Paper Reviewed (1)

- Chris Stolte, Diane Tang, Pat Hanrahan

  “*Query, Analysis, and Visualization of Hierarchically Structured Data Using Polaris*”

Overview

- Hierarchical Structure of Data
- Relational Databases VS. Data Cubes
- Nest Operand VS. Dot Operand
- New Interface in support of data cube
- Critiques

Hierarchical Structure of Data

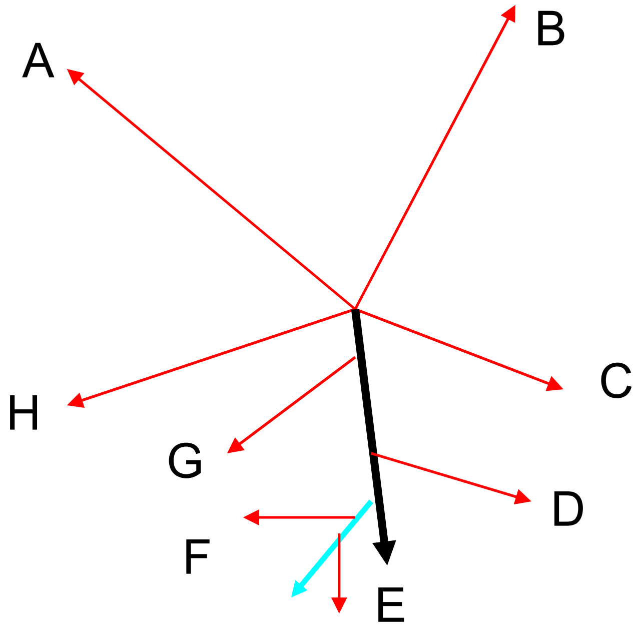
- How to derive the Hierarchical Structure of Data
  - Known hierarchical structure (country, province,city)
  - Using data mining algorithm (decision trees, clustering technique)
- Benefit of hierarchical structure over relational structure
  - Flexible and efficient in obtaining data summaries of different aspects of data during data exploration process.
  - Support “semantic zooming” visualization
- Realization of organizing data into hierarchical structure
  - Concept of Data Cube

Relational Database VS Data Cubes

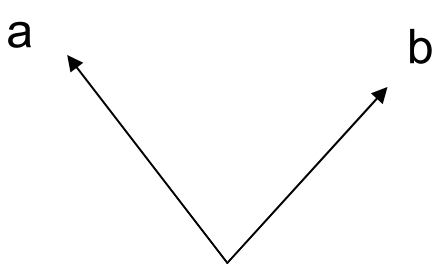
- Aspects of data dimensions
  - **Relational Database**: Dimensions are independent
  - **Data Cube**: Dimensions can be hierarchically dependent

- Aspect of data summary
  - **Relational Database:** Use SQL queries to retrieve
  - **Data Cube:** Aggregated values (summation, average, etc.) are readily stored in the cells of data cube

“Dimension” type dimensions



“Measure” type dimensions



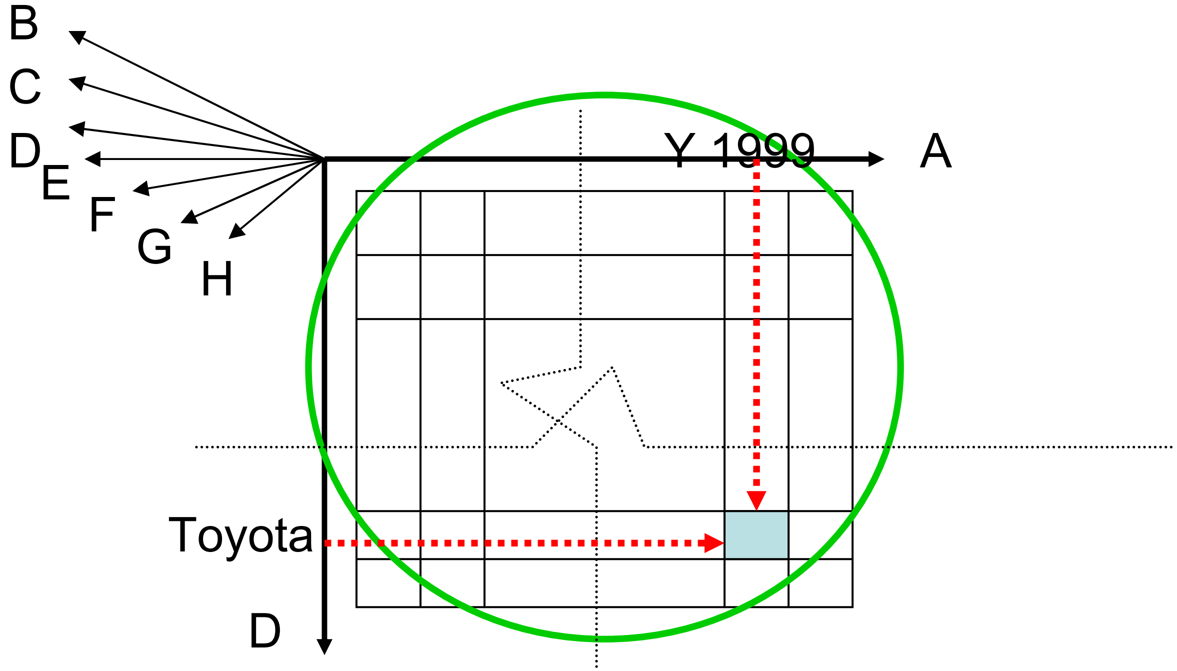
				Aggregation of {D,Agg.{E,F},G}						
					Aggrgation of {E,F}					
	A	B	C	D	E	F	G	H	a	b
tuple1										
tuple2	Toyota	Red	Y 1999	Corolla		Auto Mall				35
tuple3										
tuple4										
tuple5										
.										
.										

We might want to know the summation of values of dimension b where values corresponds to only dimension A and dimension D (*Ex: # of sales of used cars of different years + model*):

- Relational databases:

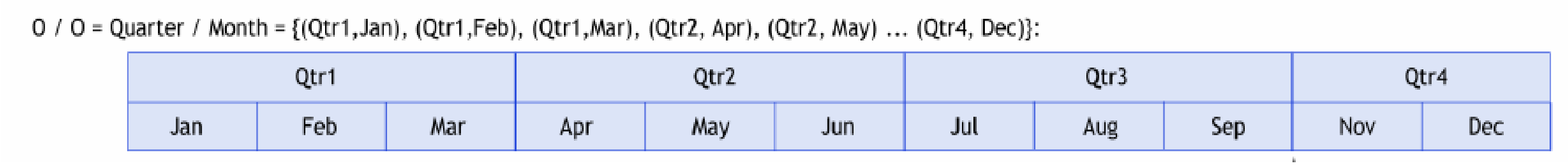
```
SELECT A, D, sum (b)

FROM table

GROUP BY A,D
```

- Data Cubes:



Nest Operand VS. Dot Operand

- Nest operand (no hierarchy implication)

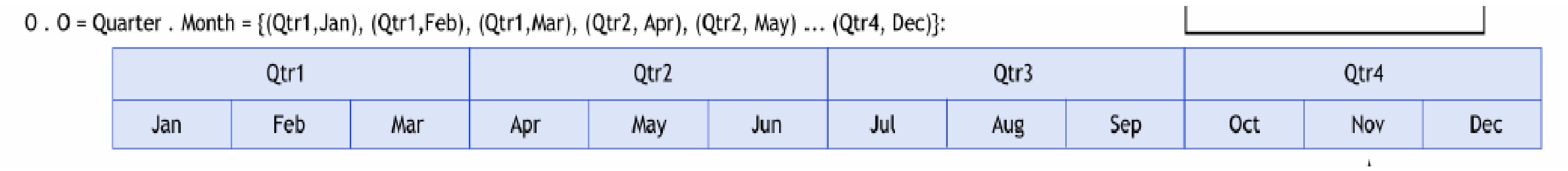


O / O = Quarter / Month = {(Qtr1,Jan), (Qtr1,Feb), (Qtr1,Mar), (Qtr2, Apr), (Qtr2, May) ... (Qtr4, Dec)}:

Qtr1			Qtr2			Qtr3			Qtr4	
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Nov	Dec

The datasets do not have any data of October. So after nesting, we do not see Oct nested under Qtr4

- Dot operand (hierarchy implication)



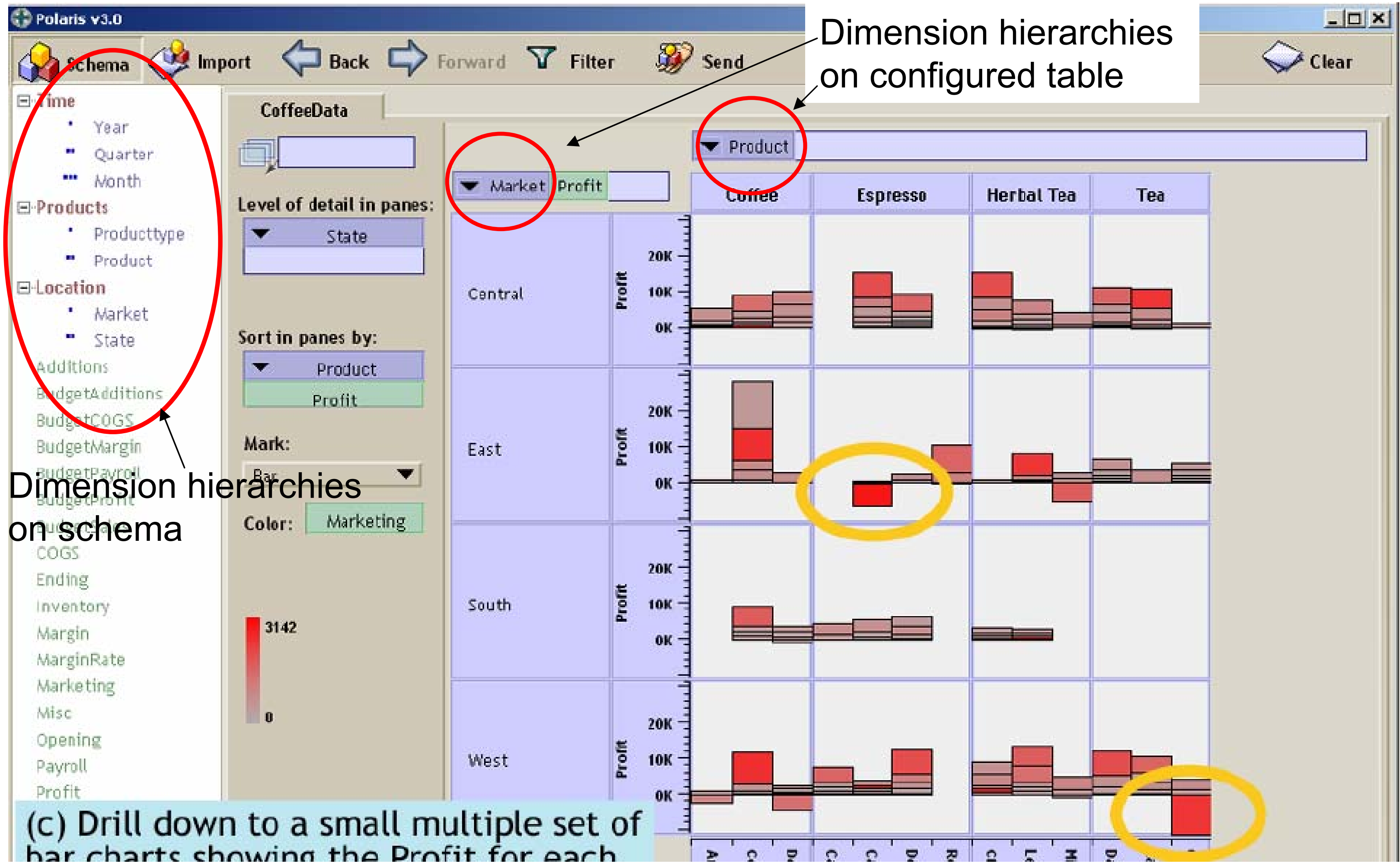
O . O = Quarter . Month = {(Qtr1,Jan), (Qtr1,Feb), (Qtr1,Mar), (Qtr2, Apr), (Qtr2, May) ... (Qtr4, Dec)}:

Qtr1			Qtr2			Qtr3			Qtr4		
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec

Semantically, Quarter and Month have hierarchy implications. So after doting, Oct is still displayed under Qtr4 even that there is no corresponding data

New Interface in support of data cube

- Display dimensions hierarchies for more quickly configuring the table (determine the number of panes
  - On the schema
  - On the “shelves” of table
- Distinguish between “Node” and “Path
  - *Example: When selecting dimension “Month” from schema, Default is Year.Quarter.Month. But can change to “Month” or “Year.Month” or “Quarter.Month*
- Change level of detail within panes to reflect the change of dimension hierarchy (will change number of marks within panes as well)



