



Interactive Visualization of Oil Reservoir Data

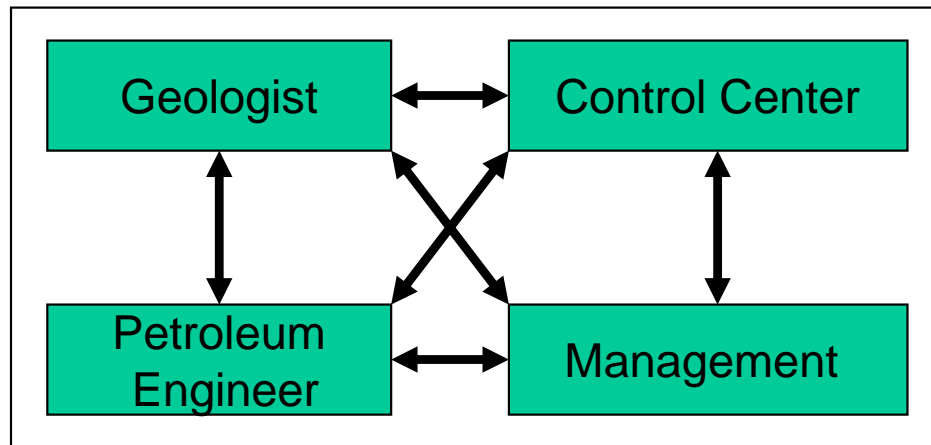
Sep 23rd, 2008

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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:

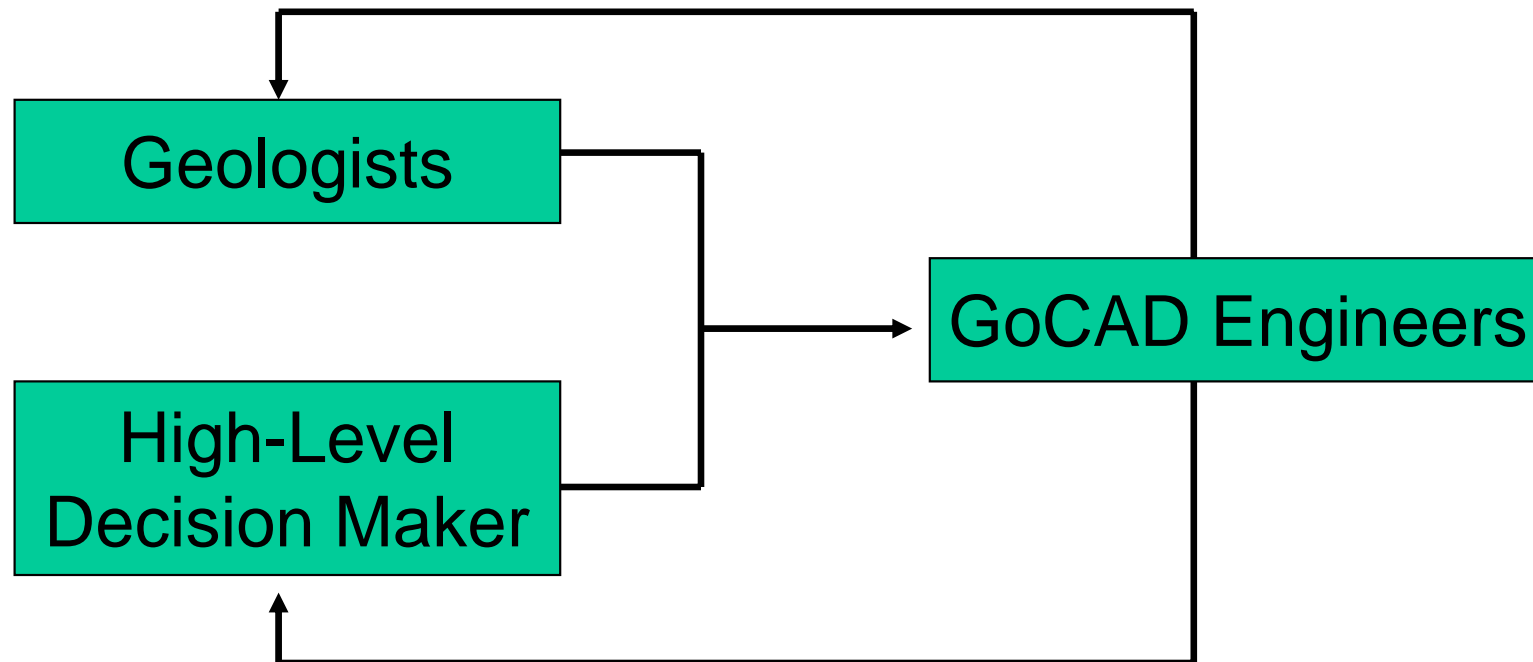
In addition, I want to see the **wells** and their **pipes** in the reservoir.

