Eidgenössische Technische Hochschule Zürich
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Object-Oriented Databases

Version Models

- Temporal Databases
- Engineering Databases
- Software Configuration Systems

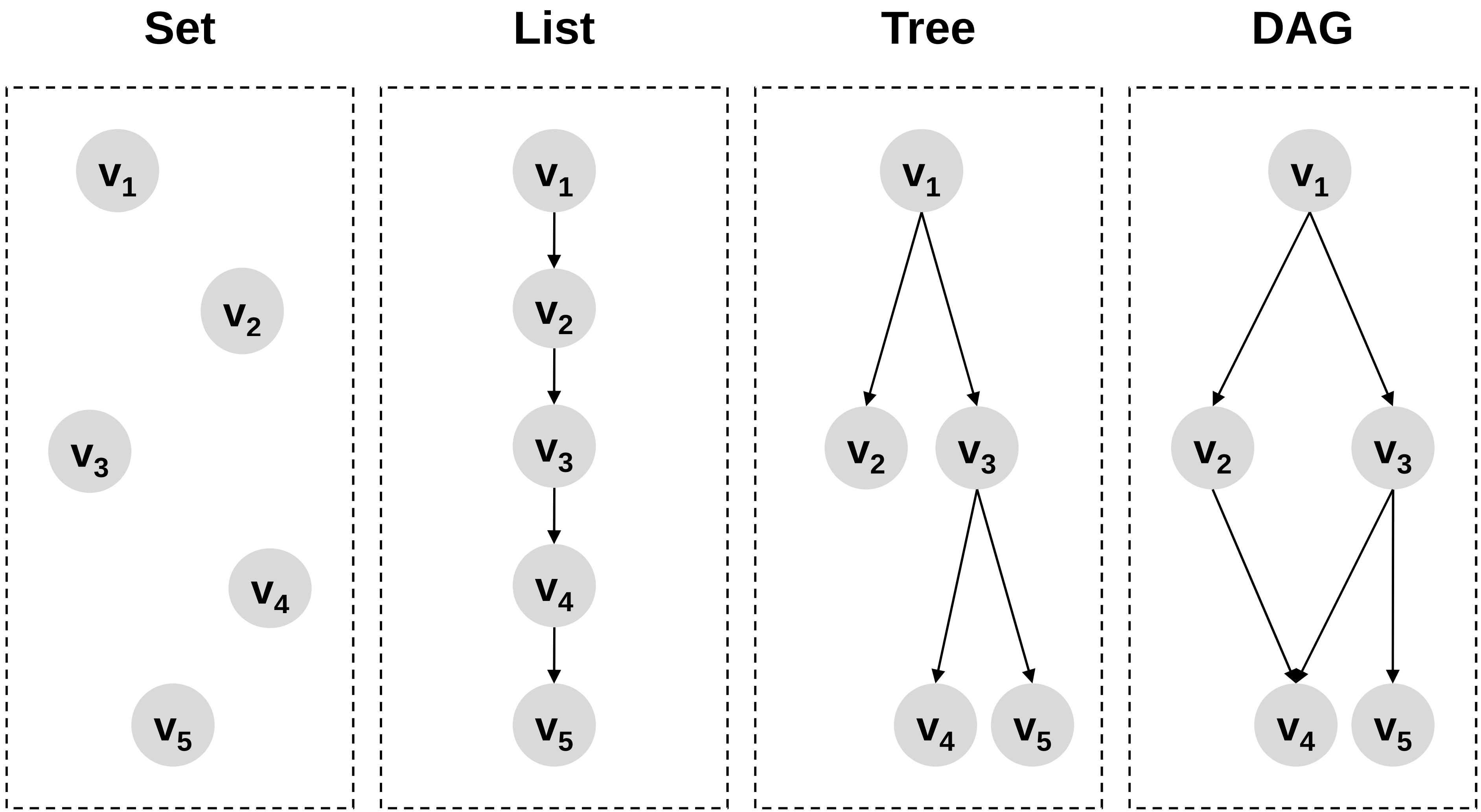
Overview

- Various version models have been proposed to meet challenges from application domains
  - temporal databases
  - computer-aided design and computer-aided manufacturing
  - software configuration and software engineering environments
- Evolution of version models
  - very simple approaches at first
  - complex and heterogeneous models emerged
  - several efforts to unify terminology and define generic models
- Association with object-oriented databases
  - version models as motivation for object-oriented databases
  - some object-oriented databases provide versioning support

