USC Viterbi
School of Engineering

Interactive Visualization of Oil Reservoir Data

Sep 23rd, 2008

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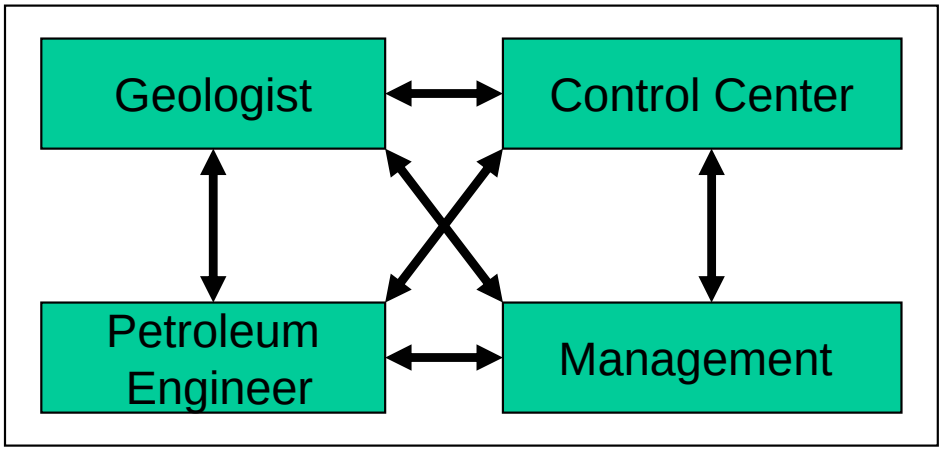
Motivation

- **Communication Overhead in Organizations.**
  - **between domains within one oil field**
  - **between domains within oil fields**



Domains in a Oil Field

- **Different data formats**
- **Different tools**
- **Not willing to learn simple tools**
- **Need IT experts help for data communication**

- **3D data visualization takes time.**
- **3D data visualization is a iterative process.**
- **Can we provide an easier and useful means?**

Example

- Geologist:

I want to see the reservoir **Reservoir_LH**'s **Oil Saturation**.

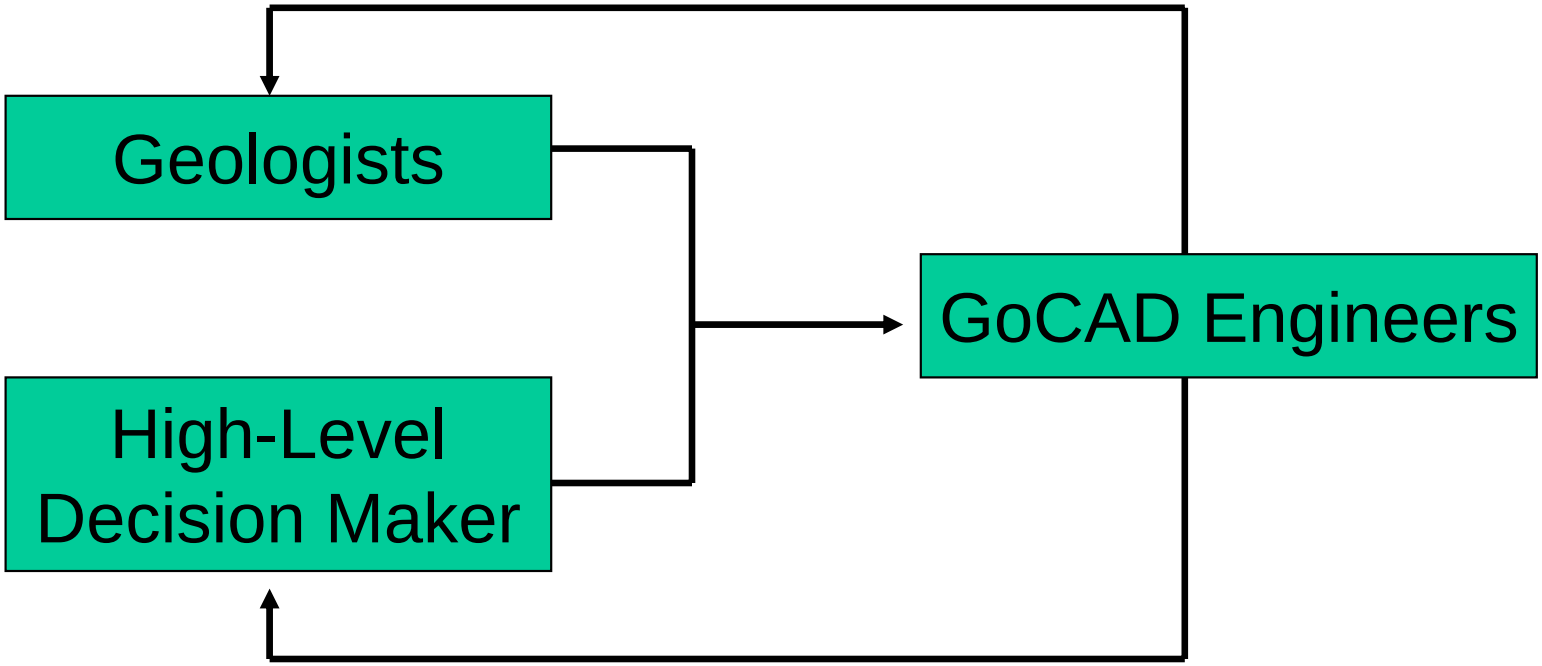
- Geologist:

