A FrameWork for Financial Modeling

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Goals

- Case study of developing a framework
- Case study of using design patterns
- Learn a framework for financial modeling

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Overview

- What is a Financial Model?
- How we developed our framework.
- The design of our framework.
- Patterns in our framework.

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What is a Financial Model?

- reports
- answer “why”
- correct errors, enter budget
- depends on database
- ensure security

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Answering Why

- answers questions about finances
  - profit, return on assets
  - detailed costs
  - compare actual, budget, predicted
- high-level and detailed
- fixed reports and ad-hoc queries

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What is a Financial Model?

- business logic is equations
  - variable margin = net sales - variable cost
  - net sales = gross sales - warrantee
  - gross sales = sum *sales* column from *sales_and_transfer* table
- User interface just as important

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Warning!
All numbers
are fake.

Top Level

Dupont Model

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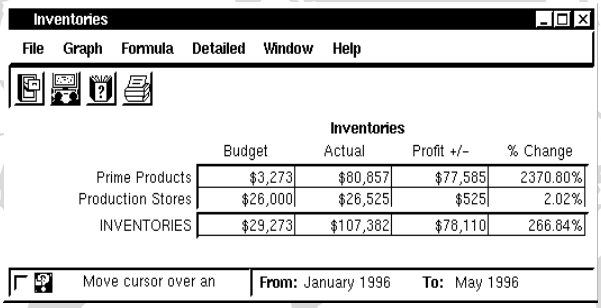
Inventories Drilldown

"Show calculation for Value"



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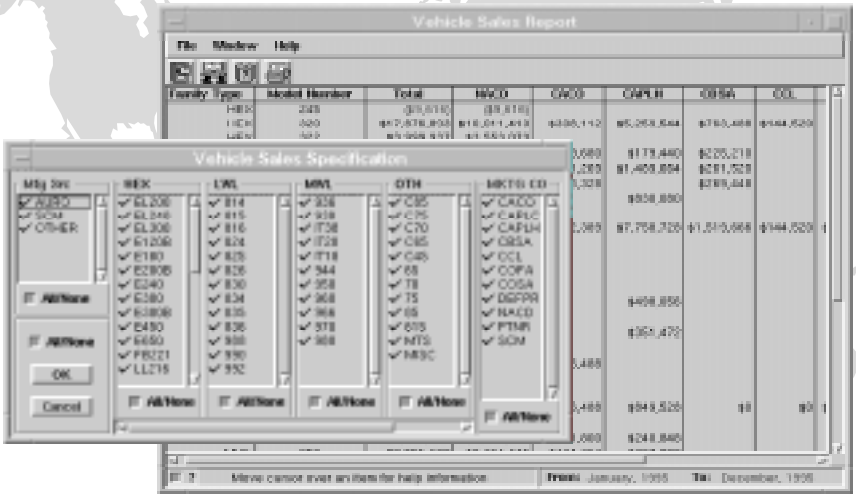
Summary Report

Vehicles by marketing company.



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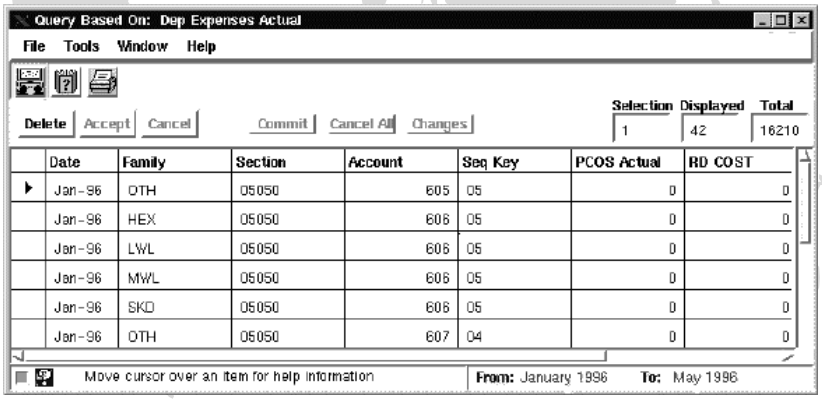
Detailed Transactions

Inspect and edit the individual transactions.