- Decision-Maker (High-Level Manager):

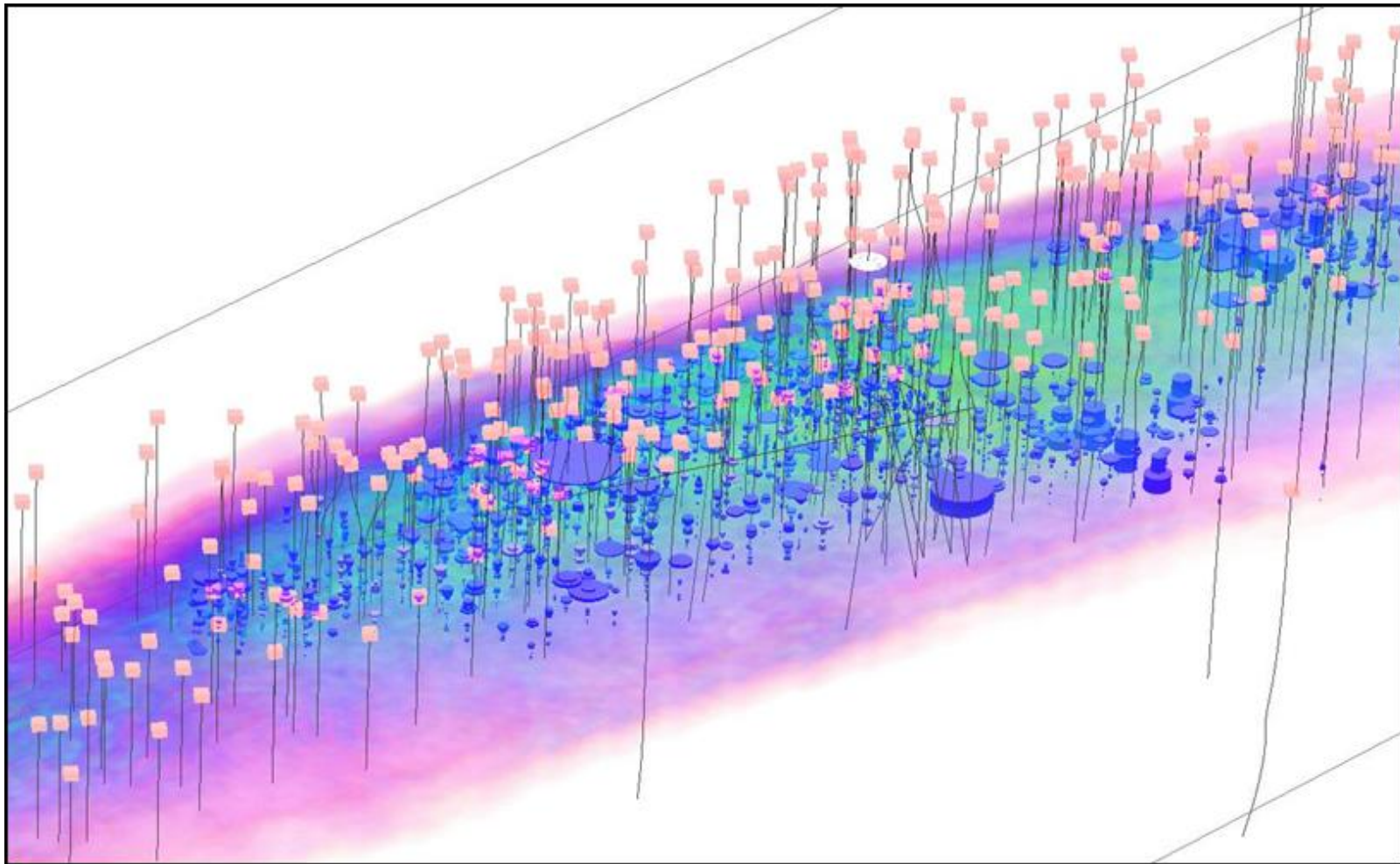
On top of this, I want to see the aggregated **water injection rate** for each injection location as a cylinder whose volume proportional to its rate.