Level of detail in panes: State

Sort in panes by: Product, Profit

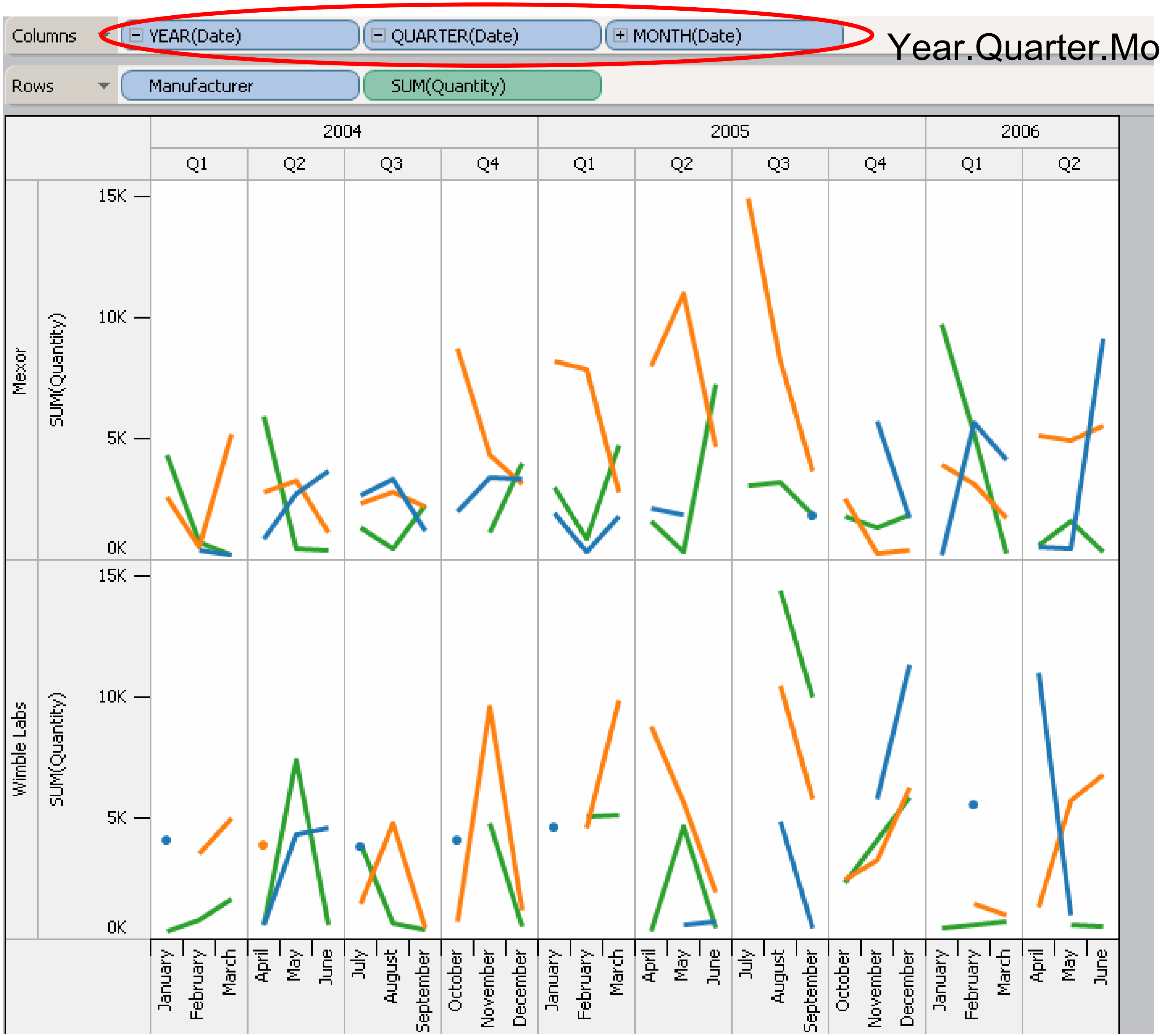
Mark: Bar

Color: Marketing

Dimension hierarchies on configured table

Dimension hierarchies on schema

(c) Drill down to a small multiple set of bar charts showing the Profit for each

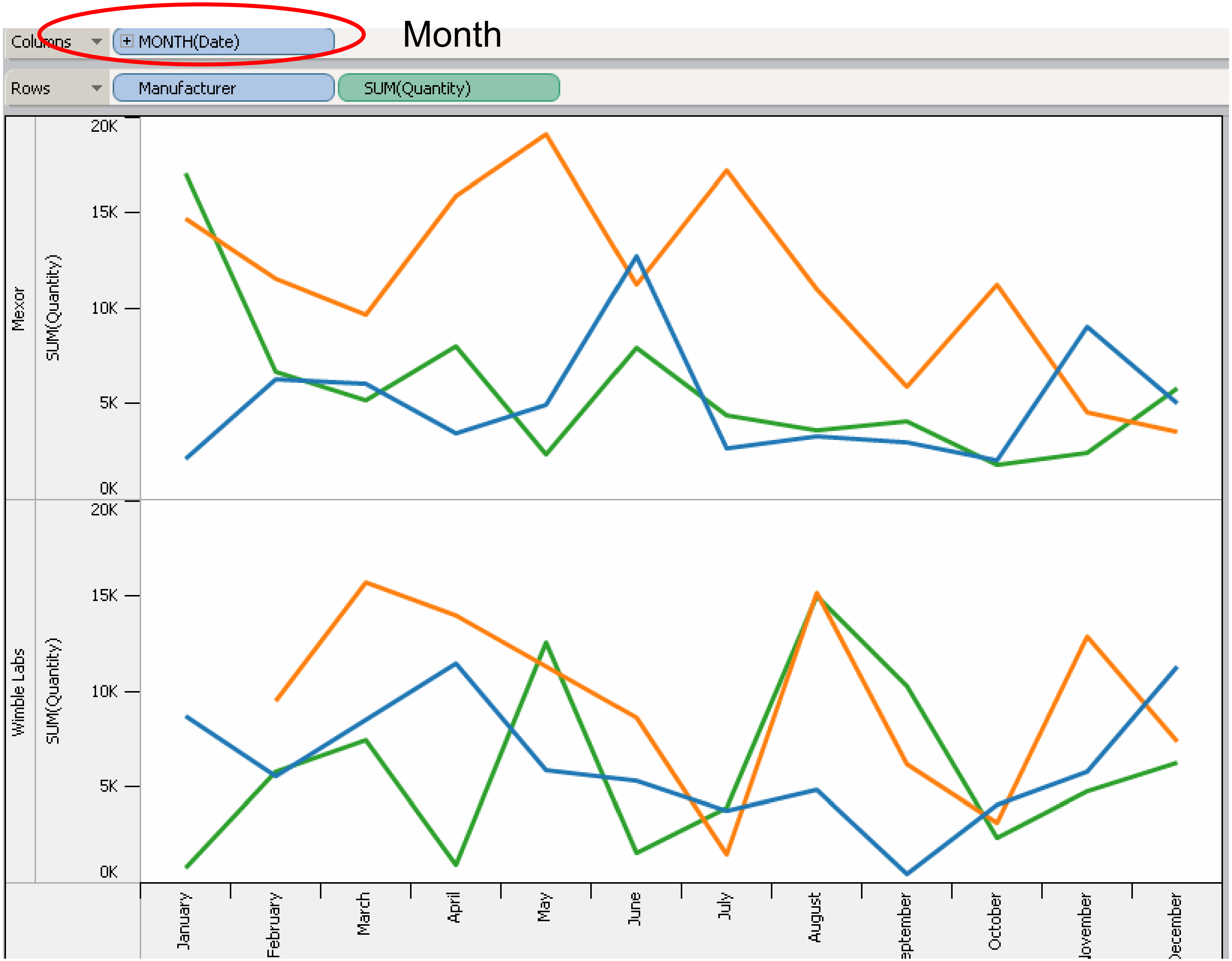


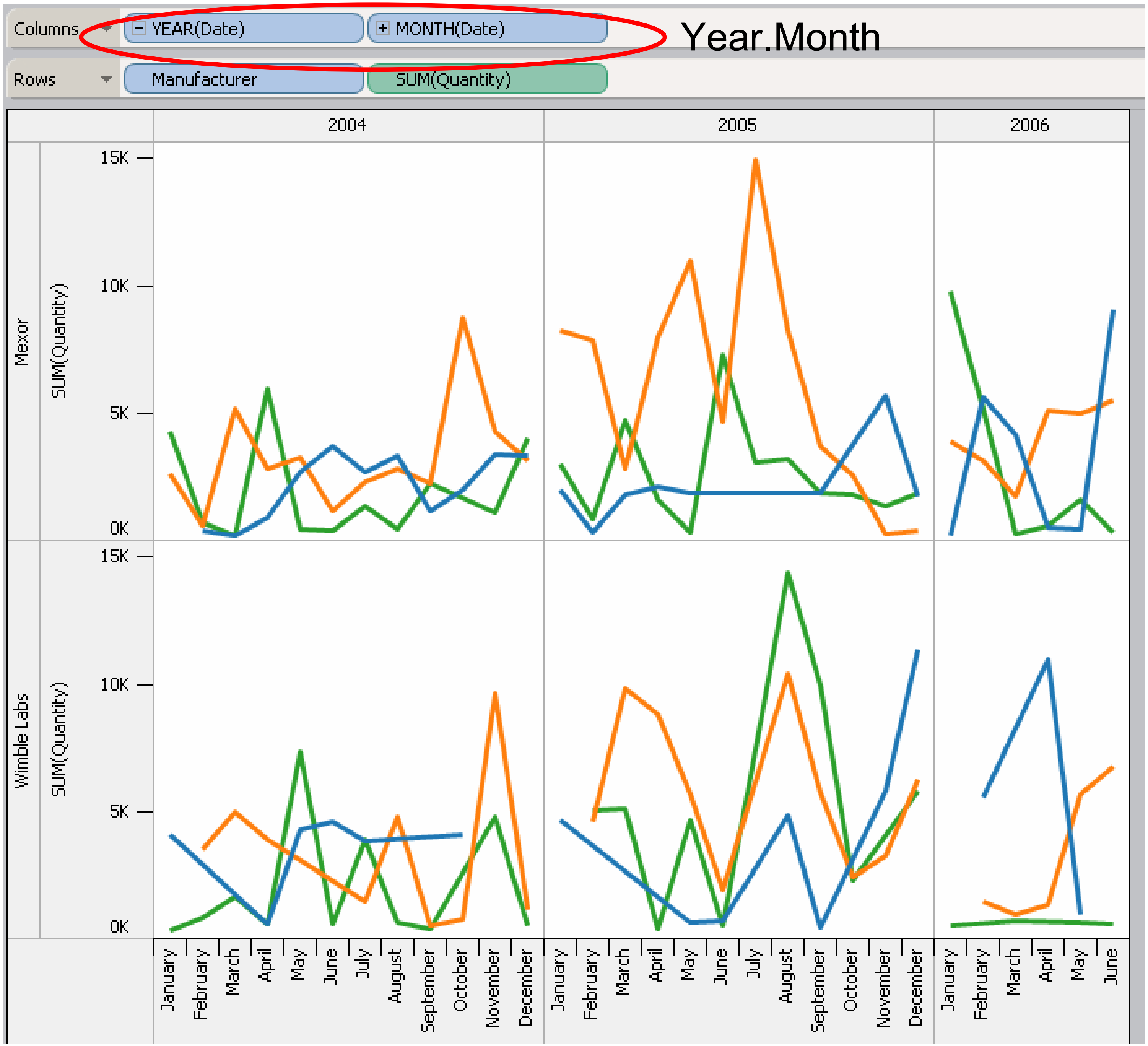
Columns ⊟ YEAR(Date) ⊟ QUARTER(Date) ⊞ MONTH(Date)

Rows Manufacturer SUM(Quantity)

Year.Quarter.Month

Month

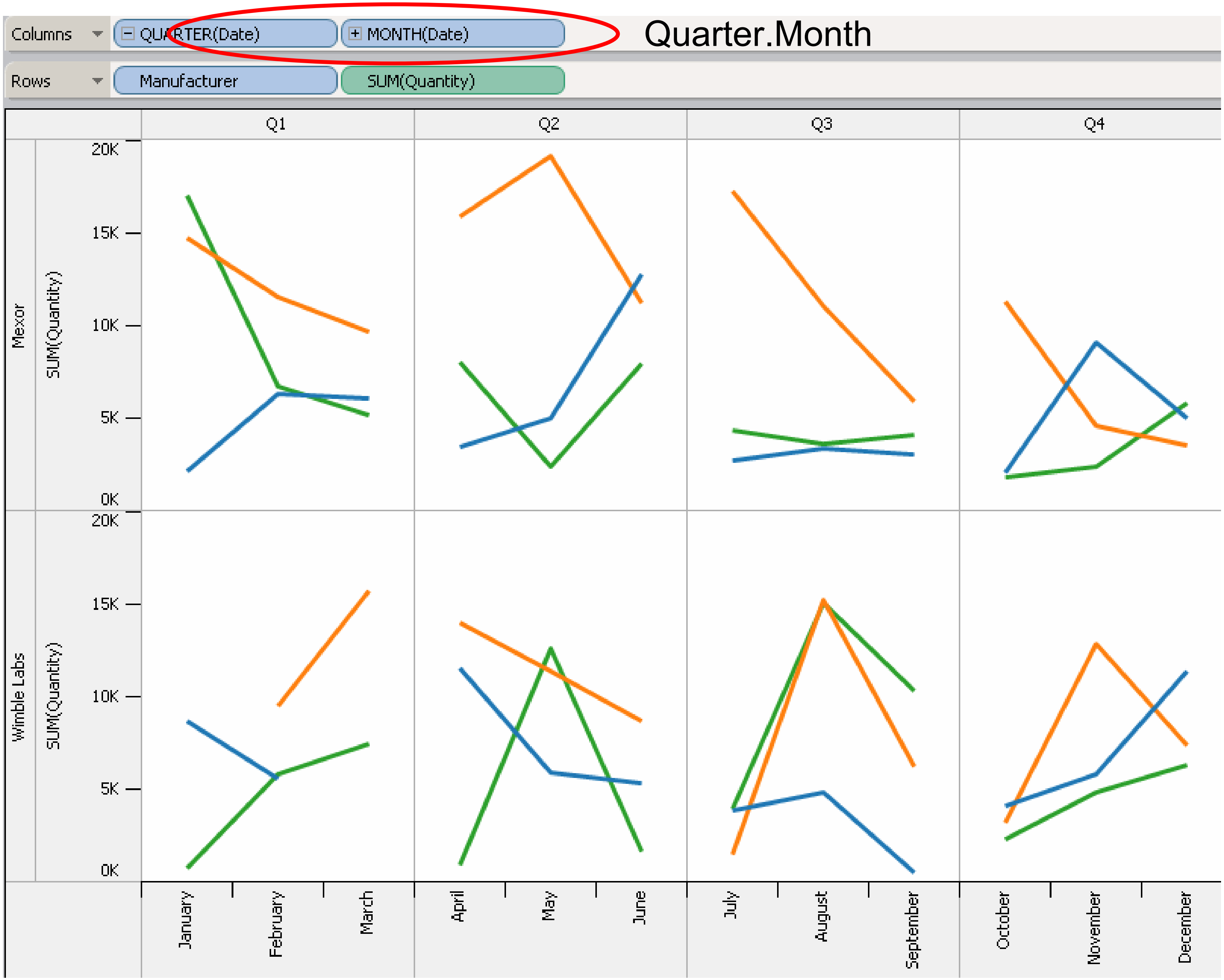

Columns
MONTH(Date)
Rows
Manufacturer
SUM(Quantity)
Mexor
SUM(Quantity)
20K
15K
10K
5K
0K
Wimble Labs
SUM(Quantity)
20K
15K
10K
5K
0K
January
February
March
April
May
June
July
August
eptember
October
Jovember
Jecember



Columns: ⊟ YEAR(Date) ⊞ MONTH(Date)

Rows: Manufacturer SUM(Quantity)

Year.Month

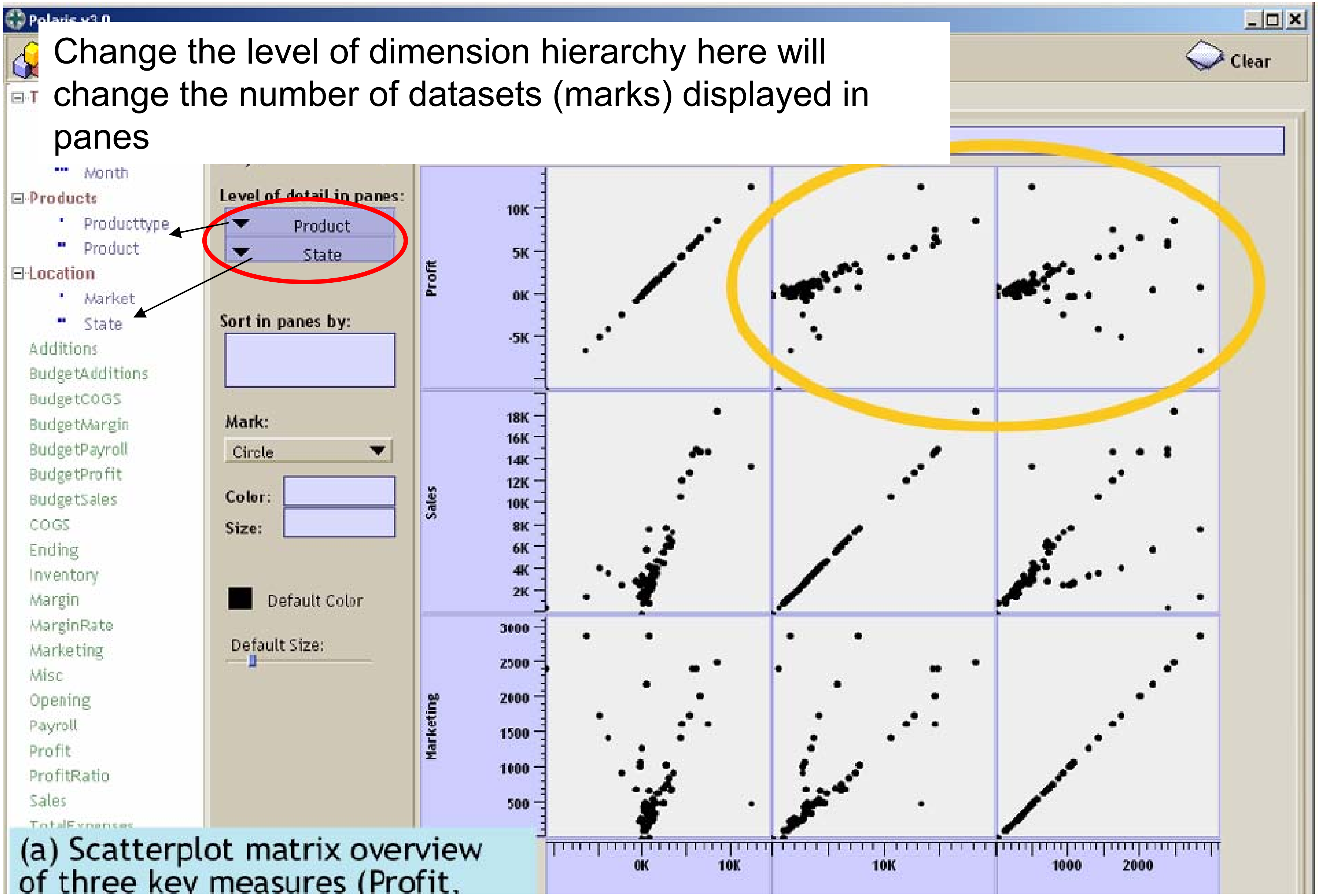


Quarter.Month

Columns: QUARTER(Date) | MONTH(Date)

Rows: Manufacturer | SUM(Quantity)

Change the level of dimension hierarchy here will change the number of datasets (marks) displayed in panes



Level of detail in panes: Product, State

Sort in panes by:

Mark: Circle

Color:

Size:

Default Color

Default Size:

(a) Scatterplot matrix overview of three key measures (Profit,

Critiques

- Pros
  - Provides interfaces for non-expert to retrieve data that involve complex data query algebra
  - Construct a robust formalism for presenting data cubes, which help reveal many aspects of data summary (different abstraction level of data and different detailed level of data)
  - Can also be an visualization tool for understanding the data mining model, which configure the hierarchical data structure.
- Cons
  - Did not use intuitive navigation techniques to facilitate changing views of data
  - Systems designed heavily focus on presenting summary of data. Could lead users only concentrate on this part of data analysis

Paper Reviewed (2)

- Chris Stolte, Diane Tang, Pat Hanrahan
  “Multi-scale visualization using data cubes”

Overviews

- Features Supported
  - Data abstraction and visual abstraction
  - Allow independently zooming along one or more dimensions
- Formalism guiding the Multi-scale visualization
  - Zoom graph
  - Polaris specification
- Proved effective design pattern
- Critique

Data Abstraction

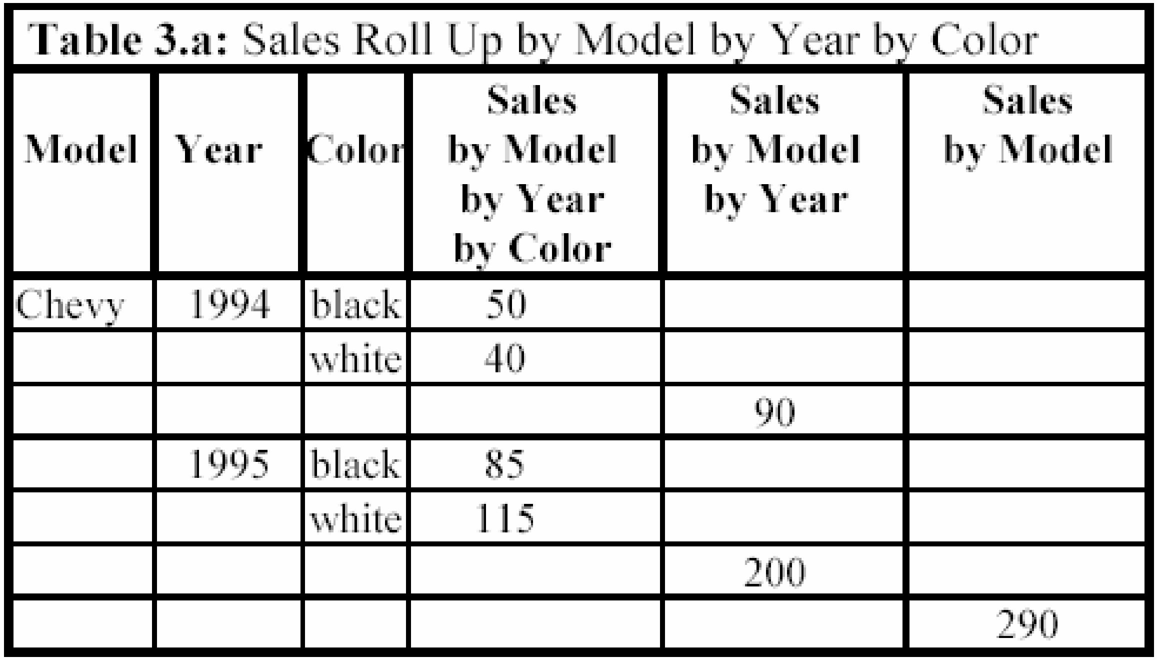
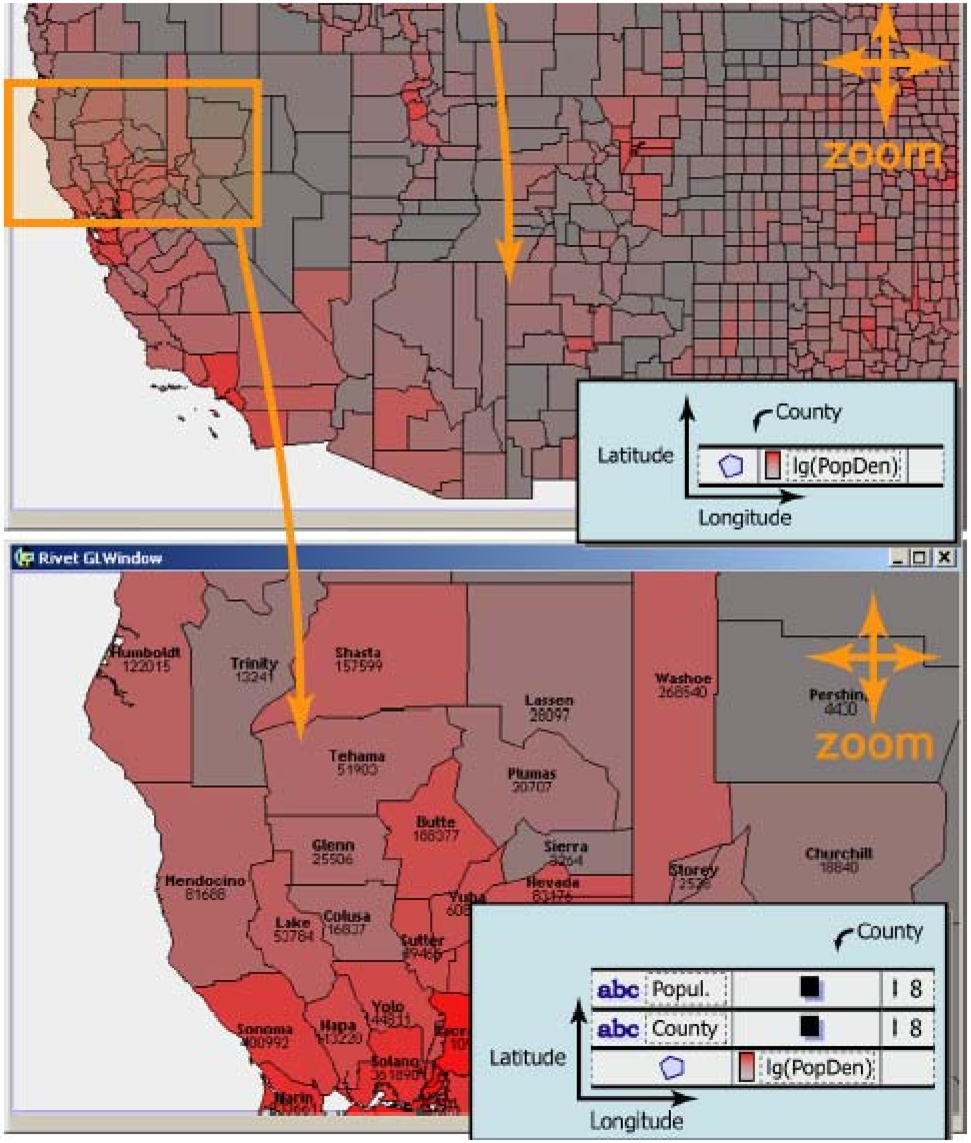


Table 3.a: Sales Roll Up by Model by Year by Color

Model	Year	Color	Sales by Model by Year by Color	Sales by Model by Year	Sales by Model
Chevy	1994	black	50		
		white	40		
				90	
	1995	black	85		
		white	115		
				200	
					290

Most detailed data: Sales by Model (M) and by Year (Y) and by Color (C)
Intermediate detailed data: Sales by M and Y or by C and Y or by M and C
Most abstract data: Sales by M or sales by Y or Sales by C

Visual Abstraction



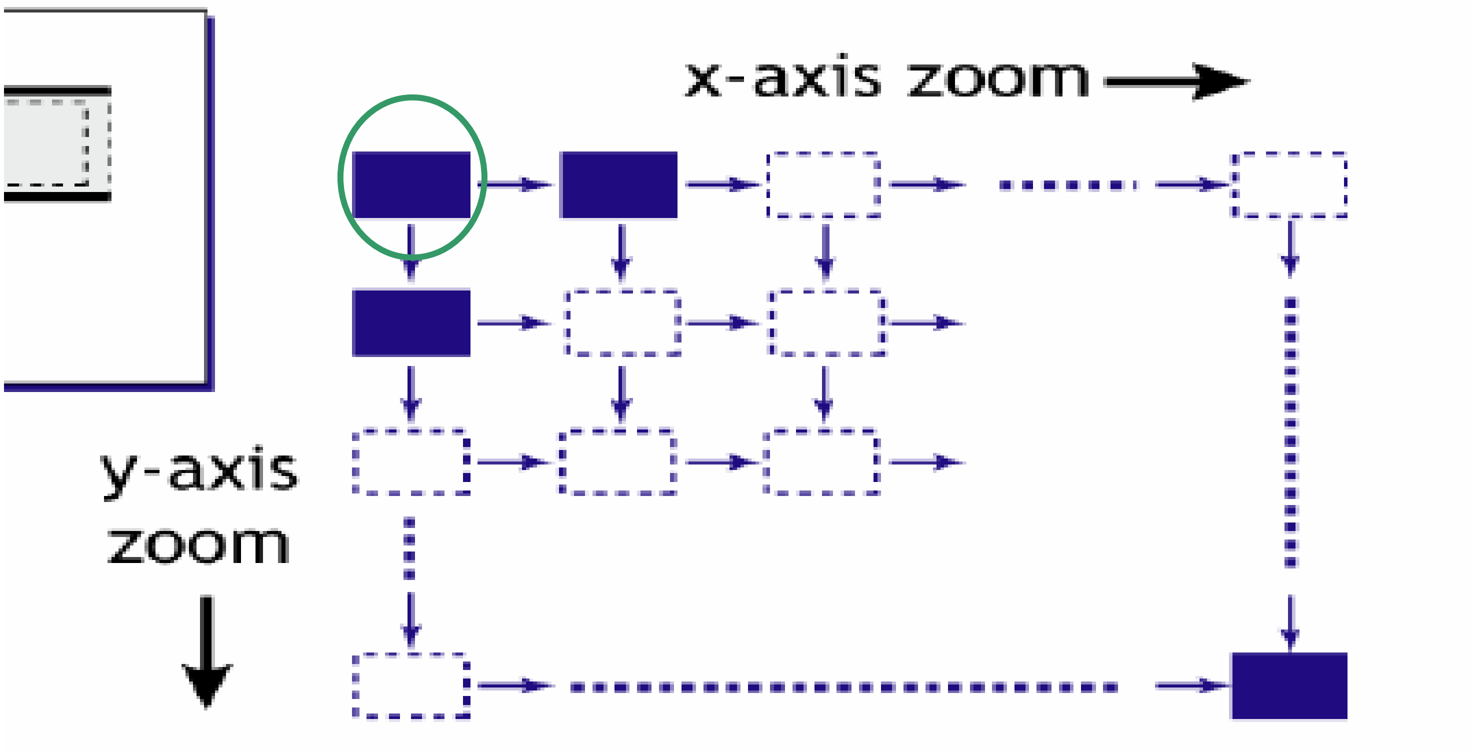
Abstract visual representation:
Smaller area without texts to denote the County

Detailed visual representation:
Lager area and texts to denote the County

Multiple Zoom Path

- Data sets are organized using multiple hierarchies (e.g.: some dimensions of data sets can be aggregated into different meaningful hierarchical level).
- So it is an advantage to be able to zoom in/out along those dimensions or combination of those dimensions.
- See later Example that zoom in X dimension and Y dimension independently.

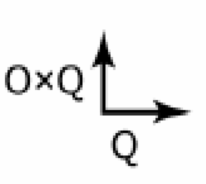
Zoom Graph



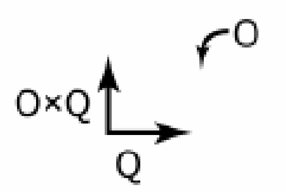
Nodes in the graph are the zoomed visualization, which can be described by Polaris specification.

Polaris Specification and its conventions

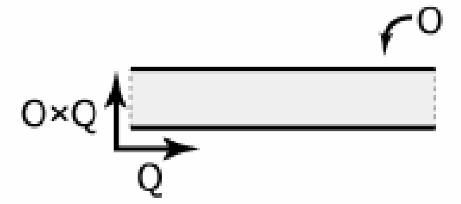
Table algebra :dot (.), cross (x), nest (/), and concatenate (+)



:Used to describe the table structure



:Used to describe any dimensions needed but not already encoded in the table structure

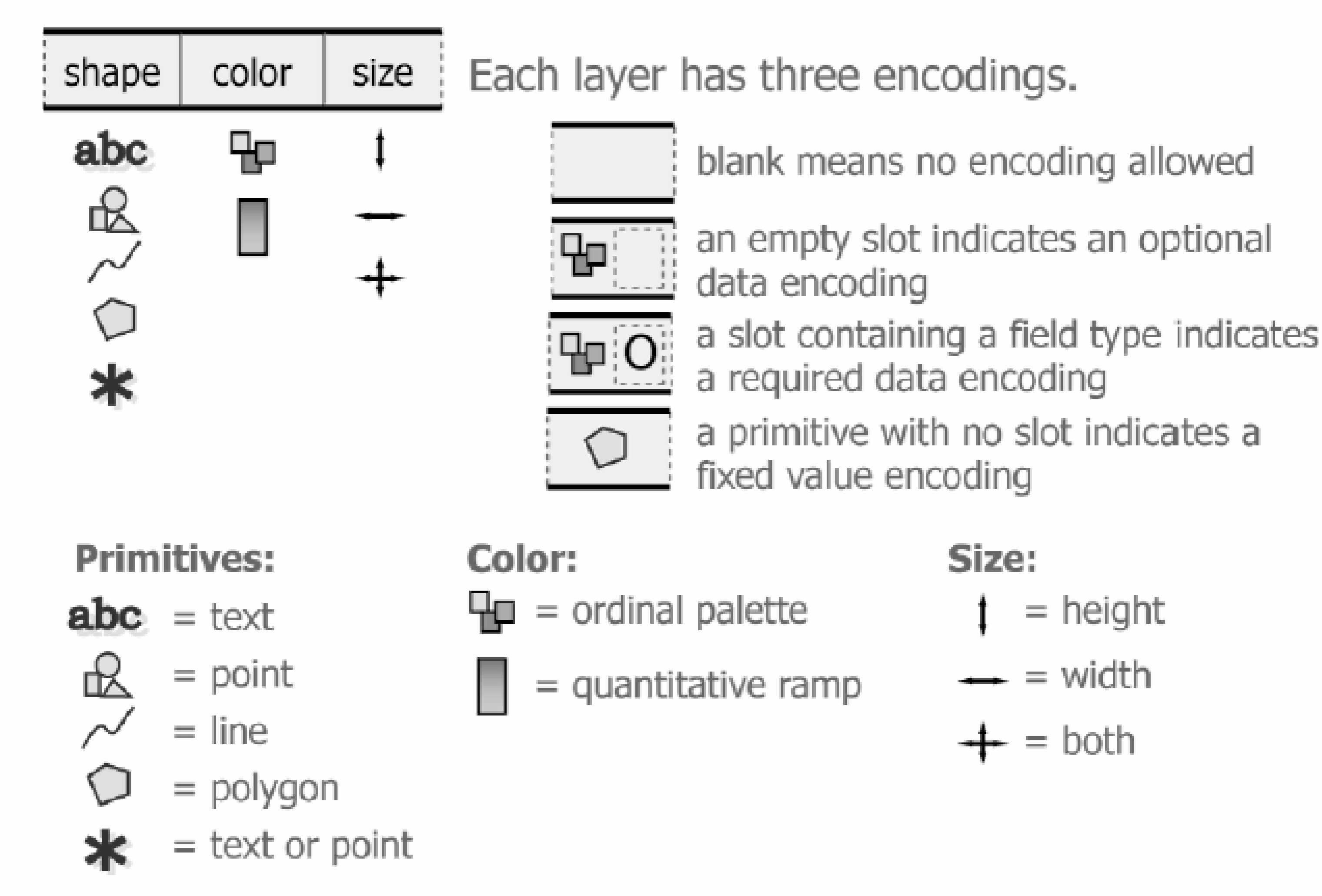


:Used to describe a layer in the visualization

shape
color
size

:Each layer can have three types of visual encodings

More on Polaris Encoding



shape	color	size
abc	▣	↕
△	▮	↔
∿		✛
⬠		
✱		

Each layer has three encodings.

blank means no encoding allowed

an empty slot indicates an optional data encoding

O a slot containing a field type indicates a required data encoding

a primitive with no slot indicates a fixed value encoding

Primitives:

abc = text

△ = point

∿ = line

⬠ = polygon

✱ = text or point

Color:

▣ = ordinal palette

▮ = quantitative ramp

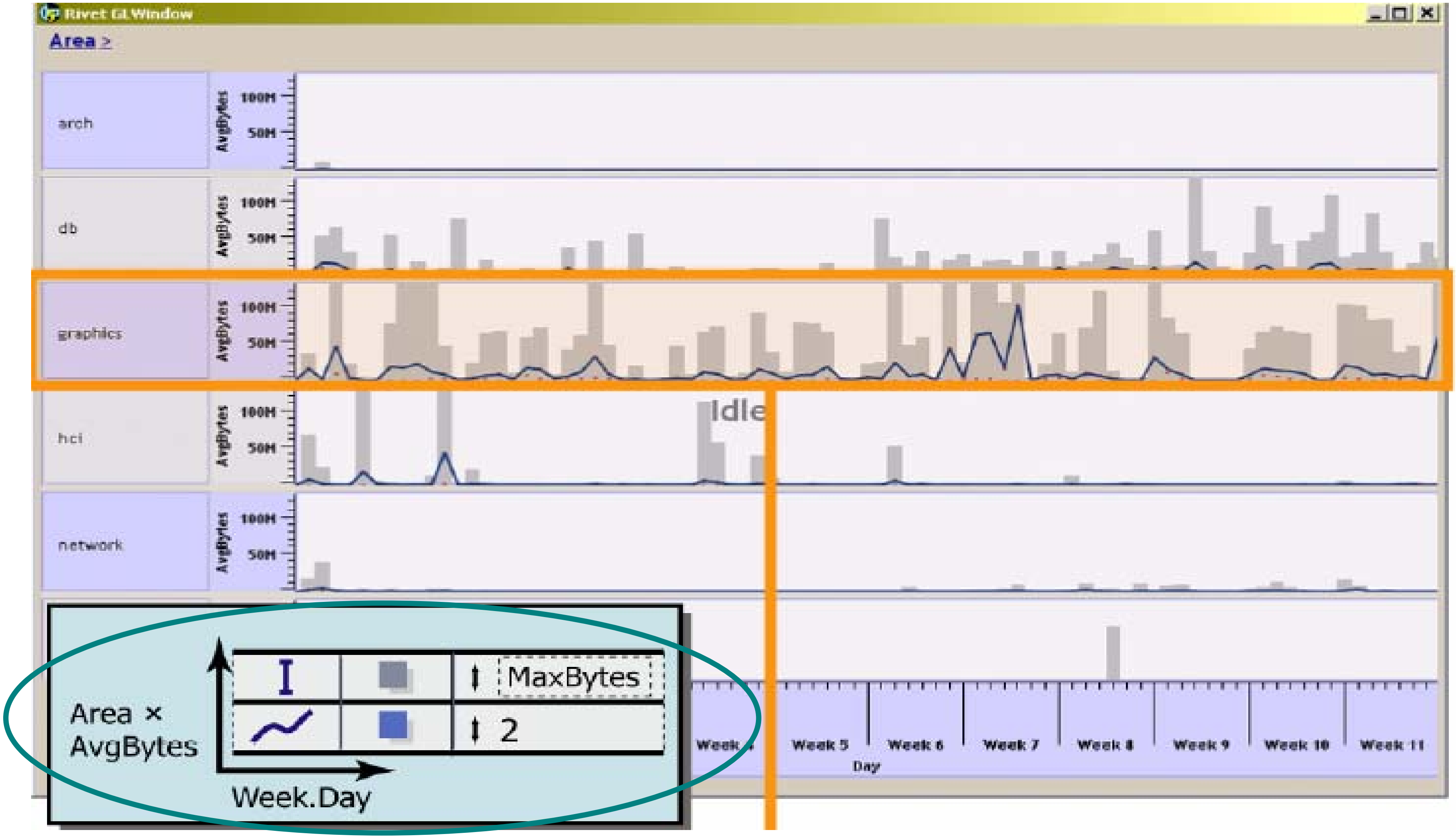
Size:

↕ = height

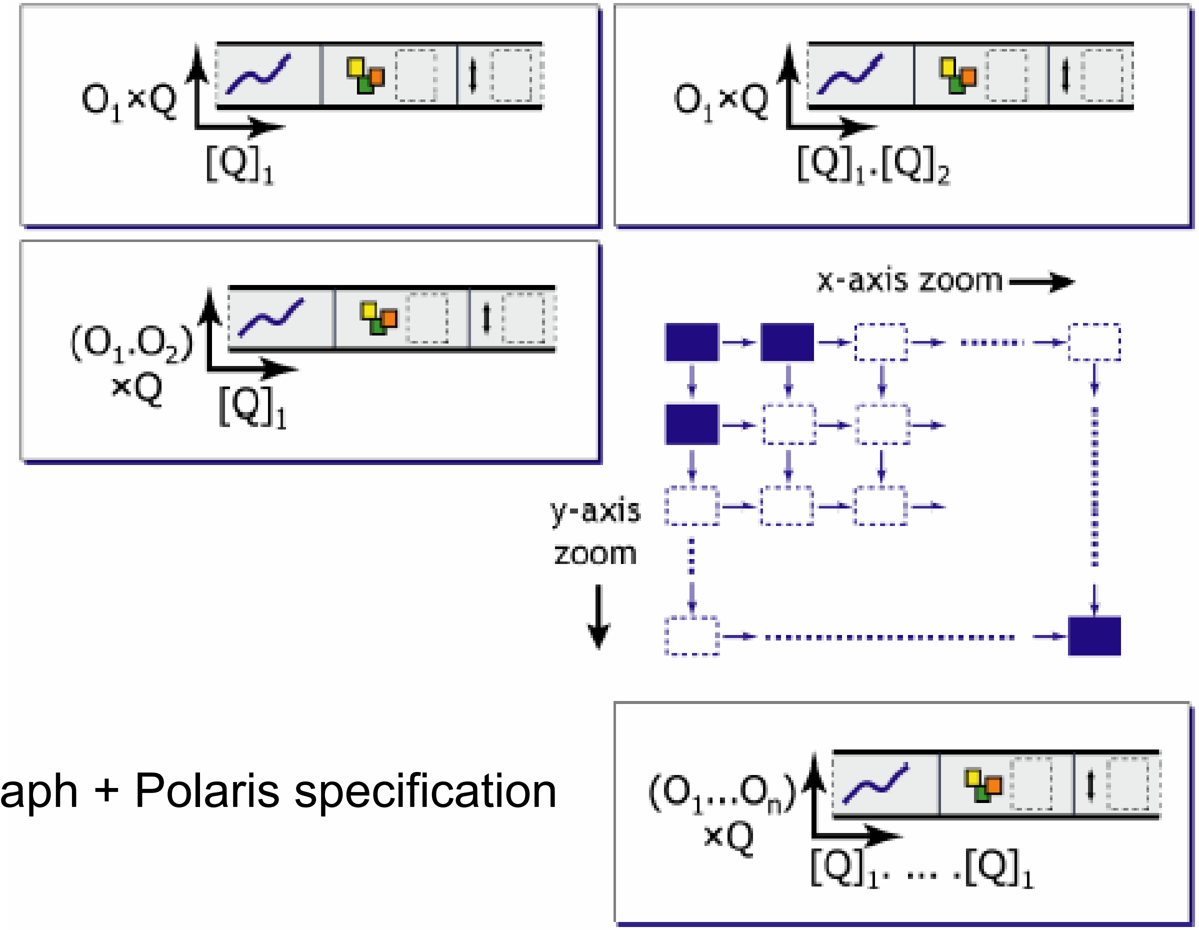
↔ = width

✛ = both

Example: conventions of Polaris specification VS. visualization

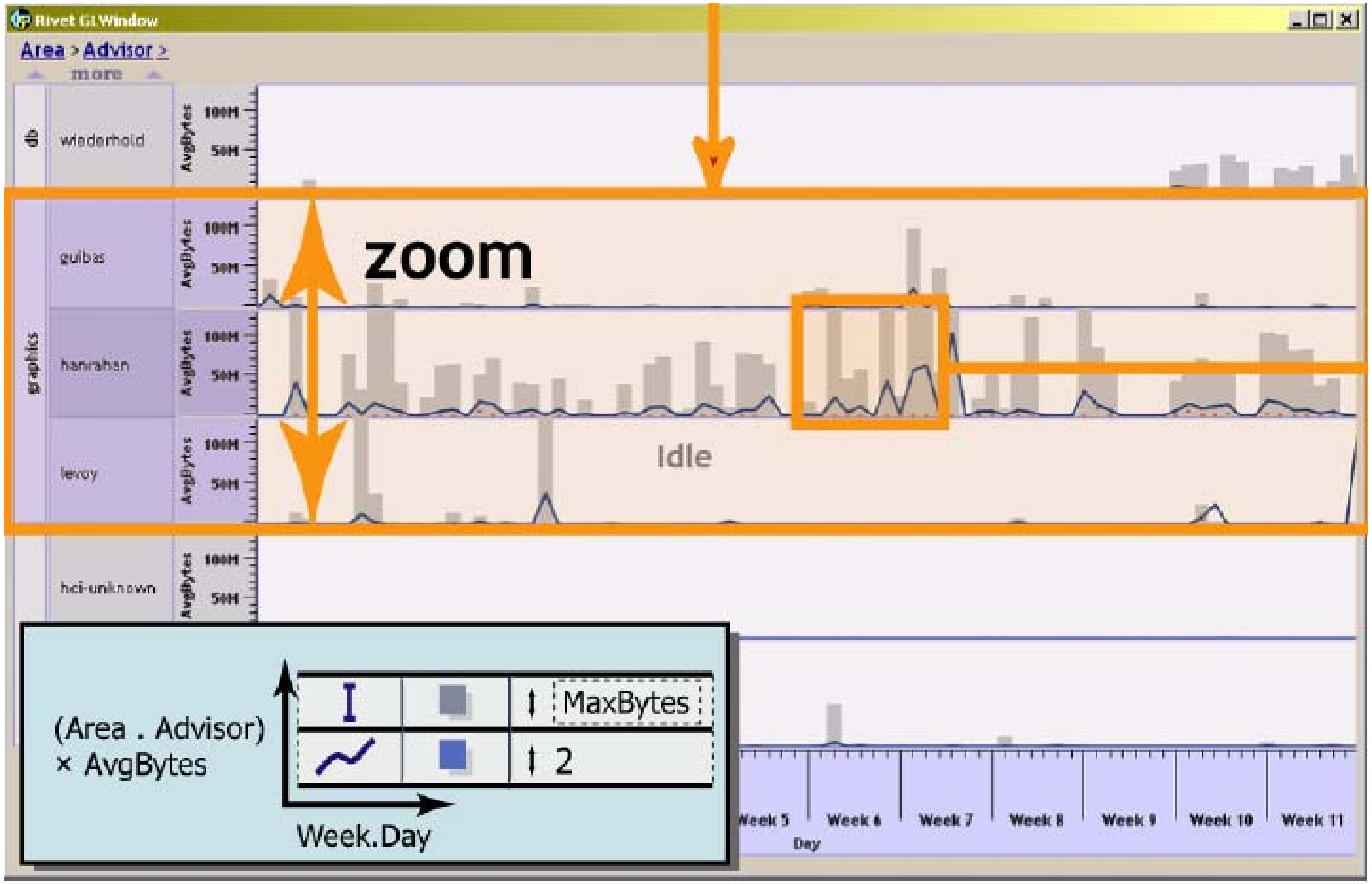


[Zoom graph]+[Polaris specification] VS. multi-scale visualization



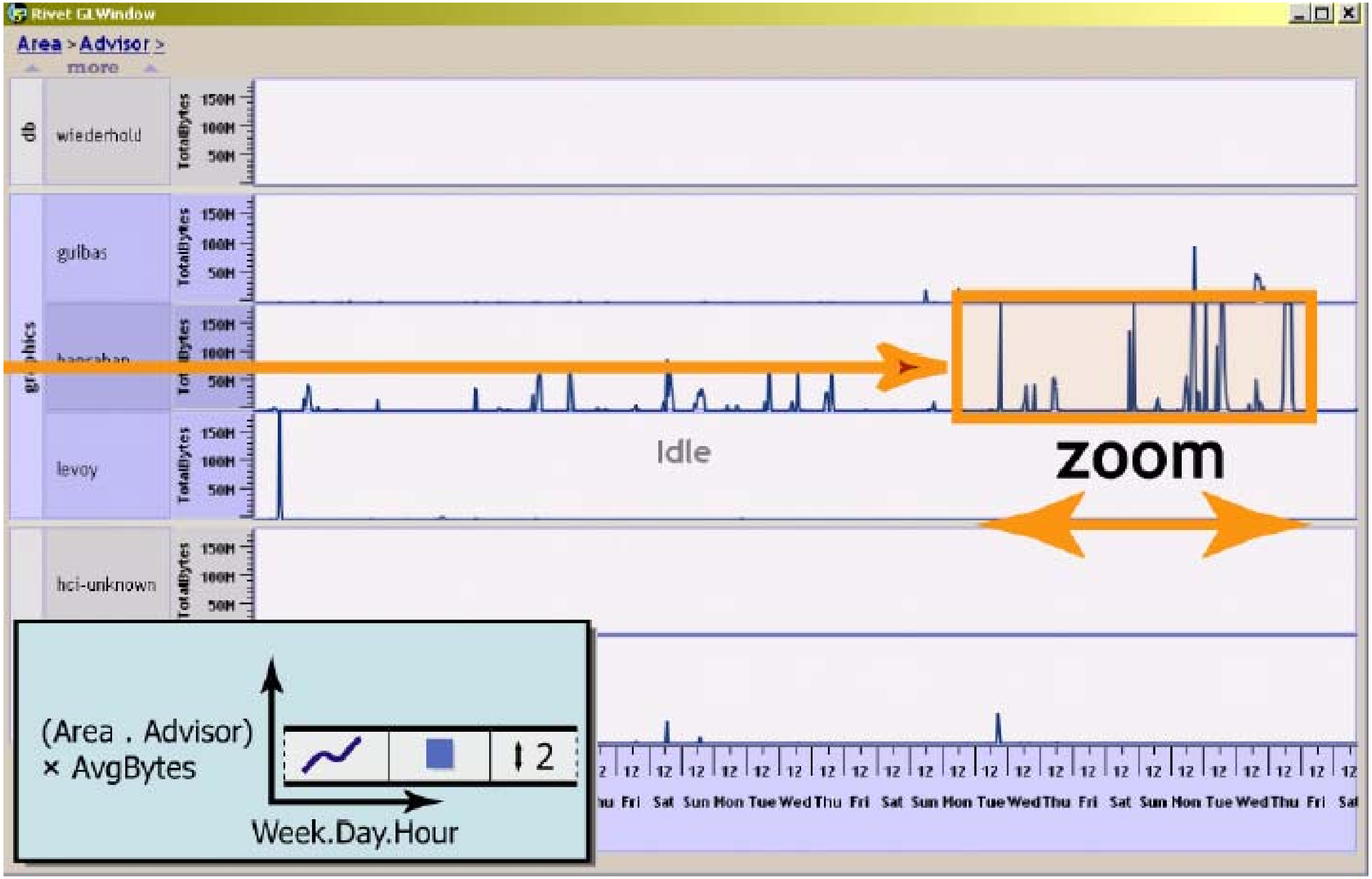
Zoom graph + Polaris specification

Y-axis (Dimension *User*) Zoom (previous example)



Dimension *User* has the hierarchical structure: *Area->Advisor->Project->Username*

X-axis (Dimension *Time*) Zoom (previous example)