	Date	Family	Section	Account	Seq Key	PCOS Actual	RD COST
▶	Jan-96	OTH	05050	605	05	0	0
	Jan-96	HEX	05050	606	05	0	0
	Jan-96	LWL	05050	606	05	0	0
	Jan-96	MWL	05050	606	05	0	0
	Jan-96	SKD	05050	606	05	0	0
	Jan-96	OTH	05050	607	04	0	0

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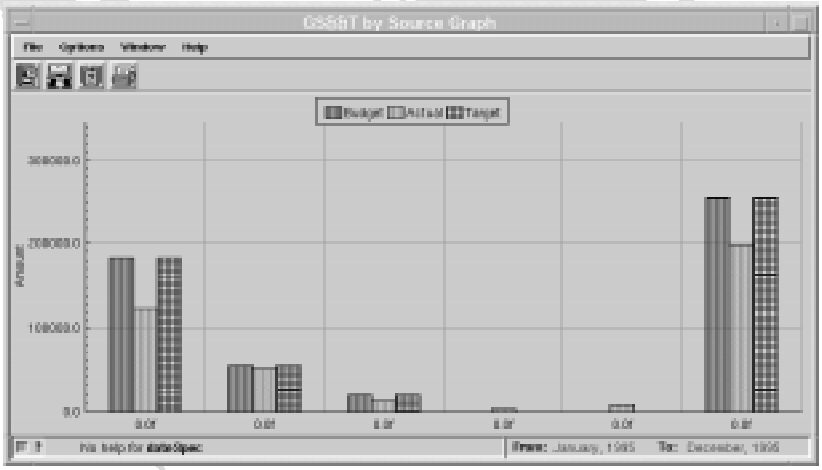
Graphs



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Summary of Reports

- Top level (Dupont or P&L)
- Drill down (ReportModel)
- Summary report
- Detailed transactions
- Graphs

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Patterns for Developing Frameworks

1) Three Examples
2) White-box Framework
3) Component Library
   – Build applications and add components to library
4) Hot Spots
   – Separate Changeable from Stable Code
   – Design Patterns

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Patterns for Developing Frameworks

5) Pluggable Objects
6) Fine-grained Objects
7) Black-box Framework
8) Visual Builder
9) Language Tools

http://st-www.cs.uiuc.edu/users/droberts/evolve.html

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Three Examples

- Models for three business units
- Seemed completely different at first.
- Only one was fully implemented

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White-box Framework

Five kinds of ApplicationsModel, with lots of subclasses

- DupontModel
- ReportModel
- DetailedModel
- SummaryModel
- GraphModel

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User Interface Frameworks

- ***DuPontModel*** -
- ***ReportModel*** - Builds a spreadsheet interface using values and GUI descriptions from ***ReportValues***.
- ***SummaryReports***
- ***DetailedWindows*** - Edit and view individual transactions
- ***GraphReports***

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White-box Framework

- New window = new subclass
- Subclass has methods for
  - reading database
  - computing values
  - stuffing them in GUI
- Initialization registers with dependents

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Component Library

- First, just abstract superclasses
- Second, query objects
- Third, GUI objects

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Hot Spots

- Find aspects that change, and make them objects
- Often are patterns from *Design Patterns: Elements of Reusable Object-Oriented Software*
- QueryObjects: Interpreter pattern

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Interpreter Pattern

- Need to represent SQL to manipulate query:

  SELECT SUM(sales) FROM sales_and_transfer

  WHERE family=‘MWL’ AND date < ‘1/1/96’
  AND date > ‘1/1/97’

- Problem: how do you represent a simple language?