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.

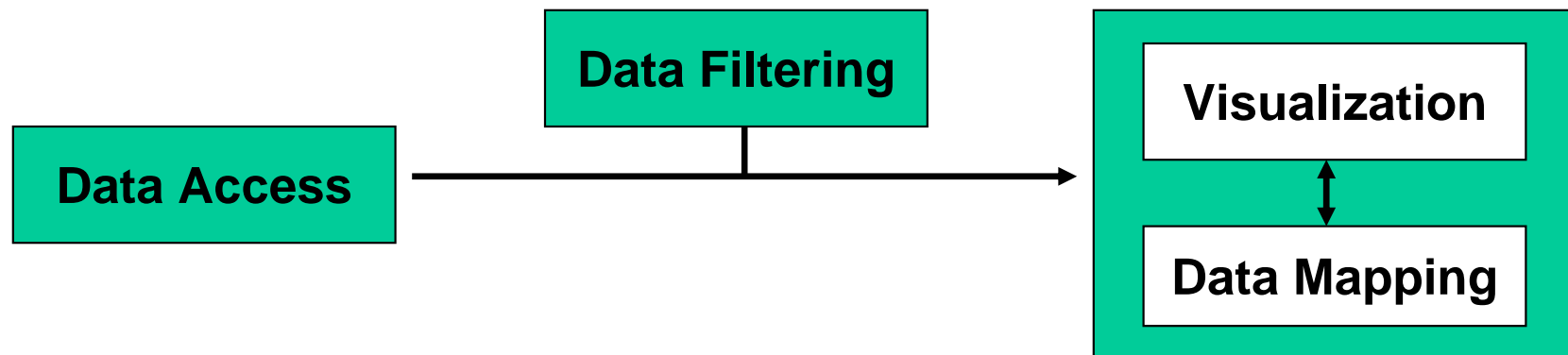
Show Cylinder of Water Injection Rate.

}



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]

