Pixel-Adaptive Visual Comparison Between Many Phylogenetic Trees

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Department of Computer Science
University of British Columbia

Asilomar Microcomputer Workshop #50
25 Apr 2024

http://www.cs.ubc.ca/~tmm/talks.html#amw24

DESIGNING for PEOPLE

CAIDA

UBC Data Science Institute

@tamara@vis.social

@tamaramunzner

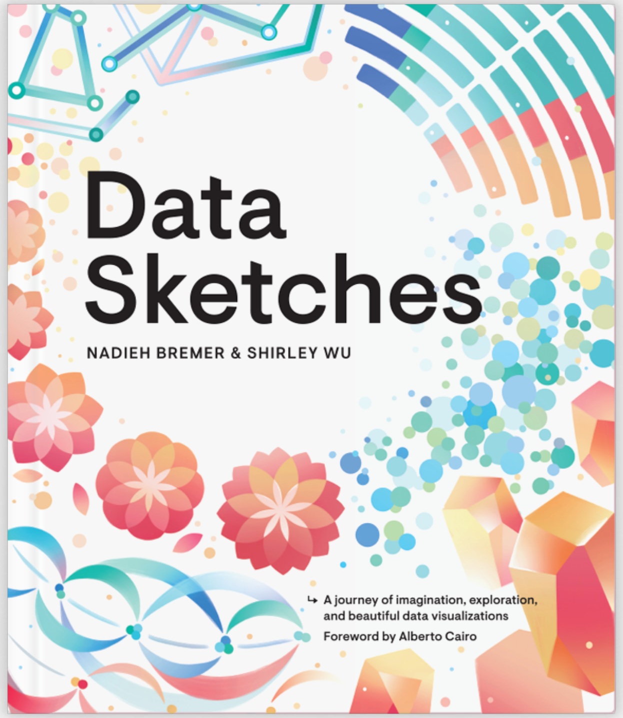
Hi again, 15 years later!

- still doing data visualization
  - yet more papers / projects / videos / software
  - I edit a book series

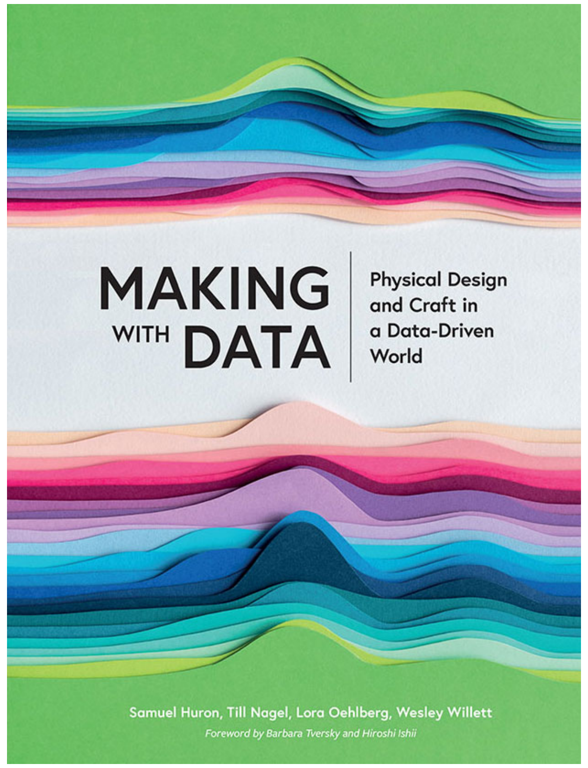
http://www.cs.ubc.ca/~tmm/talks.html#amw24

Visualization book series highlights

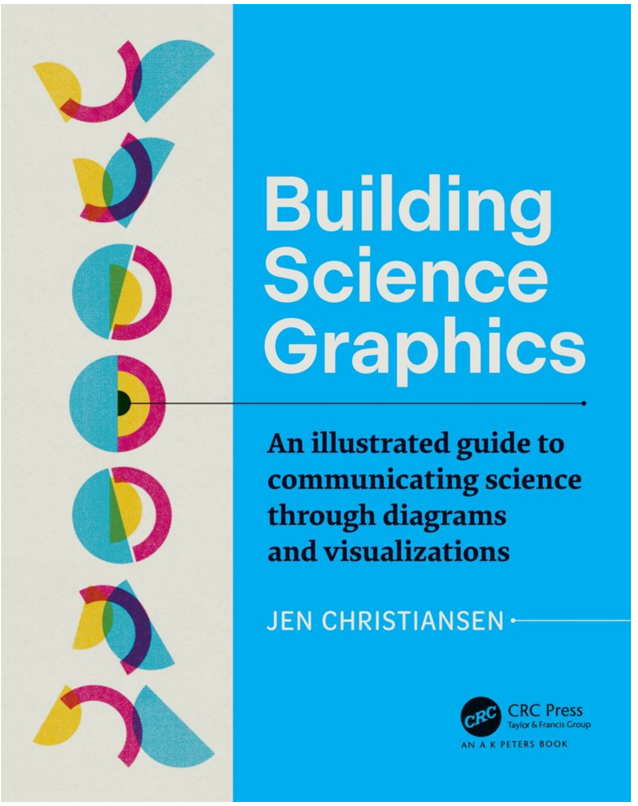
- Data Sketches, by Nadieh Bremer & Shirley Wu



- Making with Data, by multitudes



- Building Science Graphics, by Jen Christiansen



https://www.routledge.com/AK-Peters-Visualization-Series/book-series/CRCVIS

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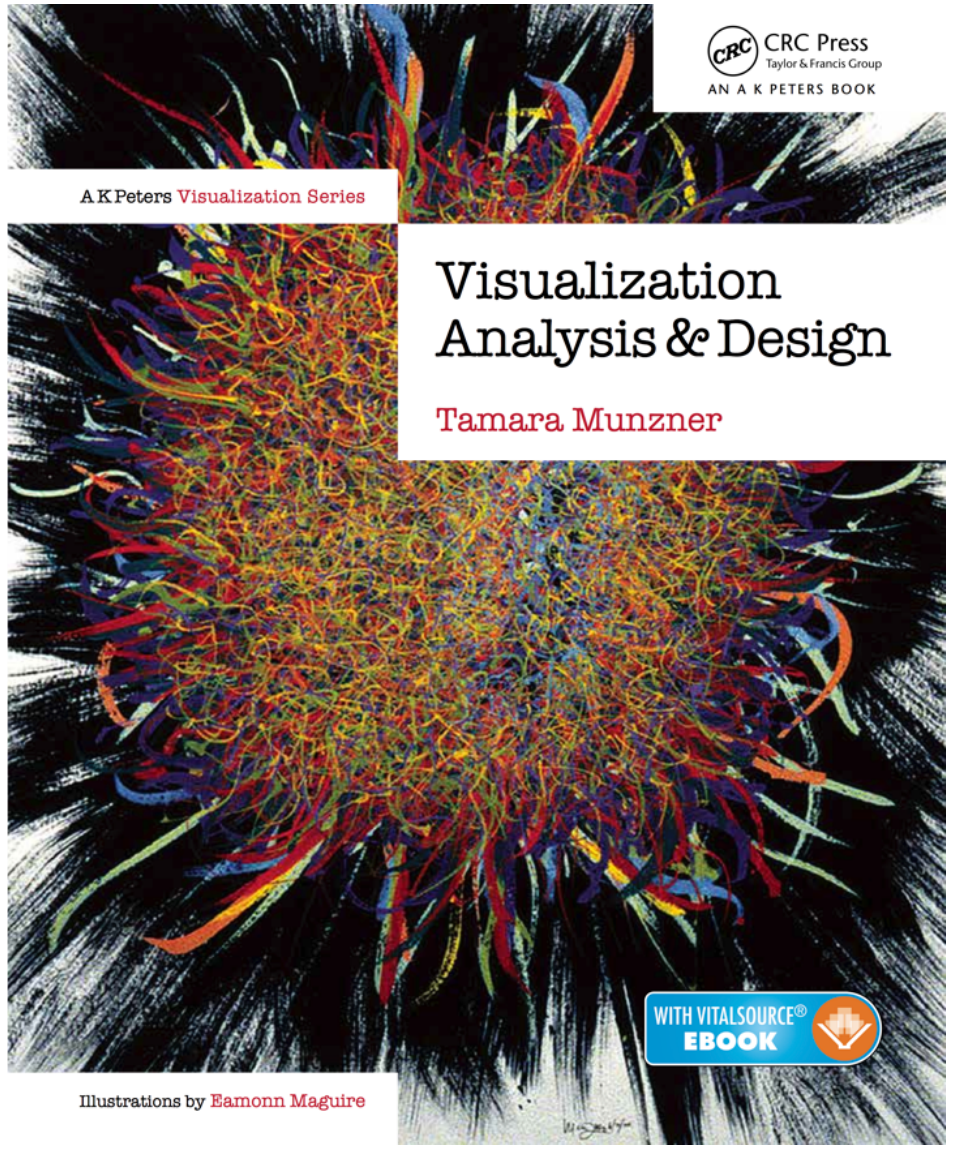

Visualization Analysis and Design. Munzner. *CRC Press, AK Peters Visualization Series, 2014.*