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Interpreter Pattern

1) make a class hierarchy that represents nodes in abstract syntax tree (SELECT, AND, <, tables, field names)

2) define methods to construct and manipulate tree

3) define method to compute value of query (this is the “interpreter”)

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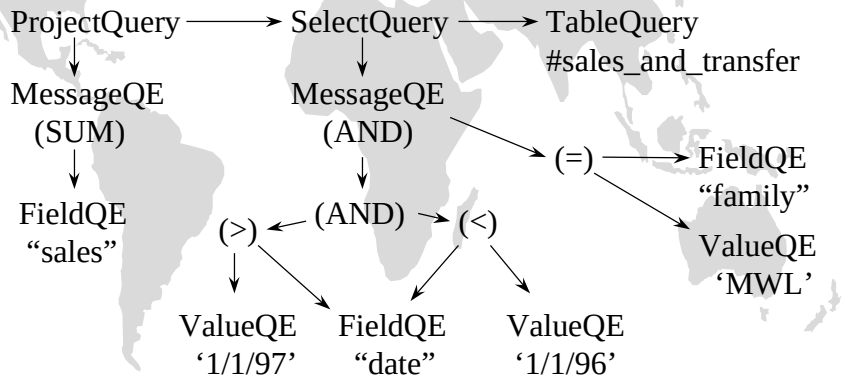
Instance Hierarchy

SELECT SUM(sales) FROM sales_and_transfer
WHERE family='MWL' AND date < '1/1/96' AND date > '1/1/97'



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QueryObjects

QueryObject
- TableQuery
- JoinQuery
- WrapperQuery
  - RenamingQuery
  - ExpressionQuery
    - SelectQuery
    - ProjectQuery
    - OrderQuery

QueryExpression
- ValueQE
- MessageQE
- FieldQE
  - RenamedFieldQE

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QueryObject Protocol

- values - answer collection of tuples
- fieldNames
- join: aQueryObject
- select: aQueryExpression
- project:, renameColumnsTo:, outerJoin:, groupBy:, orderBy:, asDistinct

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Creating a QueryObject

```
salesQ := #sales_and_transfer asQuery.
dateQ := salesQ select:
        ((salesQ @@ 'family') = 'MWL') &
        ((salesQ @@ 'date') > '1/1/96') &
        ((salesQ @@ 'date') < '1/1/97').
dateQ project: (dateQ @@ 'sales') Sum
```

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QueryExpression Protocol

+, -, <, =, &, |, Sum, Average, Count, …

Sending one of these messages to a QueryExpression builds a MessageQE with the appropriate operands, and with the message as the operator.

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Leading to Black-box

- Component Library
- Hot Spots
- Pluggable Objects
- Fine-grained Objects
- Black-box Frameworks

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First Design

- Class hierarchy of ReportModels, ReportModel creates QueryObjects.
- Improvement: separate logic and GUI
- Two hierarchies: ReportModel and ReportValues.
  - Result: twice the classes, some reuse

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First Separation

- ReportModel
  - SalesModel
  - InventoryModel
  - ...

Uses QueryObjects

- ReportValues
  - SalesValues
  - InventoryValues
  - ...

Makes QueryObjects

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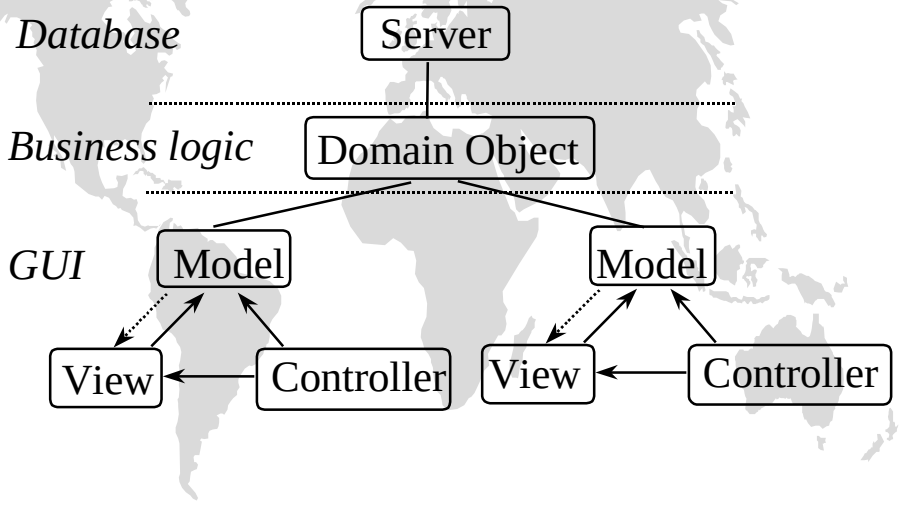
Three-tiered Client-Server