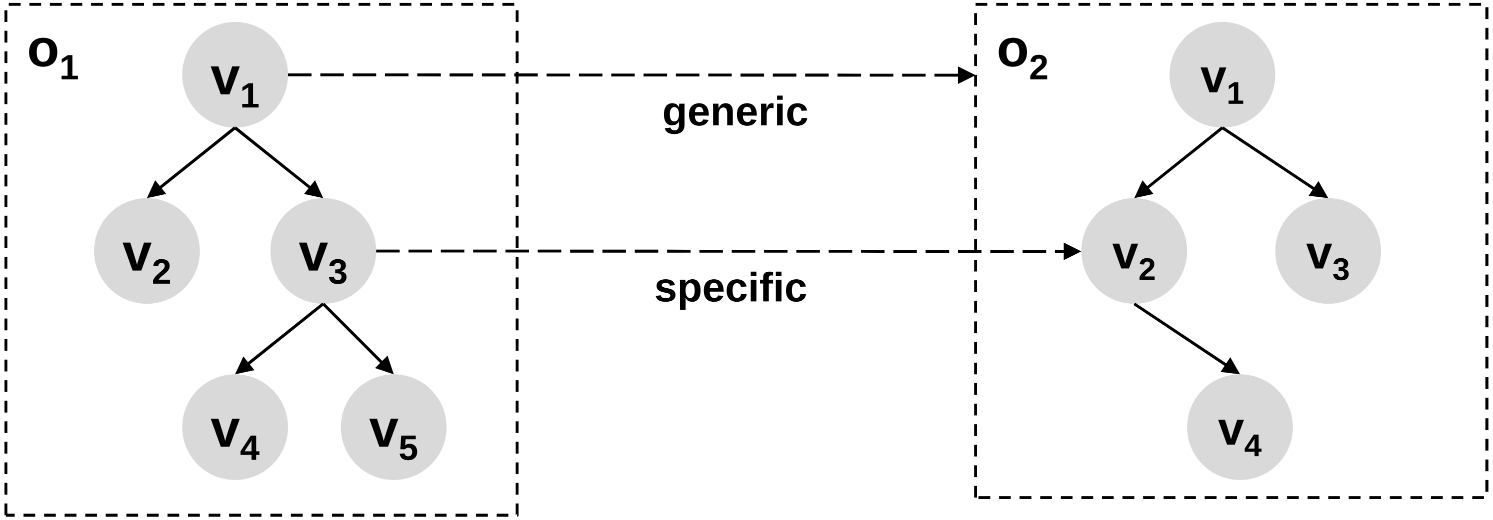
Versioned Object

- Concept that has a number of states associated with it
- Different levels of granularity
  - entire files
  - individual tuples of a relation
  - attributes of a class in object-oriented programming
  - objects in object-oriented systems
- Each version is a possible representation of the object, corresponding directly to one of its states
- Interpretation of object states depends on application of version model

Version Organisations



References



- Specific reference
  - references single version of object directly
- Generic reference
  - references entire object
  - has to be dereferenced to a version when traversed

Storage Strategies

- Representing versions at the physical level
  - storing complete versions of objects
  - storing changes or deltas between versions
- Delta-based approaches come in several variations
  - forward and backward deltas
  - state-based and operation-based deltas
- Performance of approaches
  - storing complete versions performs well when changes between versions are substantial
  - storing deltas performs well when data changes little, but is not suited to store parallel versions
  - space versus time performance

Operation and Interaction Models

- Operations control evolution of versions of single objects
  - create a new version of an object
  - branch a parallel version of an object
  - merge to parallel versions of an object
  - delete a version of an object
- Interaction or transaction models support working with complex objects and objects graphs
  - automatic versioning is transparent to the user
  - library model uses check-out and check-in high-level operations
  - long running and nested transactions