Dimension *Time* has the hierarchical structure: *Week->Day->Hour->Minute*

Effective Design Pattern

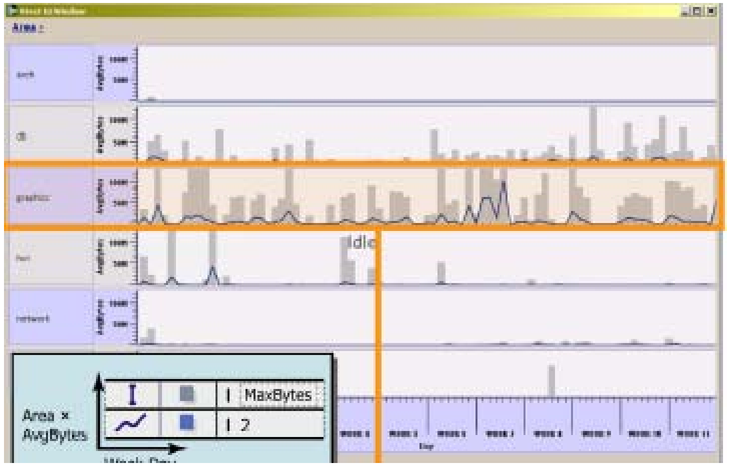
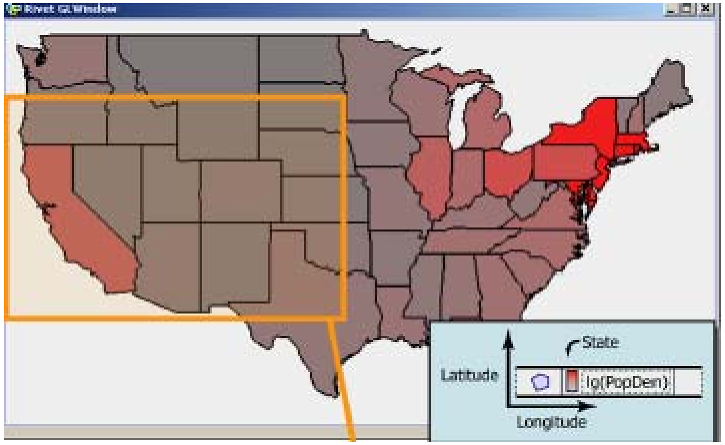
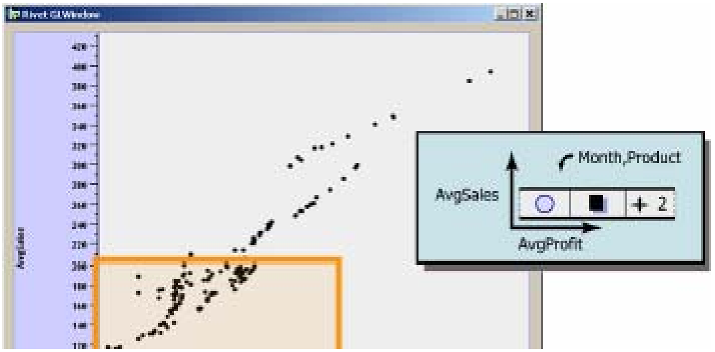


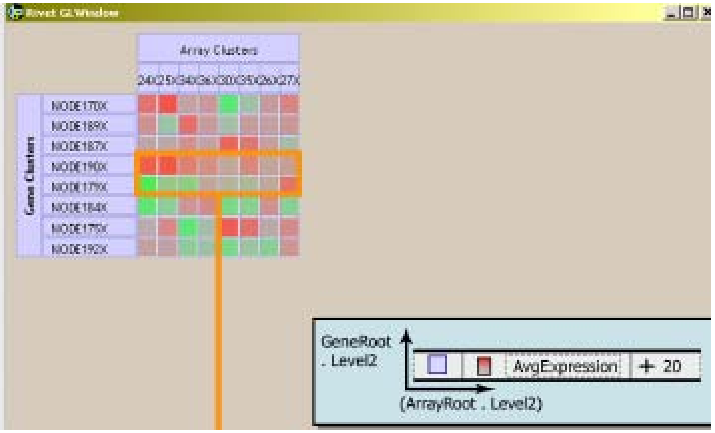
Chart stack



Thematic map



Scatter plot



Matrices

Critiques

- Pros
  - Support normal zooming and semantic zooming (make use of the “structured” nature of data) on databases visualization
  - Try to formalize the relationship between zooming and data semantics. Not just treat zooming as a HCI technique
- Cons
  - The generality of proposed formalism for zooming has not been proved (currently applicable to 4 design patterns)
  - Did not address Focus+Context or retaining original visualization for referencing after zooming

Paper Reviewed (3)

- Mihael Ankerst, David H. Jones, Anne Kao, Changzhou Wang

  “*DataJewel: Tightly Integrating Visualization with Temporal Data Mining*”

Overviews

- Temporal Databases
- Information Tasks of Temporal Data Mining
- Non-expert integrated Solutions-DataJewel
- Aircraft Maintenance Data Scenario
- Critiques

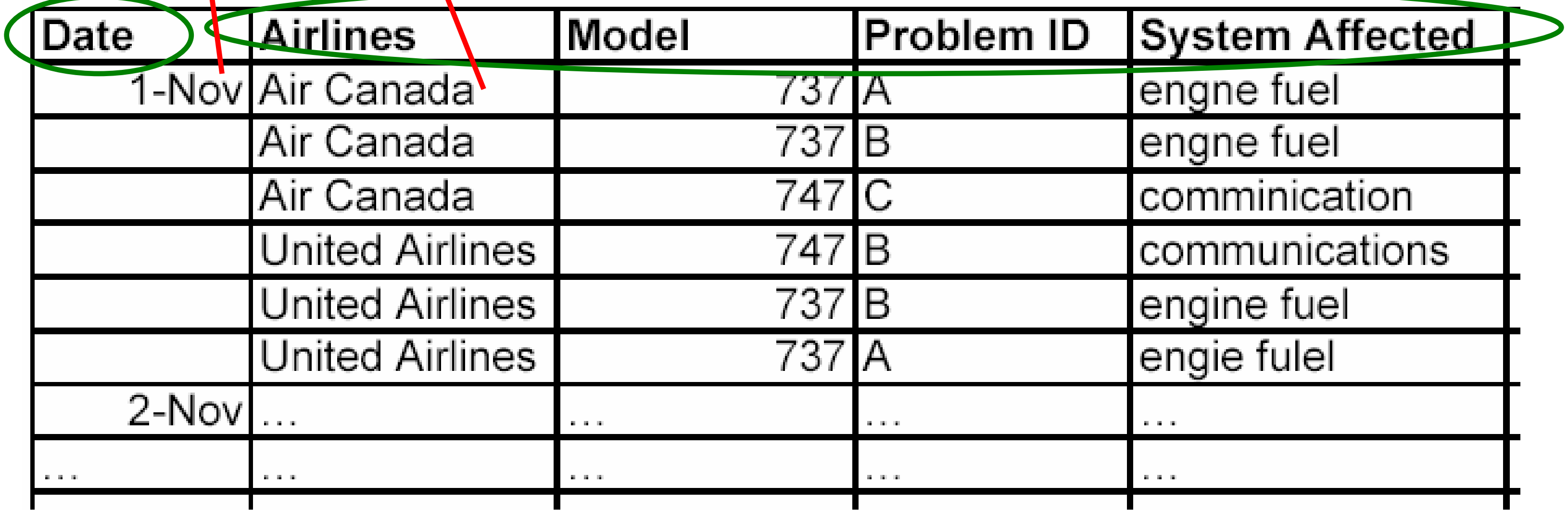
Temporal Databases

Column: Time Stamp + Event Attributes

Row : Time + Events

Event Attributes

Time Stamp



Date	Airlines	Model	Problem ID	System Affected
1-Nov	Air Canada	737	A	engne fuel
	Air Canada	737	B	engne fuel
	Air Canada	747	C	comminication
	United Airlines	747	B	communications
	United Airlines	737	B	engine fuel
	United Airlines	737	A	engie fulel
2-Nov	…	…	…	…
…	…	…	…	…

Information Tasks of Temporal Data Mining

- Which event has anomaly during the a certain period of time?
- Is there any other event that has the similarly abnormal pattern like the already observed event?
  - Within same event attribute
  - Cross event attributes
- *Example:*

  During 1990 to 2000:

  - Which airplane system has significantly low or high relative frequency of being affected by problems reported?
  - Which else airplane system has the similar troublesome situation? (within event attribute)
  - Which model, airline, etc has the similar troublesome situation? (cross event attribute)

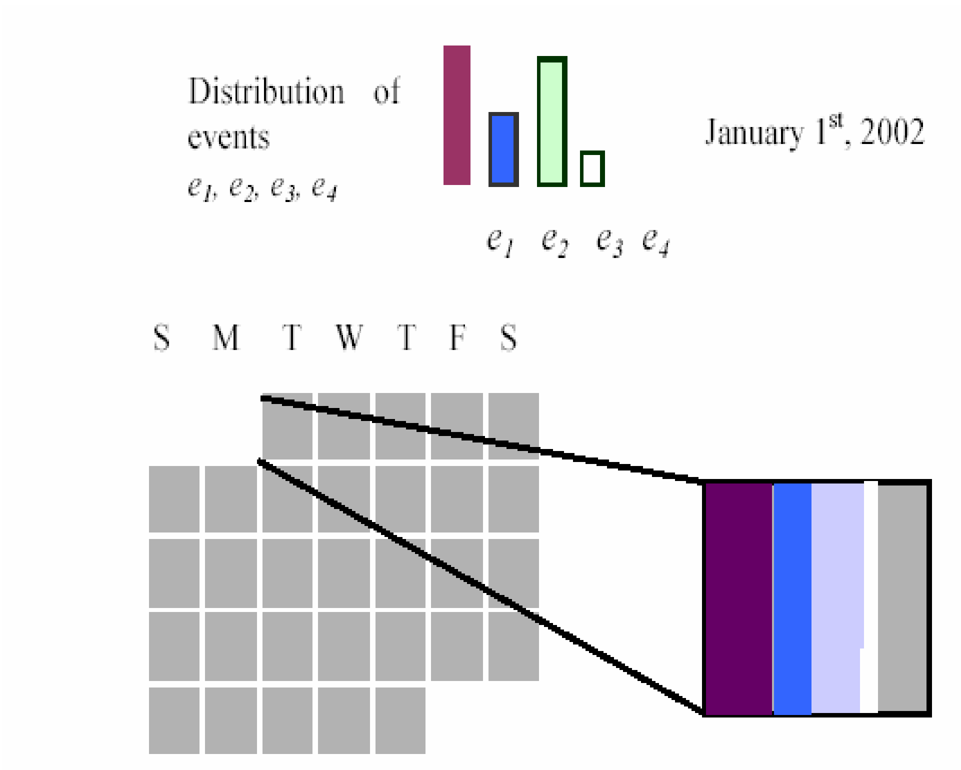
Non-expert Integrated Solutions-DataJewel

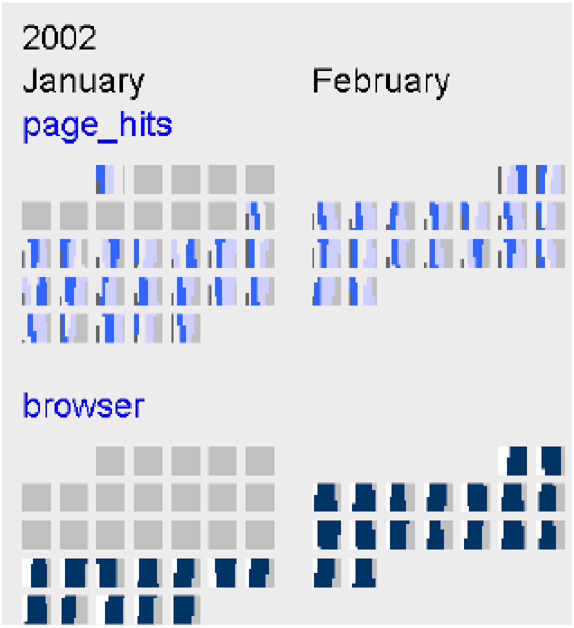
- [Visualization guided] + [Domain expert centric] data mining
- Innovative Temporal Data Visualization: CalendarView
- Visualization Interaction
  - Select Date Range, Ascending/Descending order, Interactive color assignment, Zooming, Detail on Demand
- Data Mining algorithm
  - *LongestStreak*: Single Event Anomaly Identification
  - *MatchingEvents:* Events Anomaly identification within Event Attribute
  - *MatchingEvents2:* Events Anomaly identification across Event Attribute
- Aggregated Database
  - Data amount is reduced by computing statistics summary

Visualization guided + Domain expert centric

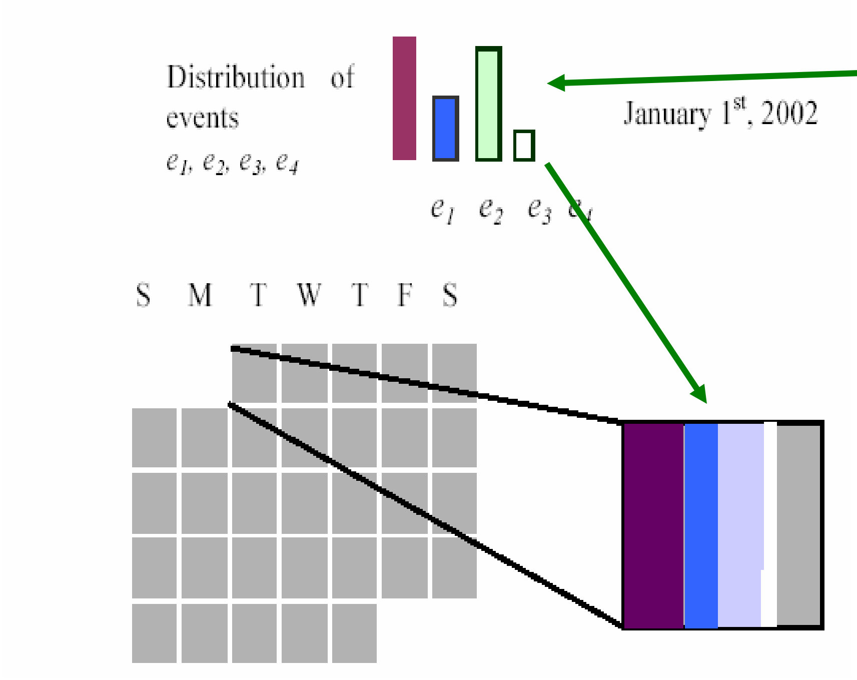
- Overview of data are first given by visualization
- Domain expert iteratively takes following actions based on his knowledge and the visualized overview of data
  - Filter data by selecting date range, or
  - Interact with the visualization to explore patterns, or
  - Initiate data mining when spotting suspicious patterns
- Also can select different visualization techniques in accordance with the data size

CalendarView(1)





CalendarView(2)

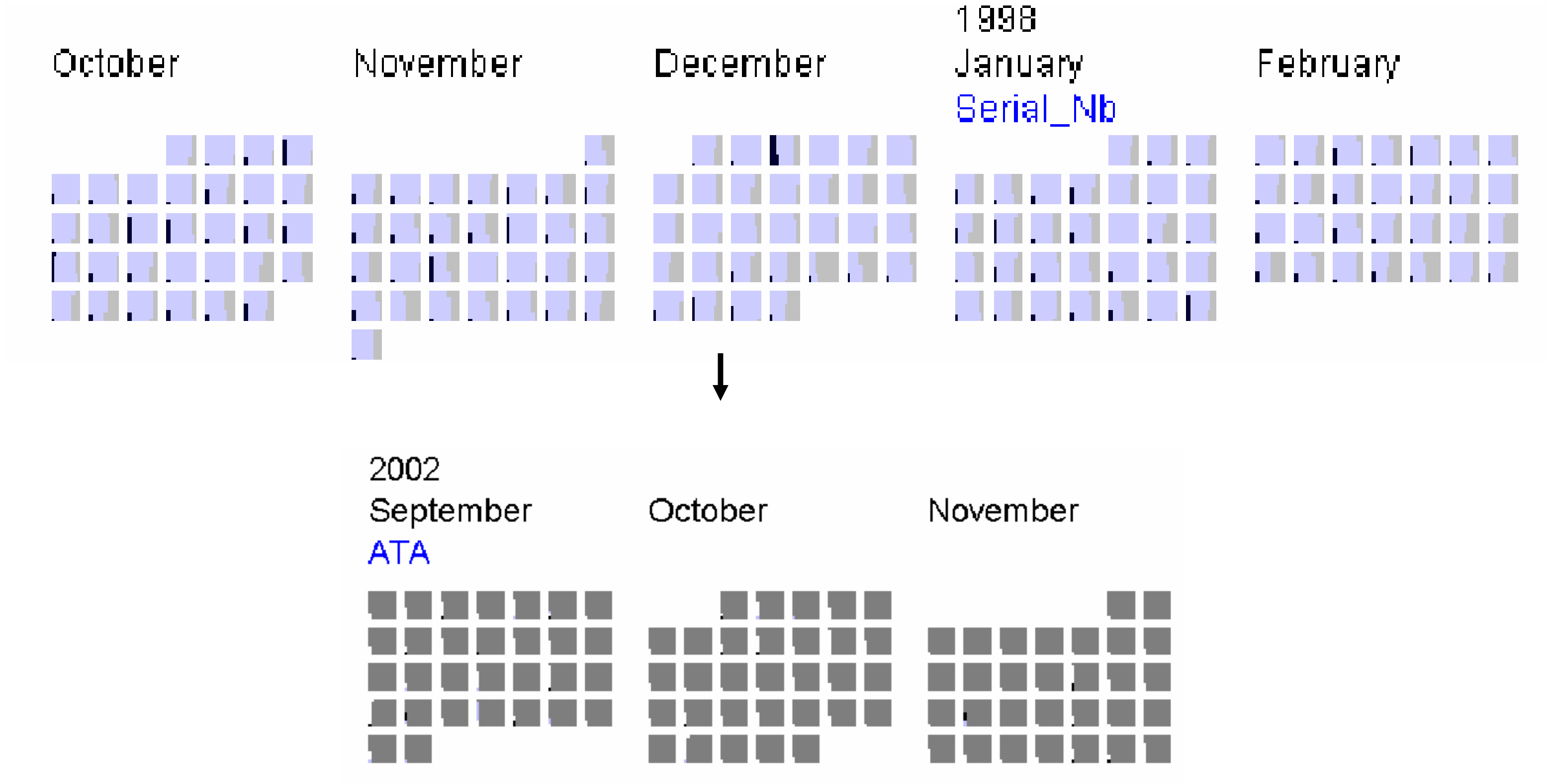


data of each day is encoded in the calendar day as a histogram where height indicates occurring frequency while color means different events