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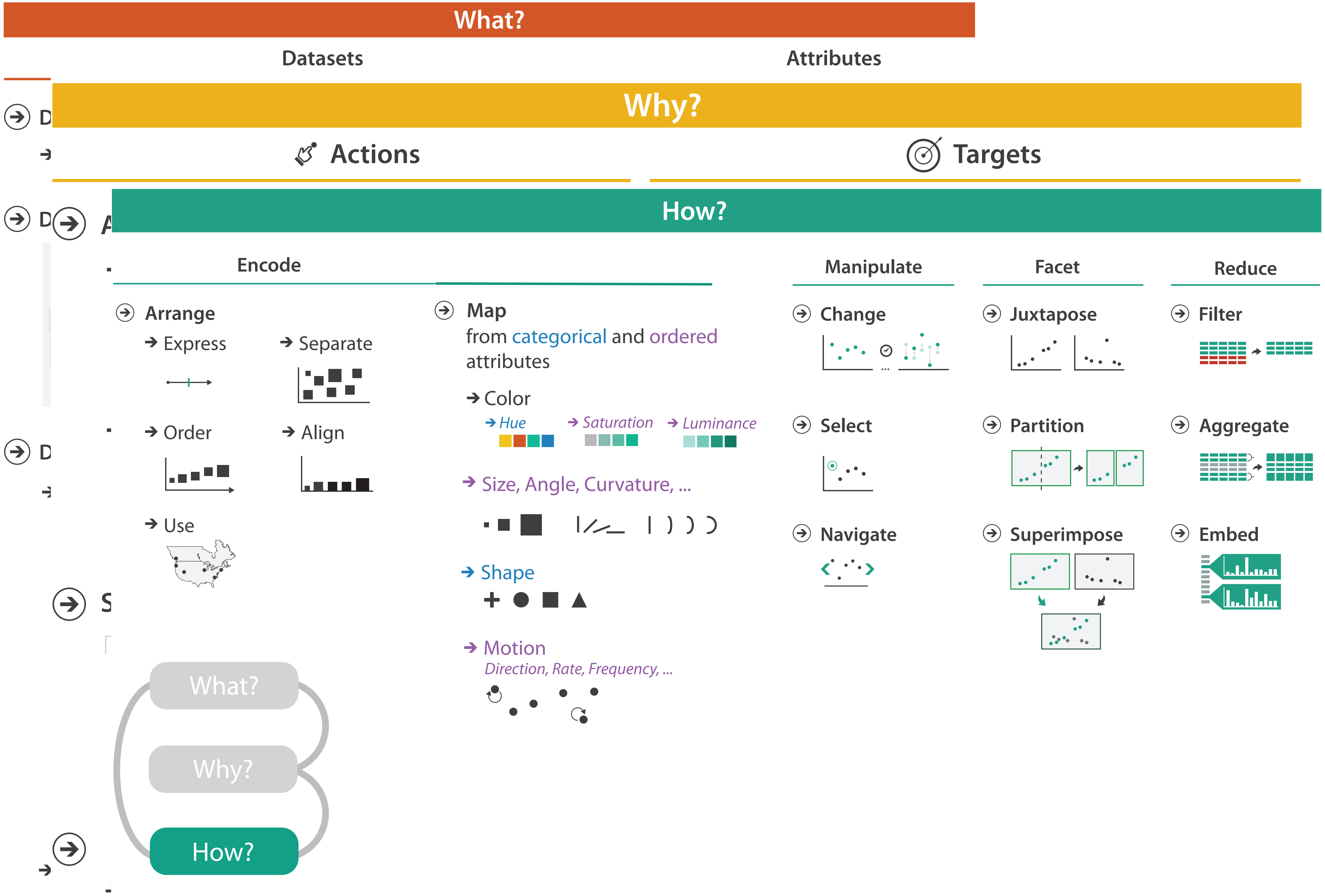
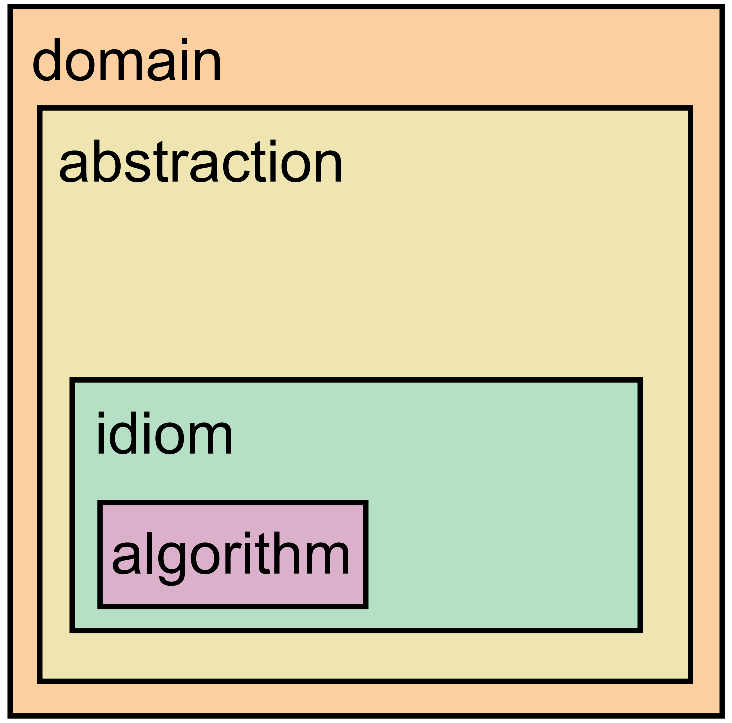
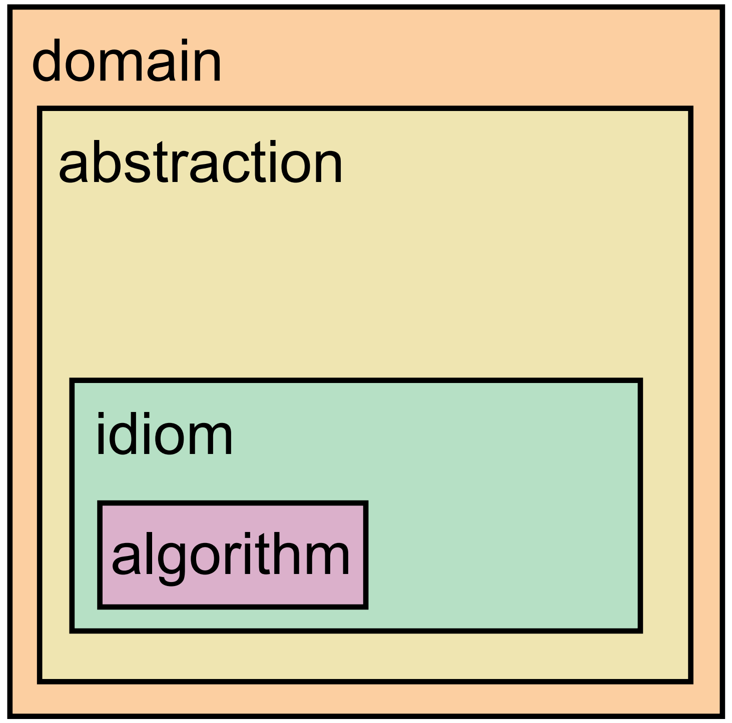
Visualization Analysis & Design book





Nested model: Four levels of visualization concerns



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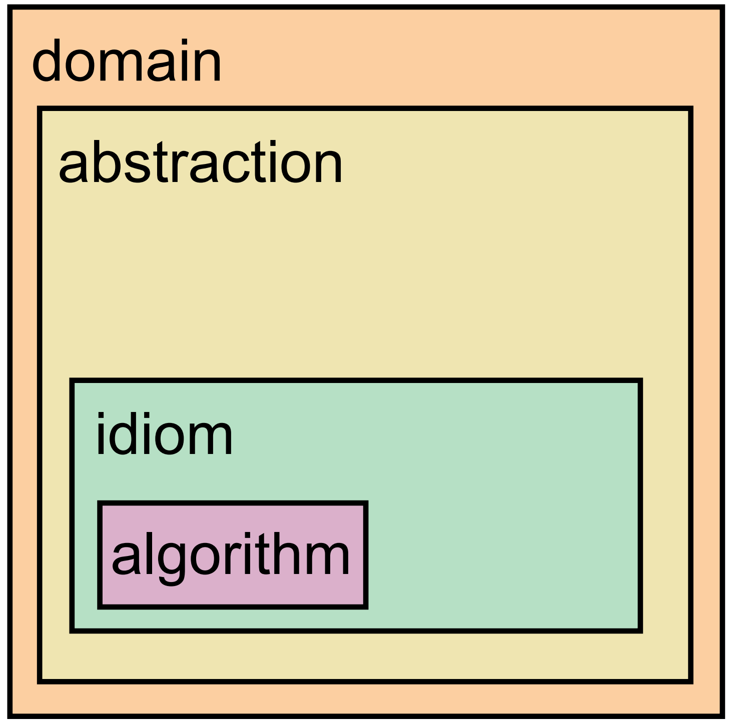

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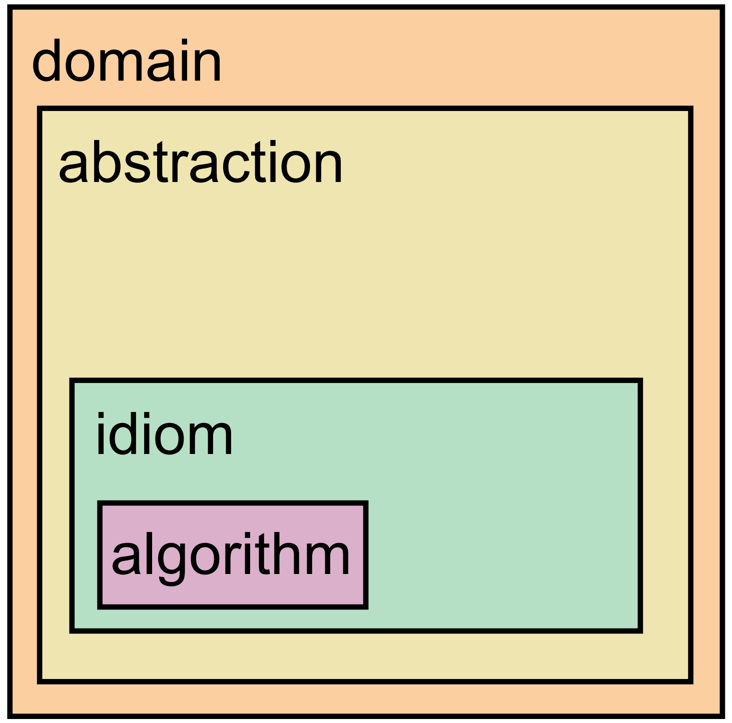

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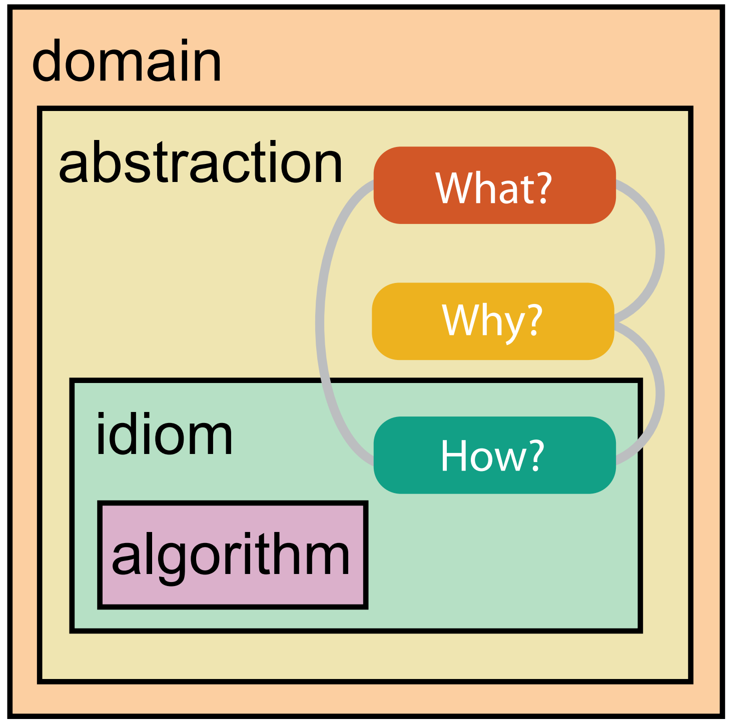

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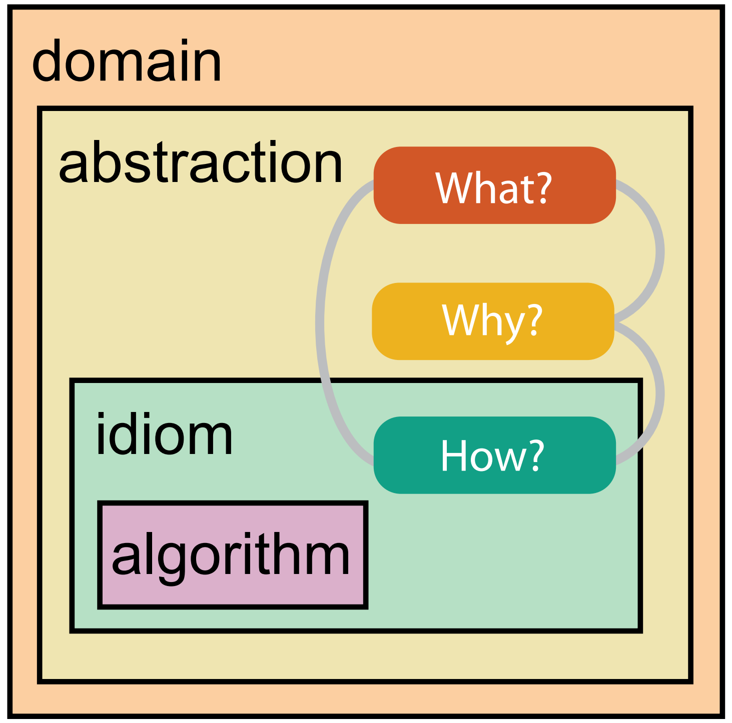