In addition, I want to see the **wells** and their **pipes** in the reservoir.

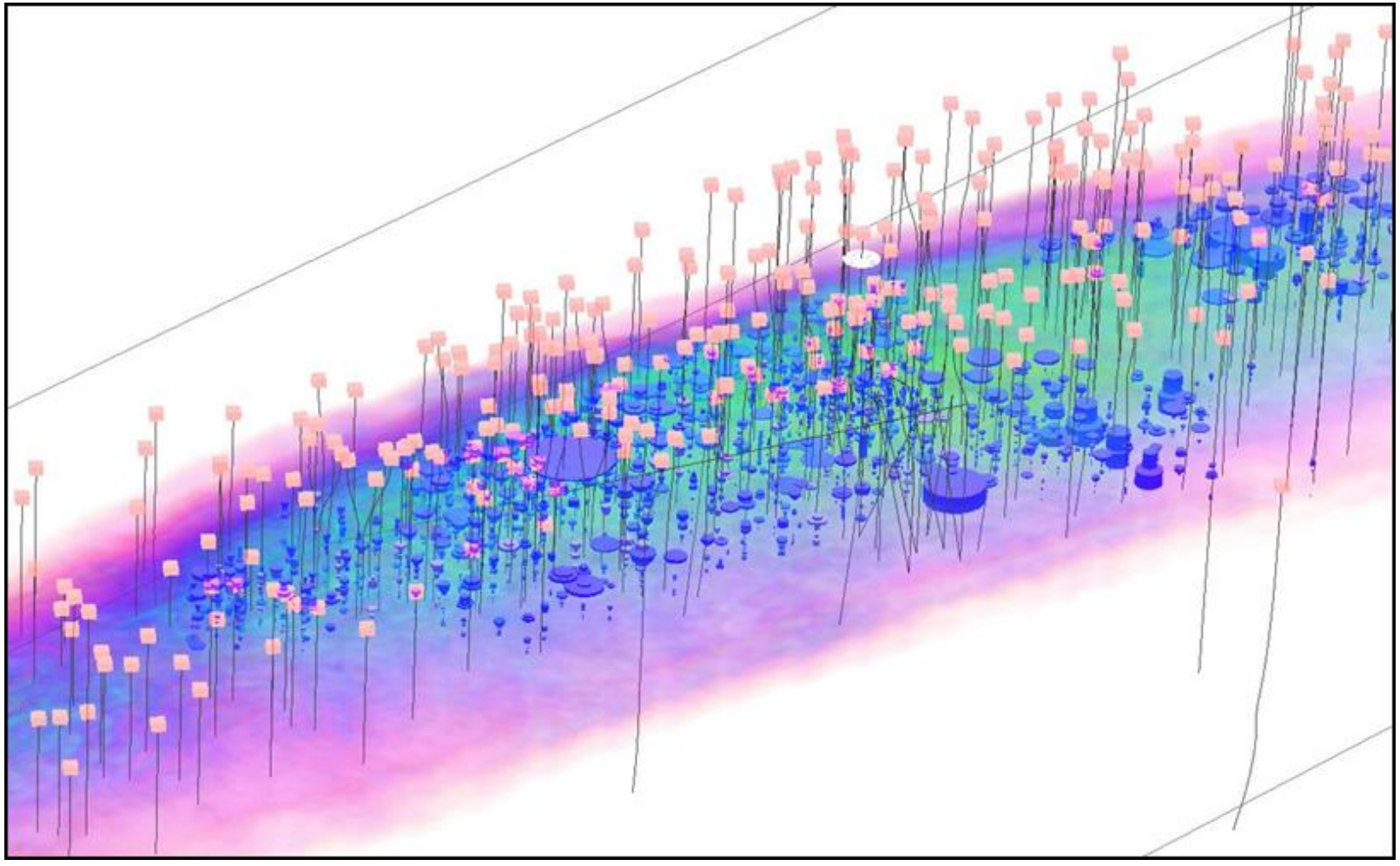
- Decision-Maker (High-Level Manager):

