in rows): Owner, Designer, Builder
- Product Abstractions (in columns): What is it made up of (data), How it works (process), Where are the components located (geometry)
- 3 additional columns: Who (people), When (time), Why (motivation)
- 2 additional rows: Planner, Subcontractor
- Columns have no order

Zachman Row 1: Planner's view Things important to business

- Column *why* (Motivation)
  - Business motivation, End: goals and measures of each goal, defines scope and boundaries
- Column *How* (Process)
  - Class of High level processes with inputs and output
- Column *What* (Data)
  - Class of Business data objects that enterprise is interested in
- Column Who (People)
  - Class of business organizations/people
- Column When (Time)
  - Events related to each process
- Column Where (Network)
  - Class of locations where the processes are executed

Zachman Row 2: Owner's view Enterprise Semantic model

- Column *why* (Motivation)
  - Ends/business goals and means/business strategy
- Column *How* (Process)
  - E.g. structured method-processes and flows
- Column *What* (Data)
  - E/R type model representing business entities, business relationships
- Column Who (People)
  - Work flow model- control, coordination, operation
- Column When (Time)
  - Master schedule (e.g. PERT)
- Column Where (Network)
  - Nodes, branches, warehouses etc.

Zachman Rows 3,4,5

- Designer
  - Logical models-e.g. data entity relations, ooad
- Builder
  - Physical models-e.g. Tables, hardware
- Subcontractor/Implementor
  - Filelds, control blocks, statements

Open Distributed Processing Reference Model

- For architecture supporting distribution, internetworking, interoperability and portability
- Five viewpoints
  - Enterprise (purpose, scope and policies)
  - Information (semantics of information and information processing)
  - Computational (functional decomposition)
  - Engineering (infrastructure to support distribution)
  - Technology (for implementation: Mappings between objects and specific standards and technologies)
- The set of viewpoints is not closed
- Each of the viewpoint is object oriented

ODP: Enterprise viewpoint

- Directly understandable by managers and end users
- Defines business purpose, scope and policies
- Includes permissions, prohibitions and obligations
- Example:
  - Active objects: managers, tellers, customers
  - Passive objects: accounts
  - Bank managers must advise customers when interest rate changes (obligation)
  - Cash less than 40000 can be drawn per day (prohibition)
  - Money can be deposited (permission)

ODP: Information viewpoint

- Definitions of information schemas as objects
  - State and structure of objects
    - E.g. account = balance and amount withdrawn today
- Three kinds of schemas:
  - static
    - At midnight, amount withdrawn today=2000
  - Invariant
    - At anytime, amount withdrawn today <=40000
  - Dynamic
    - A deposit of X increases the balance by X and a withdrawal of X decreases the balance by X
    - Always constrained by invariant
- Schemas may relate objects
  - E.g. in customer object: *owns account* static schema

ODP: Computational viewpoint

- Software components which are capable of supporting distribution
- Large grained object encapsulations, subsystem interfaces and behaviors
- Objects can offer multiple interfaces
- 3 types of interactions among objects
  - Operational : client-server, RPC : with parameters and results
  - Stream oriented
  - Signal oriented
- Inheritance of Interface and subtyping
- Operations such as object creation, trading for an interface, interface creation, binding, operation invocation
- Examples
  - Application objects: Bank branch with bank teller (deposit, withdraw) and bank manager (create account, deposit, withdraw) interfaces for customers
  - ODP infrastructural objects: Trader

ODP: Engineering viewpoint

- Brings out the distributed nature of the system
- Objects and Channels
- Objects
  - Basic engineering objects correspond to computational objects
  - Infrastructural objects such as protocol objects
    - E.g. stub, binder and protocol object (proxy/skeletons) + communication interface between protocol objects
- Engineering structure of the system is described
  - E.g. cluster, nucleus object, capsule of clusters, a machine node, a cluster may contain many engineering objects, an object can contain many activities, inter-cluster communication via channels

ODP: Transparencies Defined

- Access
  - hides the difference in data representation and invocation mechanism – enables heterogeneous systems to communicate
- Failure
  - Hides failures and possible recoveries of objects for fault tolerance
- Location
  - Hides the location information while finding and bind to an object
- Relocation
  - Masks the changes in the location of an object from its clients
- Migration
  - Masks the awareness of changes in location of the object from itself and from others
- Replication
  - Masks the existence of replicated objects
- Persistence
  - Masks activation and deactivation of objects
- Transaction
  - Masks coordination of activities to achieve consistency