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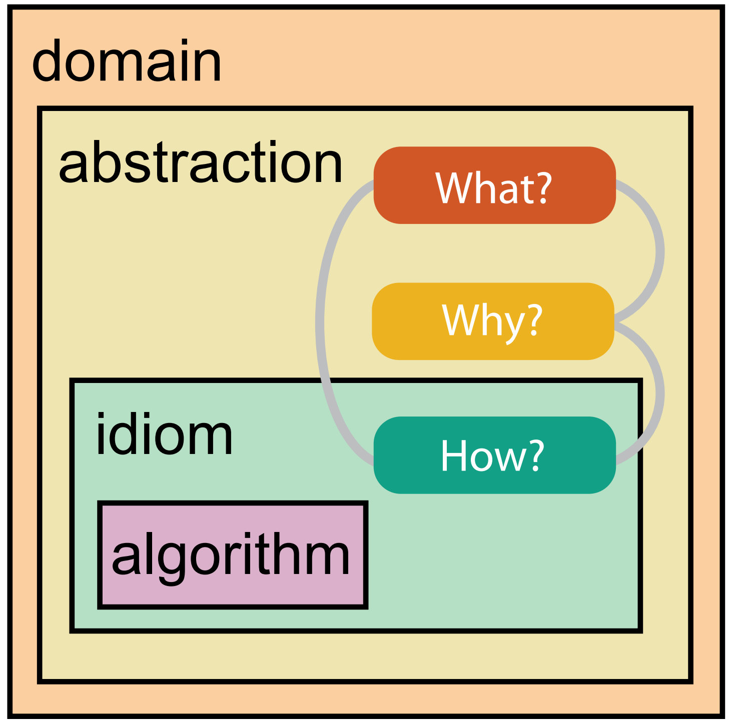

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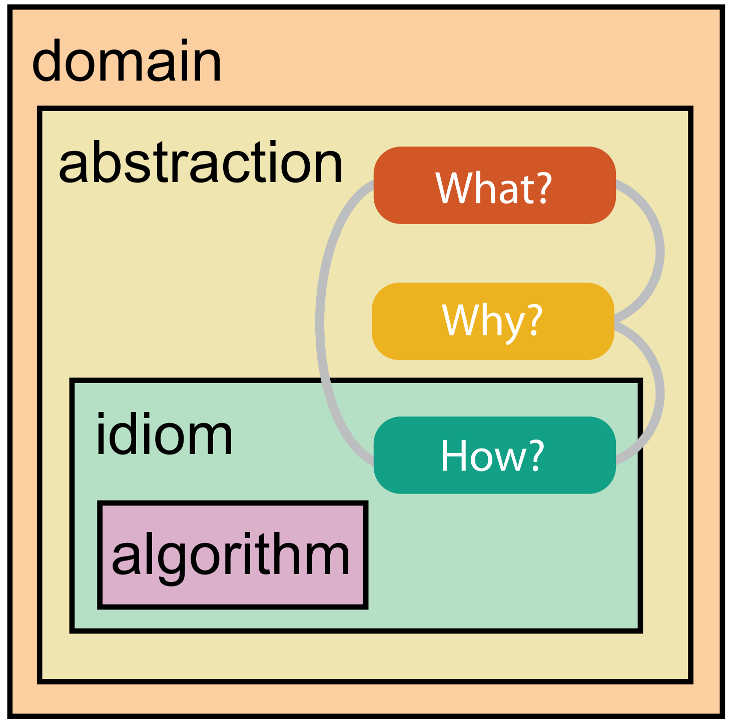

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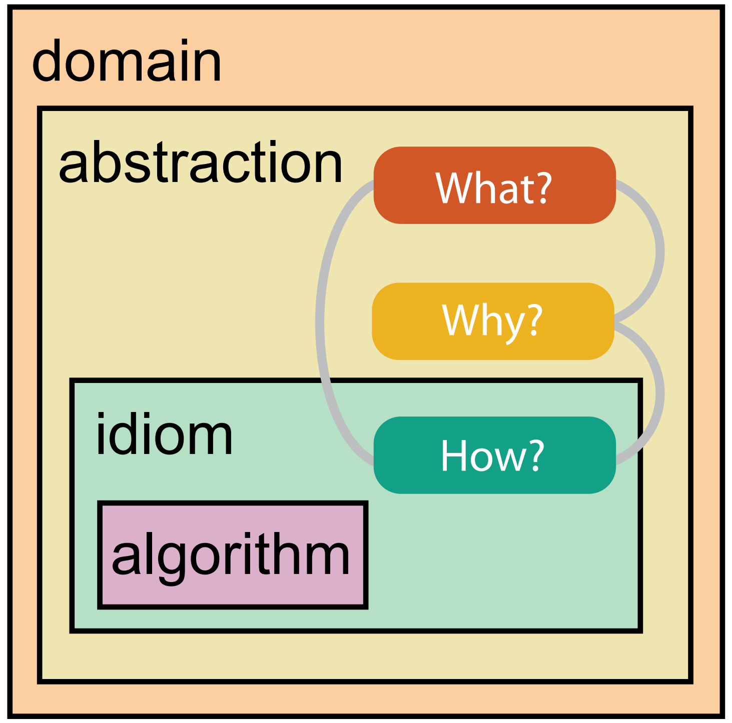

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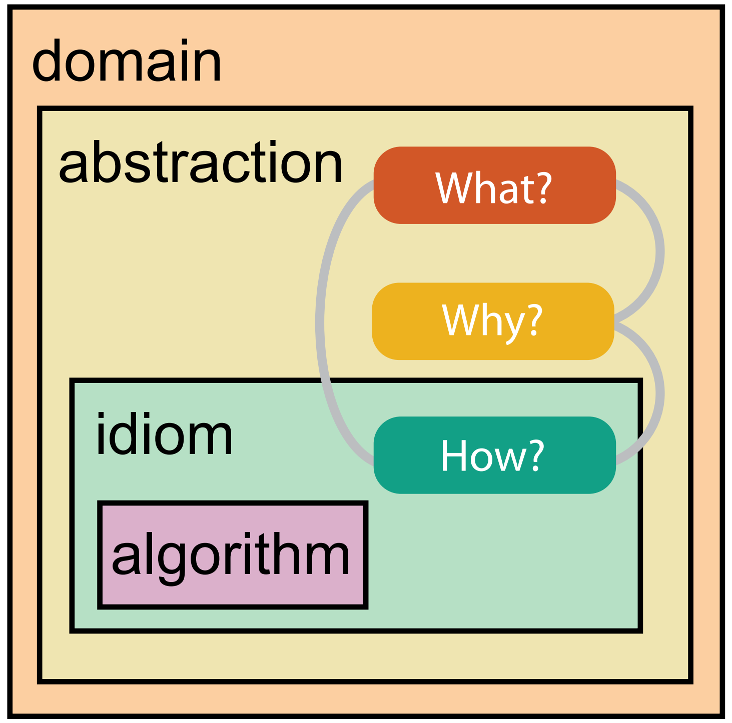

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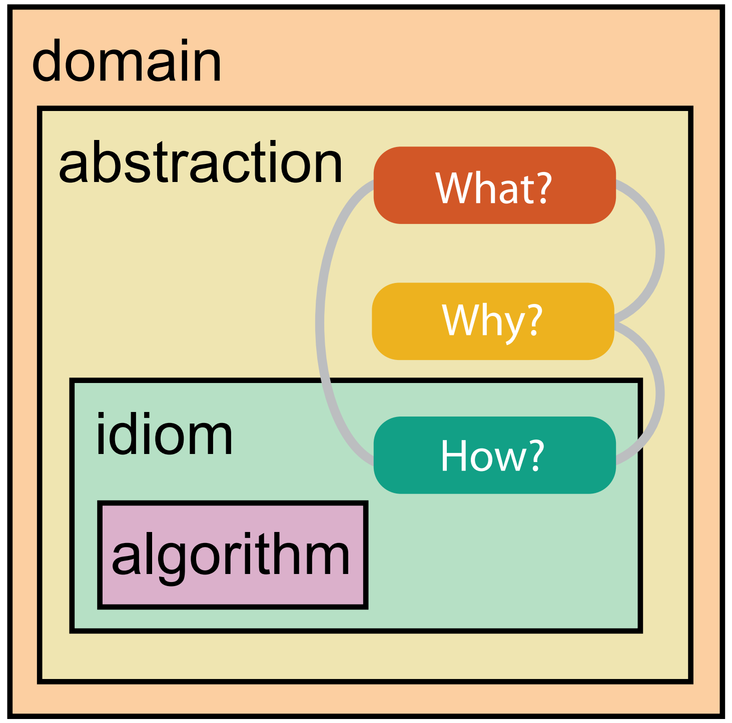
- *algorithm*
  - efficient computation



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Why is validation difficult?

- different threats to validity at each level

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Domain situation
You misunderstood their needs

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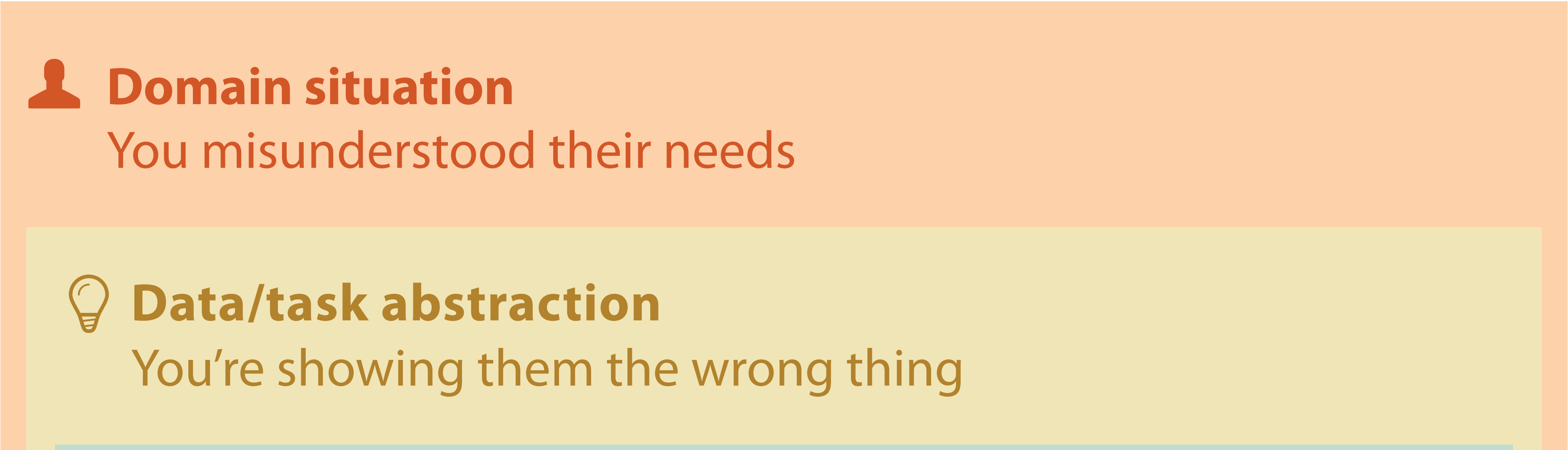

