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Extending the UML for Multidimensional Modeling

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Contents

Introduction

- Multidimensional (MD) modeling → Data warehouses, MD databases, OLAP applications
- Many years of historical information
- Different approaches for the conceptual design:
  - Golfarelli *et al*
  - Husemann *et al*
  - Sapia *et al*
  - Tryfona *et al*
  - …

Own graphical notations

↓

Learn a new notation

Extending the UML for Multidimensional Modeling

Introduction

- UML → Standard OO modeling language for software systems
- Minimize the efforts in learning new notations
- Extensible language → Stereotypes, tagged values, and constraints → Profile
- Allows the user to introduce new elements for specific domains (web applications, business modeling, etc.)

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Introduction

- Some proposals to extend the UML for DB design…
  - Persistence Modeling (Ambler)
  - Data Modeling (Rational Software)
  - UML Profile for DB Design (Naiburg *et al*)
  - Object-Relational DB Design Methodology (Marcos *et al*)
- …but not for MD modeling

Extending the UML for Multidimensional Modeling

Introduction

- UML profile for MD modeling based on our previously proposed approach
  - Main MD properties:
    - many-to-many
    - degenerate dimensions
    - multiple and alternative path classification hierarchies
  - OCL: well-formedness rules of the new defined elements → Avoids an arbitrary use of our extension
- Rational Rose

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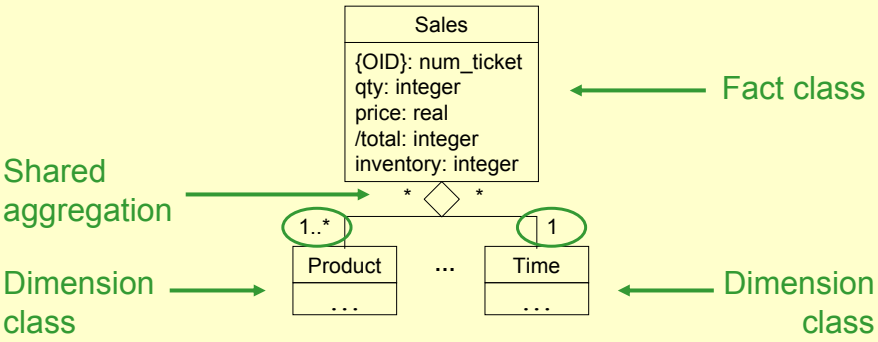
- **OO Multidimensional Modeling**
- UML Extension for MD Modeling
- MD Modeling in Rational Rose
- Conclusions and Future Work

OO Multidimensional Modeling

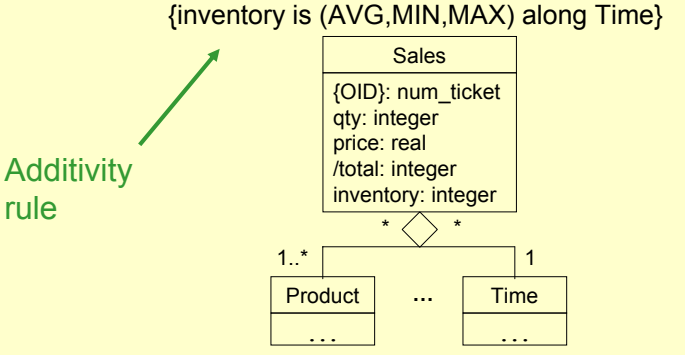
- Our MD modeling approach represents both the structural and ~~dynamic~~ parts of MD modeling using the UML
- MD modeling structural properties are specified by means of a UML class diagram
- Facts and dimensions are considered by *fact classes* and *dimension classes*

OO Multidimensional Modeling



•Fact classes are specified as composite classes in shared aggregation relationships of *n* dimension classes