Queries and Configurations

- Queries over versioned objects involve additional constraints to select correct representations
- Various implementations exist
  - configurator evaluates rules against versioned object network
  - declarative queries express constraints in extended language
  - logical unification based on feature logic
- Dereferencing of generic references
  - query evaluator needs to select specific version of an object
  - main derivation guides generic access for parallel versions
  - active versions guide generic access for sequential versions
  - main derivation and active versions can be used in conjunction to dereference a generic reference

Temporal Databases

- One of the first application domains for version models
- Manage different flavours of time-dependent data
- Vast field of research with numerous approaches
  - conceptual models
  - data models
  - storage models
  - temporal algebras
  - query languages
- Research in temporal databases done mostly based on relational databases systems

Time in Databases

- Different types of time can be used to characterise temporal data
- Transaction, registration or physical time
  - captures when values were stored in the database
  - as-of operation
- Valid or logical time
  - used to express when values existed in real world
  - when operation
- User-defined time
  - all aspects of time not covered by other two notions of time

Classification of Temporal Databases

- Static or snapshot database
  - conventional database
  - does not manage temporal data
- Static roll-back database
  - keeps track of transaction time
  - supports AS-OF operation
- Historical database
  - keeps track of valid time
  - supports WHEN operation
- Temporal database
  - keeps track of both transaction and valid time
  - supports both AS-OF and WHEN operation

Representing Temporal Data

Object Versioning

- object is extended with attribute capturing temporal dimension
- can be realised without violating the relational first normal form

Employee	Office	Salary	T_S	T_E
Anne	A 12	5500	2000	now
Bob	B 34	4000	2002	2003
Bob	B 34	5500	2003	now
Charles	C 56	6700	1995	2000
Charles	C 56	7500	2000	2006
Charles	C 56	7000	2006	now
Denise	B 34	3000	1990	1995
Denise	B 34	5300	1995	2002

Attribute Versioning

- each attribute is extended with temporal information
- requires non-first normal form NF^2 relational systems

Employee	Office	Salary
Anne	A 12	(5500, 2000, now)
Bob	B 34	(4000, 2002, 2003) (5500, 2003, now)
Charles	C 56	(6700, 1995, 2000) (7500, 2000, 2006) (7000, 2006, now)
Denise	B 34	(3000, 1990, 1995) (5300, 1995, 2002)

Conceptual and Data Models

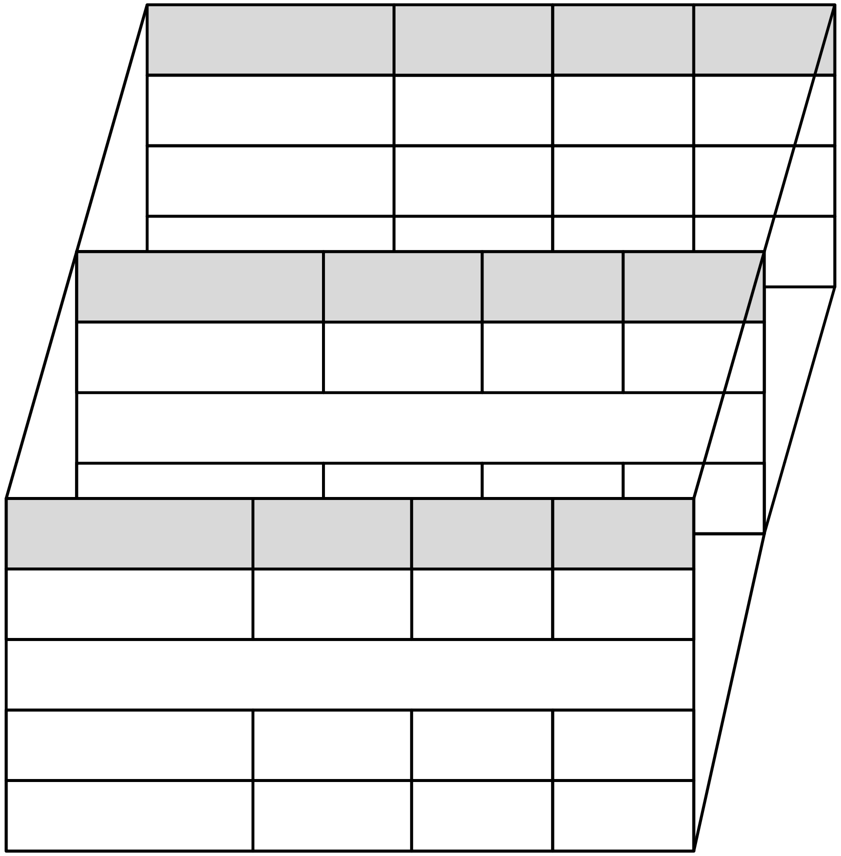
- Early approaches extended existing models such as the relational model or the E/R model
- Bitemporal Conceptual Data Model (BCDM)
  - tuple versioning
  - implemented using four additional columns per tuple
  - transaction time and valid time with special "until changed" and "now" values to indicate if a tuple is current
  - query language TSQL2 is an extension of SQL that introduces a VALIDTIME and WHEN clause
  - TSQL2 has been integrated into SQL3 as SQL/Temporal

