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Why Visualization?

Task Abstraction for Analysis & Design

March 23, 2016
PhD Defence

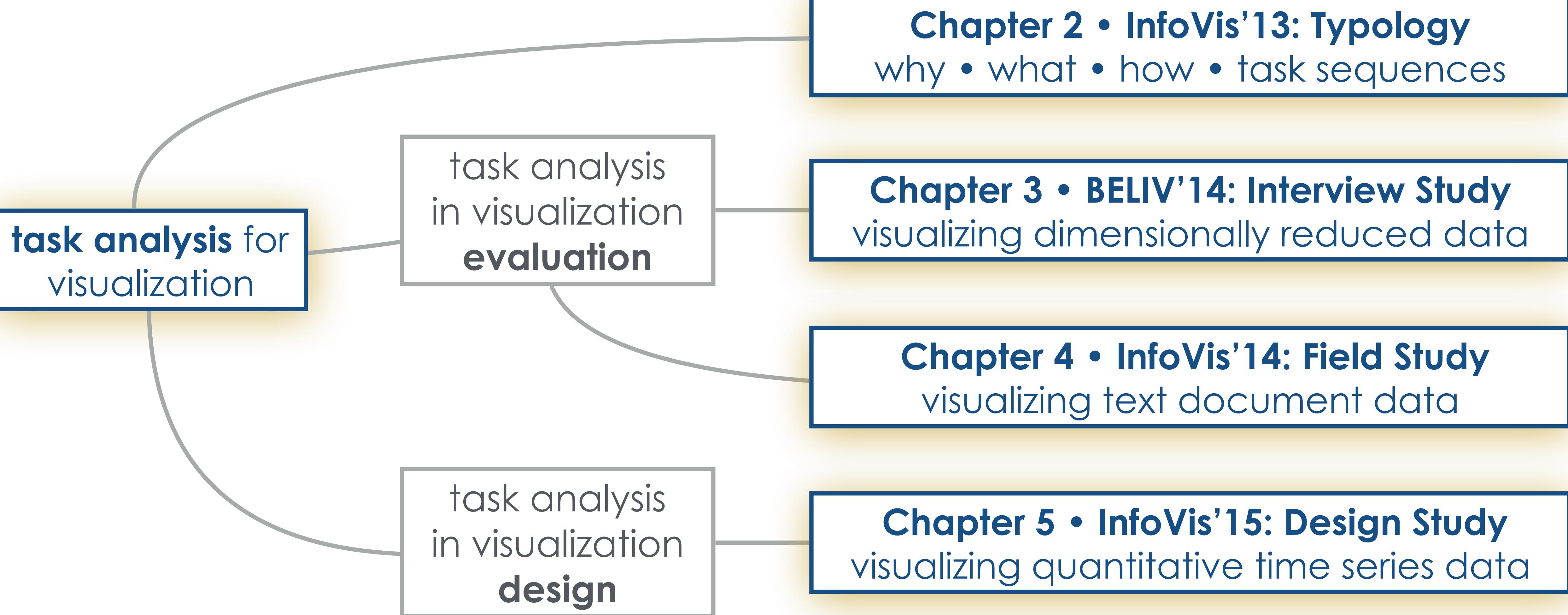
cs.ubc.ca/~brehmer



Chapter 1

Introduction & Motivation: Why do people visualize data?

Primary contribution

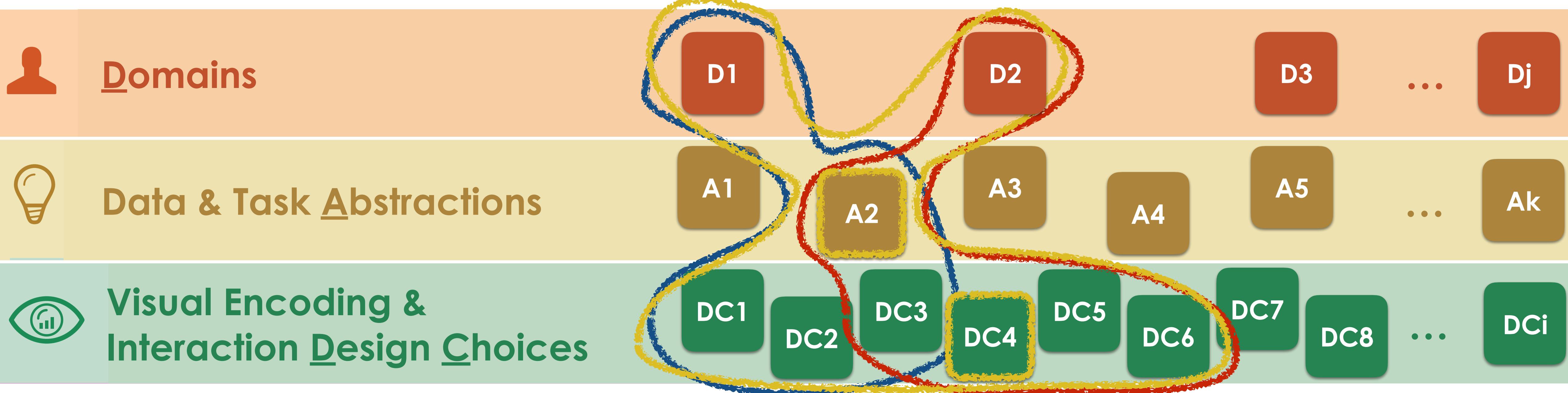


Chapter 2 • **Typology**

A typology of abstract visualization tasks

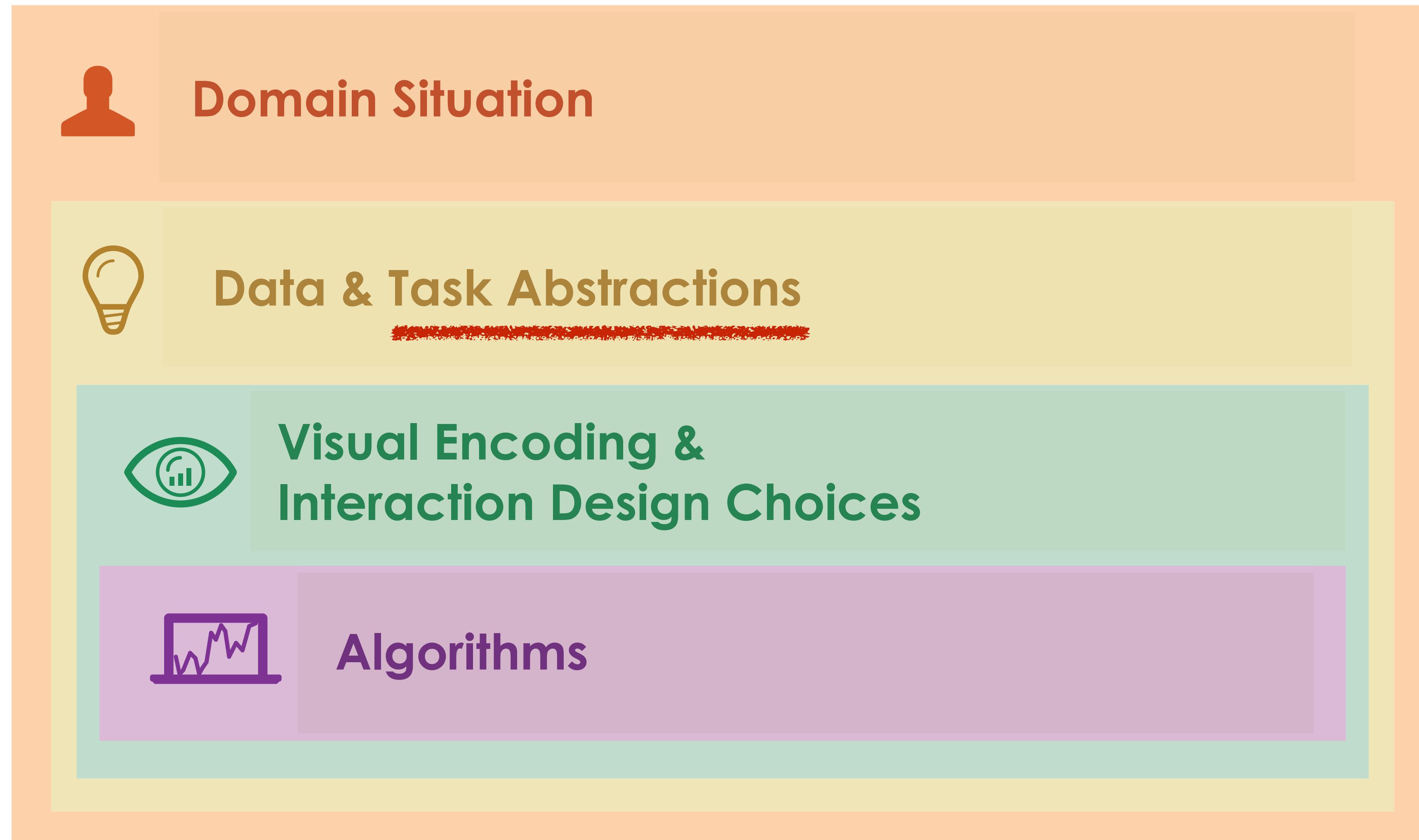
Brehmer & Munzner. IEEE TVCG / Proc. InfoVis 2013.

Communicating tasks across domains



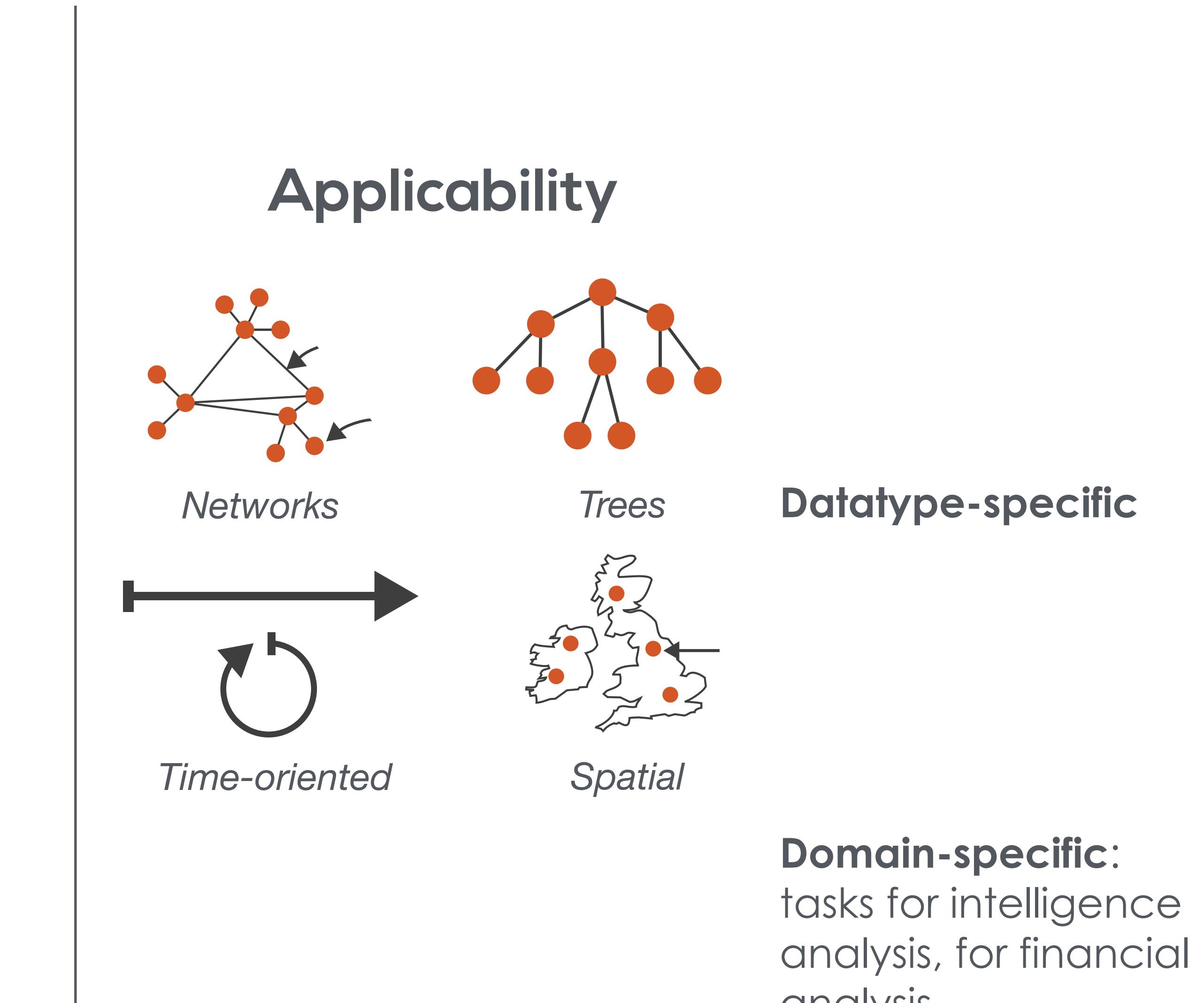
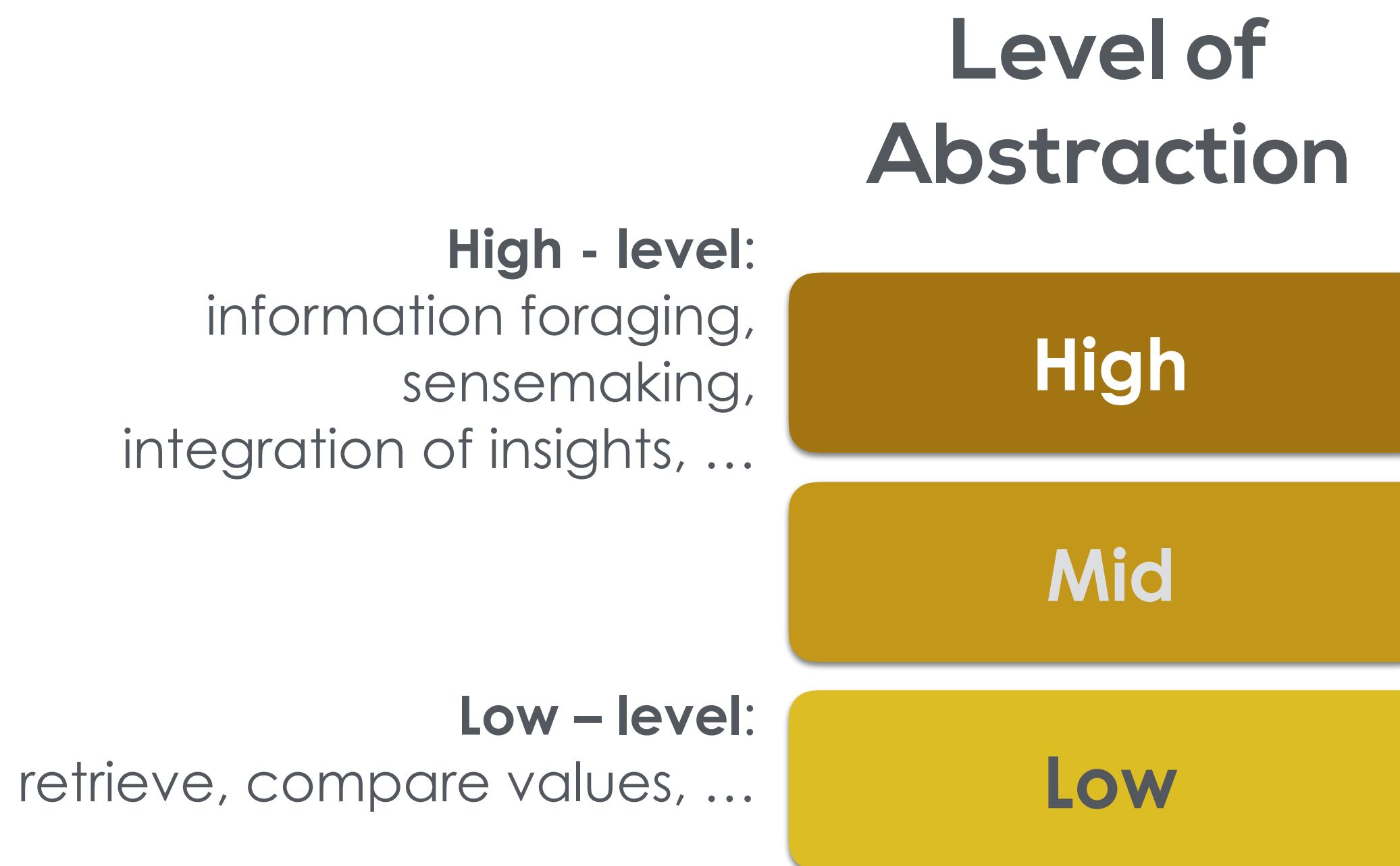
Task abstraction widens the design space, promotes **cross-pollination** of design choices across domains and enables **communication** among visualization practitioners.