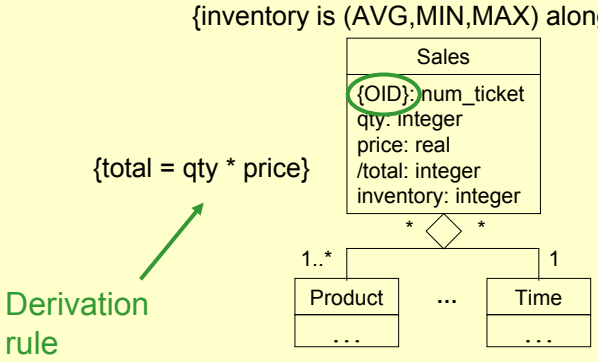
OO Multidimensional Modeling



•All measures in the fact class are considered additive

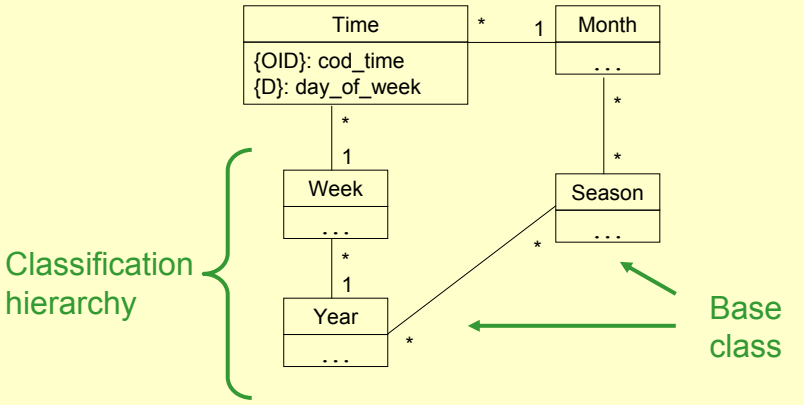
•Non-additive measures → *Additivity rules* defined as constraints

OO Multidimensional Modeling



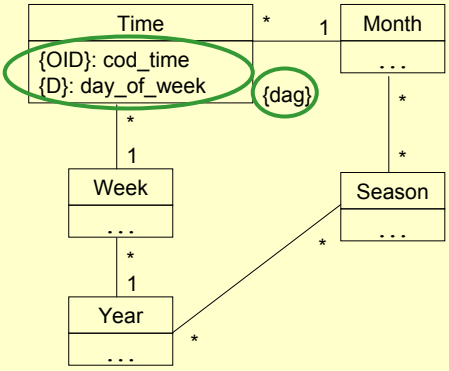
- Derived measures are defined by means of *derivation rules*
- *Identifying attributes* **{OID}** → Represent degenerate dimensions

OO Multidimensional Modeling



- An association of classes specifies the relationships between two levels of a **classification hierarchy**
- Every classification hierarchy level is specified by a class called **base class**

OO Multidimensional Modeling



- The classes in a classification hierarchy must define a Directed Acyclic Graph (DAG) rooted in the dimension class (**{dag}**)
- Every classification hierarchy level must have an *identifying attribute* (**{OID}**) and a *descriptor attribute* (**{D}**)

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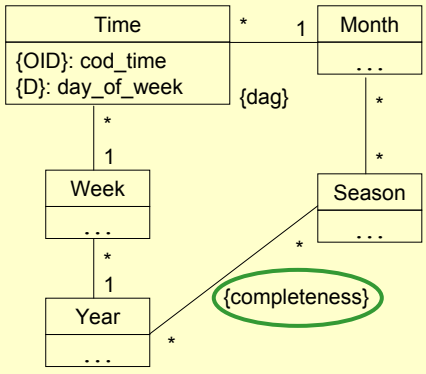
OO Multidimensional Modeling



- The multiplicity **1** and **1..*** addresses the concepts of *strictness* and *non-strictness*
- The **{completeness}** constraint addresses the *completeness* of a classification hierarchy

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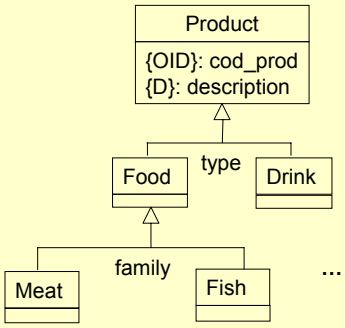
OO Multidimensional Modeling



•The categorization of dimensions is considered by means of generalization-specialization relationships