On top of this, I want to see the aggregated **water injection rate** for each injection location as a cylinder whose volume proportional to its rate.

Example



Example



Example

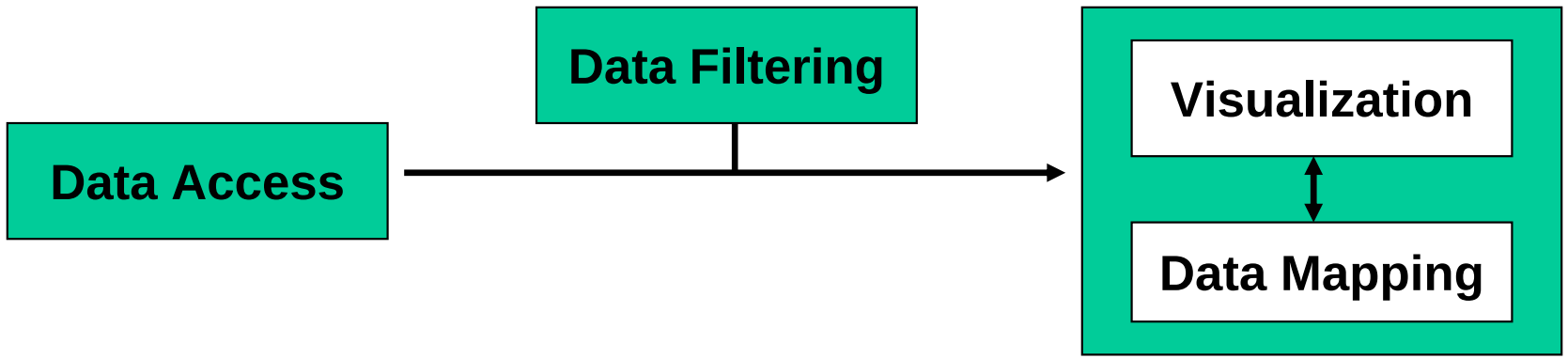
Show Visualization {

For Reservoir_LH with Geometry,
show 3D Volume of Oil Saturation.
Show Cube of Well.
Show Line of Well Pipe.
Show Cylinder of Water Injection Rate.

}

Objectives

- To provide a consistent and ease-to-use interface for inexperienced or occasional users.
- To deal with 3D volume and temporal data sets.
- To provide an Interactive and intuitive manipulation for 3D volume data access and visualization.
  (Selection/Narrow-down/Clipping/Aggregation/Classification)