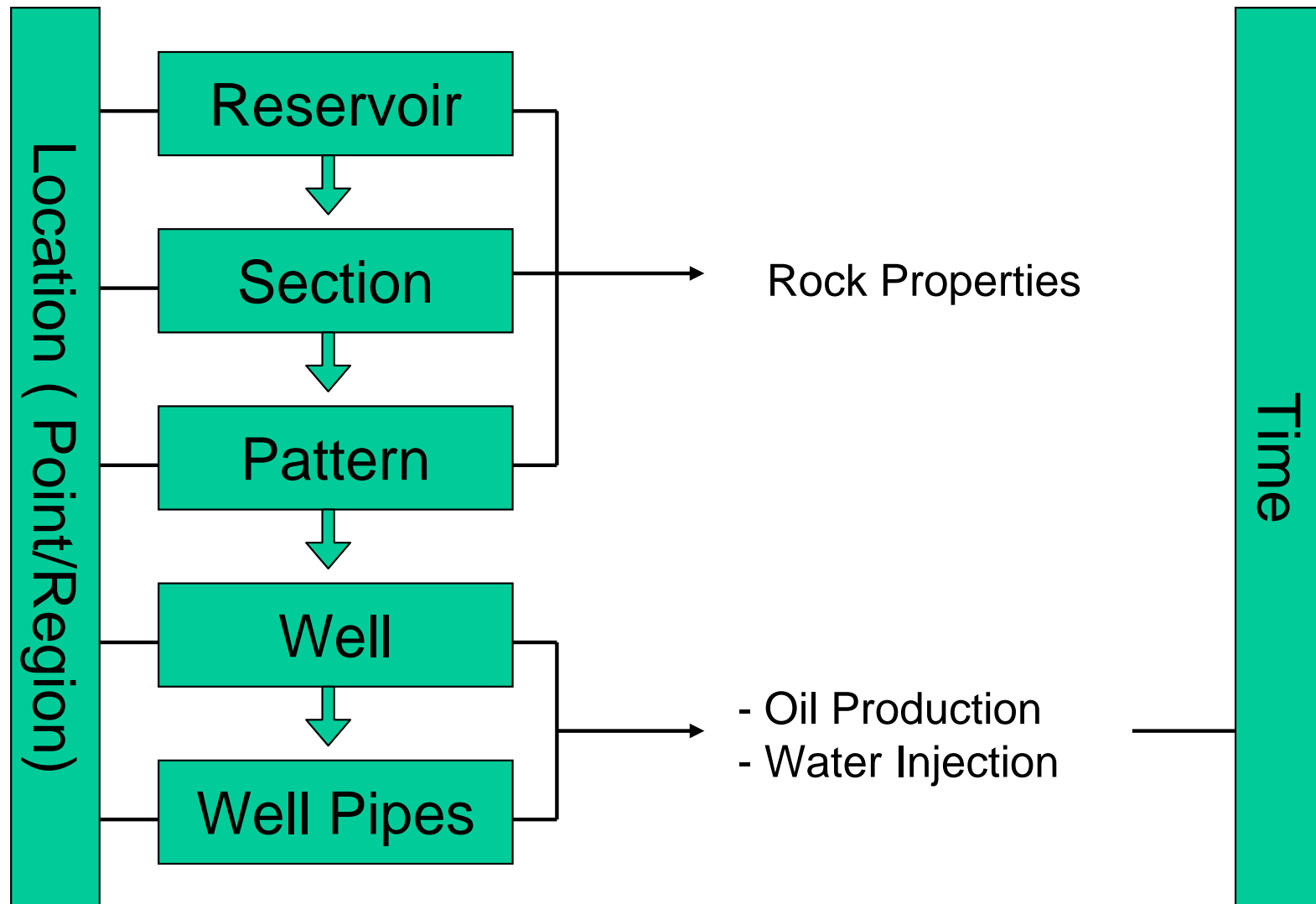


Phrase-Driven Grammar System

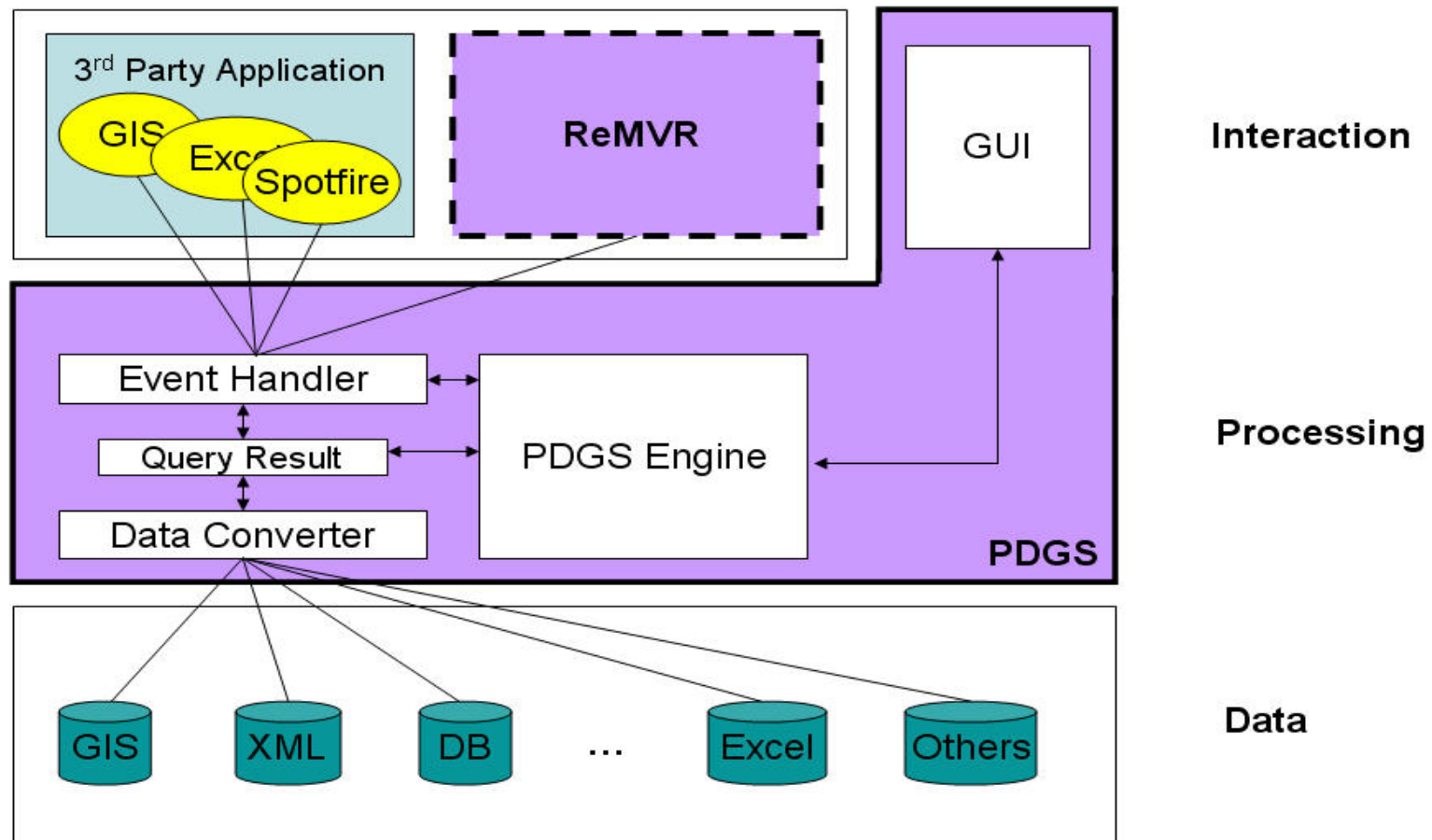
- **A GUI, which facilitates data visualization while working as a middleware between data sources and visualization applications.**
- **English-Like Sentence using PDG**
- **Active Menu GUI from NLMenu [H.R. Tennant et al, 1983]**
- **Procedurality from TABLET [D. W. Stemple, 1978]**
- **User Interaction: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