Contents

UML Extension for MD Modeling

- UML Extensibility Mechanism → Extension mechanisms: stereotypes, tagged values, and constraints
- UML can be adapted to fit a specific method, organization, or user

Extending the UML for Multidimensional Modeling

UML Extension for MD Modeling

- **Stereotype**: a new model element that specializes a UML element (Class, Attribute, Package, Association, etc.)
- **Tagged value**: a new property of a model element
- **Constraint**: refines the semantics of a model element → Informal or formal (Object Constraint Language)

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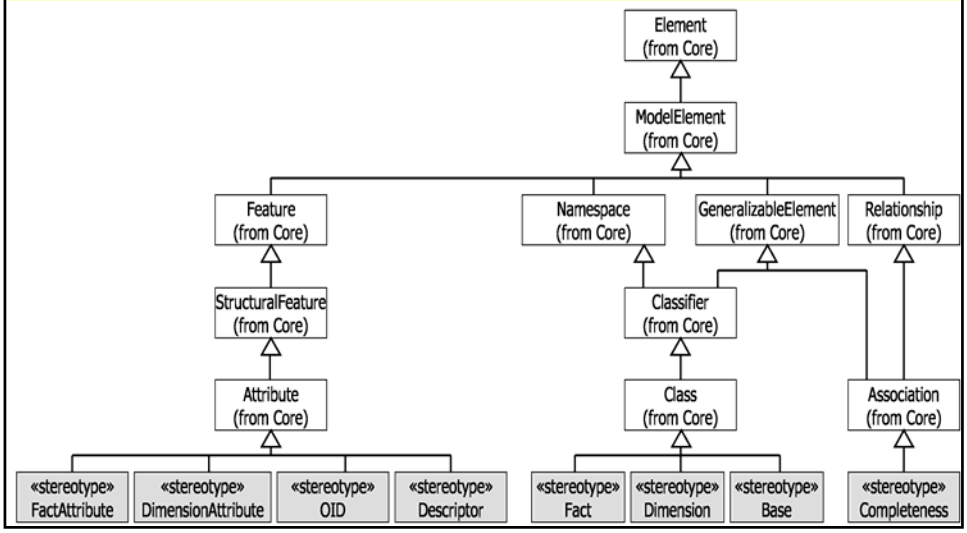
UML Extension for MD Modeling

- Extension summary:
  - 8 stereotypes:
    - Class: **Fact**, **Dimension**, and **Base**
    - Attribute: **FactAttribute**, **DimensionAttribute**, **OID**, and **Descriptor**
    - Association: **Completeness**
  - 2 tagged values:
    - **isTime** and **derivationRule**
  - 23 constraints

UML Extension for MD Modeling

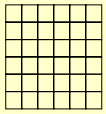


UML Extension for MD Modeling

- Facts and dimensions → **Fact**, **Dimension**, and **Base**
- Fact attributes → **OID** and **FactAttribute**
- Dimension attributes → **OID**, **Descriptor**, and **DimensionAttribute**
- Derived measures: **derivationRule** tagged value
- Classification hierarchies → Association between **Dimension** and **Base**
- Completeness → **Completeness** stereotype

UML Extension for MD Modeling

- Name: **Fact**
- Base class: **Class**
- Description: **Classes of this stereotype represent facts in a MD model**
- Icon:



- Tagged values: **None**

UML Extension for MD Modeling

- Constraints:
  - All attributes of a Fact must be OID or FactAttribute:

    self.feature->select(oclIsKindOf(Attribute))->
    forAll(oclIsTypeOf(OID) or oclIsTypeOf(FactAttribute))
  - All associations of a Fact must be aggregations:

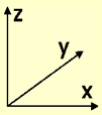
    self.association->forAll(aggregation = #aggregate)
  - A Fact can only be associated to Dimension classes:

    self.allOppositeAssociationEnds->
    forAll(participant.oclIsTypeOf(Dimension))

Extending the UML for Multidimensional Modeling

UML Extension for MD Modeling

- Name: **Dimension**
- Base class: **Class**
- Description: **Classes of this stereotype represent dimensions in a MD model**
- Icon:



- Tagged values: **None**

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UML Extension for MD Modeling

- Constraints:
  - All attributes of a Dimension must be OID, Descriptor, or FactAttribute:

    self.feature->select(oclIsKindOf(Attribute))-> forAll(oclIsTypeOf(OID) or oclIsTypeOf(Descriptor) or oclIsTypeOf(FactAttribute))
  - All associations of a dimension with a Fact must be aggregations at the opposite end:

    self.association.association->forAll(associationEnd.participant.oclIdTypeOf(Fact) implies associationEnd.aggregation = #aggregate)

UML Extension for MD Modeling

- Constraints:
  - All associations of a Dimension with a Fact must not be aggregations at its end:

    self.association.association->forAll(associationEnd.participant.oclIdTypeOf(Fact) implies aggregation <> #aggregate)
  - A Dimension cannot be associated to another Dimension:

    self.allOppositeAssociationEnds-> forAll(not participant.oclIsTypeOf(Dimension))

UML Extension for MD Modeling

- Name: **Base**
- Base class: **Class**
- Description: **Classes of this stereotype represent dimension hierarchy levels in a MD model**
- Icon:

- Tagged values: **None**

UML Extension for MD Modeling

- Constraints:
  - All attributes of a Base must be OID, Descriptor, or DimensionAttribute:

    self.feature->select(oclIsKindOf(Attribute))->
    forAll(oclIsTypeOf(OID) or oclIsTypeOf(Descriptor) or
    oclIsTypeOf(DimensionAttribute))
  - A Base must have an OID attribute and a Descriptor attribute:

    self.feature->select(oclIsKindOf(Attribute))->
    exist(oclIsTypeOf(OID)) and self.feature->
    select(oclIsKindOf(Attribute))->exist(oclIsTypeOf(Descriptor))

UML Extension for MD Modeling

- Constraints:
  - A Base can only be associated with another Base or another Dimension:

    self.allOppositeAssociationEnds->
    forAll(participant.oclIsTypeOf(Base) or
    participant.oclIsTypeOf(Dimension))
  - A Base can only be child in one generalization:

    self.generalization->size <= 1

Extending the UML for Multidimensional Modeling

UML Extension for MD Modeling

- Constraints:
  - A Base cannot simultaneously belong to a generalization/specialization hierarchy and an association hierarchy:

    (self.generalization->size > 0 or self.specialization->size > 0)
    implies (self.association->size = 0)

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MD Modeling in Rational Rose

- Rational Rose is one of the most well-known visual modeling tools
- RR is extensible by means of add-ins through the Rose Extensibility Interface:
  - Main menu items
  - Stereotypes
  - Properties (*tagged values*)
  - Data types
  - Event handling
  - Scripts
  - …

MD Modeling in Rational Rose

- Our add-in customizes:
  - Stereotypes → Stereotype configuration file
  - Properties → Property configuration file
  - Constraints → Menu item → Menu configuration file