Abstraction layer of the Nested Model



Munzner (2009, 2014)

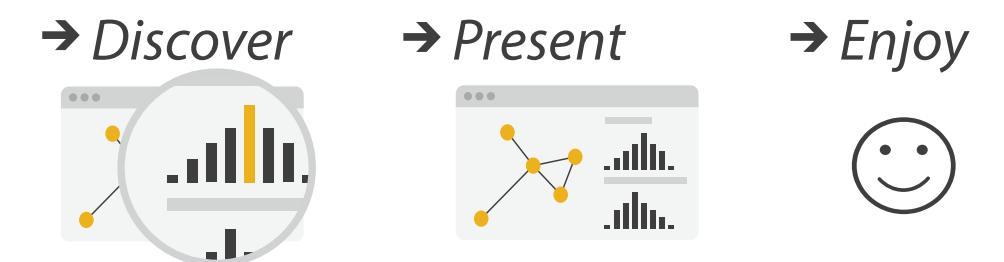
Previous work: Existing task classifications



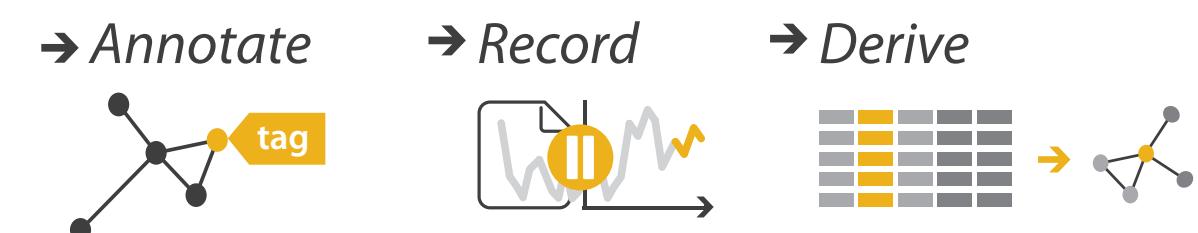
A typology of abstract visualization tasks

Why do people visualize data?

Consume



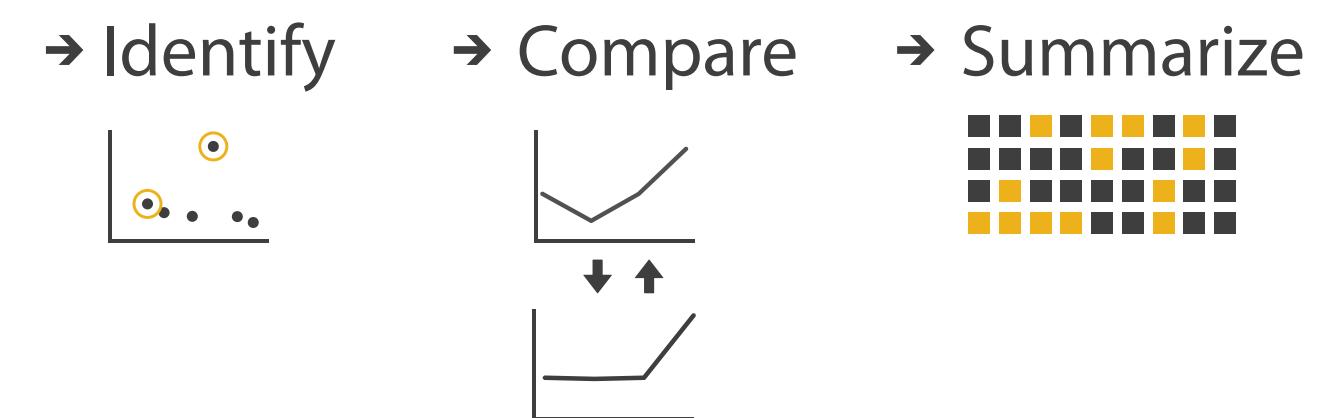
Produce



Search

	Target known	Target unknown
Location known	•..• <i>Lookup</i>	•..• <i>Browse</i>
Location unknown	◁•○▷ <i>Locate</i>	◁•○▷ <i>Explore</i>

Query



A typology of abstract visualization tasks

Why do people visualize data?

How is the task supported in terms of visual encoding and interaction, and view coordination design choices?

Encode

Navigate

Select

Aggregate

Filter

Change

Arrange

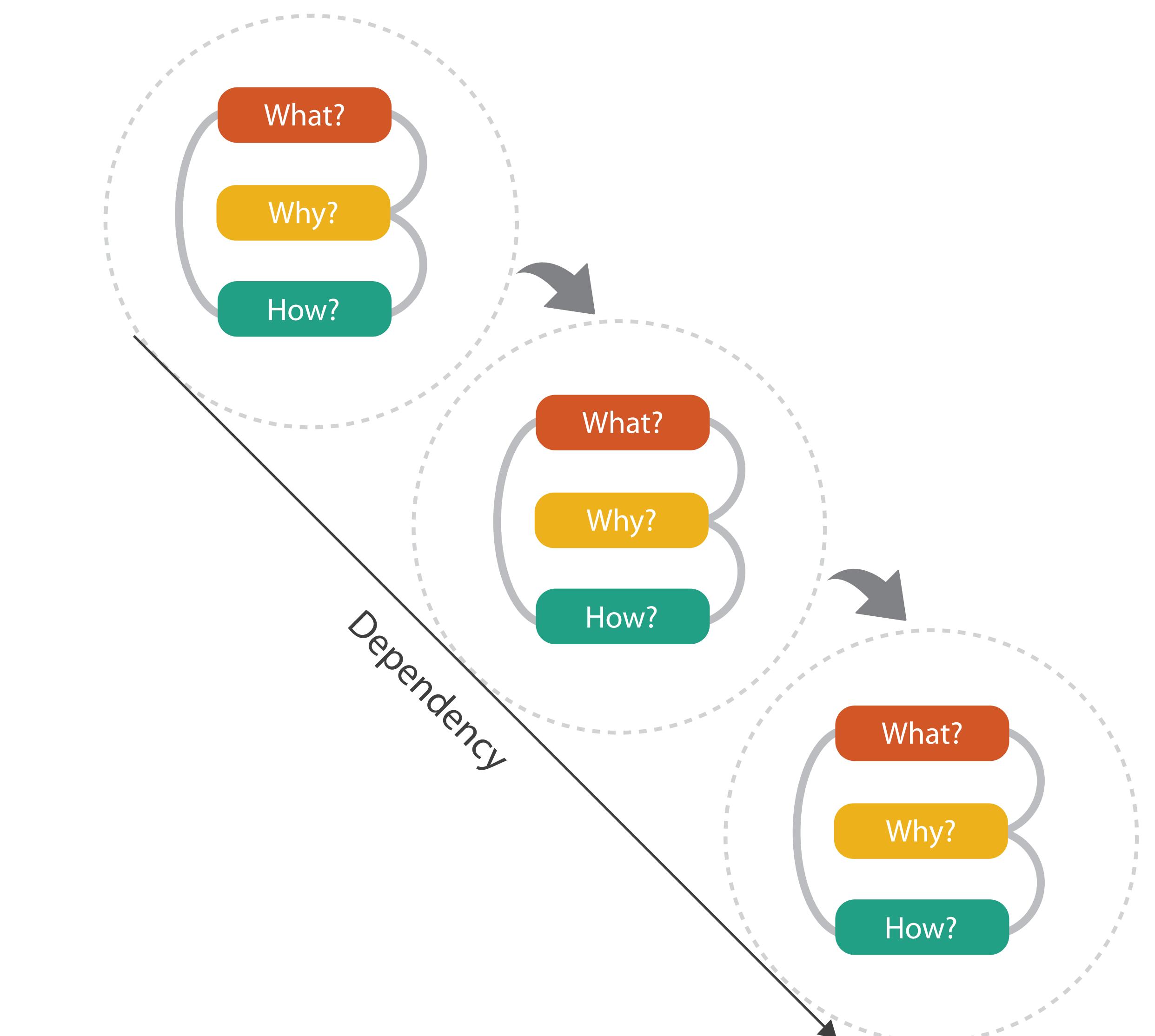
A typology of abstract visualization tasks

Why do people visualize data?

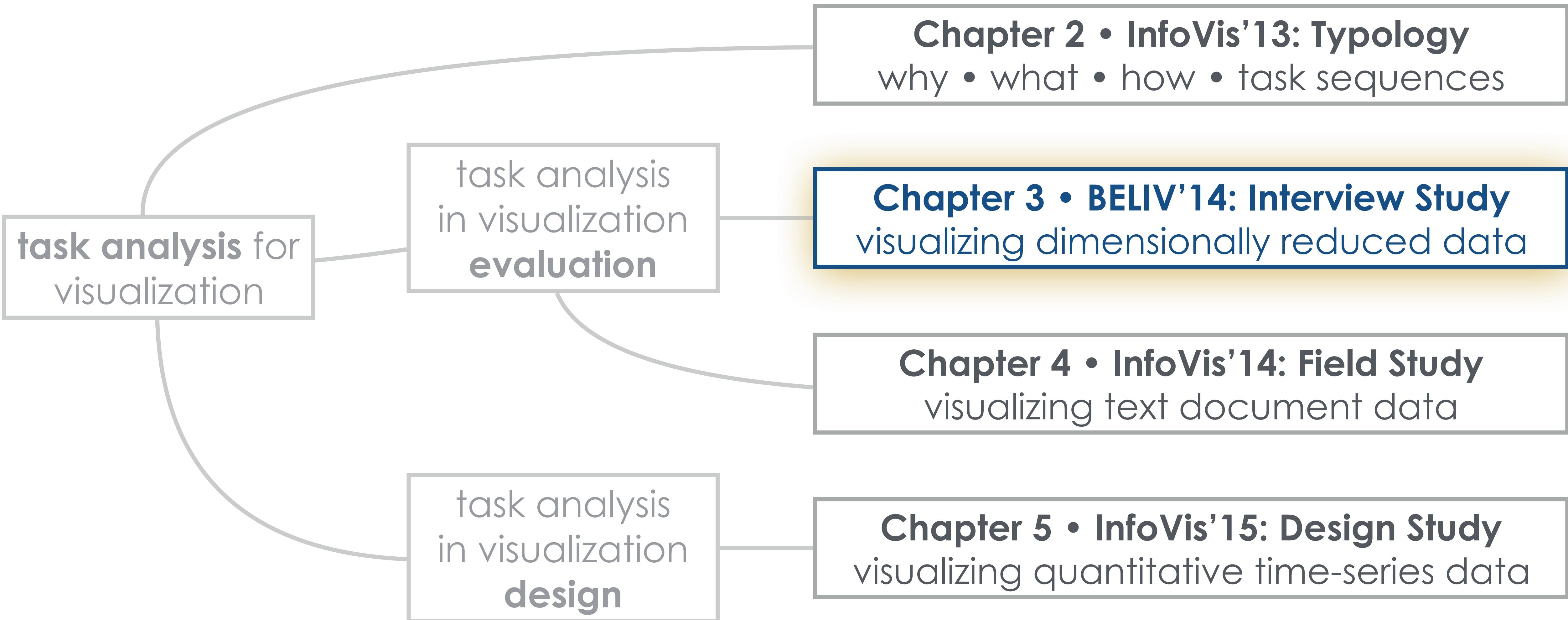
How is the task supported in terms of visual encoding and interaction, and view coordination design choices?