Event dates is represented by visual metaphor of a calendar

Visualization Interaction(1)

- **Select Date Rage**

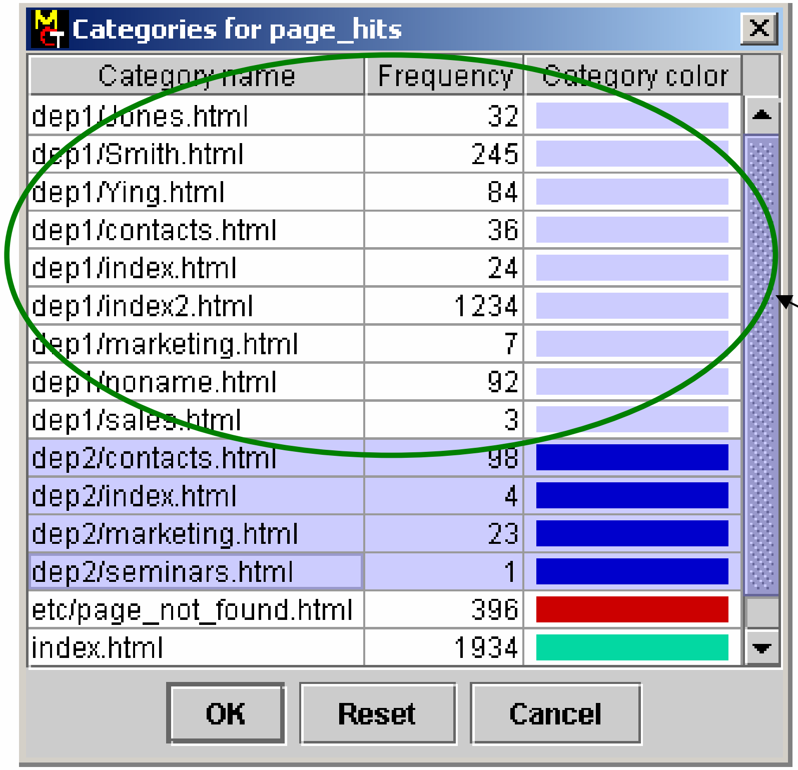


- **Ascending/Descending order**

rarest event in the front/ most frequent in the front

Visualization Interaction(2)

- **Interactive color assignment**



Categories for page_hits

Category name	Frequency	Category color
dep1/Jones.html	32	🟪
dep1/Smith.html	245	🟪
dep1/Ying.html	84	🟪
dep1/contacts.html	36	🟪
dep1/index.html	24	🟪
dep1/index2.html	1234	🟪
dep1/marketing.html	7	🟪
dep1/noname.html	92	🟪
dep1/sales.html	3	🟪
dep2/contacts.html	98	🟦
dep2/index.html	4	🟦
dep2/marketing.html	23	🟦
dep2/seminars.html	1	🟦
etc/page_not_found.html	396	🟥
index.html	1934	🟩

Conceptual generalization by giving same colors:

Htmls hitted in the directory *dep1* is abstracted/generalized into the same event by assigning them the same color

Data Mining algorithm

- LongestStreak
  - Calculate “relative frequency” of event E of each day
  - Calculate the mean and deviation of the relative frequencies of event E
  - Days in which the relative frequency of event E is significantly lower or over the mean value are labeled “*significant day*”
  - Return the *longest streak* of *consecutive* significant days by darkening them
- MatchingEvents
  - Calculate ”significant days” for all other events in the same event attribute
  - For every event, assign bit 1 to significant days, bit 0 otherwise. Therefore, every event has its own “bit sequence”
  - Compare the bit sequences between event E with all other events; the most matched event is the correlated event to event E
  - Return both event E and the correlated event by changing their color
- MatchingEvents
  - Similar to MatchingEvents, but cross attributes comparisons

Aggregated Databases

- Original relational tables are compressed by computing the summary statistics: count(), sum(), average(), etc.
  - Example:

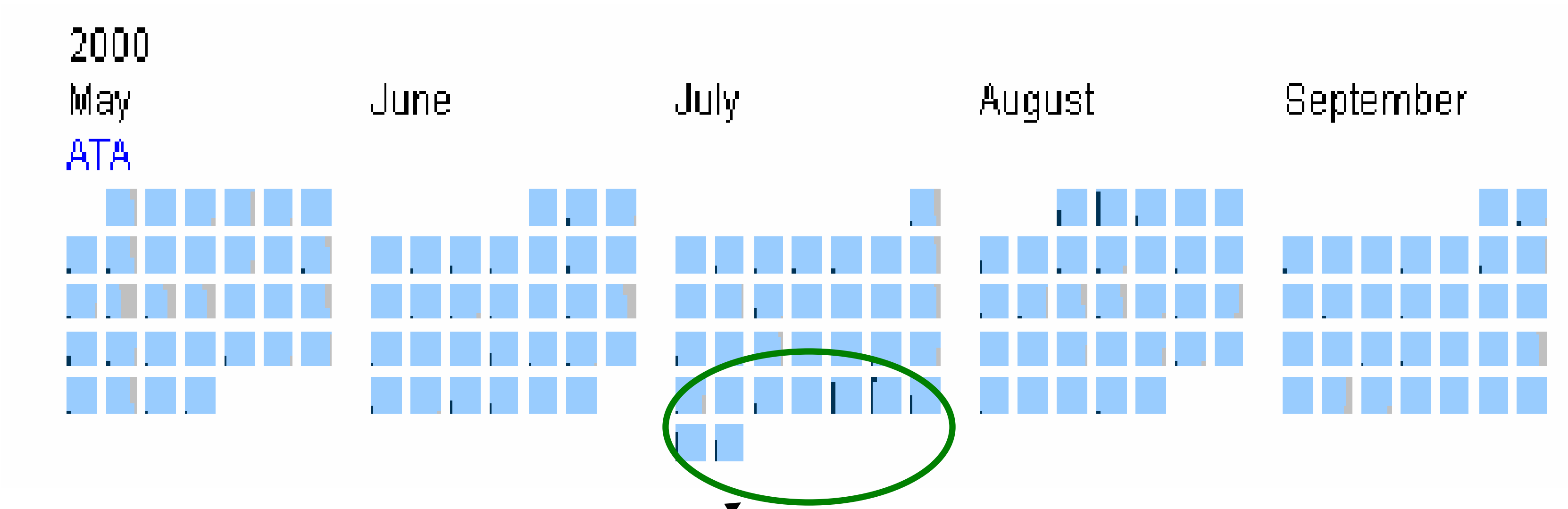
    Wireless signal disconnect 50 times a day. Without aggregation, 50 records!

    By calculating average disconnect time or count times of disconnection, 50 records becomes 1 record.
- # of events/day VS. # of distinct events/day
  - In aircraft maintenance domain:

    Average # of events per day: 402

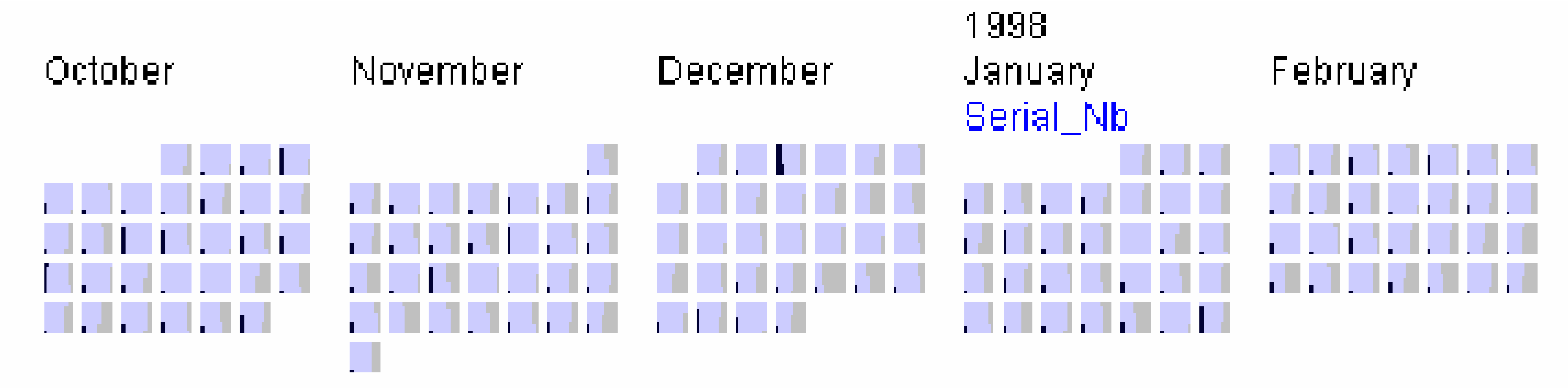
    Average # of distinct events per day (by aggregation): 32
- Greatly reduce memory capacity requirement!

Aircraft Maintenance Data Scenario (1)



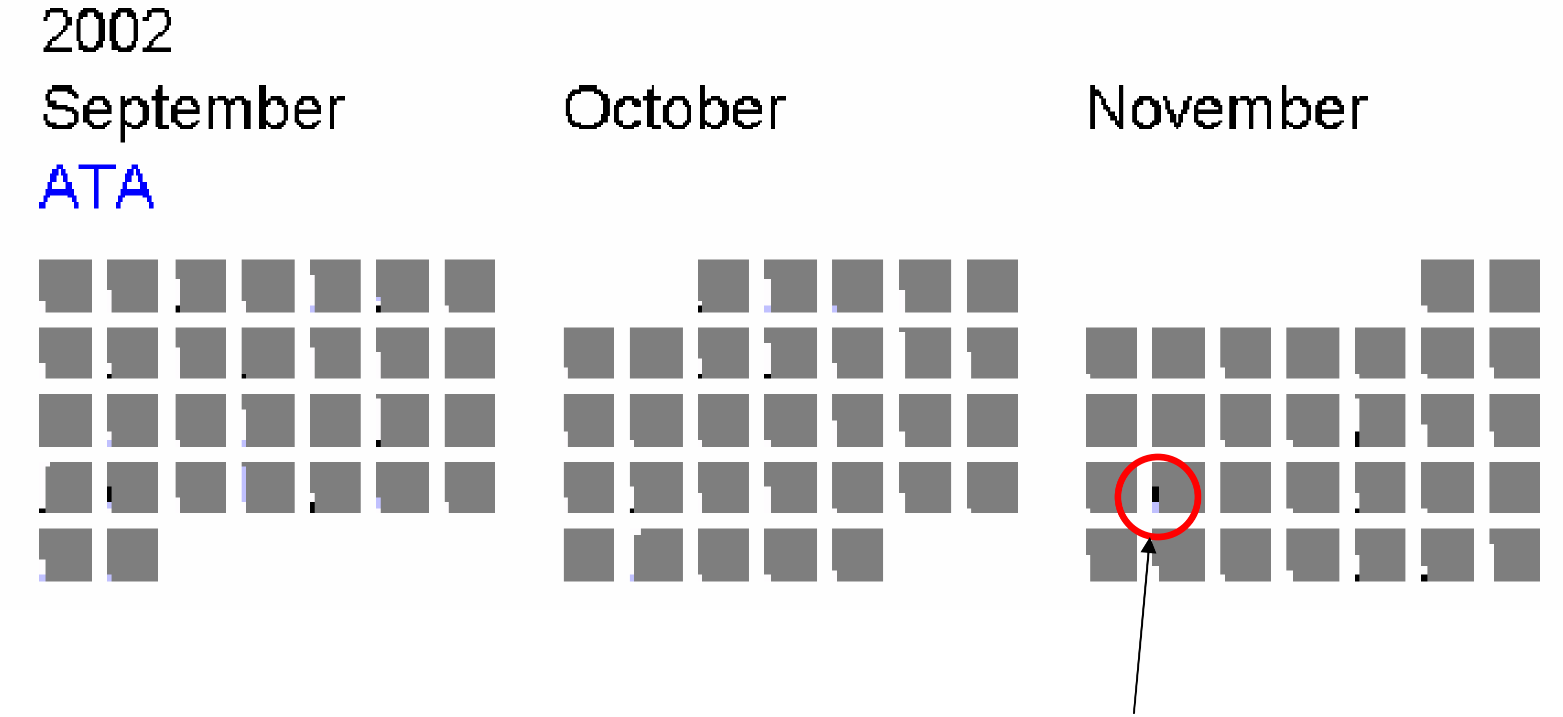
By LongestStreak and then visualization, the high occurrences of engine fuel problem are spotted during the end of July 2000

Aircraft Maintenance Data Scenario (2)



By adding a event attribute of “Plane ID”, executing MatchEvents2, and visualization, one airplane correlate to the engine fuel problem is singled out. And we can see the engine fuel problem pattern of that airplane through visualization

Aircraft Maintenance Data Scenario (3)



By conducting MatchEvents and visualization, we can find that it seems that engine fuel problem would co-occur with communication problems

Visualized results of "MatchEvents"

Critiques

- Pros
  - Interaction between data mining and data visualization for efficiently exploring huge databases
  - Non data mining experts can mine more meaningful information
- Cons
  - Application specific

    # of events attribute<10; # of events per event attribute <200; smallest time unit is day
  - Limited tasks

    Limited to find anomalies and correlations
  - Limited Data Type

    Data limited to nominal data type

Paper Reviewed (4)

- Alexander Aiken Jolly Chen Michael Stonebraker Allison Woodruff

  “Tioga-2: A Direct Manipulation Database Visualization Environment”

Overviews

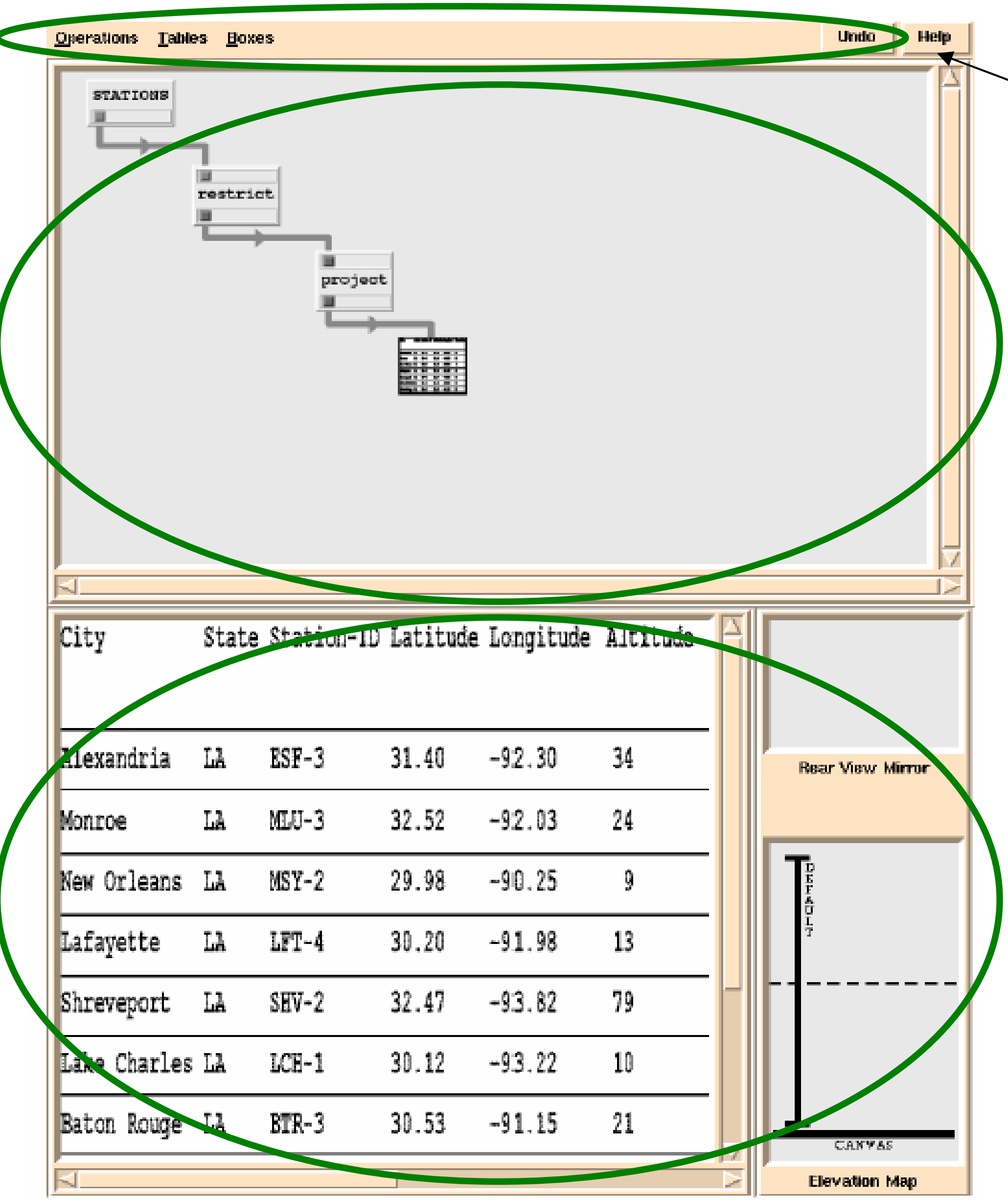
- Intro. Of Tioga-2
- User Interface of Tioga-2
- Model of Presenting Data of Tioga-2
- Details of Presenting Data of Tioga-2
- Miscellaneous of Presenting Data of Tioga-2
- Critiques

Tioga-2

- An visual SDK environment for databases applications
- Visual programming:
  - “Box” represents primitives of program operations and database operations
  - “Arrow” represents the sequencing of the primitives.
- Visual feedback:
  - Visual demonstration of results of each programming steps in real time
  - *Example:*

    Visually shows the data queried for the SQL instructions.
- Focus on the latter part—visual feedback....