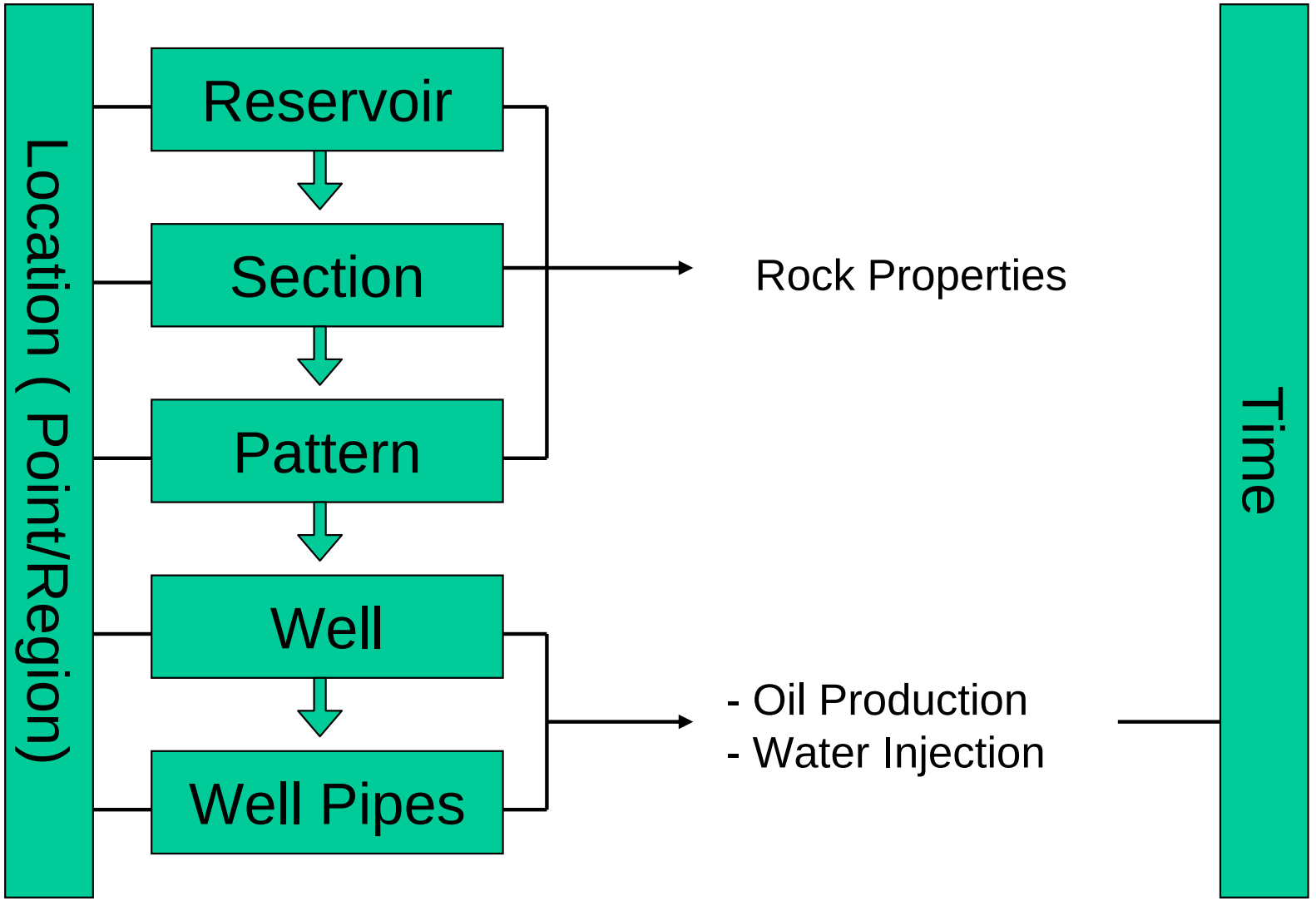
Related Works

- **Previous Work: Grammar & User Interaction**
  - Introduced the Phrase-Driven Grammar System for Data Access.
- **Data Model: Map + Multidimensional Database**
  - Modeling Multidimensional Databases [Rakesh A. et al, 1997]
  - Algebraic Formalism over Maps [Joao P. C. et al, 2000]
- **Formalism: Geo-Algebra + Data Presentation Algebra**
  - Map Dynamics [Masanao T., 1997]
  - Formal Specification of Graphics Data Type [William R. M., 1982]
  - Grammars of Graphics [Leland W., 2005]
- **3D Graphics: Scene Graph + Procedural Modeling**
  - Procedural Modeling of Building [Pascal M., 2006]