What are the **inputs** and **outputs** of a task?

Can we describe **task sequences**?



Outline

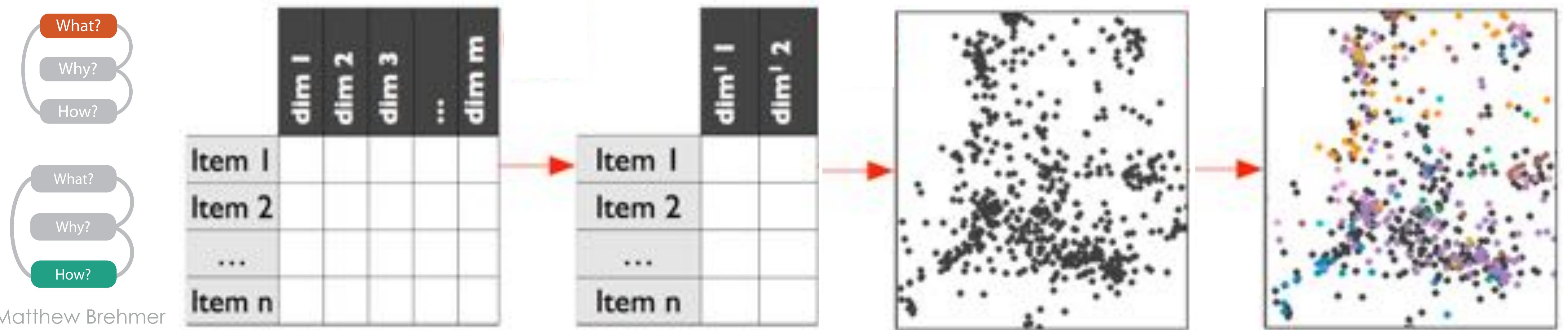
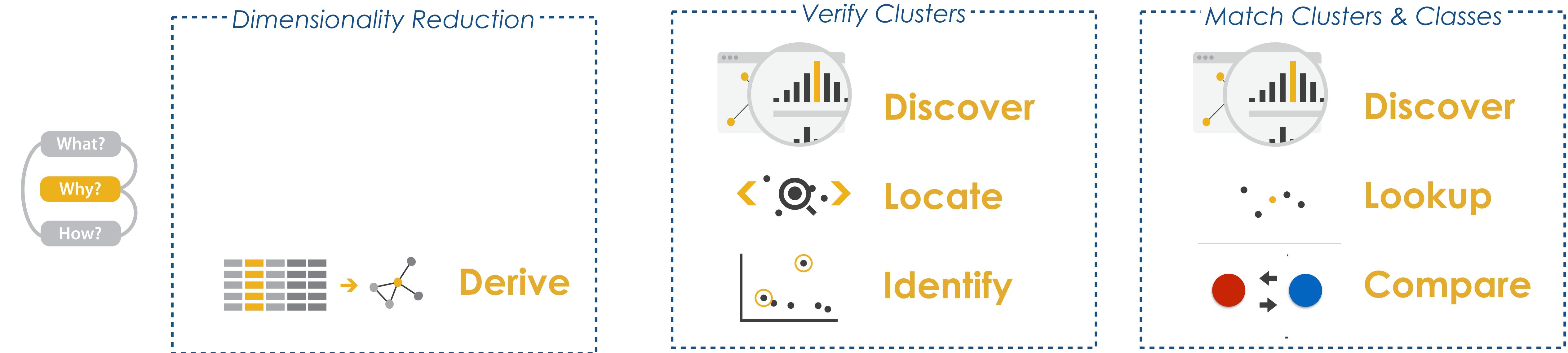


Chapter 3 • Interview Study

Visualizing dimensionally reduced data: Interviews with analysts and a characterization of task sequences

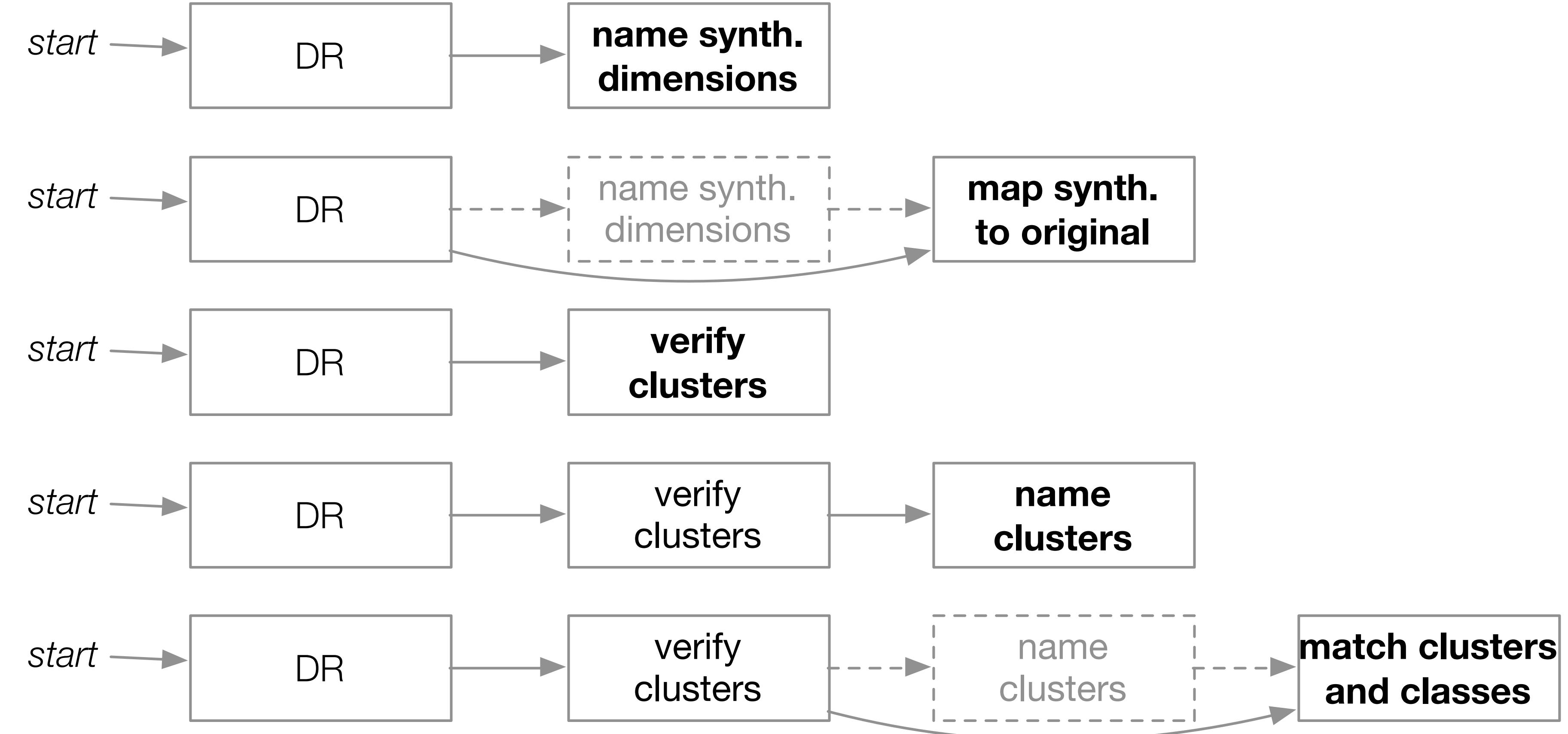
Brehmer, Sedlmair, Ingram, & Munzner. Proc. ACM **BELIV 2014**.

An example task sequence



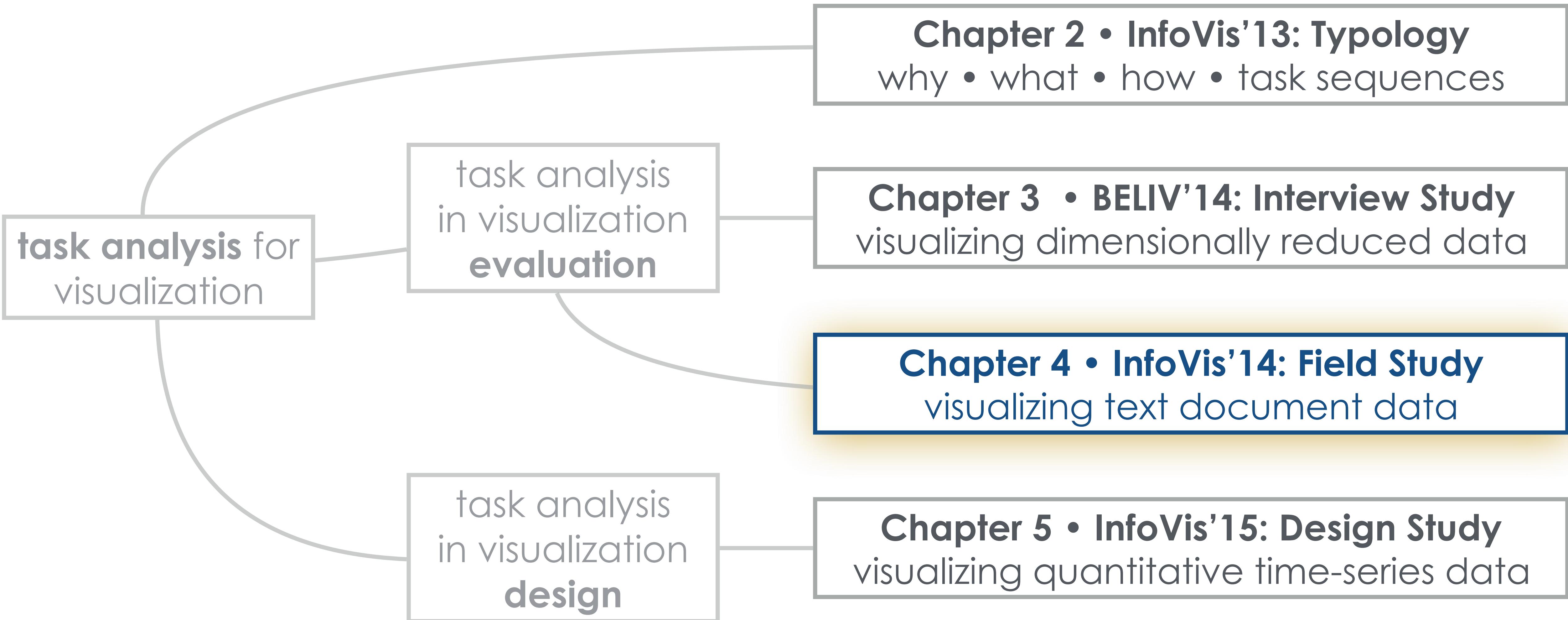
Visualization task sequences for DR data

Understanding
Synthetic
Dimensions



Understanding
Item
Clusters

Outline



Chapter 4 • **Field Study**

Overview: The design, adoption, and analysis of a visual document mining tool for investigative journalists

Brehmer, Ingram, Stray, & Munzner. IEEE TVCG / Proc. InfoVis 2014.

Adoption by journalists

The screenshot shows a web-based document management system. At the top, there's a navigation bar with links like 'Help' and 'Logout'. Below it is a search bar and a 'Back to list' button. The main area displays a hierarchical tree of documents. A specific document is selected, shown with its title: 'MMSIS_PDF_40_85_85'. The document content is visible, including a letter from the Honorable Jerry Moran, House of Representatives, Washington, D.C. 20515, dated February 3, 2009. The letter discusses energy policy and oil/gas development. The footer of the document includes a signature and the word 'Sincerely,' followed by a handwritten signature.

overviewdocs.com

What did private security contractors do in Iraq?

by Jonathan Stray on 02/21/2012 | 3 | Edit

AP

TPD working through flawed mobile system

By JARREL WADE World Staff Writer on Jun 3, 2012, at 2:19 AM

TULSAWORLD

RYAN ASKED FOR FEDERAL HELP AS HE CHAMPIONED CUTS

By JACK GILLUM — Oct. 12 7:20 PM EDT

AP

THE DAILY BEAST

Own a Gun? Tell Us Why

Michael Keller

The Brilliance of Louis C.K.'s Emails: He Writes Like a Politician

Where campaign strategy and comedy marketing collide

ADRIENNE LAFRANCE | JUL 16 2014, 6:10 AM ET

the Atlantic

Surprise! Many credit card agreements allow repossession

Analysis: 'Security interest' clause present on 200 cards

By Fred O. Williams



Private memo reveals winding tale involving John McCain, the NRA and ... condors

by Nancy Watzman

SEPT. 18, 2014, 1:59 P.M.