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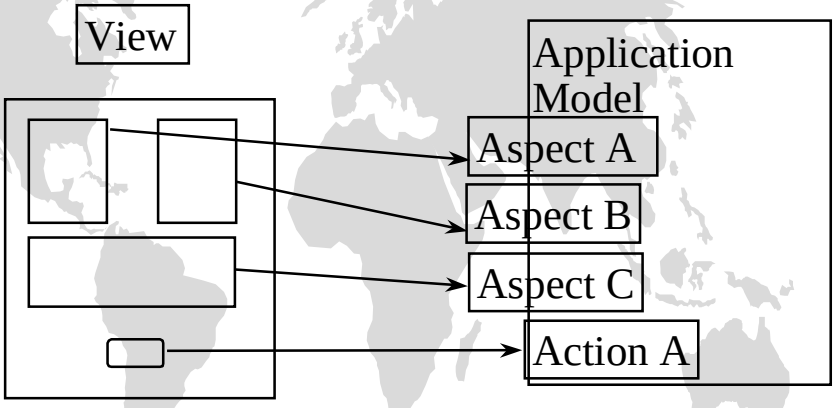
Structure of Application



View is a dependent of the aspect.
Aspect is a ValueModel.

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ValueModel

- Example of Observer pattern
- View (observer) registers with ValueModel (subject) and is notified when it changes.
- ValueModel protocol
  - value, value:
  - addDependent:, removeDependent
- Observer protocol
  - update:

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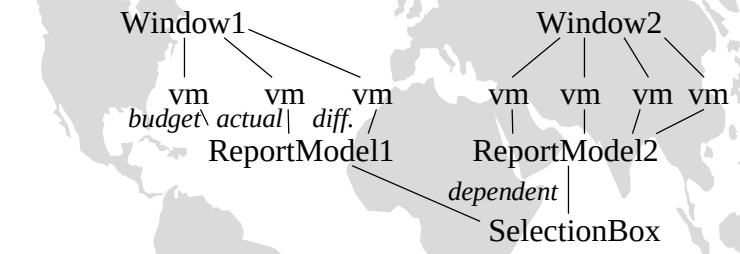
Using ValueModels



budget value: (query1 values first first).
actual value: (query 2 values first first).
difference value: budget value - actual value

A query returns a collection of tuples.

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Alternative Solutions

- ReportModel depends on SelectionBox.
  - updates for too many changes
- ReportModel depends on ValueModels from SelectionBox used in QueryObject
  - hard to manage dependencies
- ReportModel depends on QueryObject, QueryObject depends on ValueModels from SelectionBox

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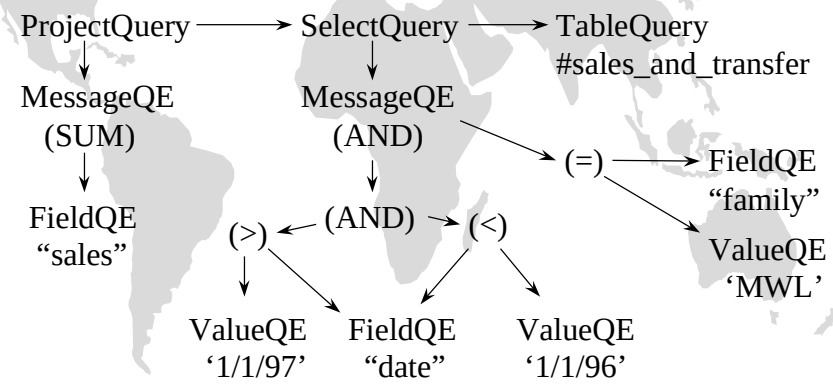
Observer and QueryObjects

Let ValueQE refer to a ValueModel.