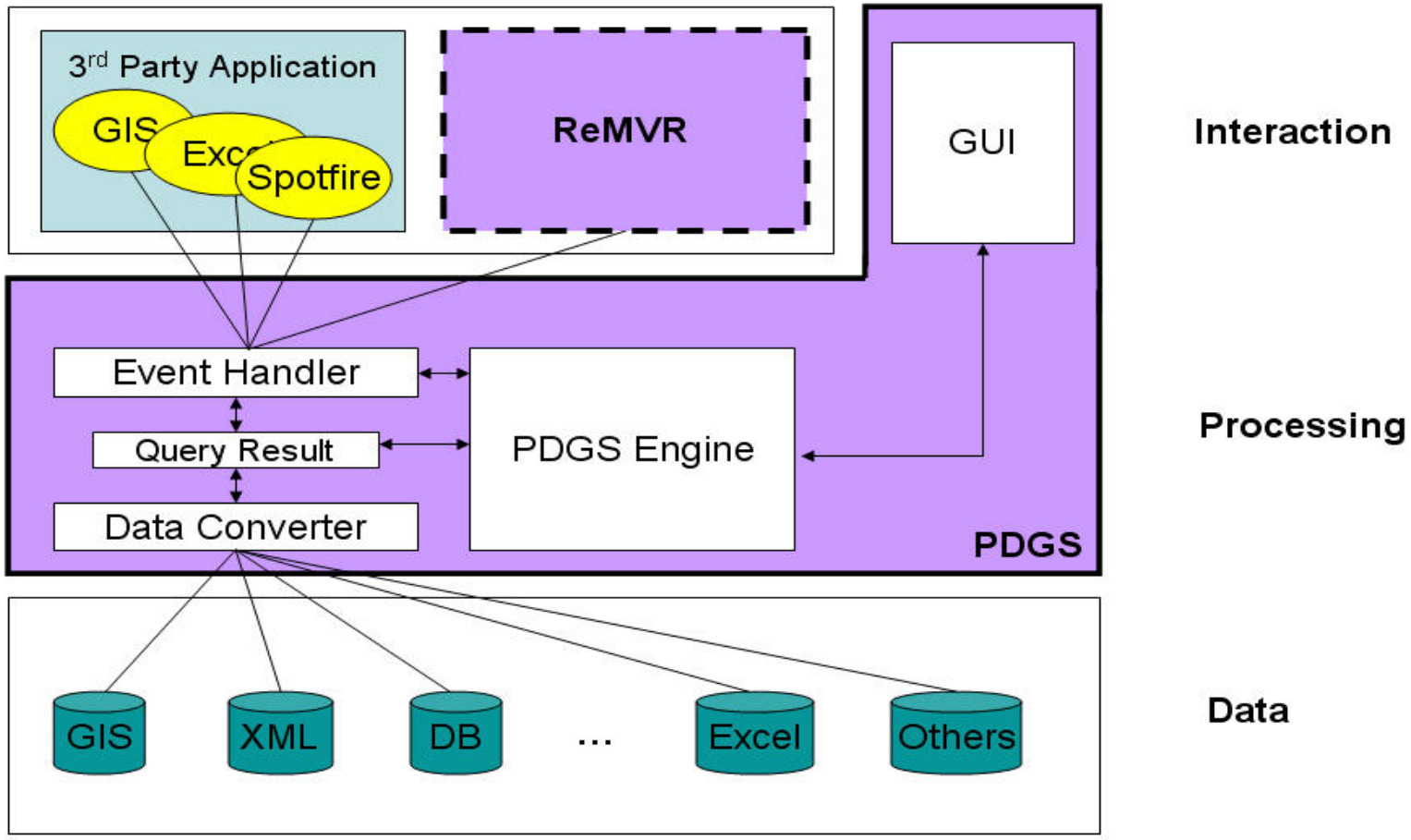
Phrase-Driven Grammar System

- A GUI, which facilitates data visualization while working as a middleware between data sources and visualization applications.
- English-Like Sentence using PDG
- Active Menu GUI from NLMenu [H.R. Tennant et al, 1983]
- Procedurality from TABLET [D. W. Stemple, 1978]
- User Interaction: Drag & Drop with Visual Guidance
  GUI: Active Menu, Grammar Editor, and Quick Info.