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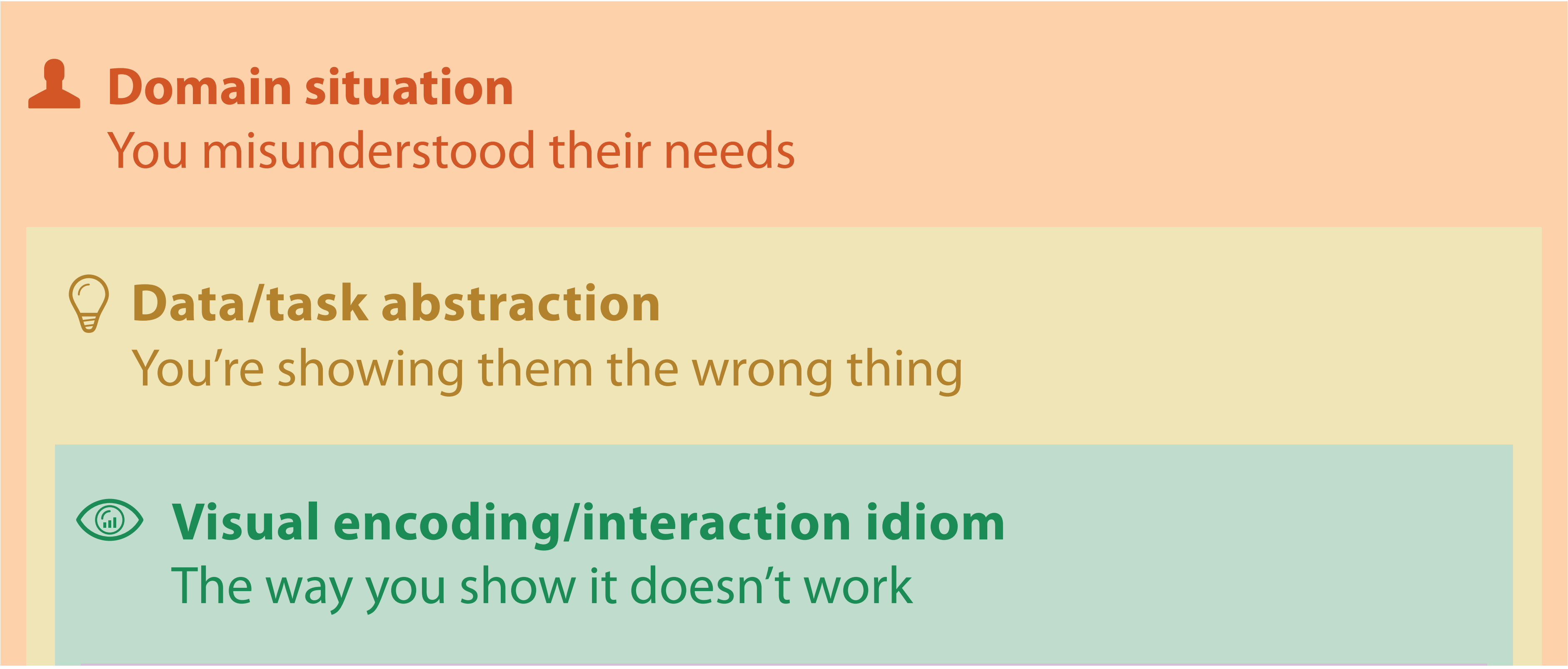

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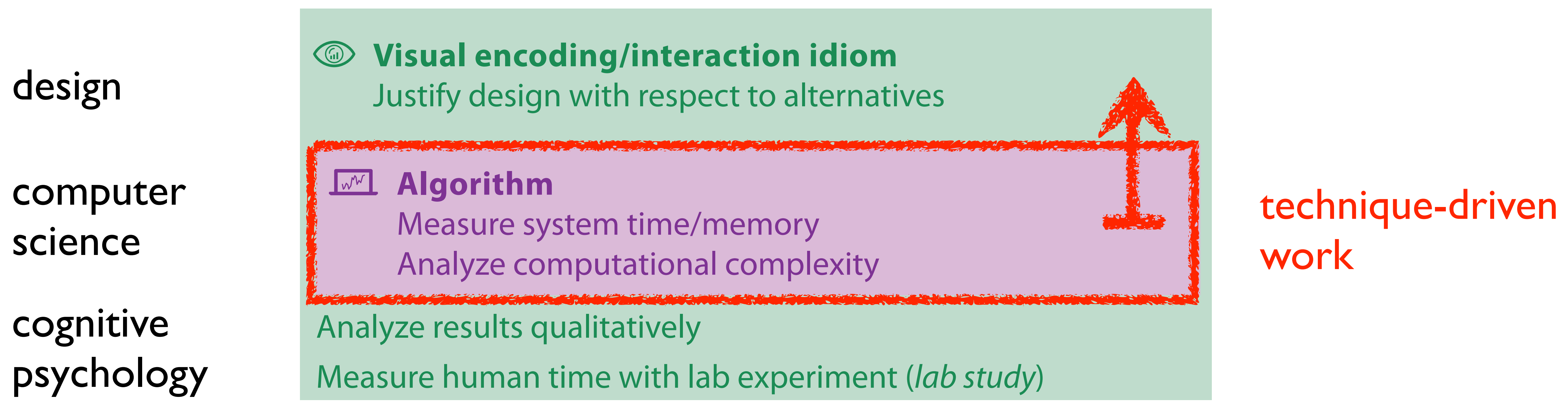

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anthropology/ ethnography

Domain situation
Observe target users using existing tools

Data/task abstraction

design

Visual encoding/interaction idiom
Justify design with respect to alternatives

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Measure system time/memory
Analyze computational complexity

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cognitive psychology

Analyze results qualitatively

Measure human time with lab experiment (*lab study*)

anthropology/ ethnography

Observe target users after deployment (*field study*)

Measure adoption

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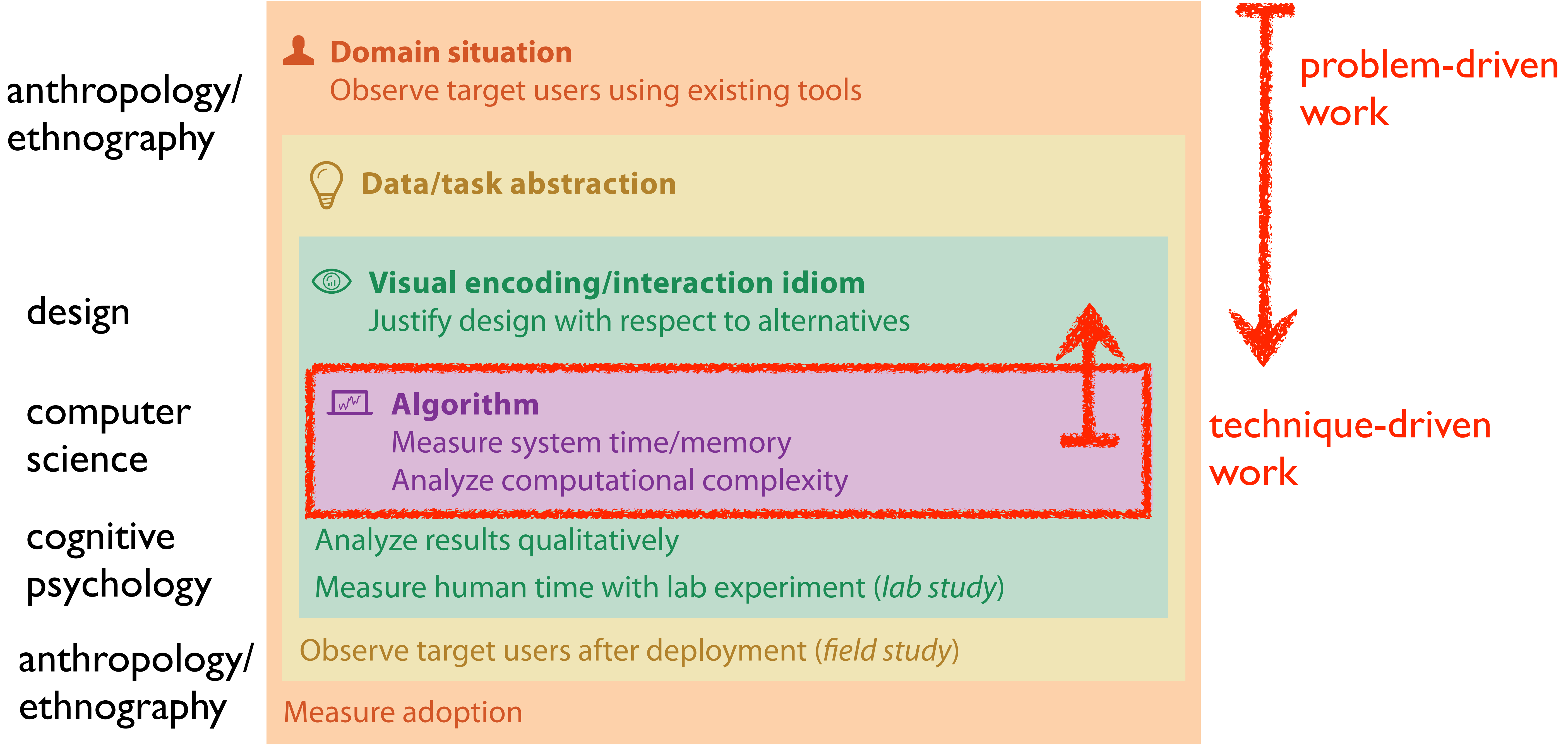

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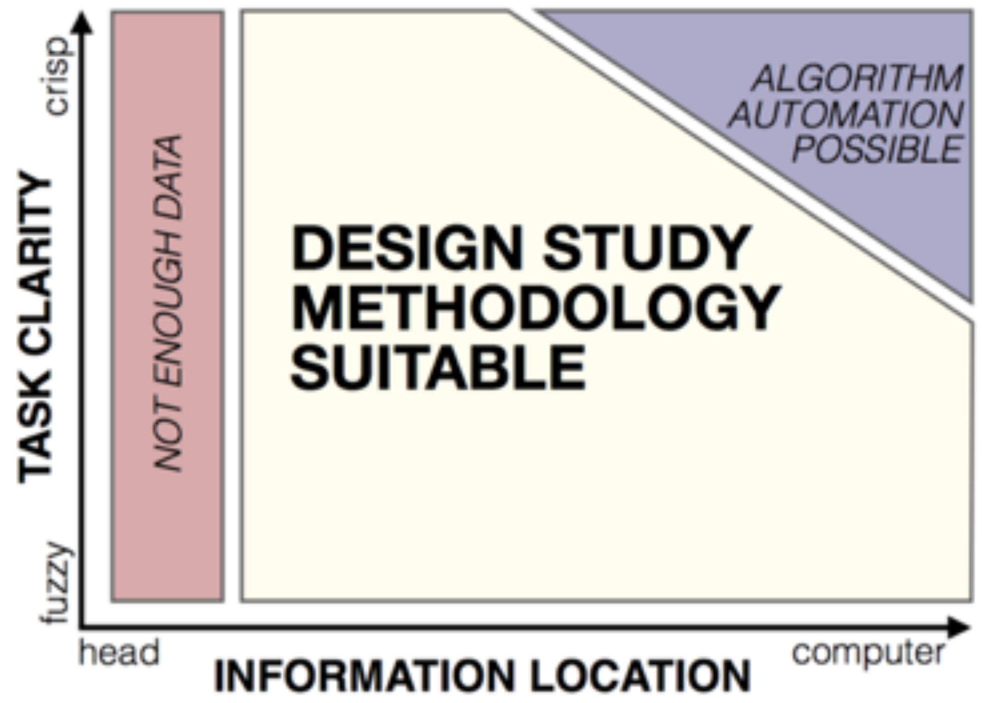