SUNLIGHT
FOUNDATION

Overview: A document mining tool

The screenshot shows the Overview document mining tool interface. At the top left is a navigation bar with "OVERVIEW" and links for "Blog", "Help", and "Contact us". The top right shows the user's email "jonathanstray@gmail.com", "Admin", "Your document sets", and "Log out". Below the navigation is a search bar with "Search all documents" and a dropdown menu. The main area displays three search results:

- letter, gas, oil, program, ocs, leases, royalty, sale, lesley, briefing
- letter, gas, program, oil, briefing, leases, ocs, royalty, lesley, decision
- letter, decision, program, comments, june, contact, leasing, oil_gas

Below these results is a search tree diagram. A node labeled "ALL: letter, urging, president" has two children: "ALL: letter, decision" and "ALL: t". Other nodes in the tree include "ALL: leases, meeting, contact, info, meeting, transitor, nap" and "ALL: letter, gas, oil, program, ocs, leases, royalty, sale, lesley, briefing".

The right side of the interface shows a detailed view of a specific document. The title is "MMS6 Pdf 22 51 52". The document is from "Hendry, Lynn" to "Nathaniel Wilson" on "Thursday, June 19, 2008 11:02 AM". The subject is "Response to 2-3-08 Letter". The body of the email reads:

Dear Nathaniel,

Please see the attached letter in response to Rep. Peters' 2-3-08 letter to President Obama, urging that the OCS be left open for oil and gas restoration. A hard copy will also be delivered to your office. If you have any questions, please do not hesitate to contact our office. Thank you!

Regards,

Lynn Hendry
Office of Congressional Affairs
Office of the Director
Minerals Management Service
U.S. Department of the Interior
T: (202) 208-6008
F: (202) 208-2968

At the bottom of the interface, there are links for "Tasks", "Create new task", and "Dashboard". The URL "https://staging.overviewproject.org/documents/1917#/" is visible at the bottom.

How Overview works:

Encode: tree

Navigate

Aggregate

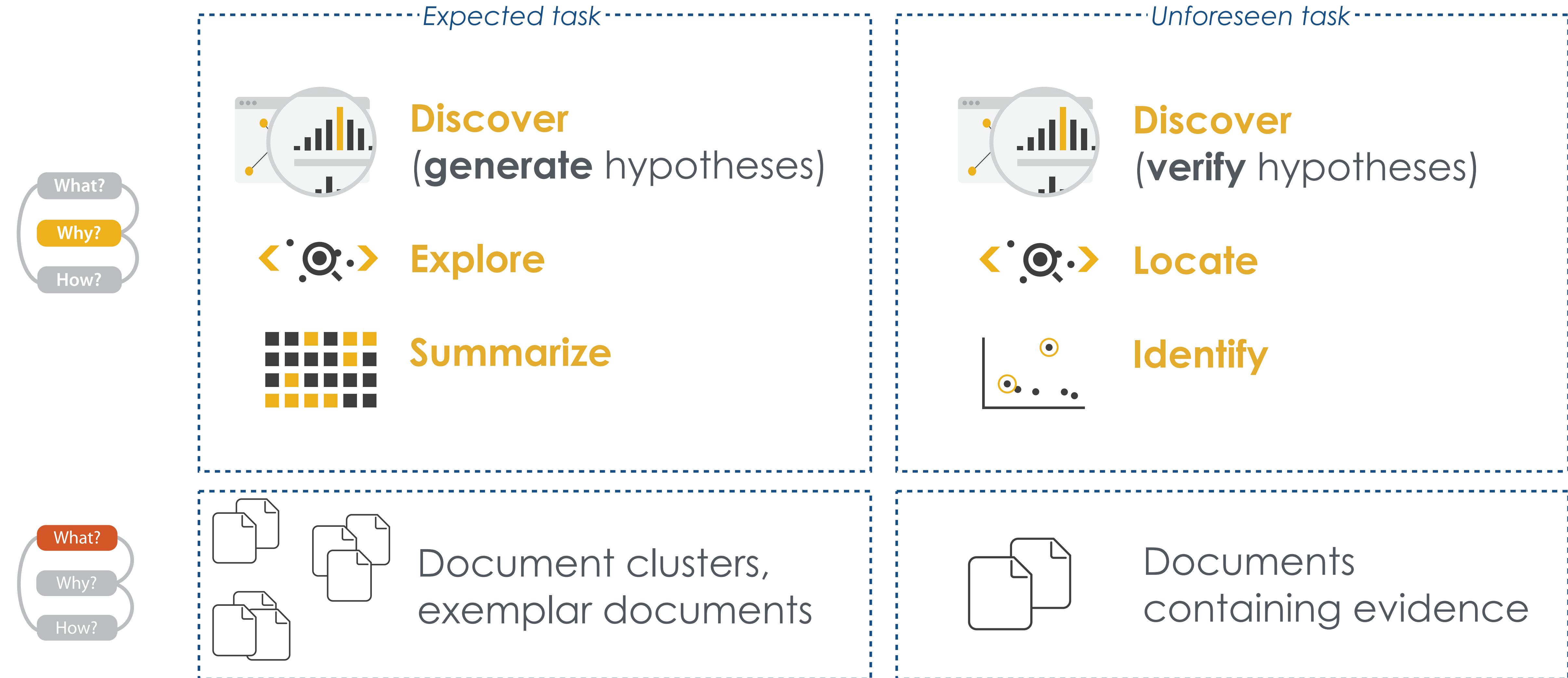
Select

What?

Why?

How?

Journalists' two document mining tasks



Lessons: Designing for document mining

Why show a tree?

Trees afford structured and systematic exploration.

How to show a tree?

Emphasize interior nodes (not edges or leaves); instil trust in the underlying algorithm.

How to interact with a tree?

Selective pruning and informative tooltips.

Why no scatterplot?

Unstructured exploration is redundant.

Why tags?

Tags provide simple annotation, progress tracking, and human-defined semantics.

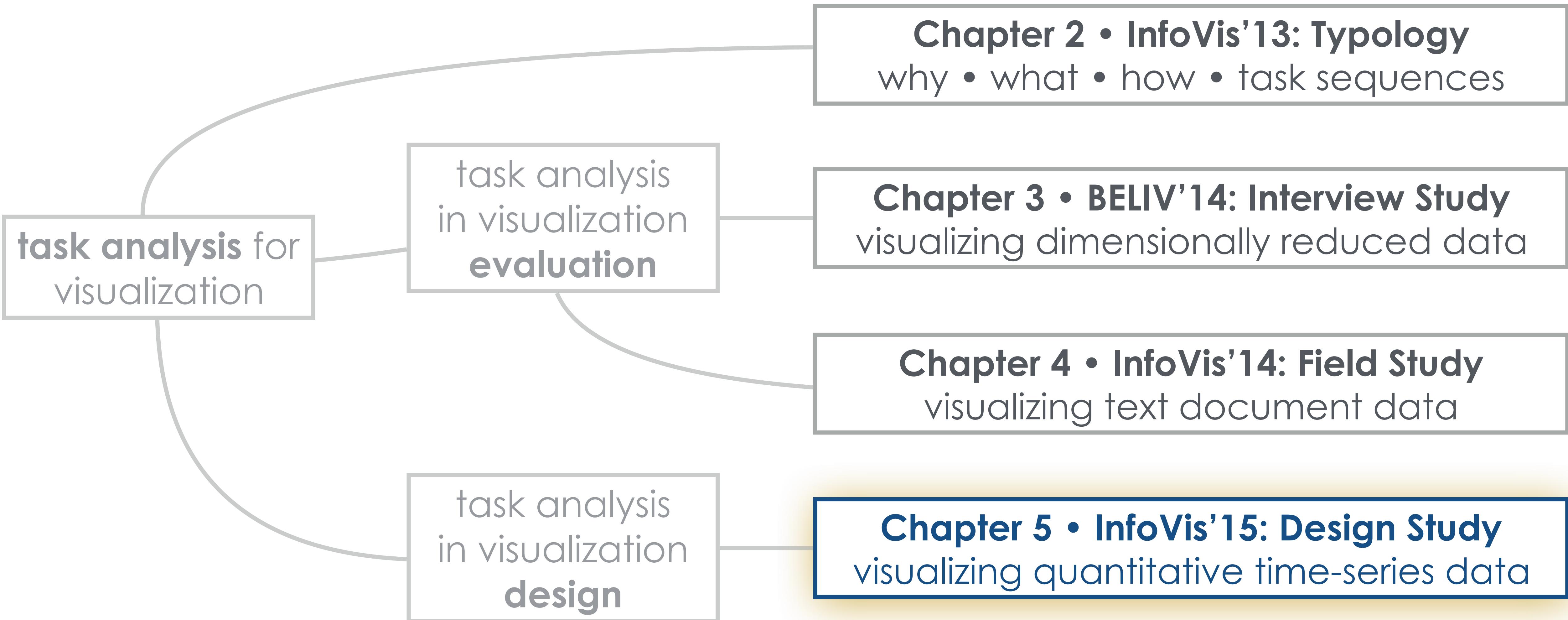
Multiple views: how many and how to coordinate?

Less is more; provide obvious affordances.

How to support workflows?

Simplify for infrequent use; reduce data wrangling.

Outline



Chapter 5 • Design Study

Matches, mismatches, & methods: Multiple view workflows for energy portfolio analysis

Brehmer, Ng, Tate, & Munzner. IEEE TVCG / Proc. InfoVis 2015.

Work domain analysis: Energy management

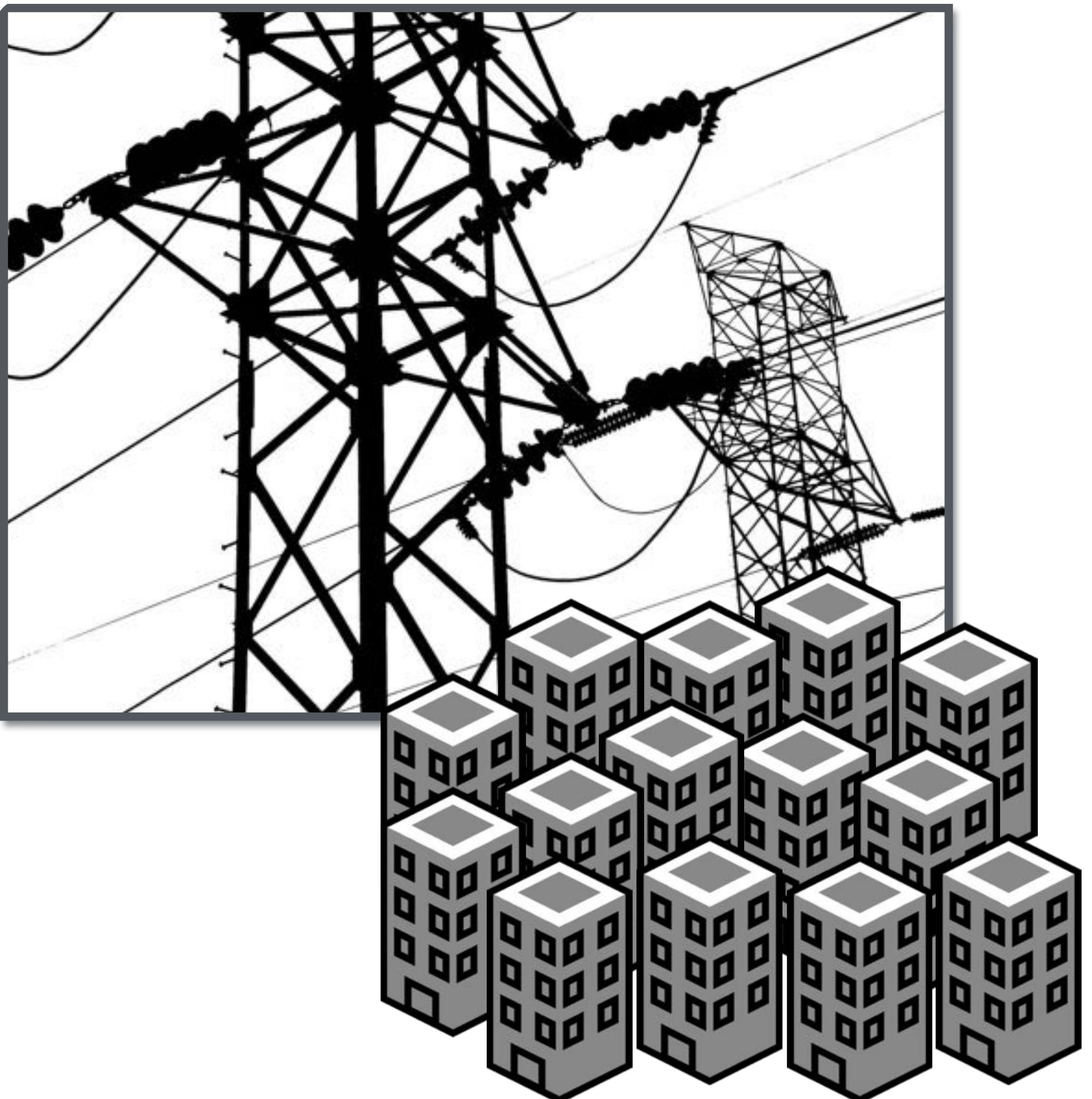
Given a **portfolio of buildings**:

Determine which buildings require energy conservation measures.