Data Model

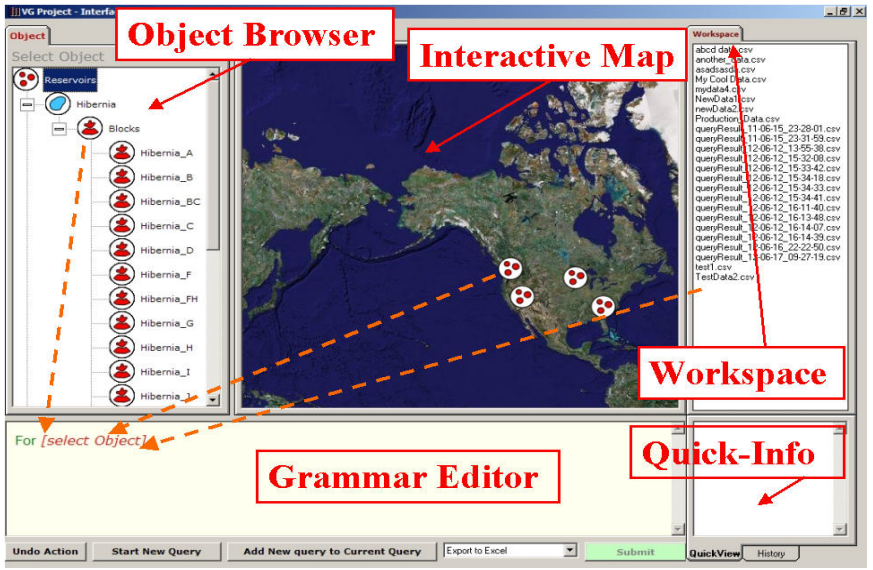

Location (Point/Region)
Reservoir
Section
Pattern
Well
Well Pipes
Rock Properties
- Oil Production
- Water Injection
Time

Architecture



Graphical User Interface

- **Object Browser : major stages (with order)**
  - Object
  - Command
  - Operation
  - Operation Parameters
  - Simplified Modifier
  - Source