Michael Sedlmair

Miriah Meyer

Design Study Methodology

Reflections from the Trenches and from the Stacks

http://www.cs.ubc.ca/labs/imager/tr/2012/dsm/

Design Study Methodology: Reflections from the Trenches and from the Stacks.
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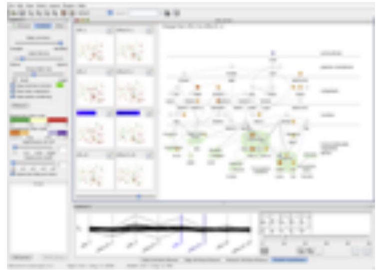
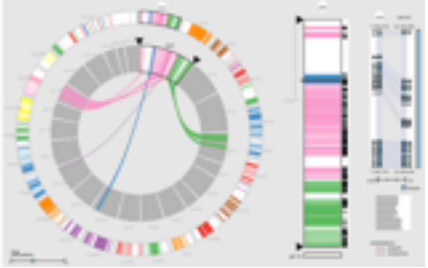
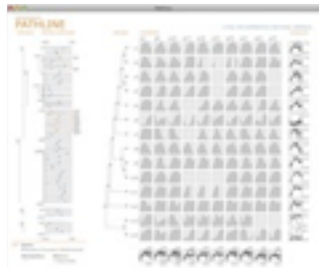
Lessons learned from the trenches: 20+ between us



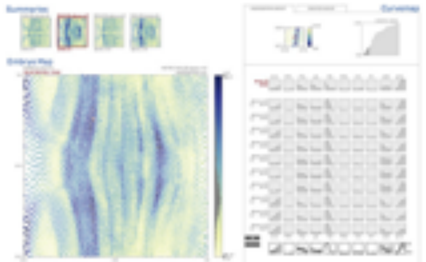
Cerebral
genomics



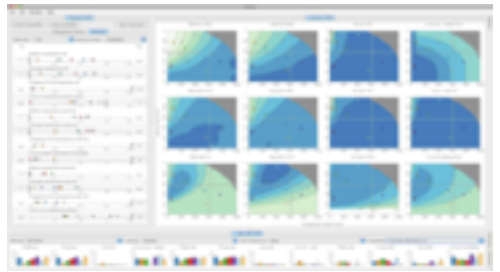
MizBee
genomics



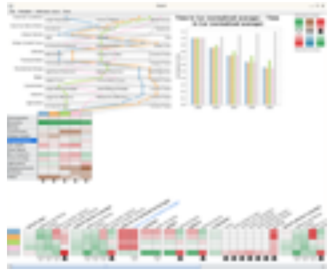
Pathline
genomics



MulteeSum
genomics



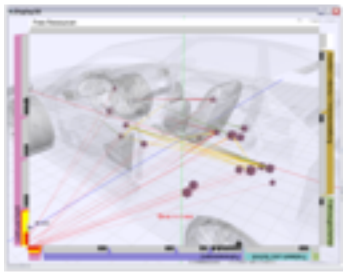
Vismon
fisheries management



QuestVis
sustainability

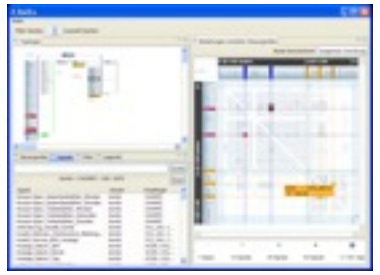
WiKeVis
in-car networks

MostVis
in-car networks

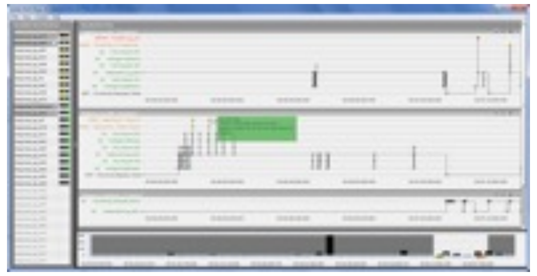


Car-X-Ray
in-car networks

ProgSpy2010
in-car networks



RelEx
in-car networks

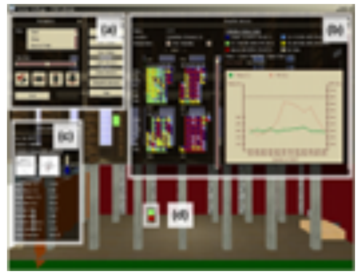


Cardiogram
in-car networks

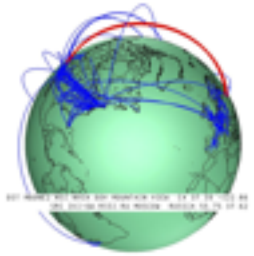
AutobahnVis
in-car networks

VisTra
in-car networks

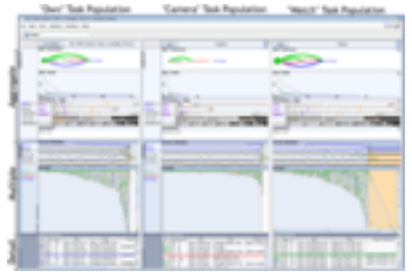
Constellation
linguistics



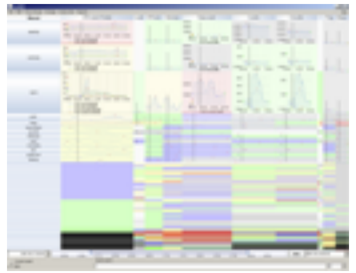
LibVis
cultural heritage



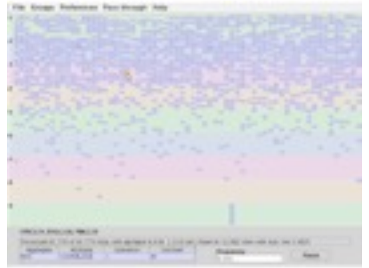
Caidants
multicast



SessionViewer
web log analysis



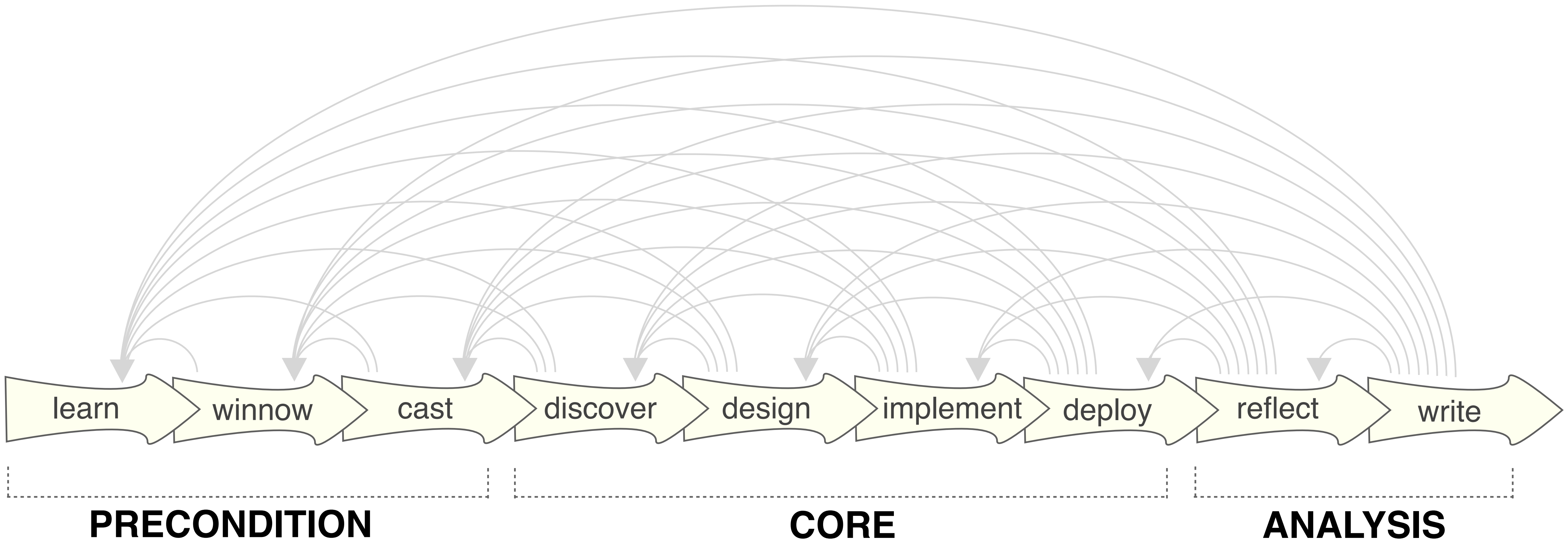
LiveRAC
server hosting



PowerSetViewer
data mining

9-stage framework

iterative



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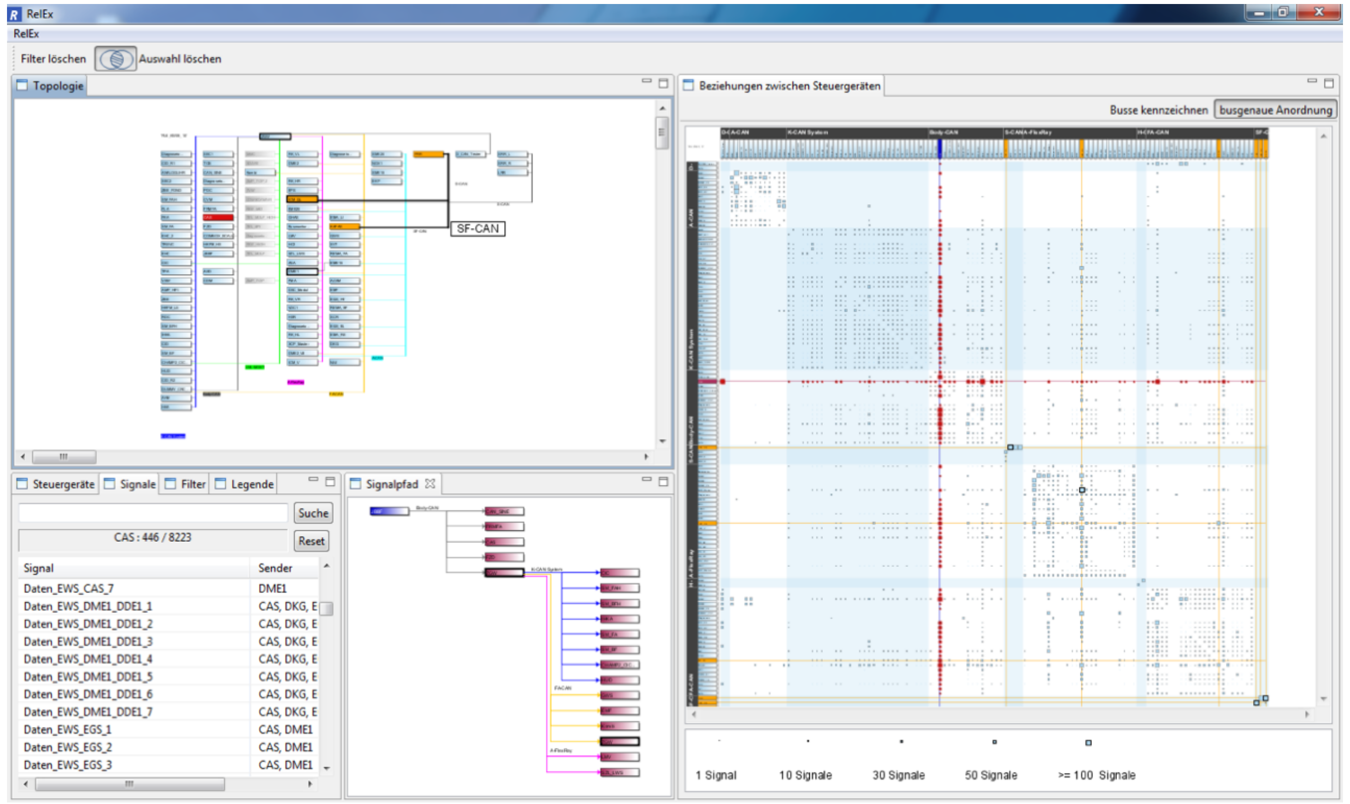