Let each QueryObject observe its components.



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Old way - route change through report

budget value: (query1 values first first).
actual value: (query 2 values first first).
difference value: budget value - actual value

Update

New way - route change directly to ValueModel

budget := QueryHolder on: query1
actual := QueryHolder on: query2
difference := budget - actual

Initialization

Requires:

QueryHolder - adapts QueryObject to ValueModel
ValueModel understands +, -, *, /, etc

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QueryHolder

Adaptor pattern - subclass of ValueModel that lets QueryObject act like ValueModel.

instance variables: query, values

```
query: aQuery
   query := aQuery.
   aQuery addDependent: self
```

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QueryHolder

```
update
    values := aQuery values
    self changed

value
    ^values first first
```

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Arithmetic on ValueModels

ValueModel implements arithmetic by creating ValueModels that compute function.

```
+ anObject
    ^BlockValue
        on: [:a :b | a value + b value]
        with: (Array with: self with: anObject)
```

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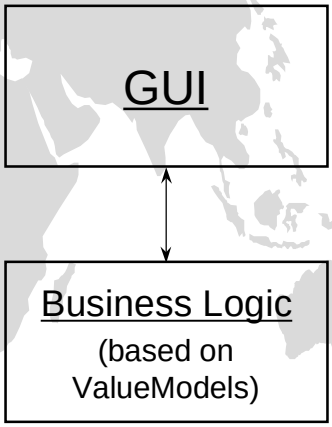
Result of Refactoring

Reuse GUIs, change ValueModels.

Hard part is creating ValueModels and connecting them to GUI.



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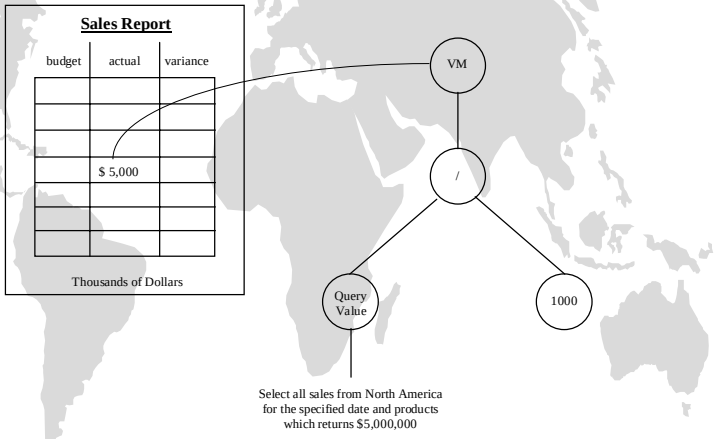
Typical Values in a Report



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Business logic is equations expressed with ValueModel and QueryObjects

- Values = functions of other values
- Values = queries from the database

variable margin = net sales - variable cost

net sales = gross sales - warrantee

gross sales = sum *sales* column from *sales_and_transfer* table

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Problems

- How do we go from one report to the next?
- How do we connect report to business model?

- Must define business model flexibly
- Must define GUI flexibly

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Specifications

- A ReportSpec
  - has name
  - has parameters
  - has menus, which name other reports
- DetailedReportSpec and SummaryReportSpec are parameterized with QueryObjects.
- GraphReportSpec is parameterized with ValueModels

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ReportValues

Many tables.

Many columns

Each table has a sequence of valueModels

Total at end.

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Solution

- ReportValues responsible for
  - knowing values
  - knowing how to compute values
  - knowing how to display more detail (drill-down) on values
- Top level starts up ReportValues which starts up next.