Homogeneous and Heterogeneous Models

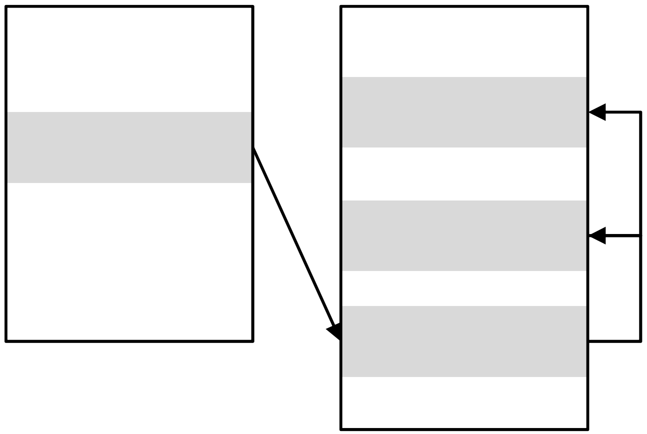
- Temporal data model is homogeneous if the temporal domain does not vary from one attribute of an object to another
- All models that use tuple versioning are homogeneous
- Heterogeneous models can suffer from two anomalies
  - if a horizontal anomaly is present, a versioned object is spread across several records in different data sets
  - if a vertical anomaly is present, a versioned object is spread across several records of the same data set
- Anomalies also apply to object-oriented databases on the physical level

Storage Models

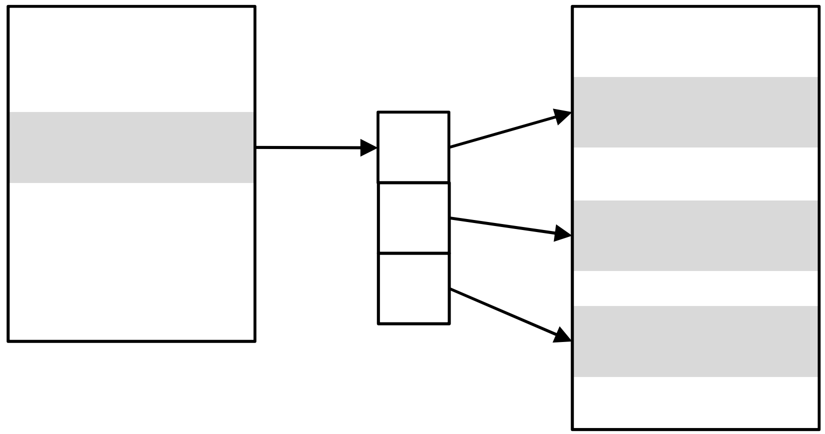
- Temporal relation can be viewed as tree-dimensional data structure
  - sequence of relations
  - data cube
- Implemented using a two level store structures
  - primary store contains current versions which satisfy all non-temporal queries
  - history store hold the remaining history versions
- Traditional access methods cannot be used on such a storage model