RelEx

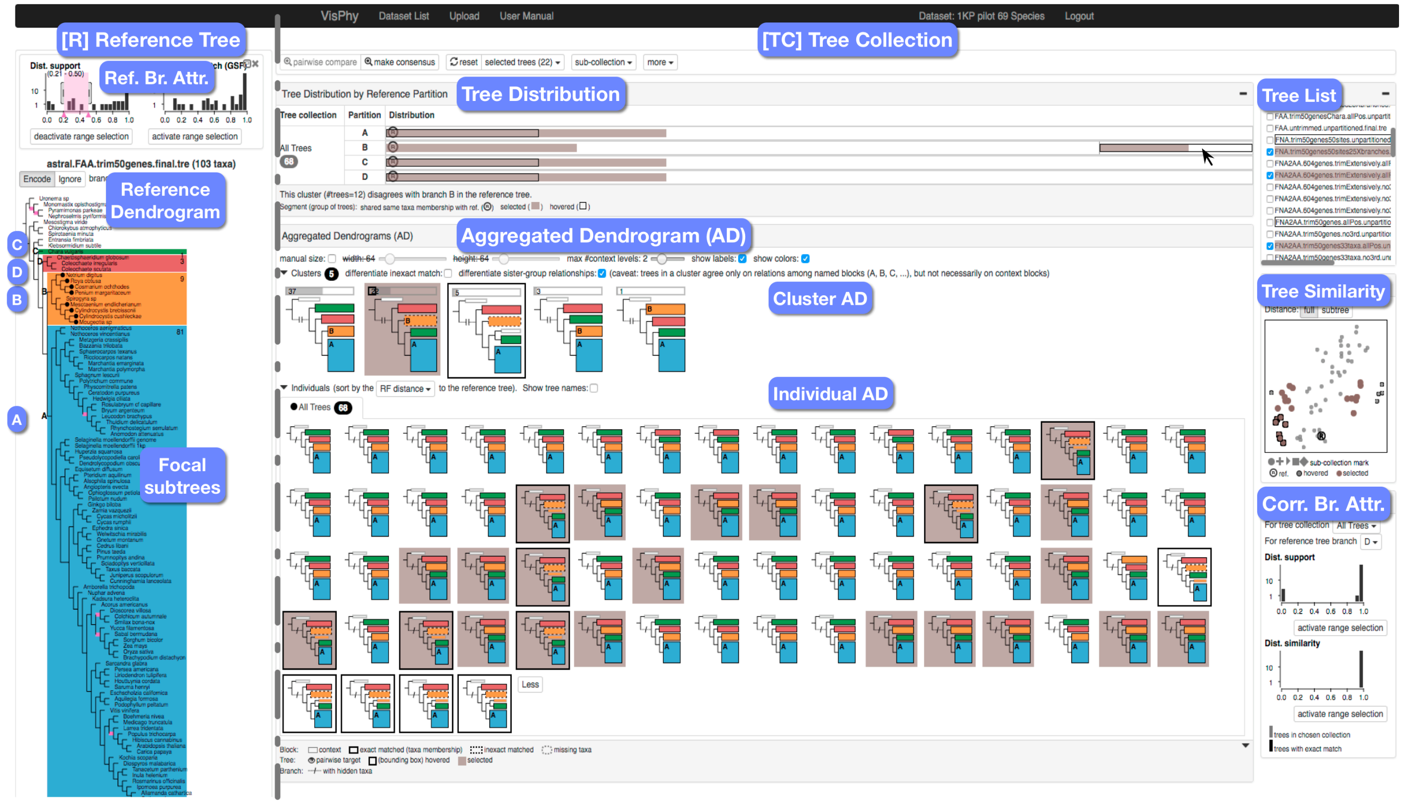
Visualization for Actively Changing Overlay Network Specifications

joint work with:

Michael Sedlmair, Annika Frank, Andreas Butz

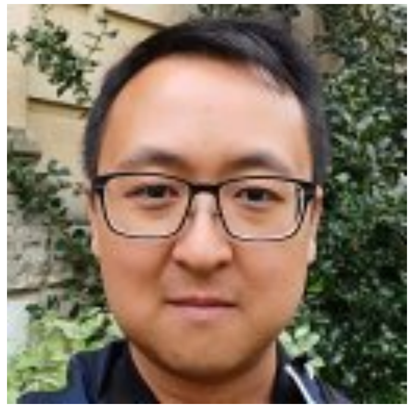
http://www.cs.ubc.ca/labs/imager/tr/2012/relex/

RelEx: Visualization for Actively Changing Overlay Network Specifications.
Sedlmair, Frank, Butz, Munzner. IEEE TVCG 18(12): 2729-2738, 2012 (Proc. InfoVis 2012).



Zipeng Liu

Shing Hei Zhan



Aggregated Dendrograms

for Visual Comparison Between Many Phylogenetic Trees

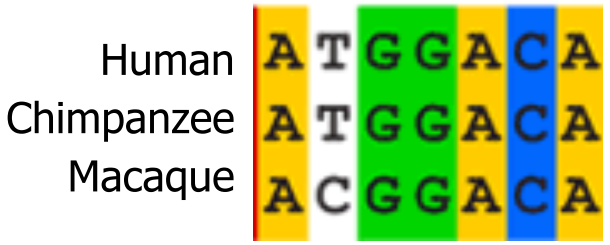
http://www.cs.ubc.ca/labs/imager/tr/2019/adview

Aggregated Dendrograms for Visual Comparison Between Many Phylogenetic Trees.

Liu, Zhan, Munzner. IEEE Trans. Visualization and Computer Graphics (TVCG) 26(9):2732-2747, 2019.

Phylogenetic tree

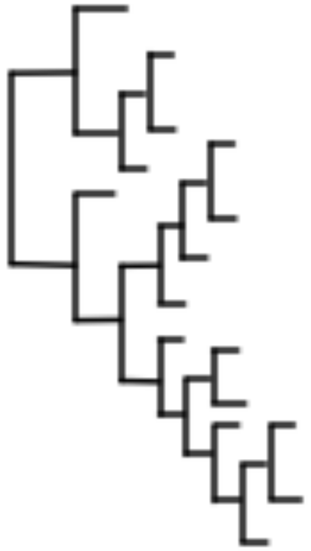
Evolutionary relationships of organisms



Genetic information

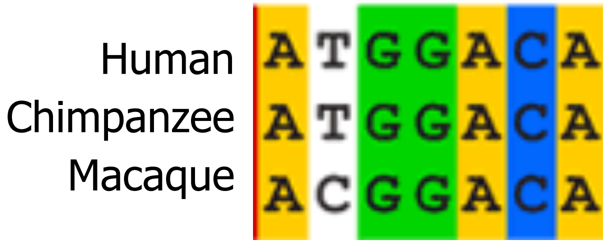
Computational workflow

Phylogenetic tree



Many phylogenetic trees

- Understand relationships between genes and species trees
- Explore trees generated with different methods and data



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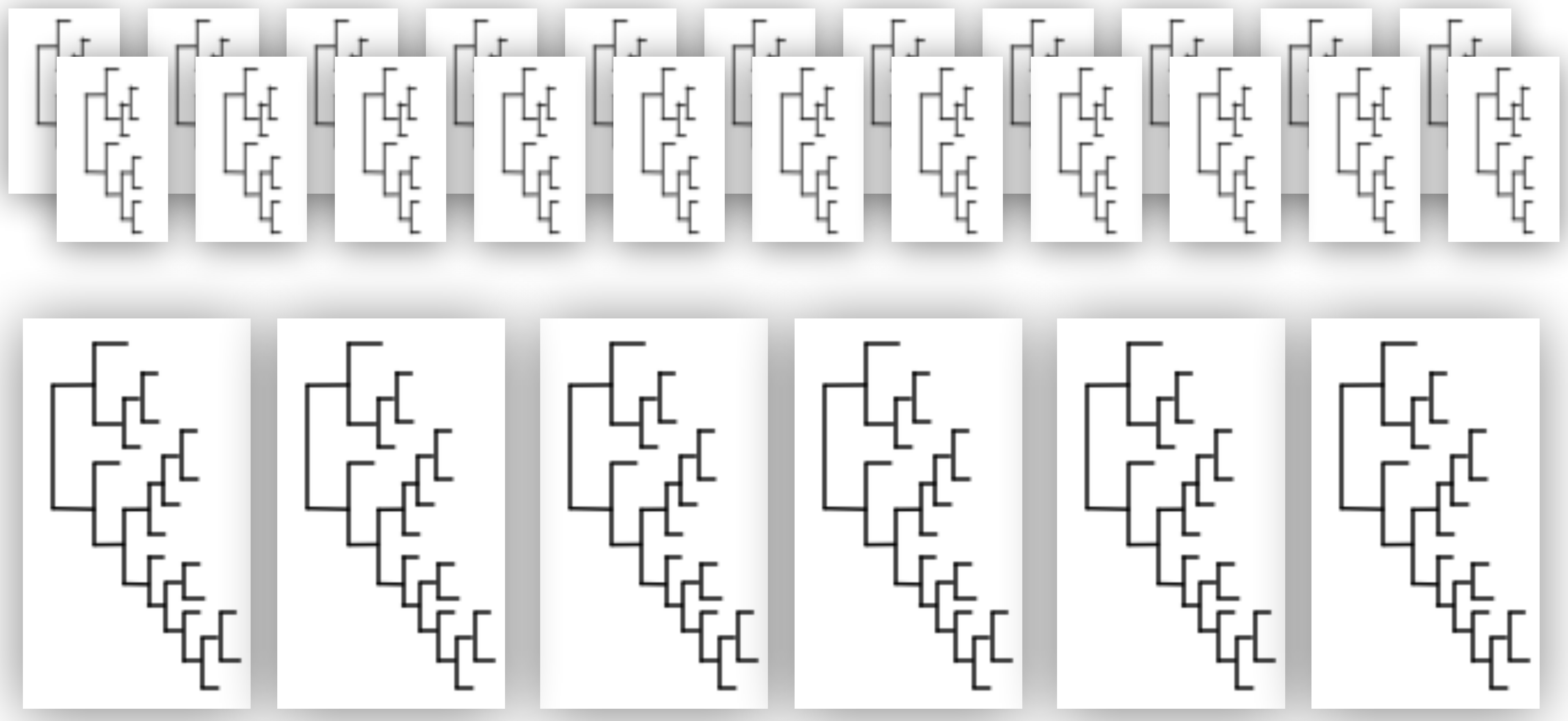
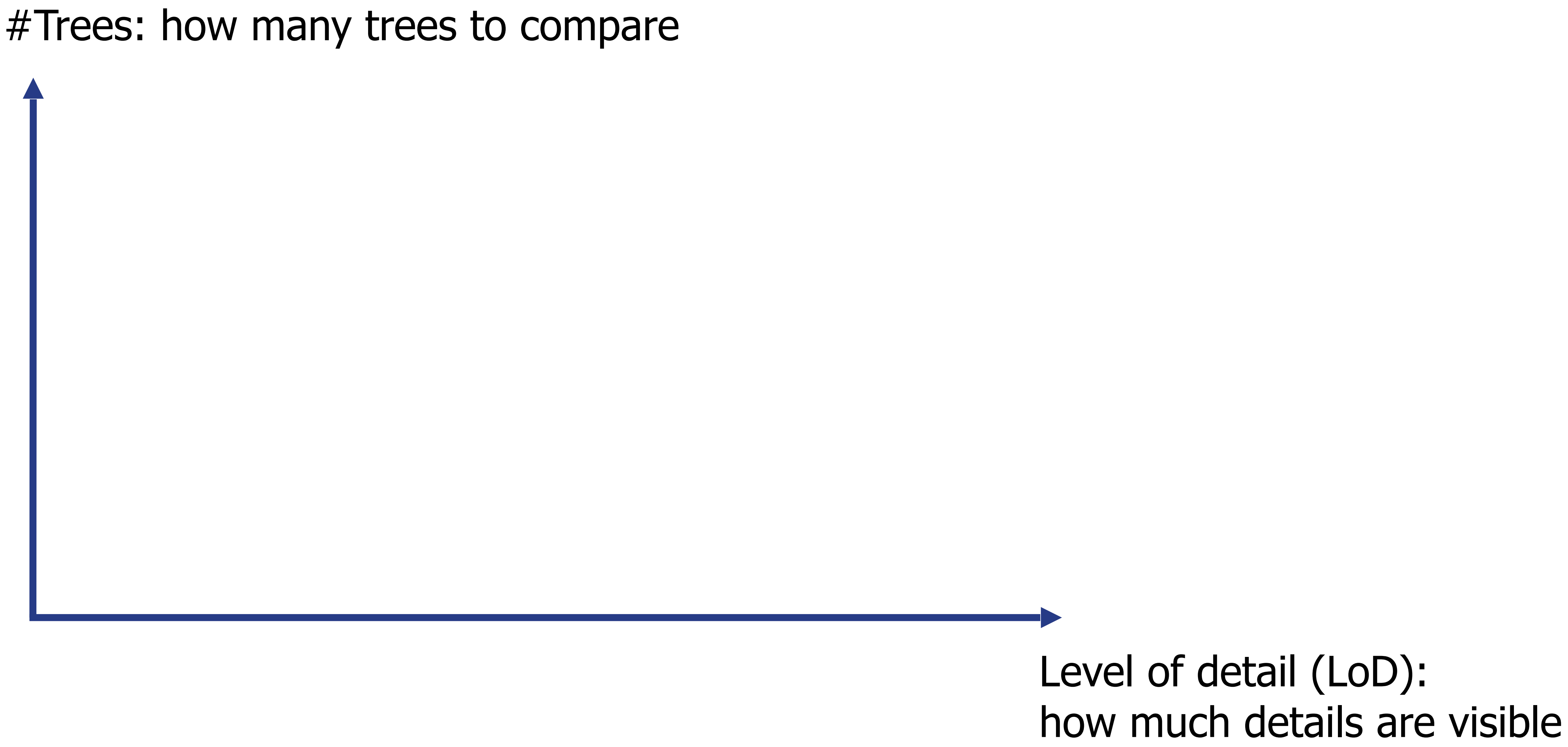