Assess the performance of buildings following the implementation of an energy conservation measure.

Find and diagnose anomalous energy performance.

Reduce consumption, **save money**.



Starting point: Previous tool

The diagram illustrates the starting point of a previous tool, organized into two main sections:

- Domains** (Orange section): Contains a red square icon and the text "Energy Management".
- Visual Encoding & Interaction Design Choices** (Green section): Contains a green eye icon and the text "superimposed line graphs" and "grouped bar charts".

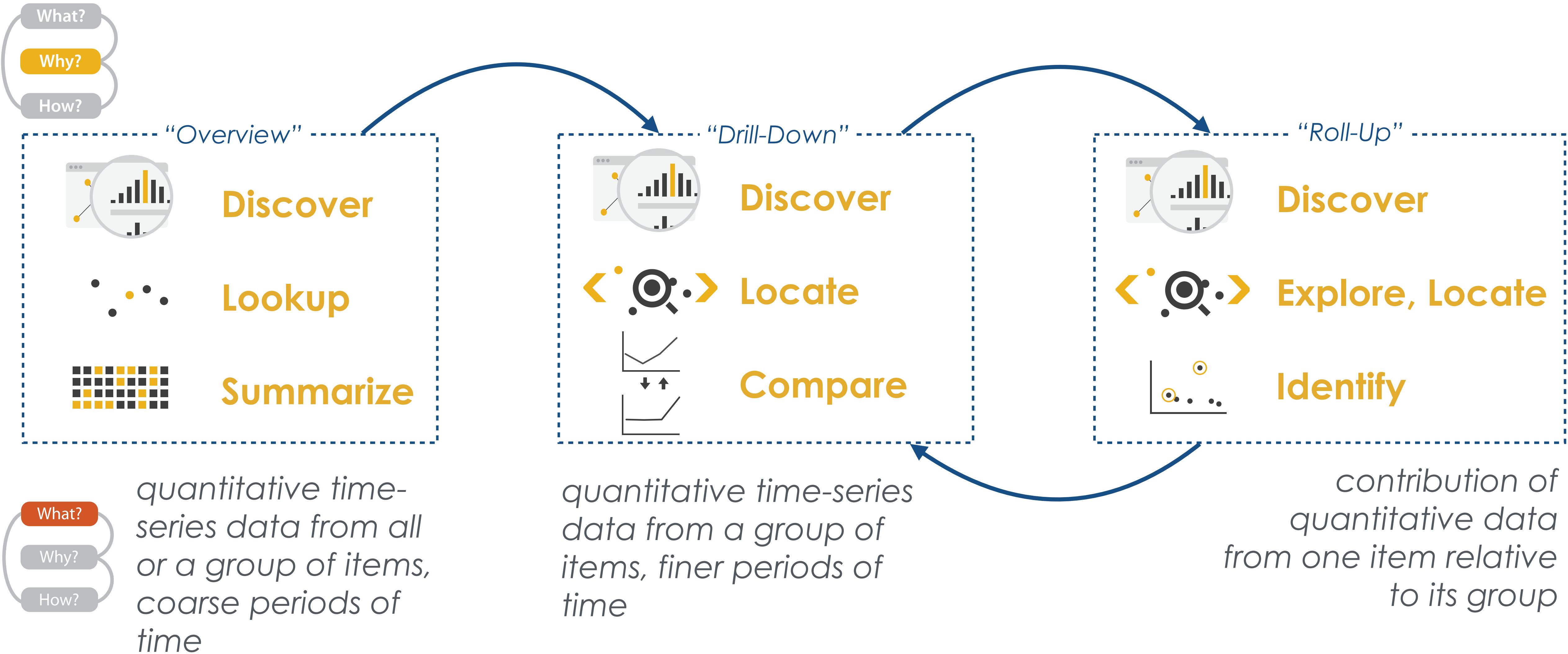
Two green arrows point from the "Visual Encoding & Interaction Design Choices" section to specific charts:

- An arrow points to a chart titled "superimposed line graphs", which displays multiple green line graphs representing energy usage over time.
- An arrow points to a chart titled "grouped bar charts", which displays grouped orange bars for one category and grouped teal bars for another across different time periods.

Below the charts, there is a date range from "2013-01-01" to "2013-03-31".

Page number 24 is located at the bottom center, and the date 16-03-23 is at the bottom right.

Energy management: task abstraction



Expanding the design space



Domains

Energy Management

...



Task & Data Abstractions

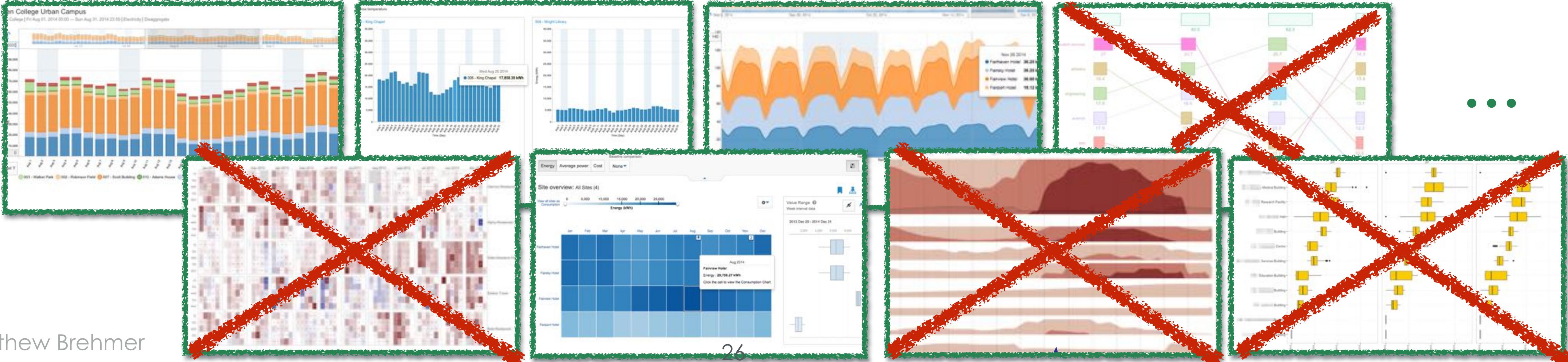
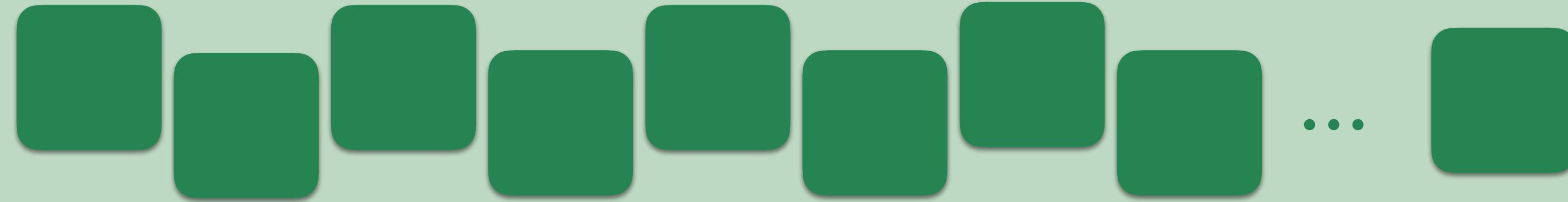
Overview

Drill-Down

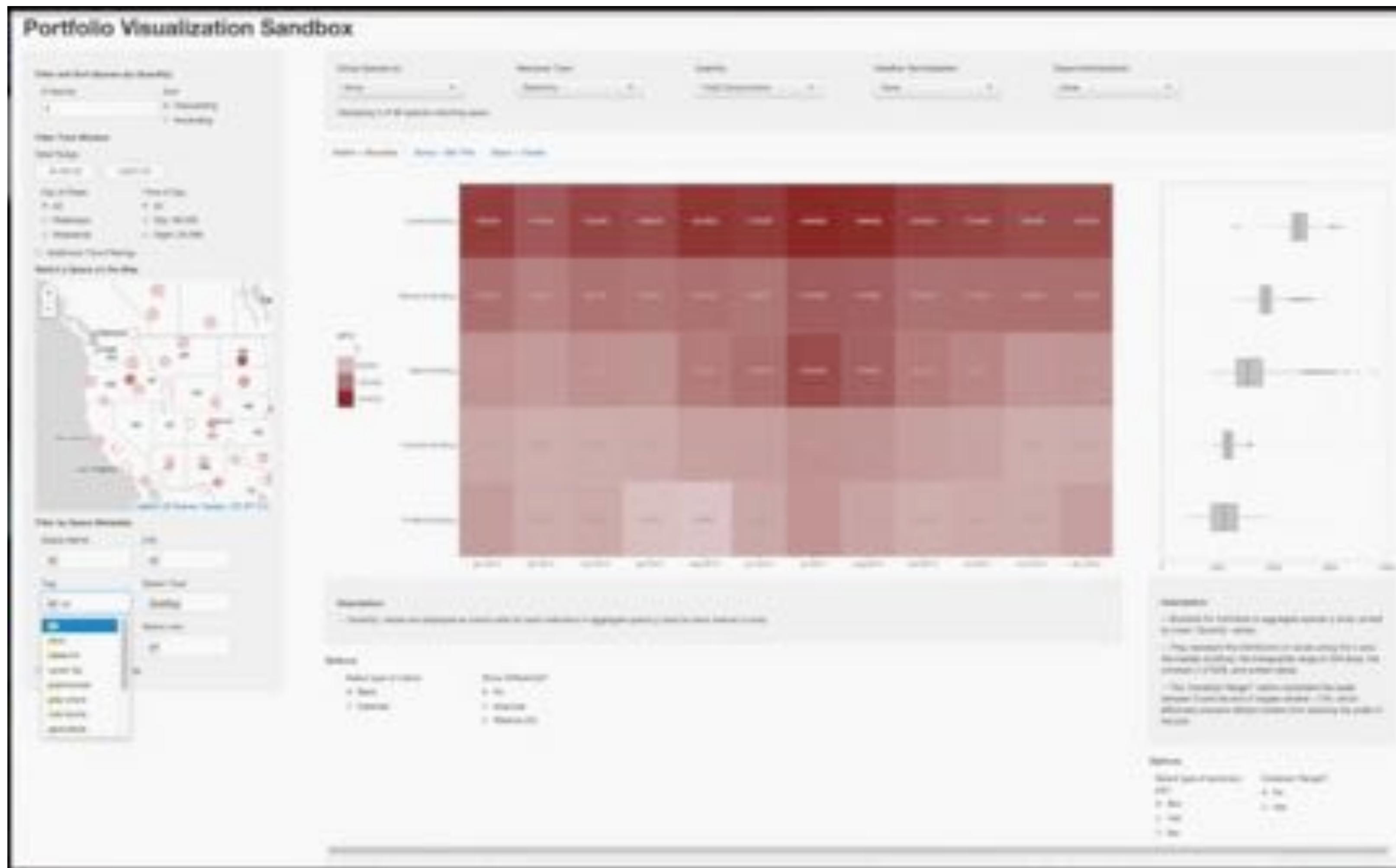
Roll-Up



Visual Encoding & Interaction Design Choices



Sandbox prototyping



Energy management
visualization **sandbox**.