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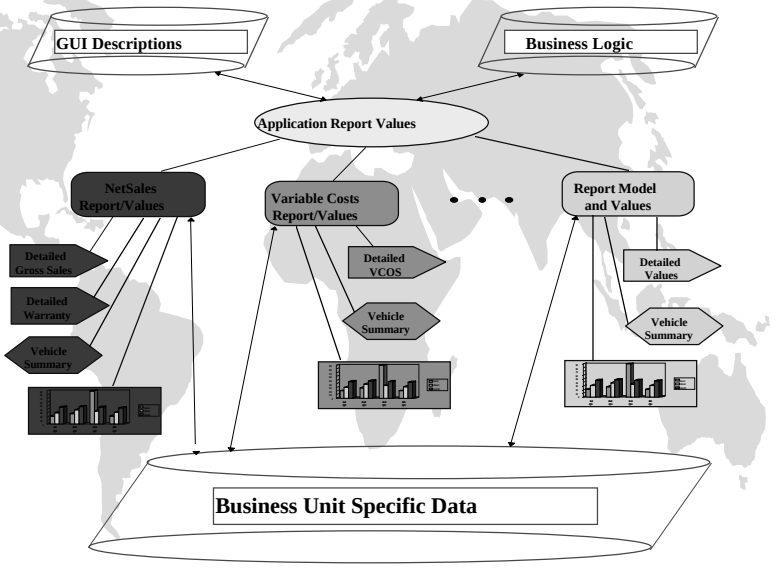
Report Values



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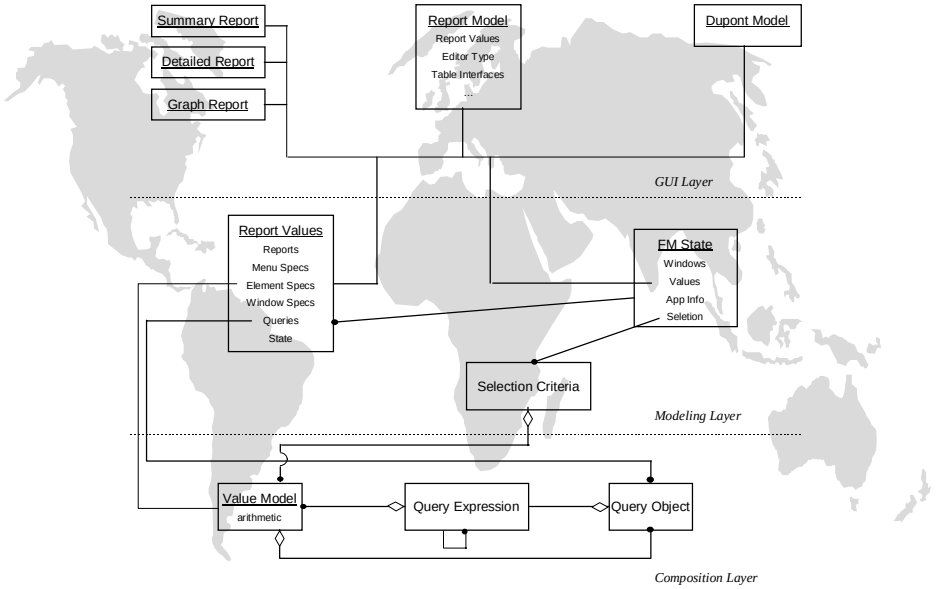
User View Architecture



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ReportValue protocol

- budget, actual - ValueModels
- openEditor - open “drill down”
  - specify spreadsheets, ValueModels to go in the spreadsheets, menus, reports on menus
- openWith: aSymbol - opens named report

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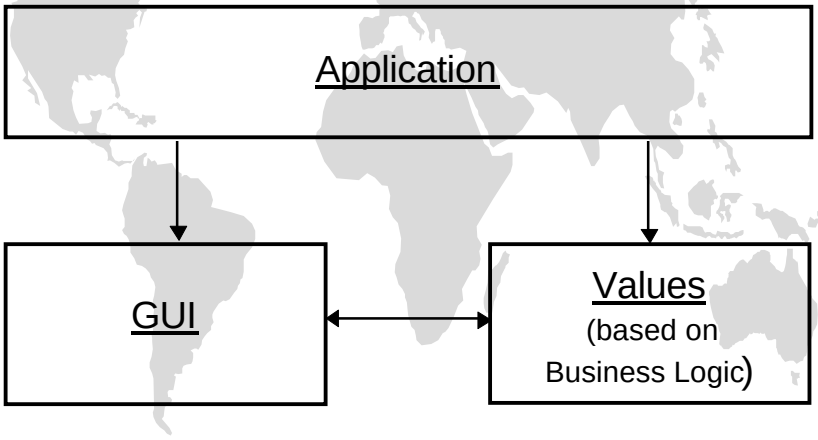
Layered Architecture