User Interface of Tioga-2 (1)



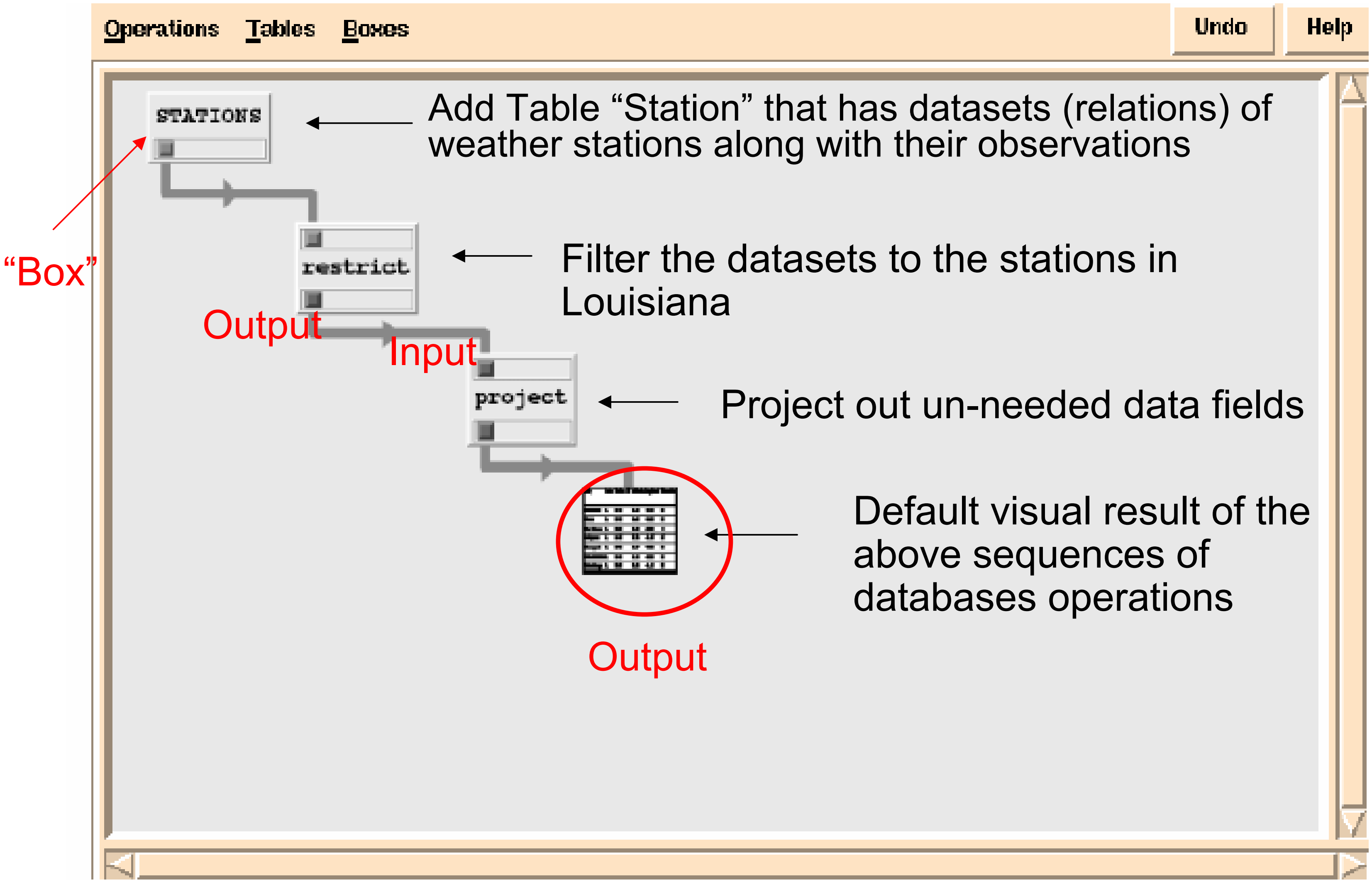
City	State	Station-ID	Latitude	Longitude	Altitude
Alexandria	LA	ESF-3	31.40	-92.30	34
Monroe	LA	MLU-3	32.52	-92.03	24
New Orleans	LA	MSY-2	29.98	-90.25	9
Lafayette	LA	LFT-4	30.20	-91.98	13
Shreveport	LA	SHV-2	32.47	-93.82	79
Lake Charles	LA	LCH-1	30.12	-93.22	10
Baton Rouge	LA	BTR-3	30.53	-91.15	21

Menu bar for invoking primitive operations

Windows for visual programming

“Canvas” for “painting” results of programming

User Interface of Tioga-2 (2)



Add Table "Station" that has datasets (relations) of weather stations along with their observations

Filter the datasets to the stations in Louisiana

Project out un-needed data fields

Default visual result of the above sequences of databases operations

* Case of US weather stations & weather observation

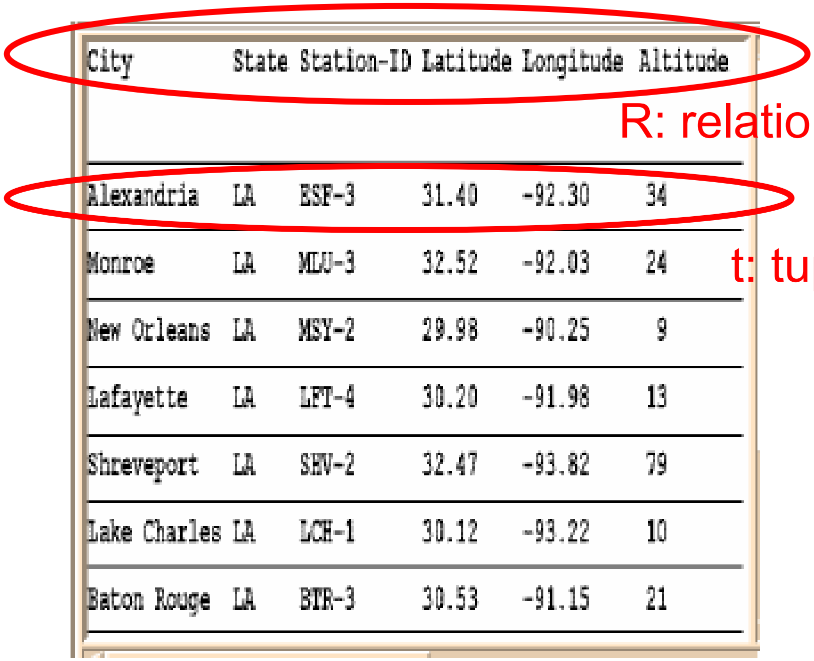
Model of presenting data of Tioga-2 (1)

- “Box” (or primitive procedure) will generate “output”, which is the “input” of the successor “Box”.
- “Inputs” or “Outputs” of database primitive procedures actually are datasets (relations or tuples). They are referred as “displayable” in the Tiago-2.
- “Displayable” includes:
  - Extended Relations (R)
  - Composite (C)
  - Group (G)

Model of presenting data of Tioga-2 (2)

- Extended Relations:

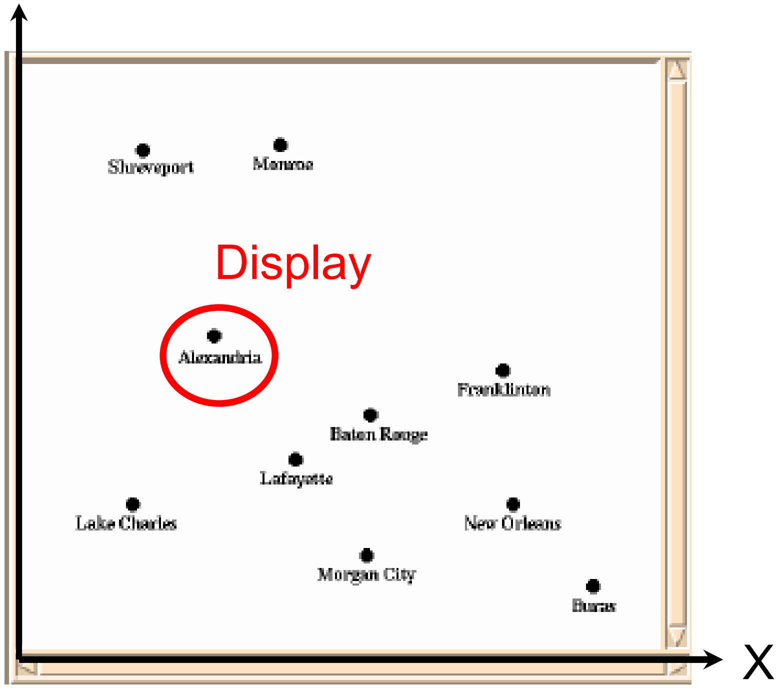
Relations in data itself + relations on "Canvas"



City	State	Station-ID	Latitude	Longitude	Altitude
Alexandria	LA	ESF-3	31.40	-92.30	34
Monroe	LA	MLU-3	32.52	-92.03	24
New Orleans	LA	MSY-2	29.98	-90.25	9
Lafayette	LA	LFT-4	30.20	-91.98	13
Shreveport	LA	SHV-2	32.47	-93.82	79
Lake Charles	LA	LCH-1	30.12	-93.22	10
Baton Rouge	LA	BTR-3	30.53	-91.15	21

R: relation

t: tuple



Display

Relations in data itself

Relations on "Canvas"

N dimensions of R ↔ *N* dimensions of "Canvas" (x, y, sliders)

Each tuple of R ↔ Each display on "Canvas"

Model of presenting data of Tioga-2 (3)

- Composite:
  - Data semantic: Union of different relations
  - Visual semantic: Superimposition of “Canvases” (or visualization) of different relations
- Group:
  - Data semantics: Union of different composites
  - Visual semantics: Juxtaposition of visualizations of different composites.
- Elevation:
  - Data semantics: number of tuples shown on the “Canvas”
  - Visual semantics: degree of zooming (the height you watch the image)

Detail of presenting data of Tioga-2 (1)

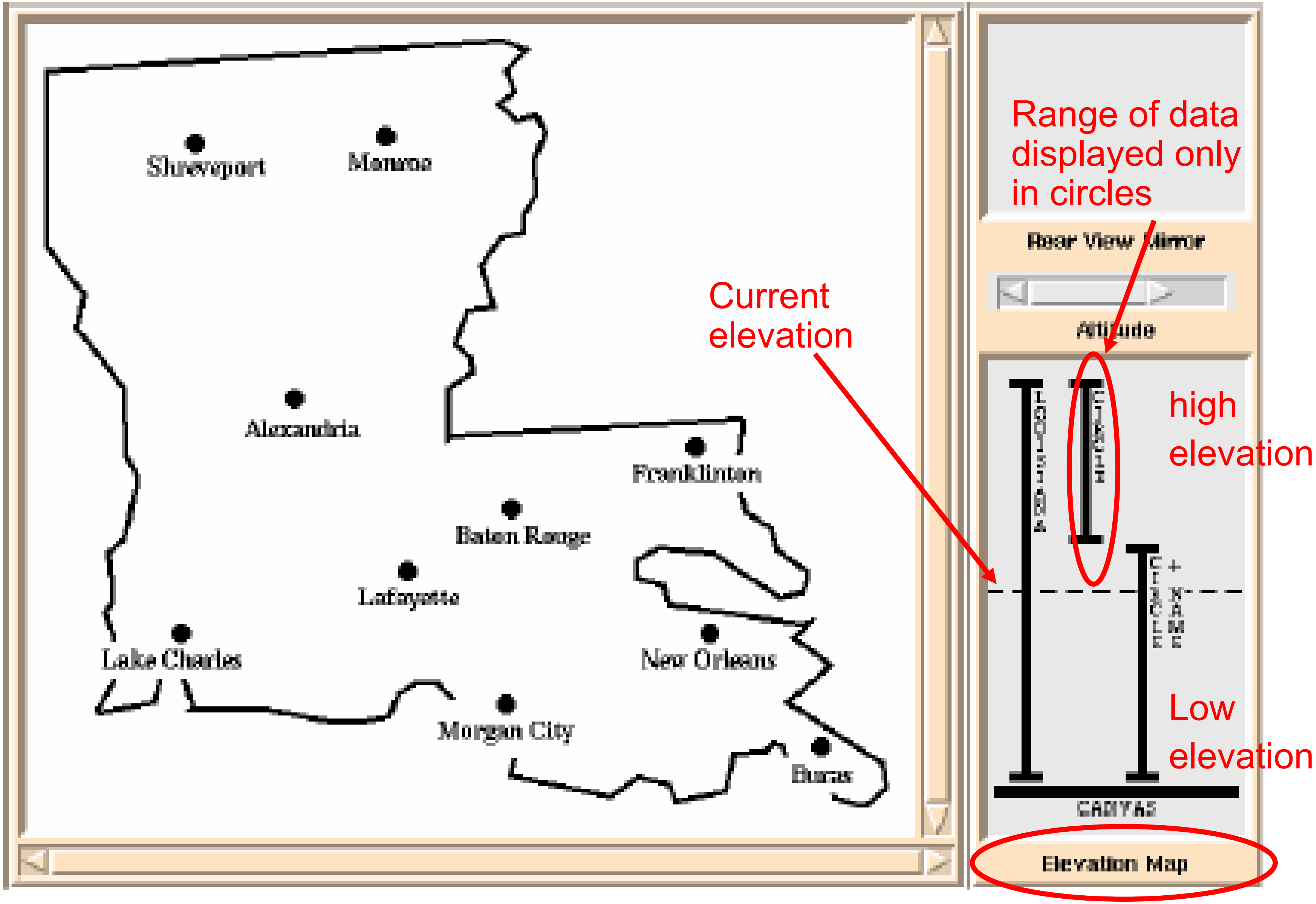
- Location and display attributes of data
  - Location attributes determines how to position tuples on 2D canvas (x axis, y axis, sliders)
  - Display attributes determines how tuples look like on 2D canvas (point, line, rectangle, circle, polygon, text, viewer (viewer on canvas))
- Default location and display of tuples (default visualization)
  - Spreadsheet like table
- Operations for altering visualization
  - Add attribute of data itself along with location or of display
  - Set attribute of location or display)
  - Remove attribute of data itself along with location or of display)
  - Swap attribute of data itself along with location or of display)
  - Scale, Translate attribute of location
  - Combine attribute of display)

Detail of presenting data of Tioga-2 (2-1)

- Drill down
  - Refined view of the same data
  - Changed view of different but related data
  - Rear View Mirror
- Refined view of the same data
  - Set Range: Set range of data that a view can zoom in/out
  - Overlay: Overlay different displays of the same data.