Narrowing in on good matches

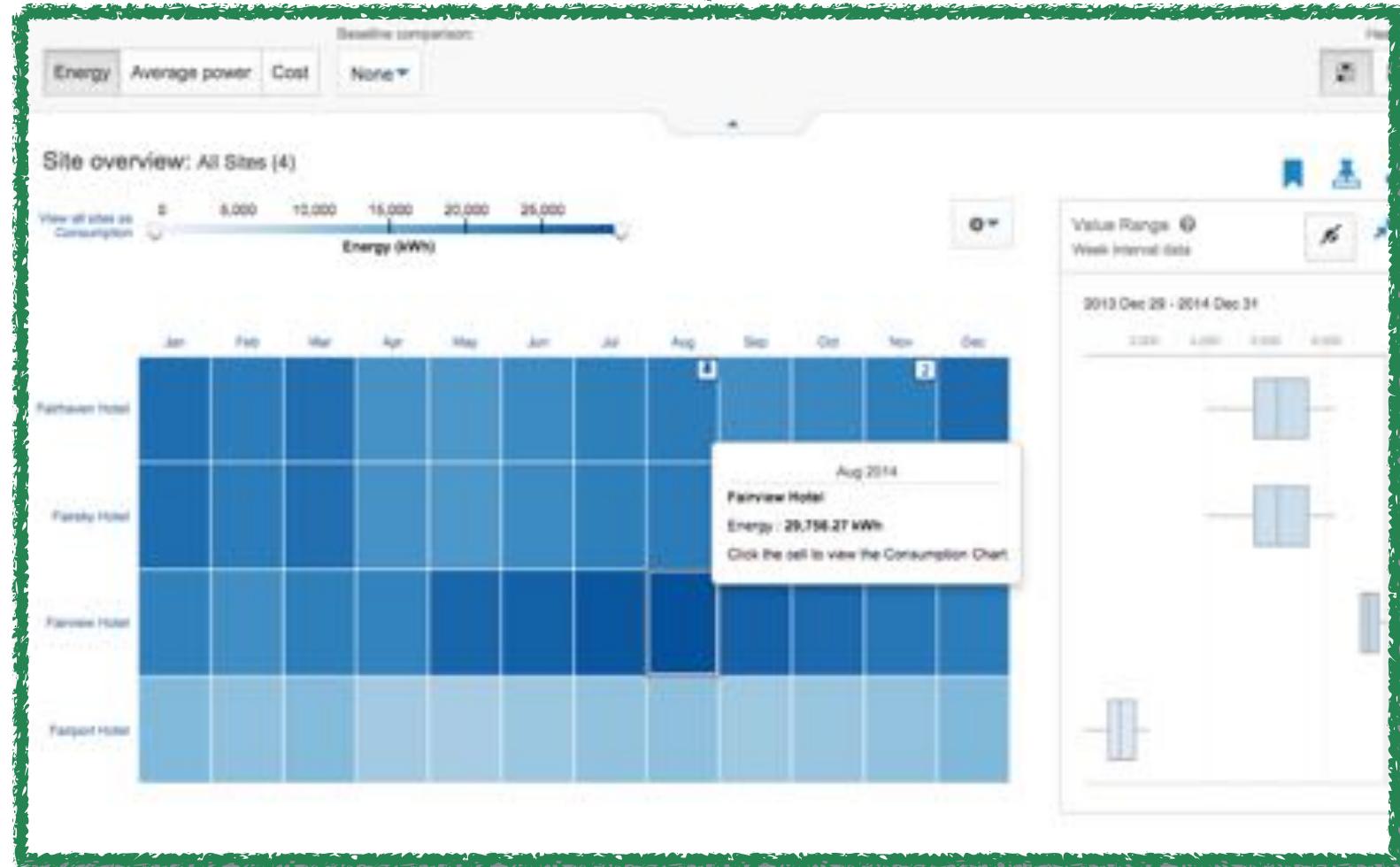


Task & Data Abstractions

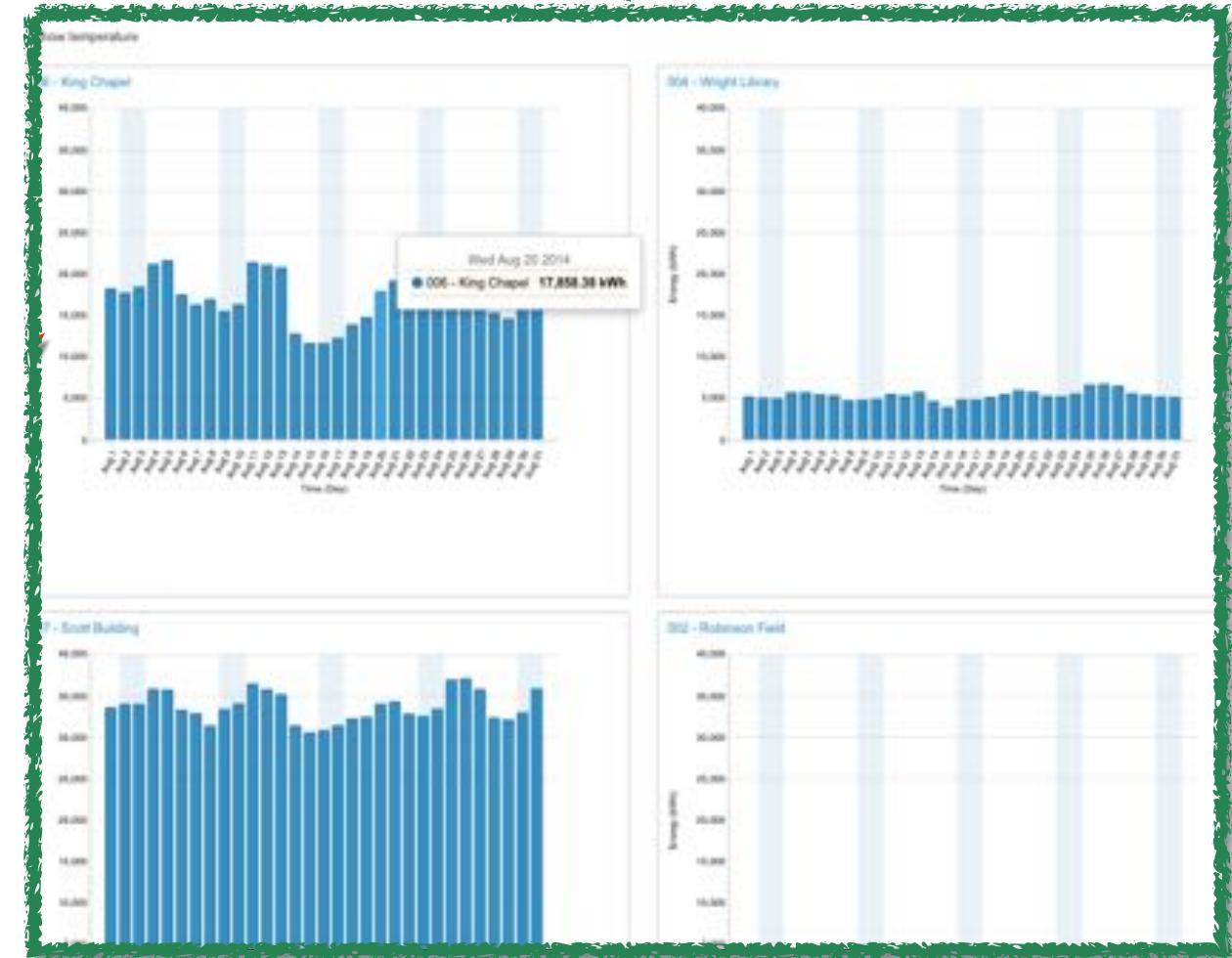


Visual Encoding & Interaction Design Choices

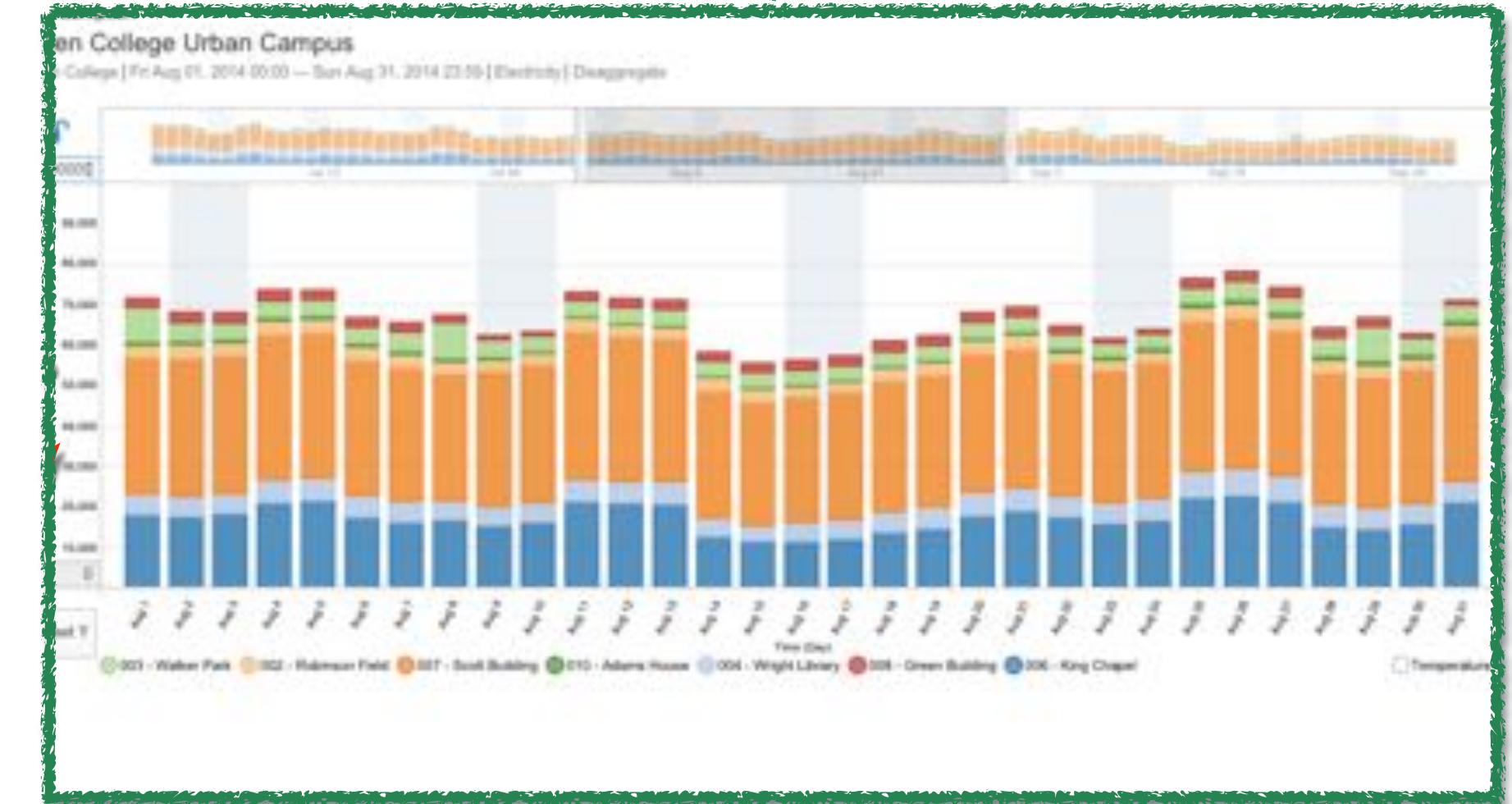
matrix
+ boxplots



faceted
bar charts

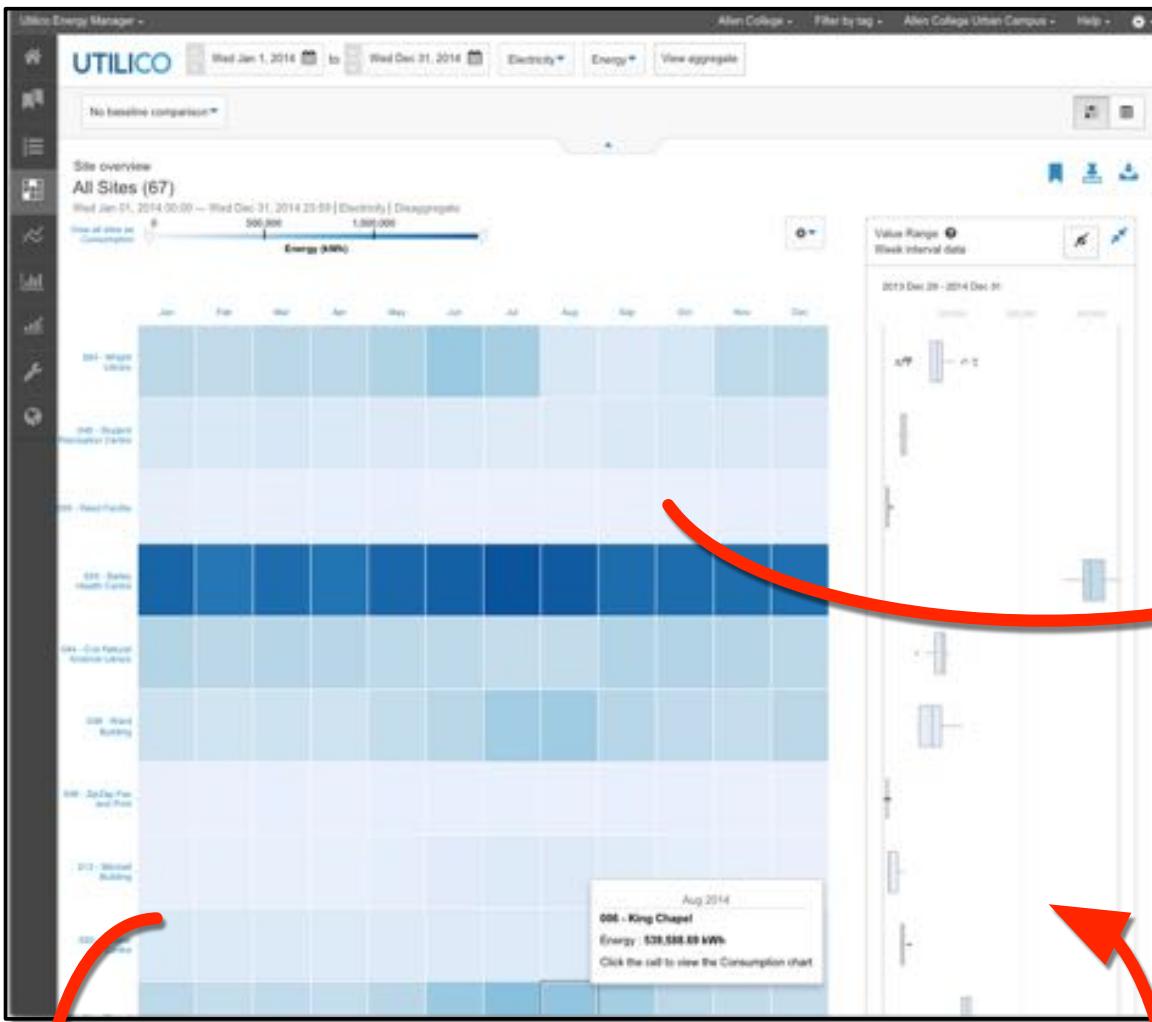


stacked
bar chart



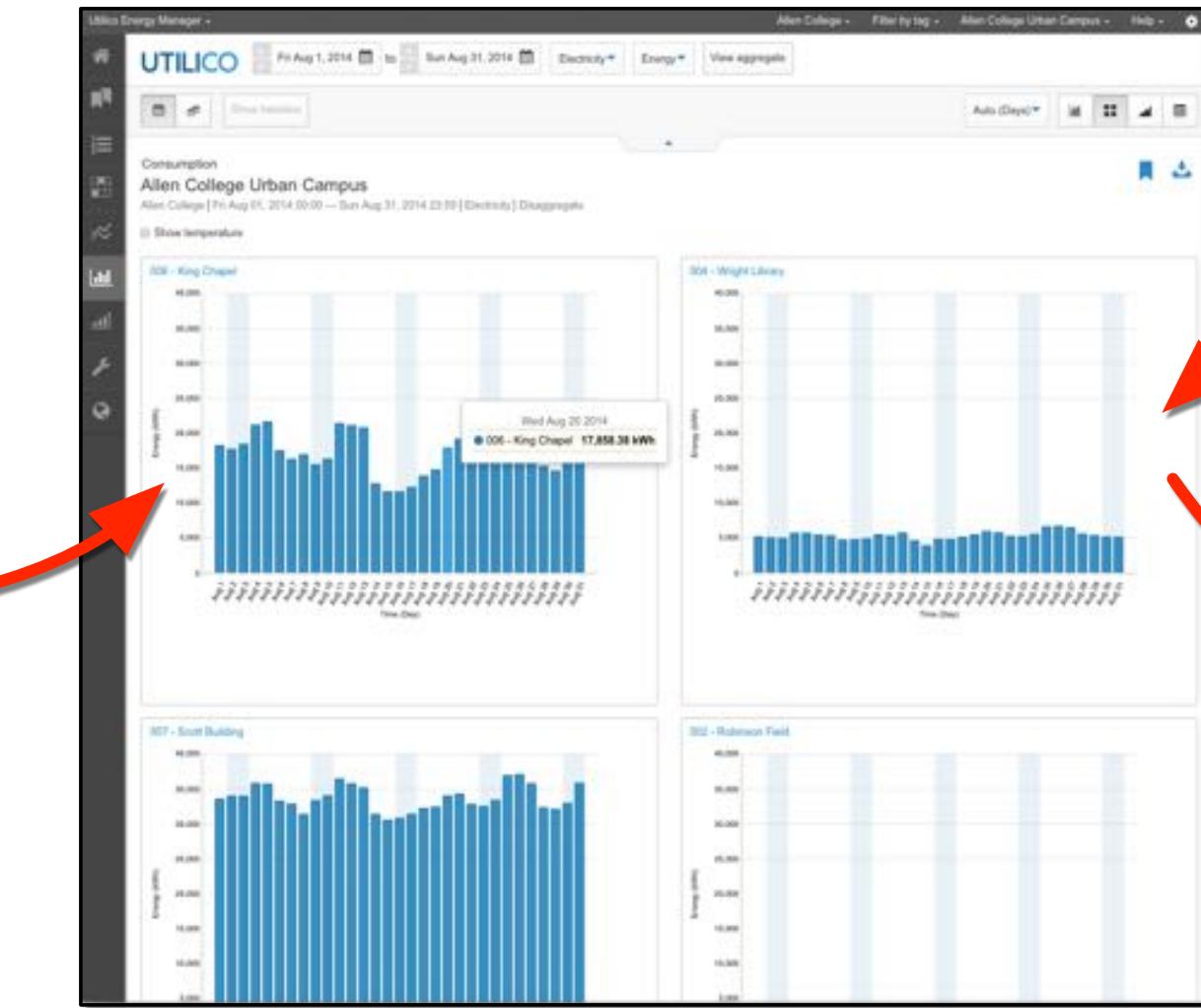
Resulting design

MATRIX + BOXPLOTS: *consumption*



OVERVIEW (T1)

FACETED BAR CHARTS: *consumption*

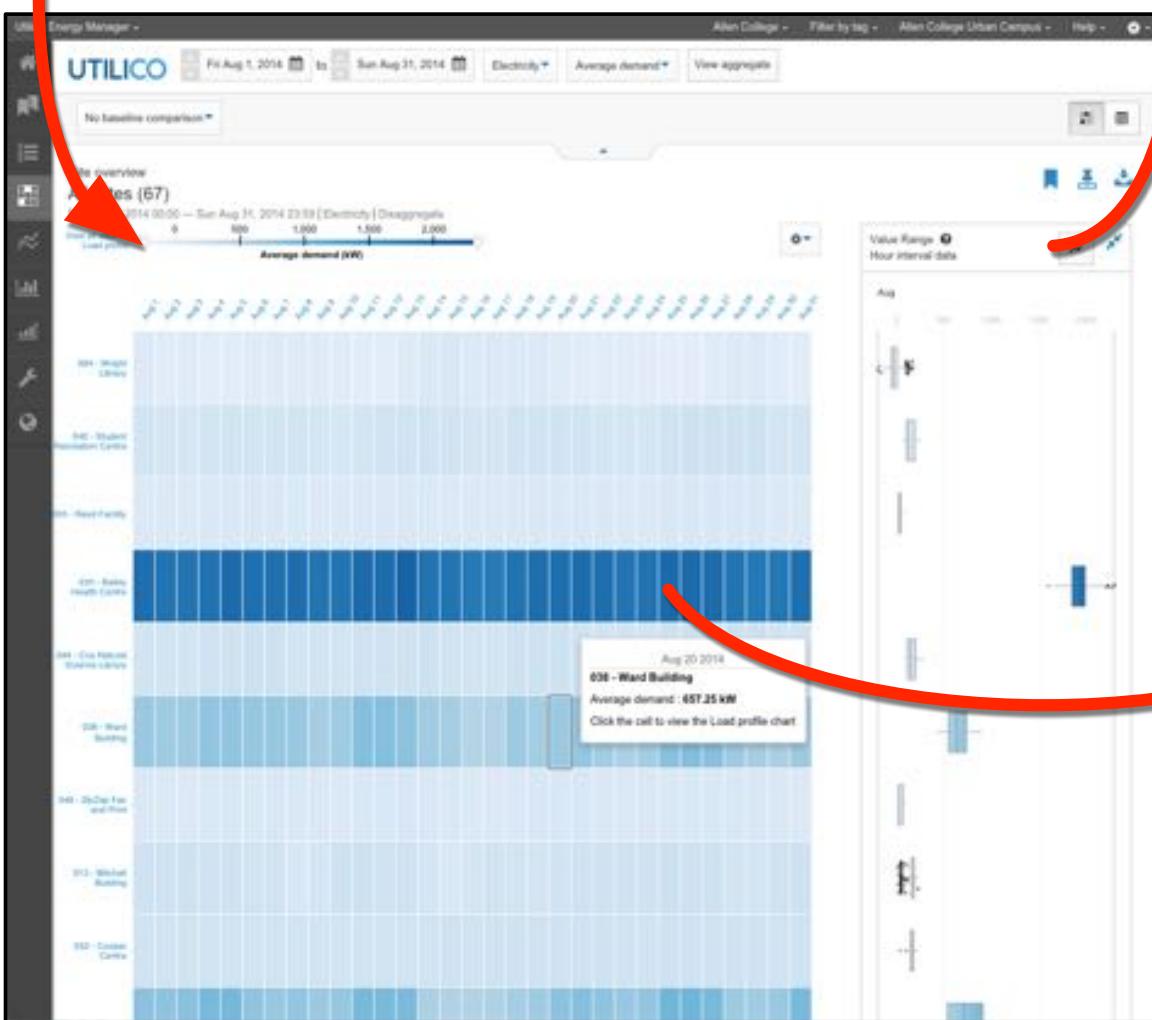


DRILL DOWN (T2)

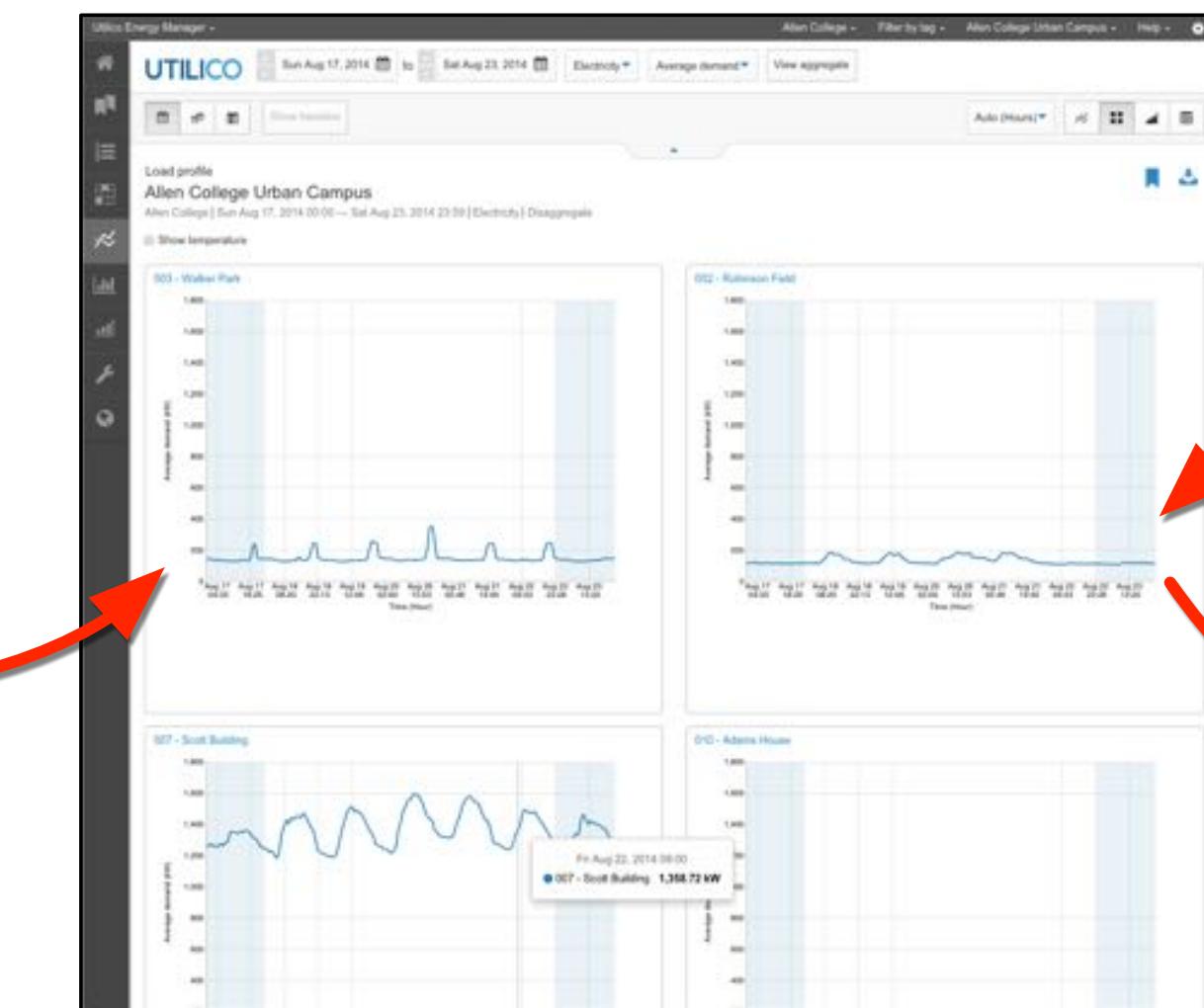
STACKED BAR CHART: *consumption*



ROLL UP (T3)



MATRIX + BOXPLOTS: *demand*



FACETED LINE CHARTS: *demand*



STACKED AREA CHART: *demand*

Chapter 6

Reflection & Conclusion

Reflection: Impact of our task typology

Chapter 2 • InfoVis'13: Typology

why • what • how • task sequences

Chapter 3 • BELIV'14: Interview Study

visualizing dimensionally reduced data

Chapter 4 • InfoVis'14: Field Study

visualizing text document data

Chapter 5 • InfoVis'15: Design Study

visualizing quantitative time-series data

Impact on the visualization community (70 citations^{*}):

Impact on teaching:
In syllabi at 5+ universities

Total citations
Cited by 70



Scholar articles

A multi-level typology of abstract visualization tasks
M Brehmer, T Munzner - ... and Computer Graphics, IEEE Transactions on, 2013

* Google Scholar, March 2016

Reflection: Impact of the interview study

Chapter 2 • InfoVis'13: Typology

why • what • how • task sequences

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Chapter 5 • InfoVis'15: Design Study

visualizing quantitative time-series data

Documenting visualization **in the wild**.