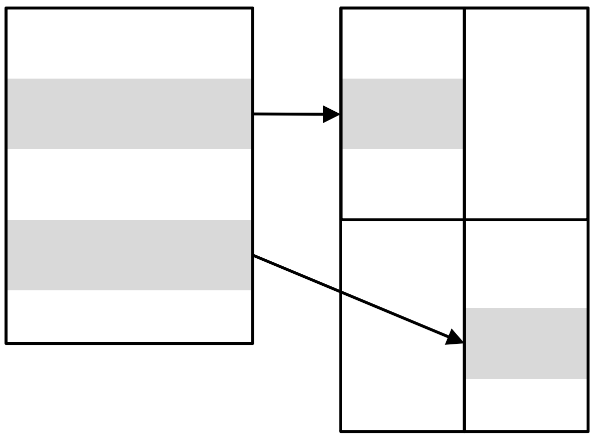
Two-Level Storage Structures



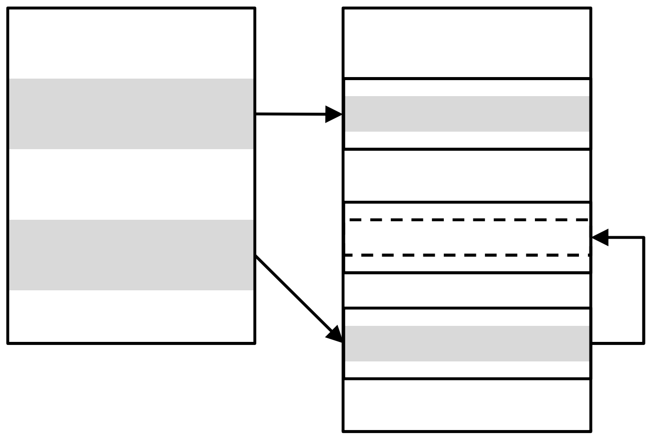
Reverse Chaining



Accession Lists



Clustering



Stacked Versions

Cellular Clustering
(Cell Size C=3)

Engineering Databases

- Developed for engineering application domains
  - Computer-Aided Design (CAD)
  - Computer-Aided Manufacturing (CAM)
- Support the development and maintenance of products
- Requirements
  - data structures and concurrency control concepts to define and manage complex, often hierarchical, design objects
  - versioning support for complex objects that supports iterative development by alternatives and trial-and-error experiments
- Two dimensional version models
  - linear revision dimension
  - non-sequential variation dimension

Early Approaches

- Extension of IBM System R relational database system with long fields and complex objects
- Long fields used to store and retrieve unstructured information of arbitrary length
  - data is written and read using extended cursor concept
  - iteration over stream representing data of a long field
- Complex objects manage several tuples as an object
  - new column types COMP_OF, INDETIFIER and REF introduced
  - component tuples reference other tuples of the same object or root tuple of another object
  - concurrent access based on check-out/check-in model