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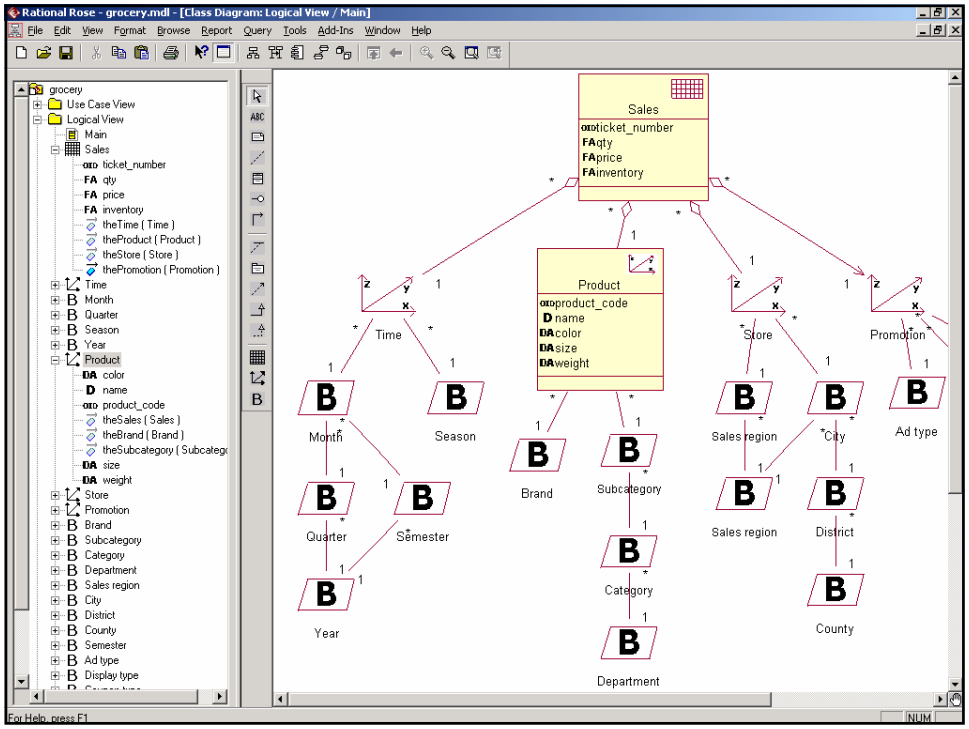

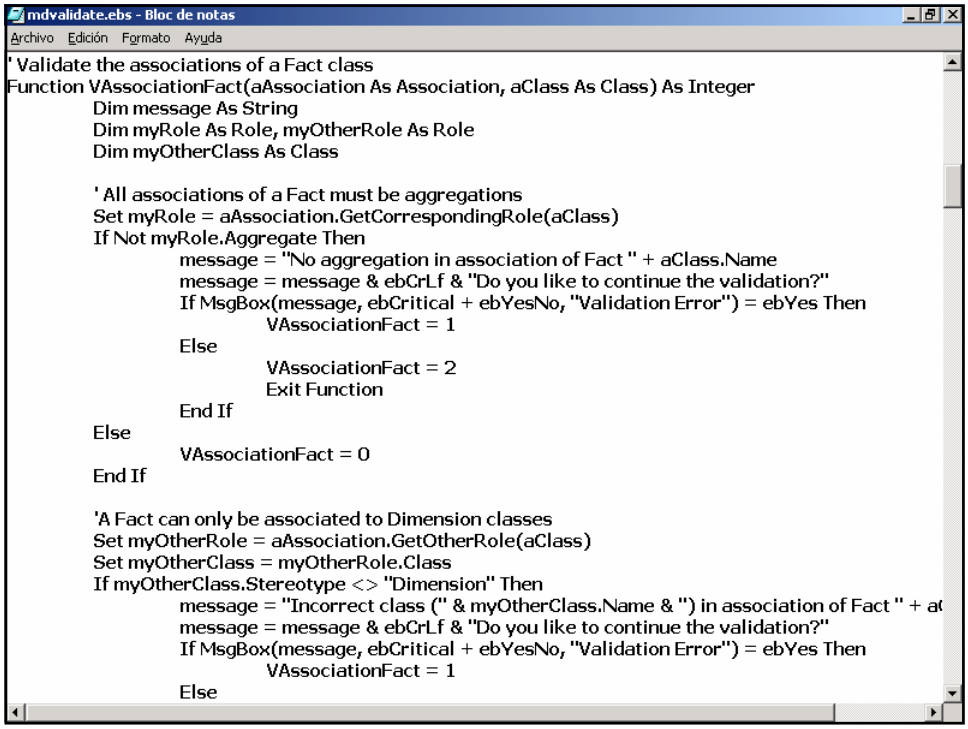

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Conclusions and Future Work

- UML extension for MD modeling: allows us to represent structural MD properties at the conceptual level
- OCL to specify the constraints, avoiding an arbitrary use of the extension
- Main advantage: UML → Avoids developers learning a new graphical notation

Extending the UML for Multidimensional Modeling

Conclusions and Future Work

- Future work:
  - Dynamic part
  - Automatic generation of database schema into object-oriented and object-relational databases
  - Methodology

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