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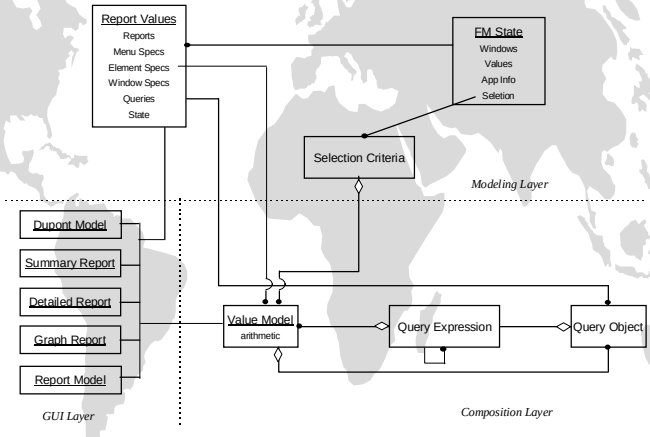
Black-box Framework



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Visual Builder

- Make a GUI to define Specs.
- This GUI is a language for defining financial models.

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Builders

- Equations in a ReportValue
  - expressions
  - queries
- GUIs
  - ReportValue (Drill down)
  - Graphs - specify business logic, labels
  - Detailed - specify query, labels, editing
  - Summaries - specify query, grouping, columns to sum and calculate
- Selection

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Language Tools

- Languages need debuggers, profilers, version control, etc.
- So far only built a testing tool.

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Summary of Architecture

- Builders
- ReportValues, Selection Criterion, FMState
- GUI frameworks
- ValueModel, QueryObject

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Summary of Architecture

- business model is not object-oriented, just a bunch of equations
- object model is the language for specifying business model, not the business model

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Data Model

- Application Specific
  - holds “real data”
  - changes with every business model
- Generic
  - specifies business logic and GUI
  - never changes

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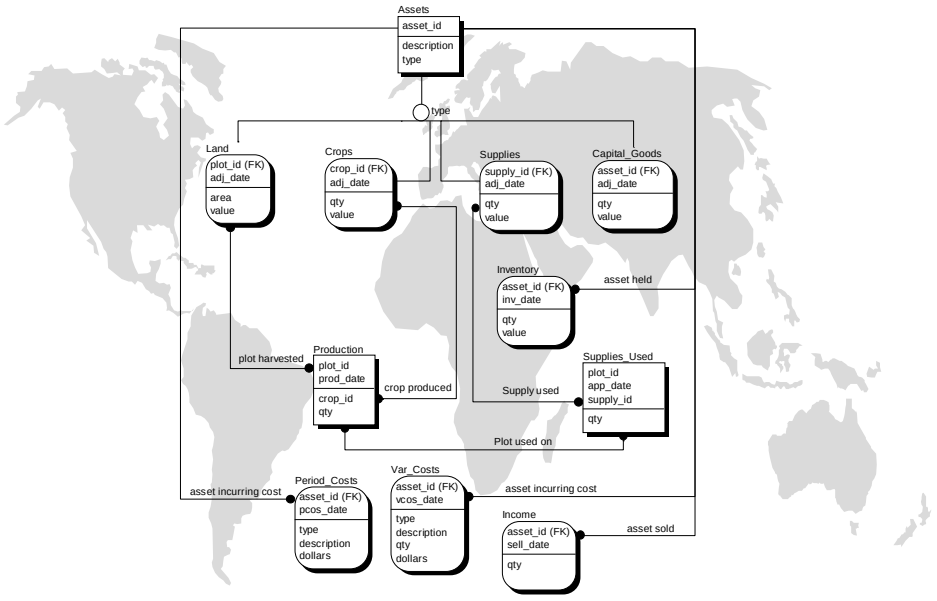
Farm Data Model