Data Model



Architecture



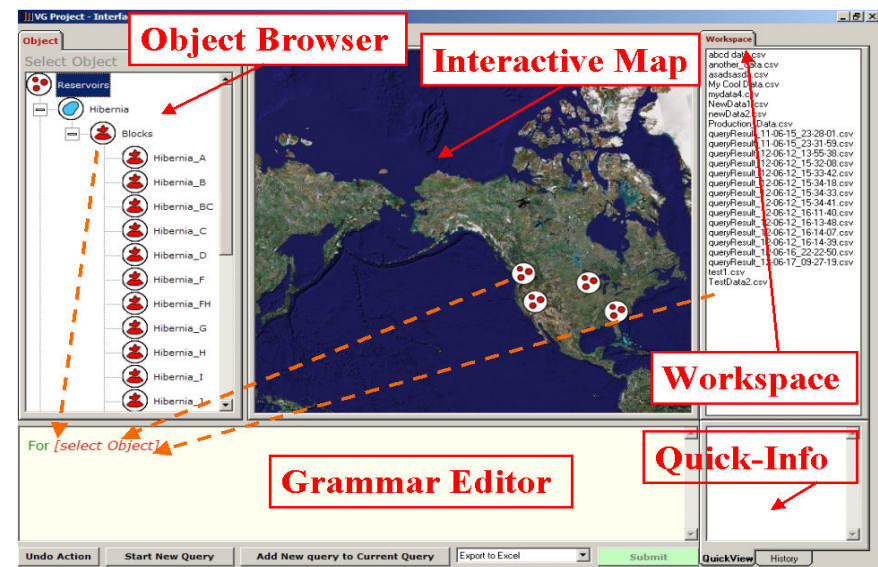
Graphical User Interface

- **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

The screenshot shows the VG Project - Interface AlphaAlpha2. The interface is divided into several panels:

- Object Panel:** A tree view under "Reservoirs" showing a "Blocks" folder with sub-items "Hibernia_A" through "Hibernia_J". "Hibernia_A" is highlighted with a red circle.
- Map Panel:** An aerial map showing a city grid with several red person icons representing data points. A red dashed circle highlights a cluster of these icons.
- Workspace Panel:** A list of data files including "abcd_data.csv", "another_data.csv", "asadasda.csv", "My Cool Data.csv", "mydata4.csv", "NewData1.csv", "newData2.csv", "Production_Data.csv", and several "queryResult_..." files.
- Query Panel:** A text input field containing the query: "For Hibernia_A Show me [select data/vis]". The text is highlighted with a red circle.
- QuickView Panel:** A panel showing the results of the query for "Hibernia_A":

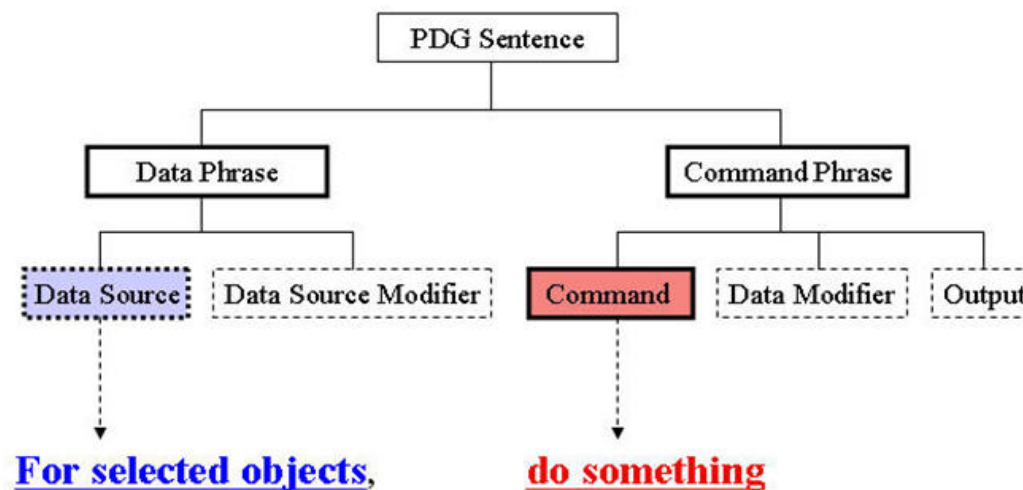
1	2	3	4	5	6
Hibernia_A					
MAX:206150					
MIN:0					
AVG:100627.18081107					
COUNT:121					

Red dashed lines and circles indicate the visual guidance: a line connects the selected "Hibernia_A" object to the query text; another line connects the highlighted "Hibernia_A" object to the cluster of icons on the map; and a third line connects the highlighted cluster of icons to the QuickView results panel.



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.

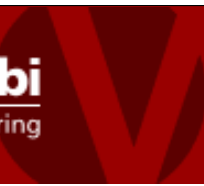
#3

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.