Scalability of existing tree comparison systems



Scalability of existing tree comparison systems

#Trees: how many trees to compare

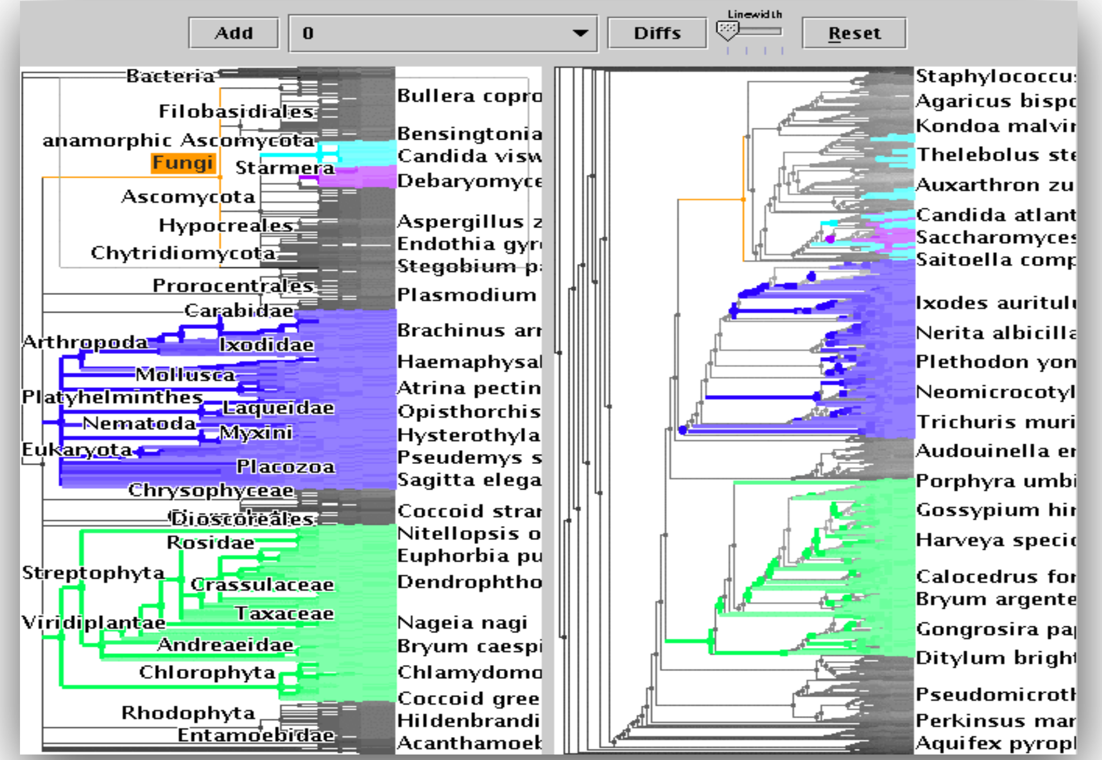
Pairs

Few in full

Simplified structure

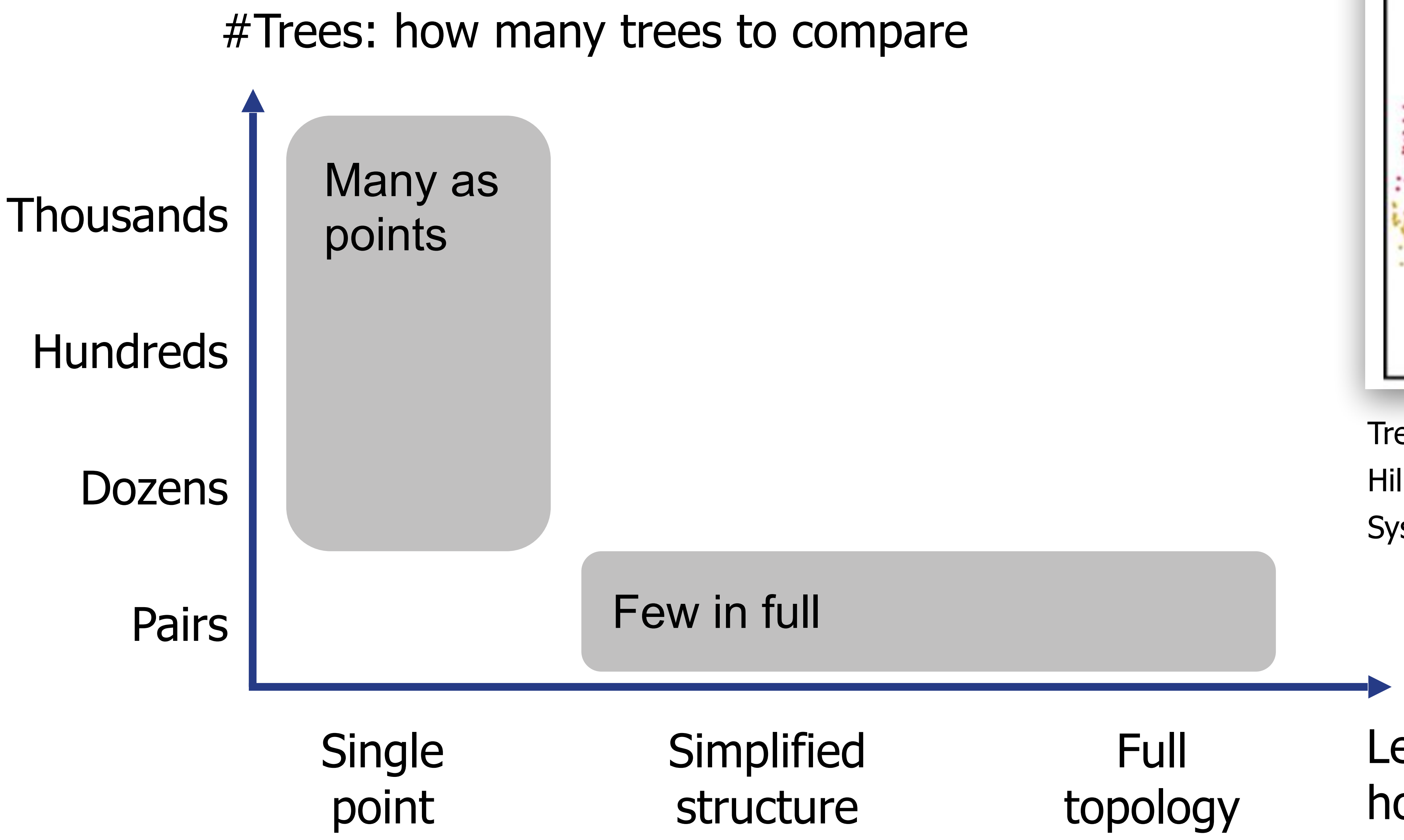
Full topology

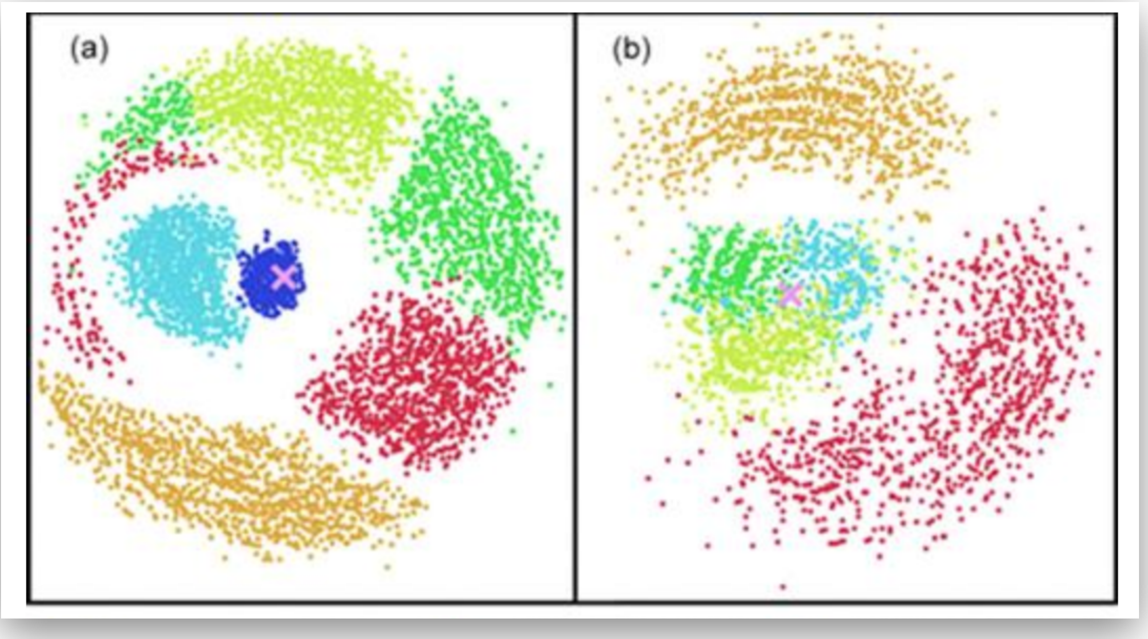
Level of detail (LoD):
how much details are visible