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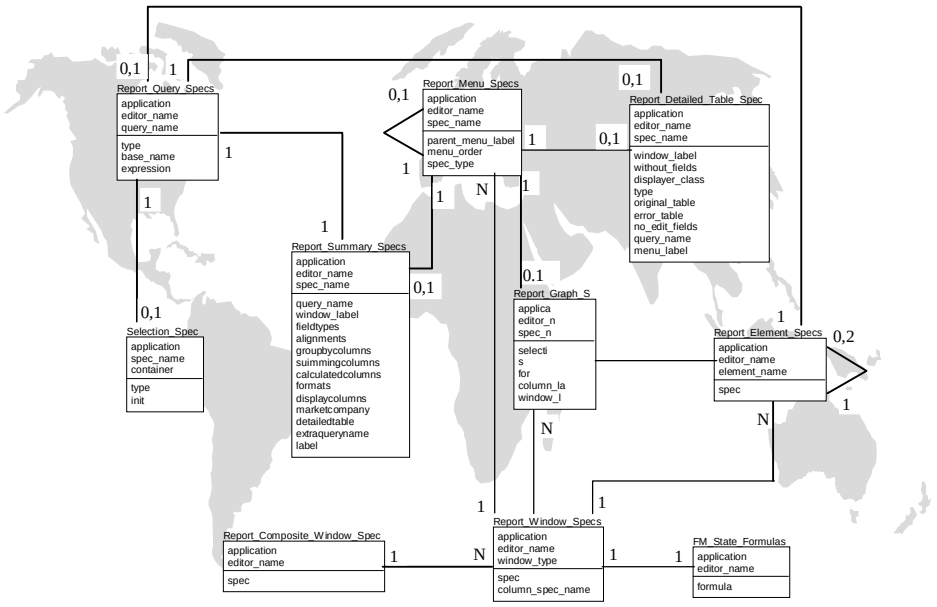
Specification Data Model



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Other Features

- Any window can print itself
- Automated testing support
- Security for editing and/or viewing the data; configured by administrators.

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Security Requirements

- Control passwords
- Control login
- Users have roles
- Role can only view a specified list of products.
- Role can only edit a subset of the specified list of products.
- All security features can be controlled by administrators

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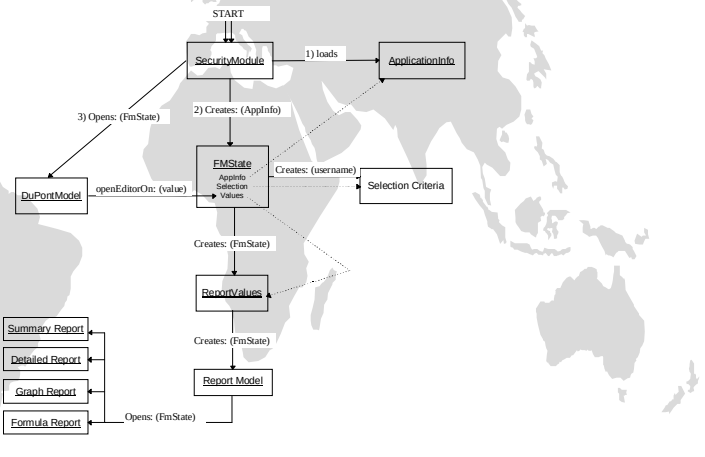
FM Creational Diagram



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How to Develop a New Financial Application

- Analyze business unit
- Build business-unit data model
- Specify GUI and business logic
- Install and Test

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Analyze Business Unit

- Questions to ask a new business unit
  - Values to be calculated (netsales, vcos, pcos, ...)
  - User interface
    - top level
    - Drill Downs (summary and detailed)
    - Graphs of values
  - Error-Correction/Analysis modules

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Summary

- We have developed a reusable design for financial applications
- Domain specific “Visual-Language”
- Framework emerges by repeatedly refactoring system to eliminate complexity and create flexibility

For more information, see http://cat.ncsa.uiuc.edu/~yoder/financial_framework/

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