    Example: Display texts and circles when zoom in; Display circles only when zoom out
  - Shuffle: Change drawing order of relations within a composite.
  - Elevation map: a bar-chart display indicating the range of data displayed, overlaid displays, and drawing orders

Elevation Map



Range of data displayed only in circles

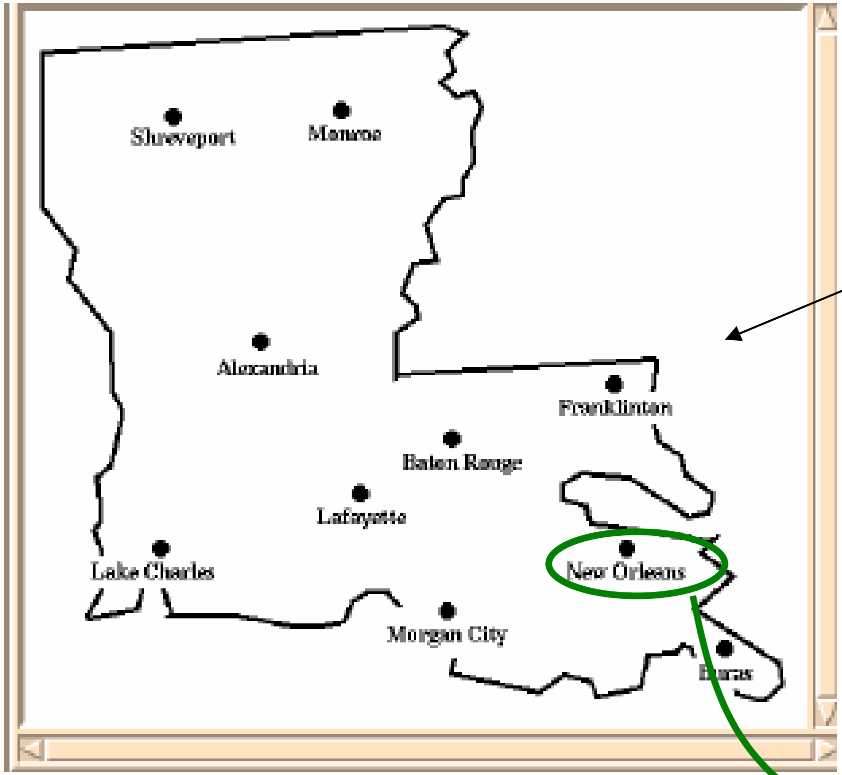
Current elevation

high elevation

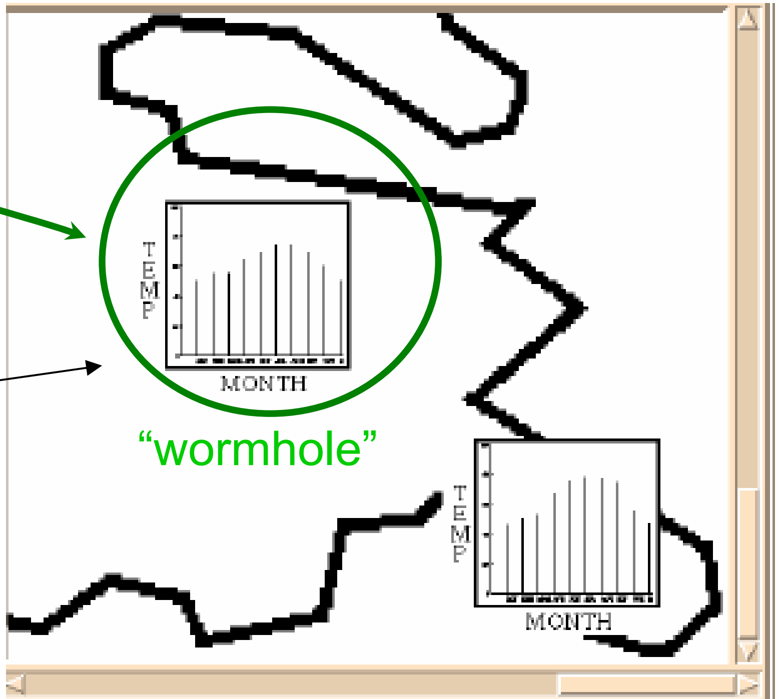
Low elevation

Detail of presenting data of Tioga-2 (2-2)

- Changed view of different but related data
  - Wormholes
    - A viewer mentioned previously
    - A viewer onto another canvas, which visualize datasets relating to the data visualized on the current canvas
    - Defined by parameters of size of the viewer, the destination canvas, the elevation (# of datasets) from which the canvas is viewed, etc.



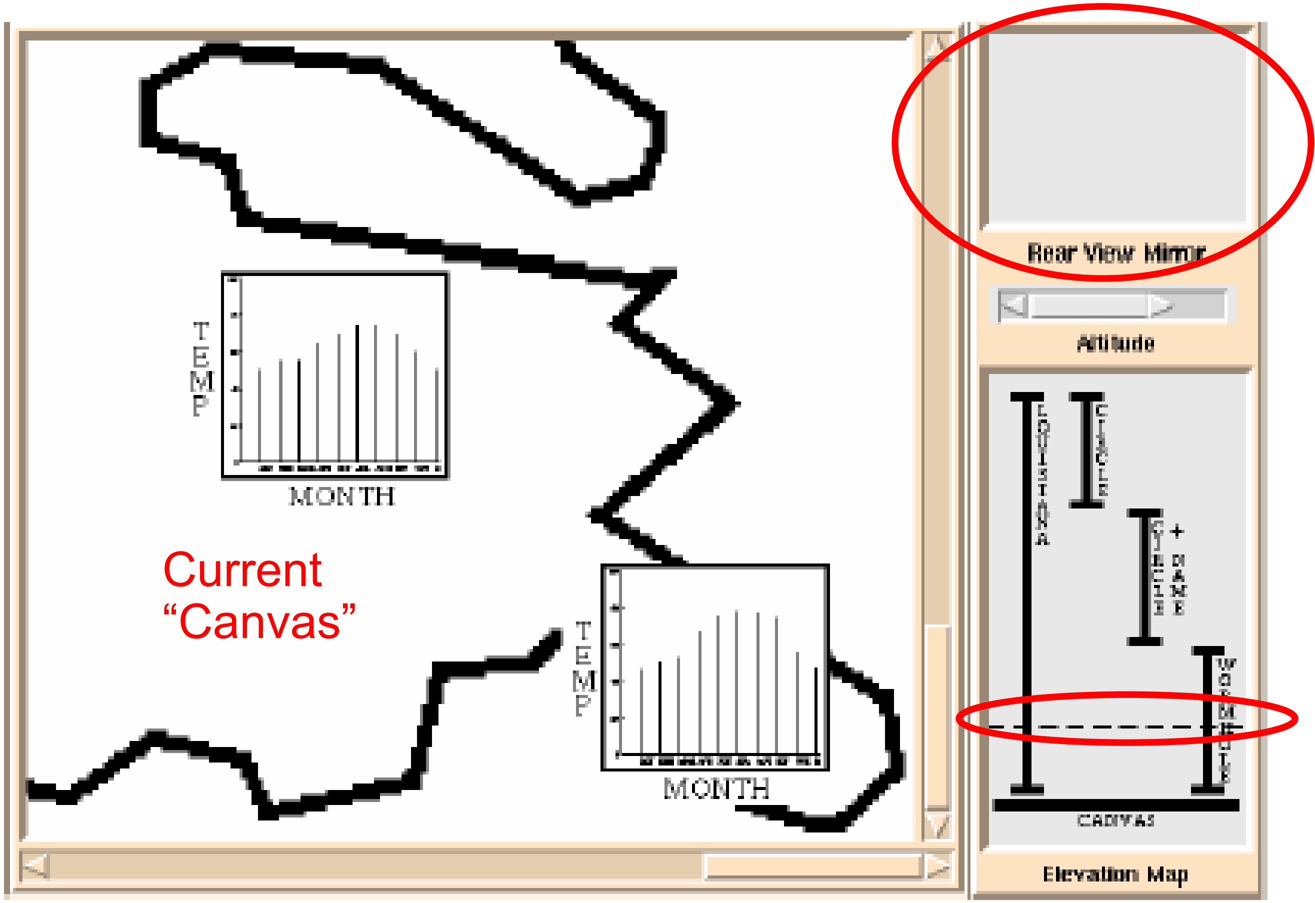
Before applying “wormhole” viewer, we zoom in/out the data of map and weather stations



After applying “wormhole” viewer, we zoom in the data related to a weather station, which is observed temperatures of that station.

Detail of presenting data of Tioga-2 (2-3)

- Rear View Mirrors
  - A mirror to retain the “canvas scenes” before zooming in/out



Current “Canvas”

Rear View Mirror that retains the current “canvas” after zooming in/out

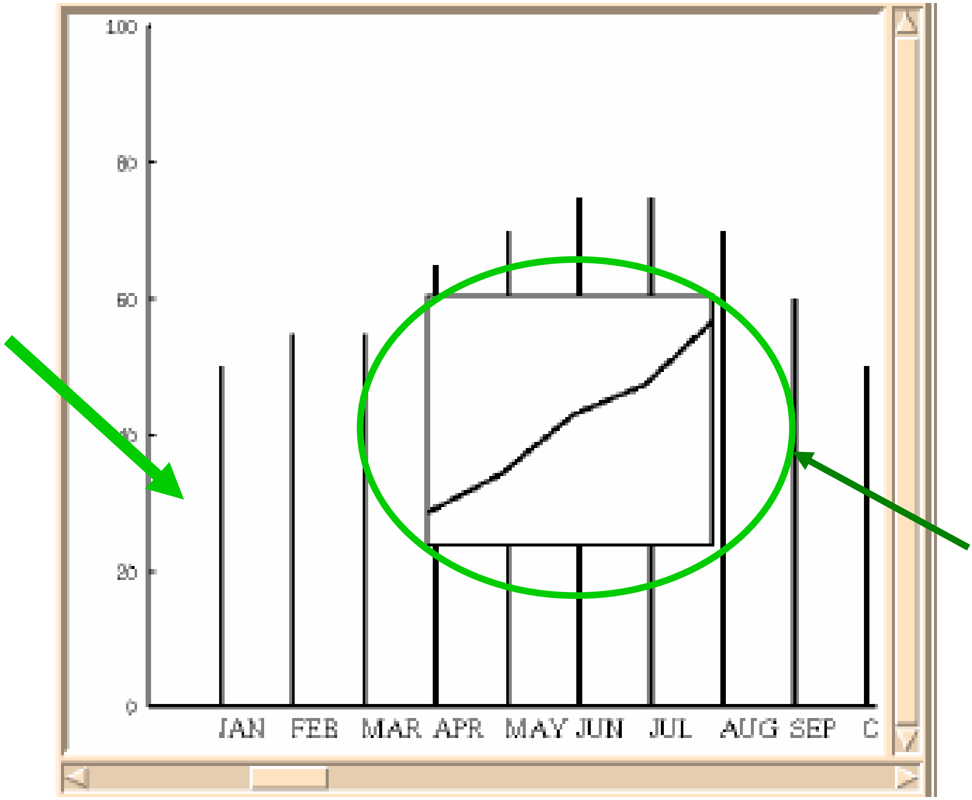
(lower elevation/raise elevation)

Current elevation

Miscellaneous of presenting data of Tioga-2 (1)

- Slaving Views: Move or delete “slaved” viewers together

- Magnifying Glasses: Overlap viewer of other data on current viewer

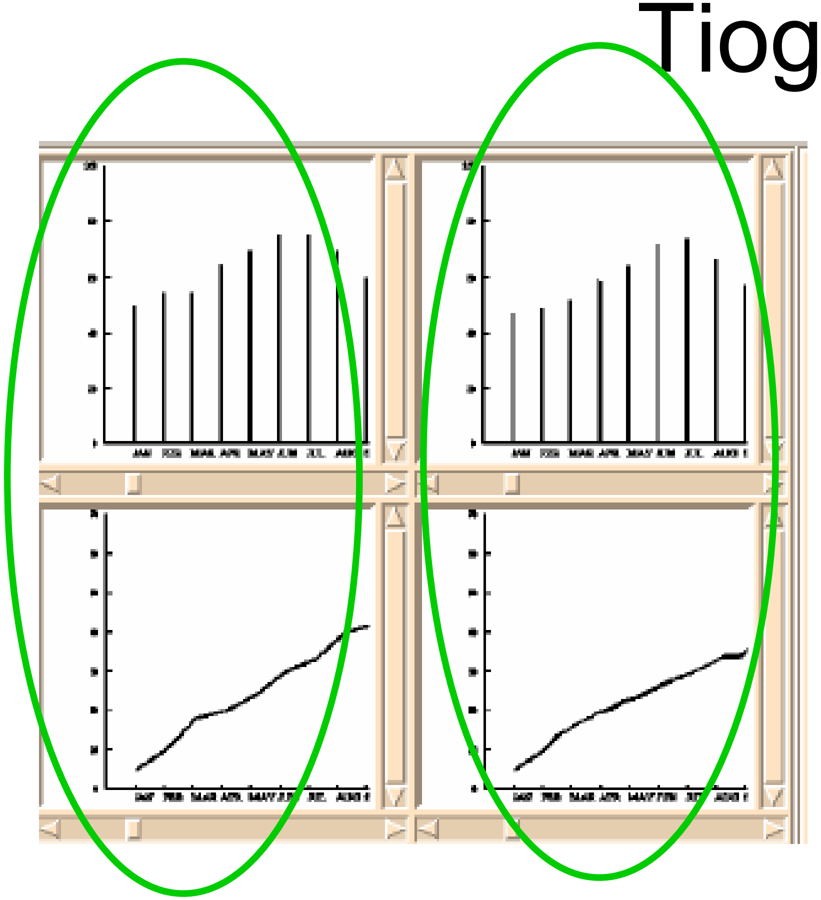


Current Viewer on data of temperature vs. time

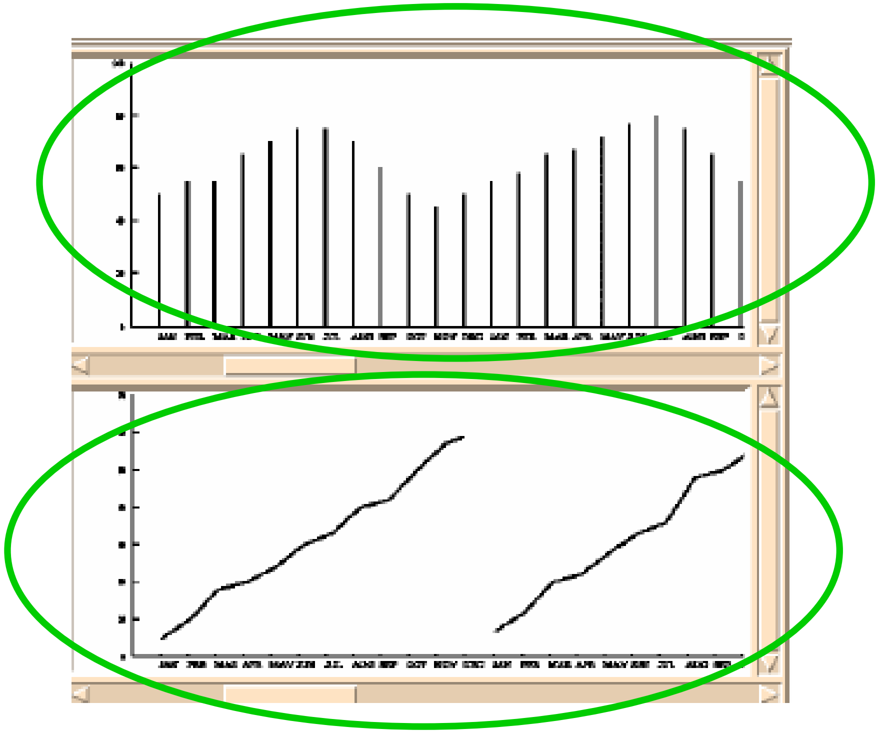
“Magnifying Glass”:

Viewer on data of precipitation vs. time during ARR to AUG

Miscellaneous of presenting data of Tioga-2 (2)



- Replicated Viewer



- Stitched View

  Stitch two viewers

Critiques

- Pros
  - Pioneered concept of multi-scale visualization of databases
  - Visualization for aiding programming in real time
- Cons
  - Users are still tasked with being required to be familiar with SQL queries and basic programming primitives– not suitable for general public
  - Users are tasked with configuring visualization- non visualization expert might not feel the advantage of flexibility