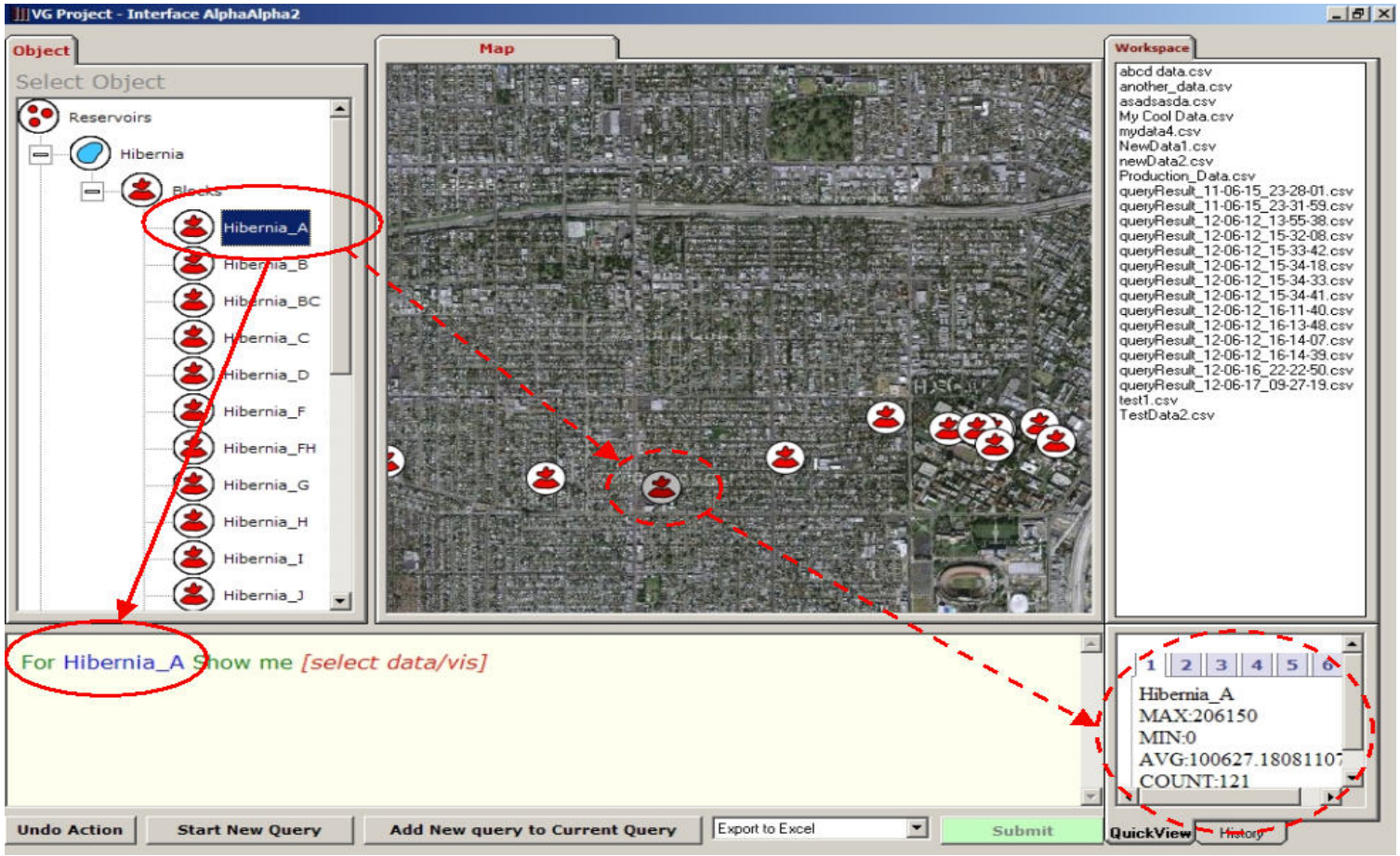


- **Sub-stages (without order)**
  - Modifier
  - Aggregator
  - Etc

- **Eight menu items represent one unique stage.**

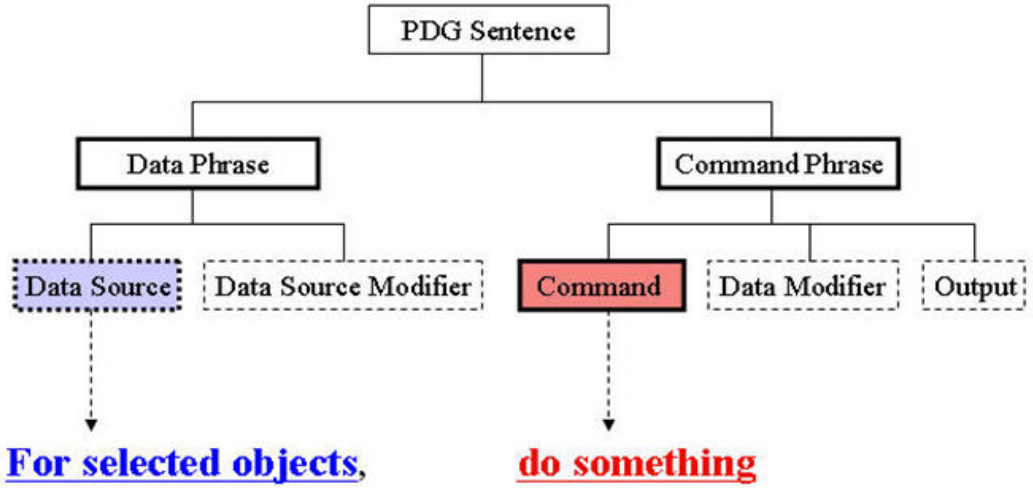
- **Guide to its next stage**
  (Highlighting + Automatic Proceeding to the next stage)

Visual Guidance



Phrase-Driven Grammar (PDG)

- For selected data objects, show their data
- Data Phrase & Command Phrase
- Data Phrase: For selected objects
- Command Phrase: show their data



"For a selected data set, show 2D plot of time vs. price onto MS-Excel"

User Interaction

- **3D Volume Visualization**

#1
For Lost Hills, show me 3D Volume of Clay

#2
Show Visualization
{
For Lost Hills, show me Cube of Well ID.
For Lost Hills, show me Line of Well Pipes.
}

User Interaction

- **3D Bubble Map**

#1

For Lost Hills, show me 3D Volume of Clay.
For Previous Result,
show me Bubble Map of Water Injection over 2 years.

#2

For Previous Result,
show me Bubble Map of Oil Production over 2 years.

#3

show Visualization
{
For Lost Hills, show me 3D Volume of Oil Saturation.
For Previous Result, show me Bubble Map of Oil Production.
For Previous Result, show me Cylinder of Water Injection.
}

Conclusion

- Phrase-Driven Grammar (PDG) and GUI form a new graphically guided English-like command system for 3D data visualization.
  - Visually guided, less ambiguous
  - Relatively expressive for complex queries compared to form-based graphical user interface approaches
  - More readable and understandable than formal languages
  - No Specific Training for usage/No Visualization tool training
- Future Works
  - Formalism
  - User Study
  - Extend to 3D volume manipulation & Reasoning

Questions.