Deliberate design support for these task sequences in **Probing Projections**
[Stahnke et al. 2016]

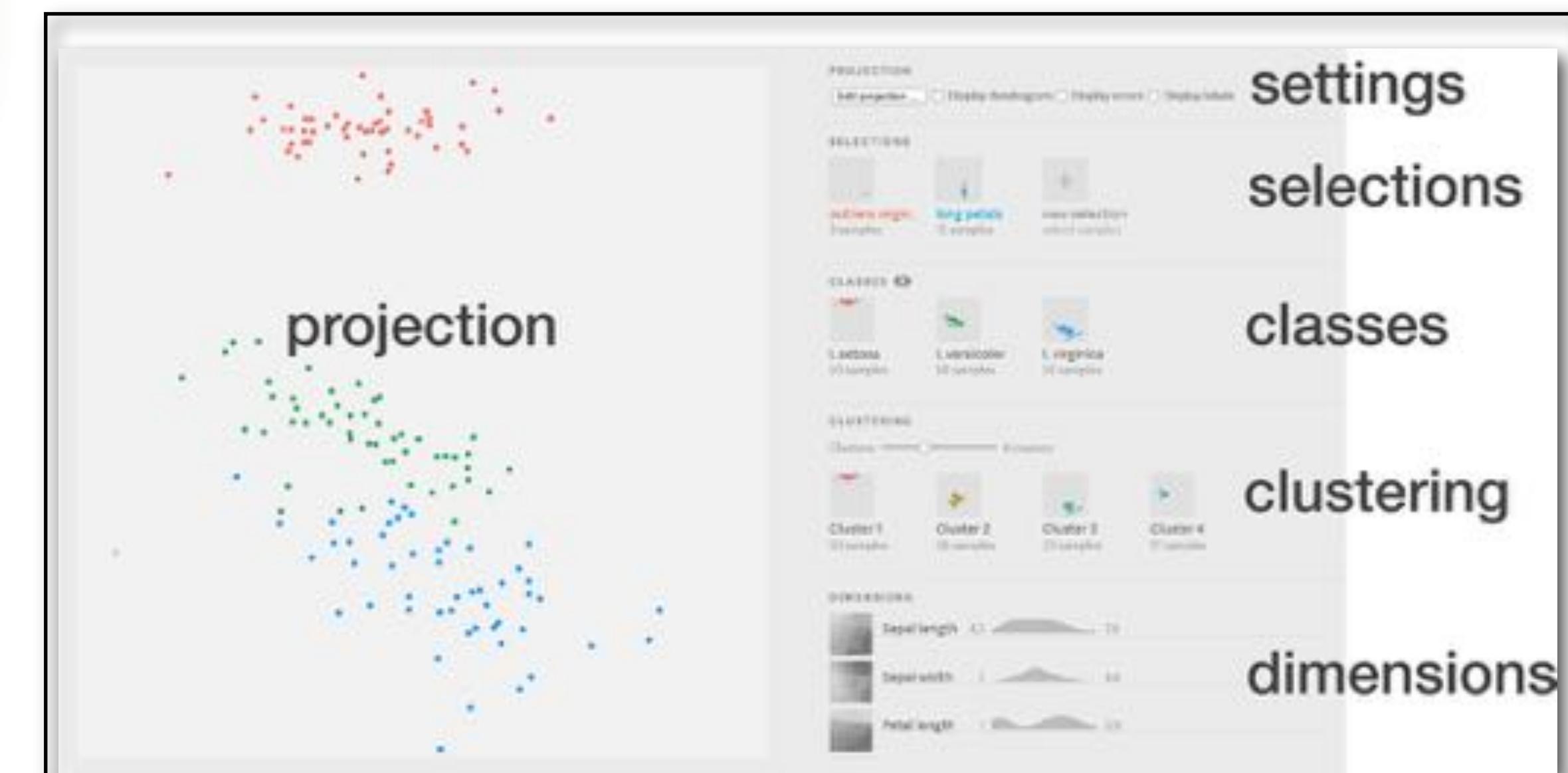


Image: Stahnke et al. (2016)

Reflection: Impact of the field study

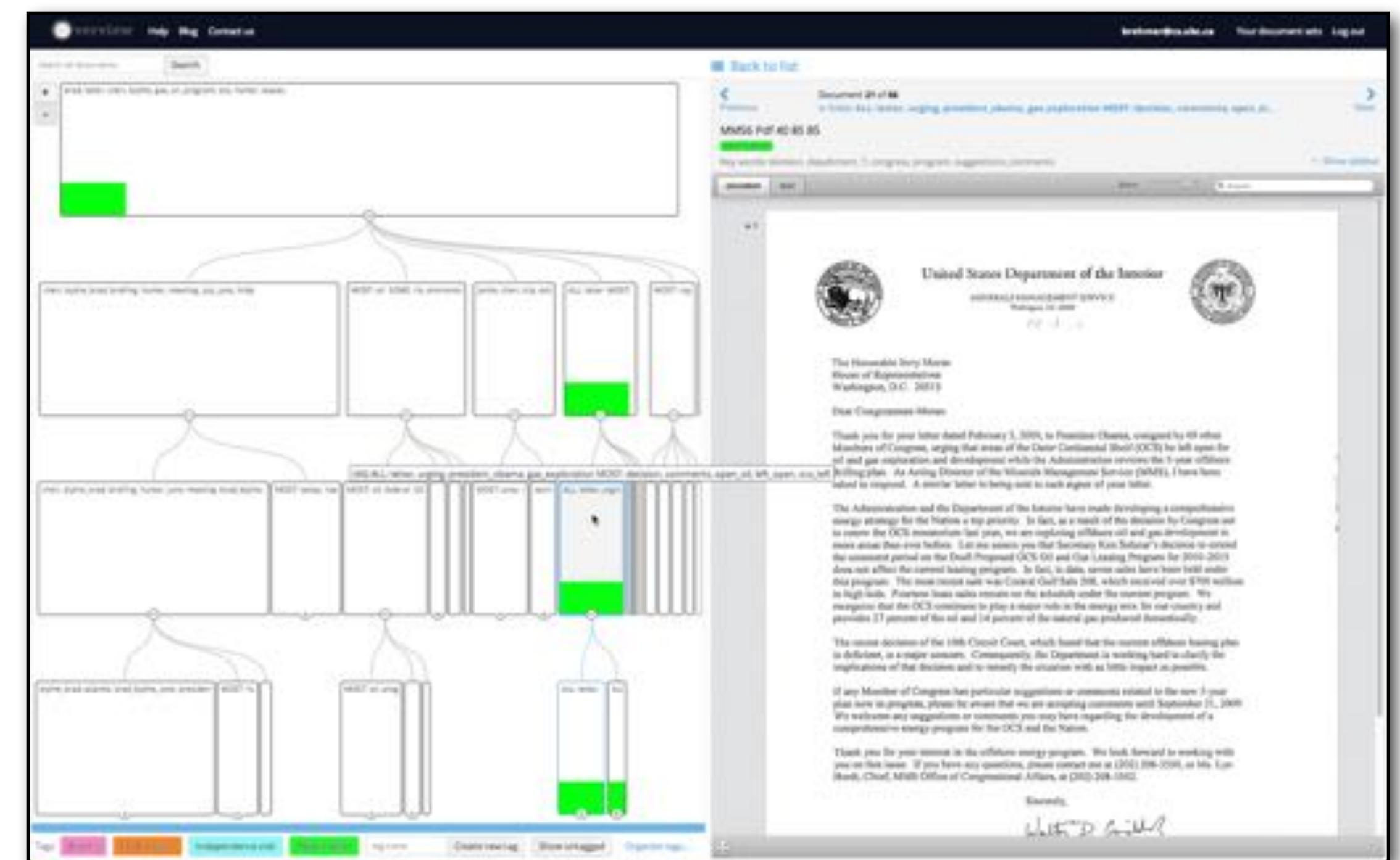
Chapter 2 • InfoVis'13: Typology
why • what • how • task sequences

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visualizing dimensionally reduced data

Chapter 4 • InfoVis'14: Field Study
visualizing text document data

Chapter 5 • InfoVis'15: Design Study
visualizing quantitative time-series data

One of the few studies documenting
adoption in the visualization literature.



Reflection: Impact of the design study

Chapter 2 • InfoVis'13: Typology

why • what • how • task sequences

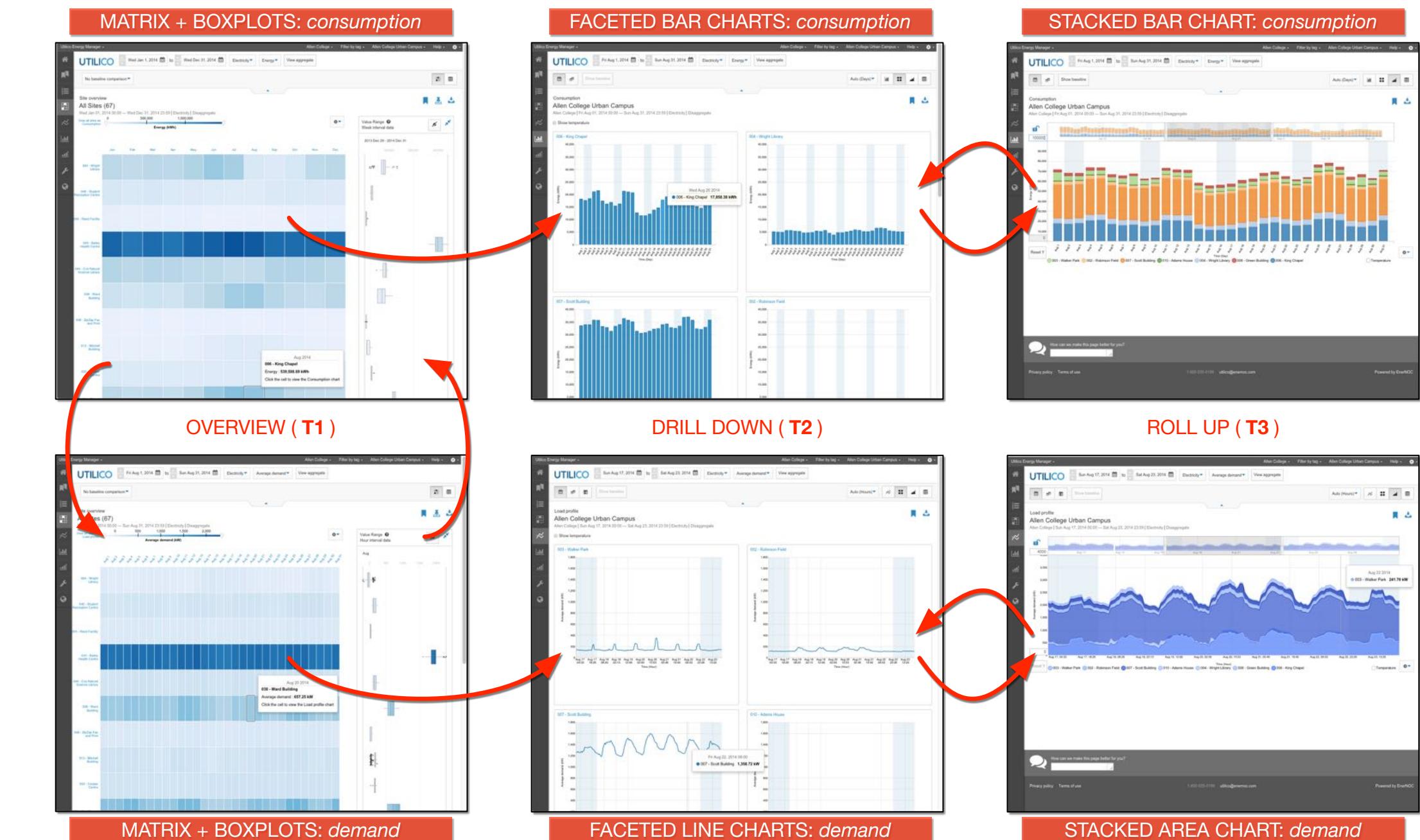
Chapter 3 • BELIV'14: Interview Study
visualizing dimensionally reduced data

Chapter 4 • InfoVis'14: Field Study
visualizing text document data

Chapter 5 • InfoVis'15: Design Study
visualizing quantitative time-series data

Adoption of another variety.

Future work: view coordination with unfamiliar visual encodings.



Summary of contributions

Chapter 2 • InfoVis'13: Typology

why • what • how • task sequences

- Task typology
- Literature synthesis

Chapter 3 • BELIV'14: Interview Study

visualizing dimensionally reduced data

- Documenting visualization *in the wild*
- Datatype-specific task classification

Chapter 4 • InfoVis'14: Field Study

visualizing text document data

- Documenting visualization adoption
- Task abstractions for document mining
- Seven lessons for supporting these tasks

Chapter 5 • InfoVis'15: Design Study

visualizing quantitative time-series data

- Task abstractions for energy portfolio analysis
- Design choices: Matches & mismatches
- Reflection: Familiarity & trust, methodology

Matthew Michael Brehmer
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Thanks:

March 23, 2016
PhD Defence

Why Visualization?

Task Abstraction for Analysis & Design

supervisory committee: Tamara Munzner, Joanna McGrenere, Ron Rensink
examination committee: Jason Dykes, Giuseppe Carenini, Alfred Hermida
examination chair: Luanne Freund

co-authors: Tamara Munzner, Stephen Ingram, Michael Sedlmair, Jonathan Stray, Jocelyn Ng, Kevin Tate
others: InfoVis & MUX groups 2011 – 2015.

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