4+1 View Model

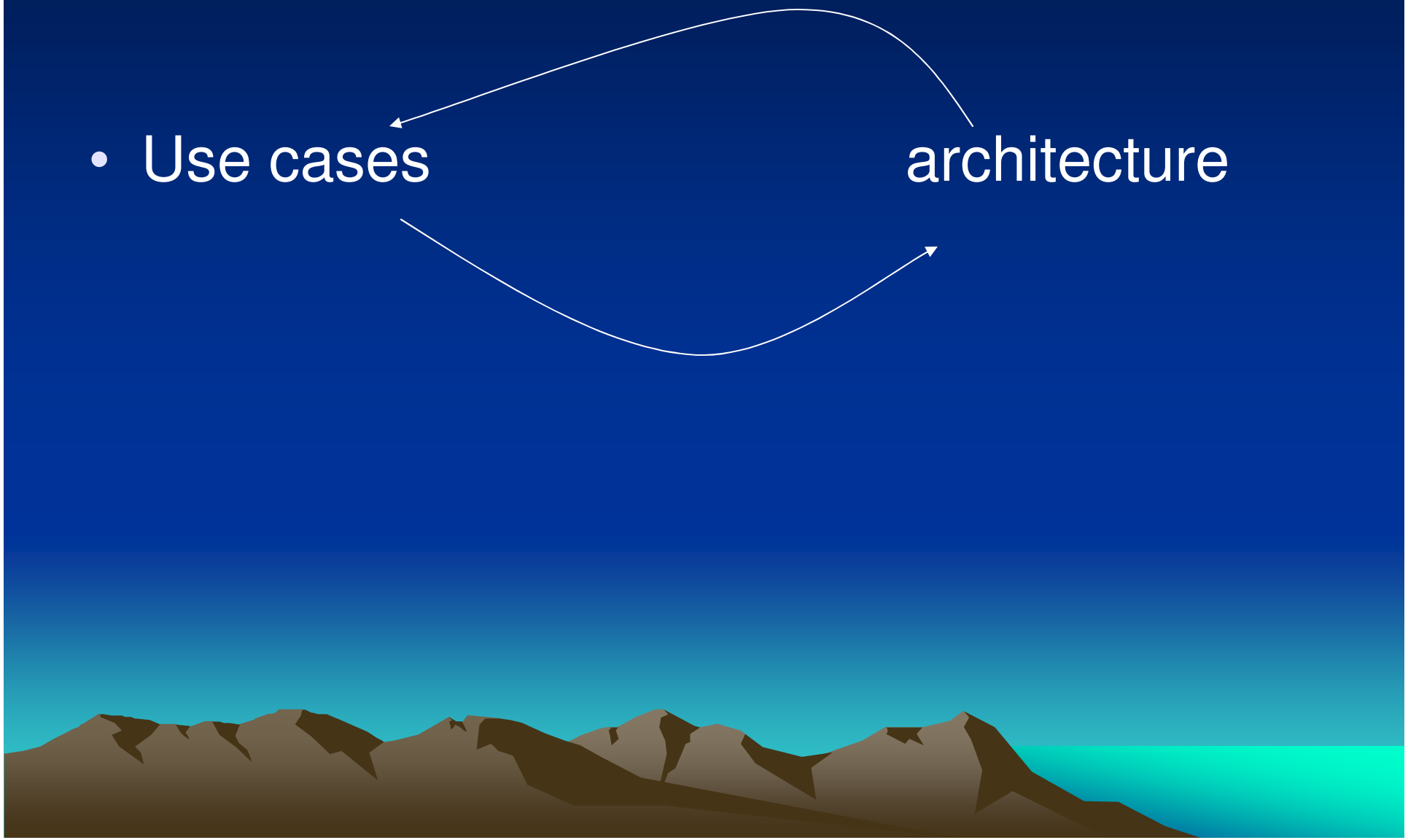
[P.B. Kutchen, 1995]

- Sometimes software architecture suffers from system designers who go too far..other software engineers fail to address the concerns of all customers
- 4+1 view model: Has 5 concurrent views
- Logical view- e.g. object model using object oriented design method
- Process view – concurrency and synchronization aspects
- Physical view – mapping of components to hardware, distribution aspect
- Development view – organization of the actual software modules – libraries, packages, subsystems
- Use case view

Unified Process Model of Architecture

- Architecture description is a proper extract of the models of the system (use case model, analysis model, design model, deployment model, implementation model)
  - e.g. Contains only architecturally significant use cases, whereas final use case model contains all use cases;
  - Similarly architectural view of design model realizes only the architectural use cases
  - First version of architecture is extract at the end of elaboration phase and so on
- Developed iteratively during elaboration phase
- Focus on significant structural elements of the system
  - Subsystems, classes, components, nodes
- Use cases and architecture

Chicken and Egg



Commonly occurring Architectural Patterns

- Fundamental structural organization schemas
- For example:
  - Layers
  - Pipes and Filters
  - Blackboard
  - Broker
  - Model-View-Controller
  - Presentation-Abstraction-Control
  - Microkernel
  - Reflection

Frameworks: An Approach to Architecture

- Partially complete software
- It is instantiated as a product
- For product families/product lines
- Frozen spots and hot spots

Enabling Techniques

- Abstraction
- Encapsulation
- Information Hiding
- Modularization
- Separation of Concerns
- Coupling and Cohesion
- Sufficiency, Completeness and Primitiveness
- Separation of Policy and Implementation
- Separation of Interface and Implementation
- Single point of reference
- Divide and Conquer

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