Software Configuration Systems

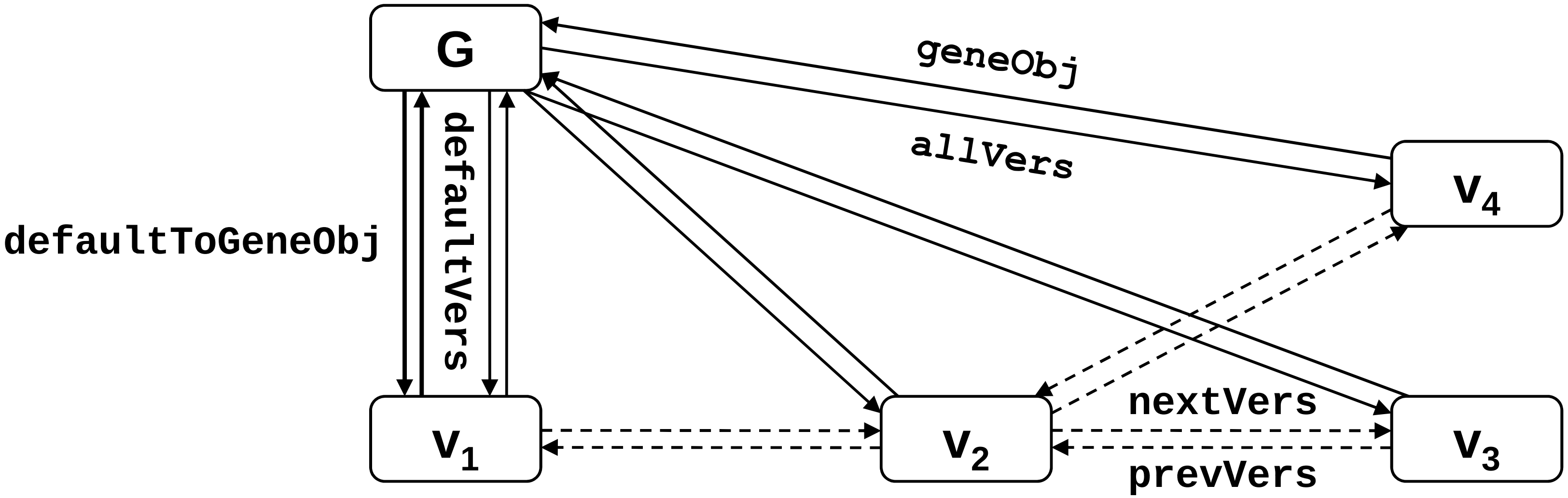
- Developed for software development
  - Software Configuration Management (SCM)
  - Software Engineering Environments (SEE)
- Software configuration systems manage product directly
  - engineering databases only manage a product representation
  - goal of fully automating process of building final product
- Also built around concept of design objects
  - source code files
  - modules of programs
- Management of references and dependencies more complex as hidden inside source code files

Version Support in Commercial Systems

- Most commercial object-oriented database systems offer some support for versioned objects
- Actual versioning functionality in terms of version set organisation, transaction model and configuration varies
  - Objectivity/DB offers basic versioning facilities allowing objects to evolve linearly or with alternative branches
  - ObjectStore provides more comprehensive support for versioned objects

Objectivity/DB

- Versioning is not supported in Objectivity/DB for Java, but it is supported in Objectivity/C++
  - enabled using **`setVersStatus`** method on object handle
  - linear versioning and branch versioning is supported
  - genealogies with default versions are supported



Creating New Versions

- When versioning is enabled, a new version is created automatically if an object is opened for update
  - handle through which opened basic object is set to new version
  - links between basic object and new version through **`nextVers`** and **`prevVers`** associations established automatically
  - new version has same versioning behavior as basic object
  - if linear version is created, versioning is automatically disabled for basic object to prevent additional versions from being created
- Updating the default version of an object
  - using **`setDefaultVers`** on object handle
  - inverse association **`defaultToGeneObj`** updated automatically

Merging Version Branches

- Two or more version branches can be merged
- Programmer must indicating that version on one branch is derived from a version on the other branch
  - **`derivedFrom`** and **`derivative`** associations
  - **`add derivedFrom`** method of the derived version or the **`add_derivatives`** method of the secondary ancestor version
  - inverse link is set automatically
  - versioned objects inherit these methods from class **`ooObj`**

ObjectStore

- Versioning based on concept of composite objects and workgroup though configurations and workspaces
- Configurations
  - objects to be treated as a unit for locking and versioning
  - class **`os configuration`** for building configurations of objects
- Workspaces
  - control access to configurations
  - form a hierarchy that is rooted at a single global workspace
- High-level operations at object level
  - **`new_version`**, **`branch`**, **`merge`**
  - check-out/check-in operational model

Literature

- Richard T. Snodgrass and Ilsoo Ahn: **A Taxonomy of Time in Databases**, In: *Proceedings of ACM SIGMOD, 236-246, 1985*
- Randy H. Katz: **Toward a Unified Framework for Version Modeling in Engineering Databases**, In: *ACM Computing Surveys, 22(4), 375-409, 1990*
- Reidar Conradi and Bernhard Westfechtel: **Version Models for Software Configuration Management**, In: *ACM Computing Surveys, 30(2), 232-282, 1998*

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Next Week

The OM Data Model

- Multiple Inheritance, Instantiation and Classification
- Collections and Associations
- Cardinality, Classification and Evolution Constraints