TreeJuxtaposer.
Munzner, Guimbretière, Zhang, Zhou.
SIGGRAPH 2003

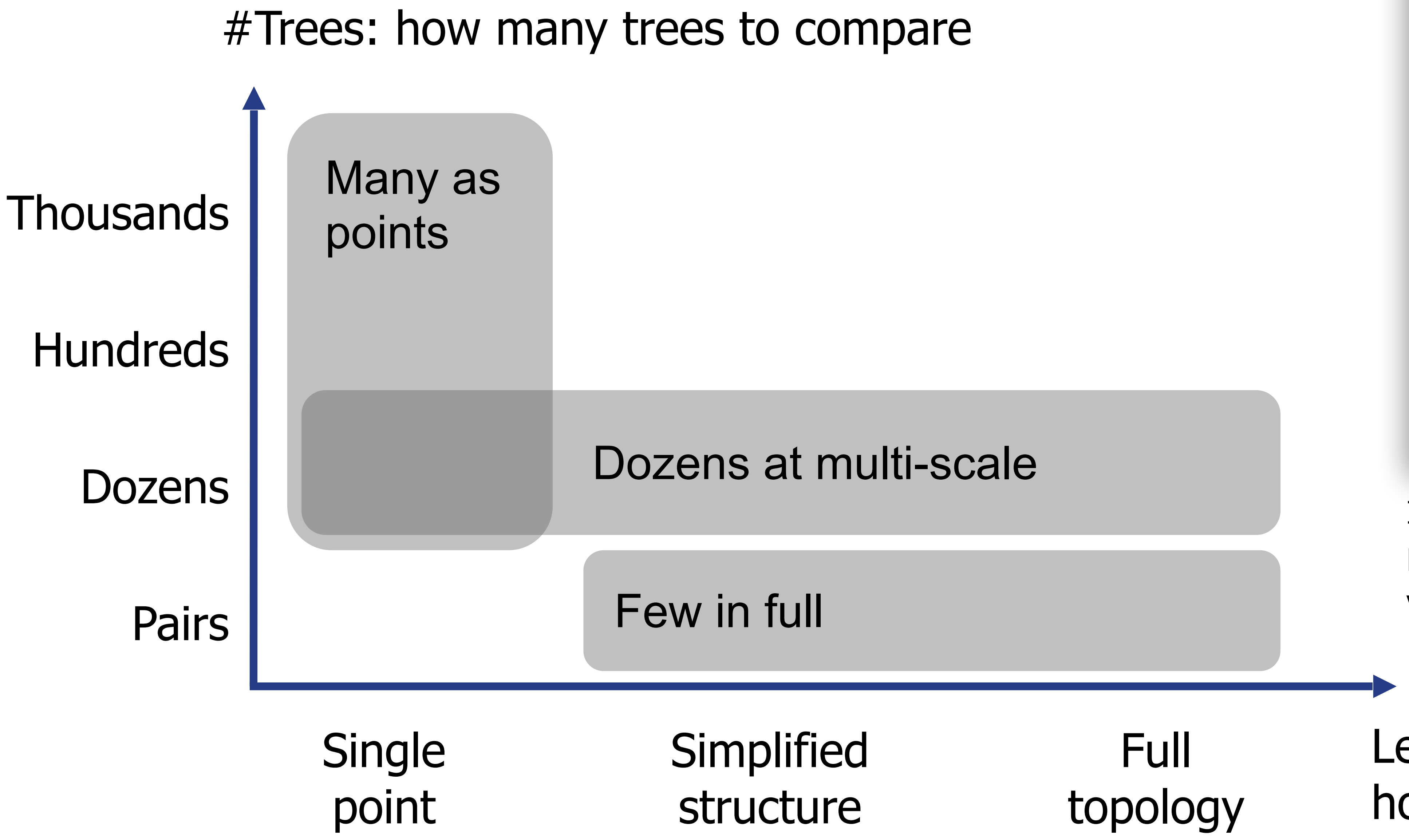
Scalability of existing tree comparison systems

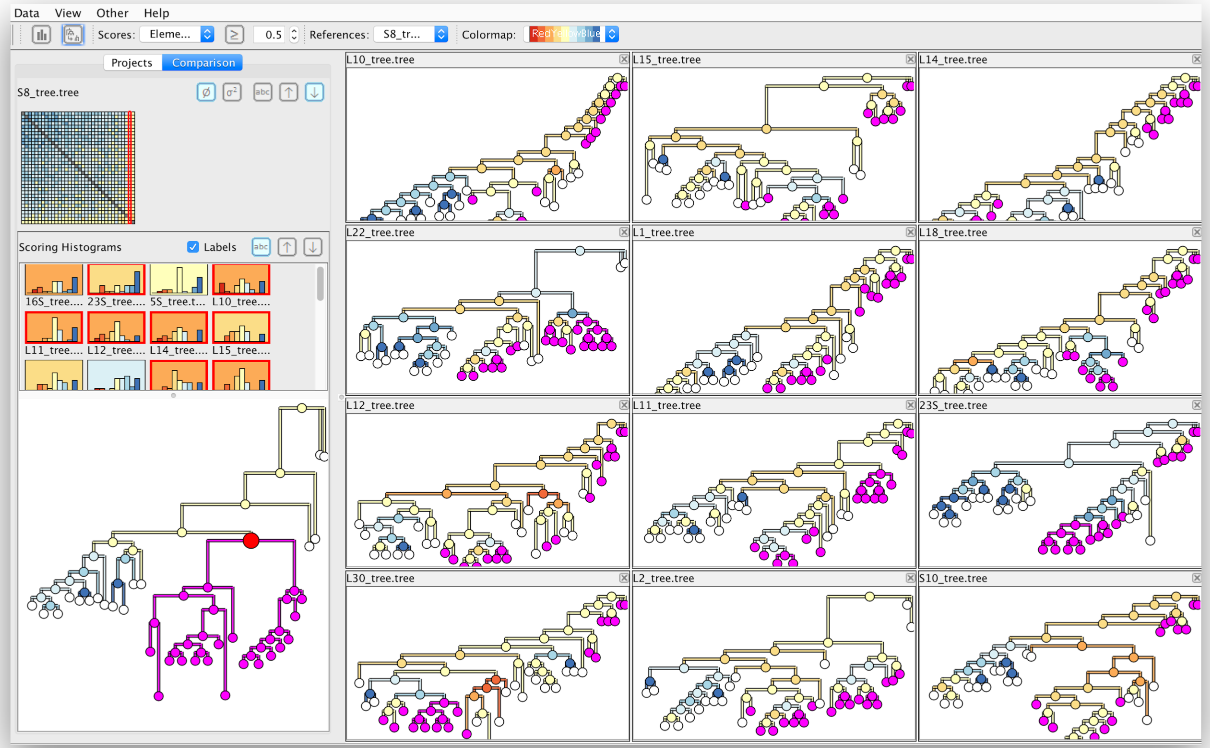




Tree space.
Hillis, Health, John.
Systematic Biology 2005.

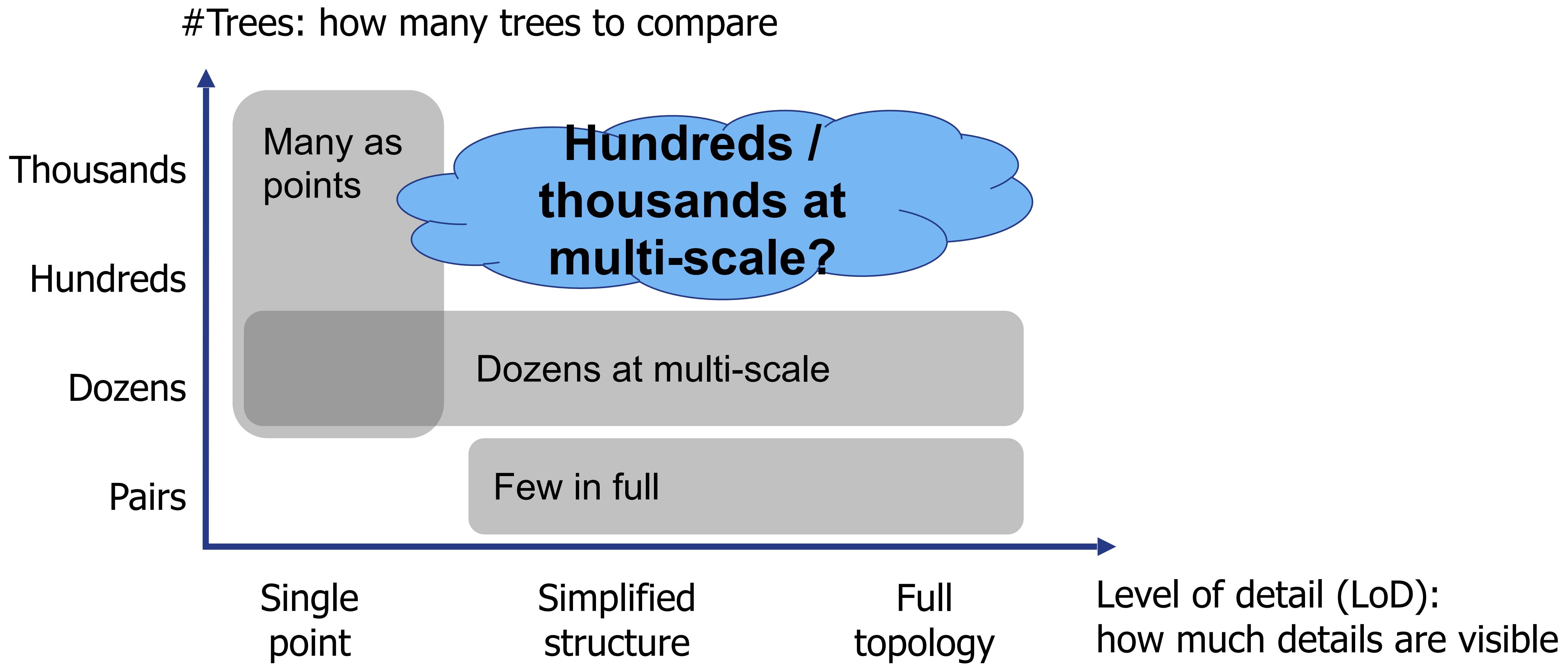
Scalability of existing tree comparison systems





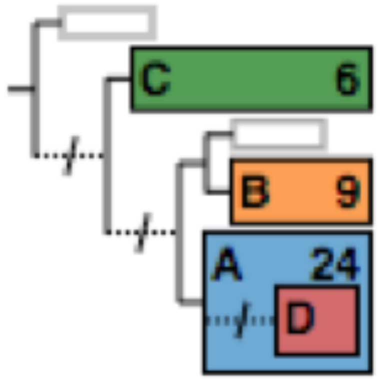
Interactive visual comparison of multiple trees.
Bremm, Landesberger, Heß, Schreck, Weil, Hamacher.
VAST 2011.

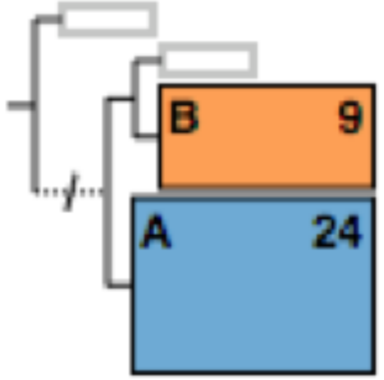
Comparing many phylogenetic trees

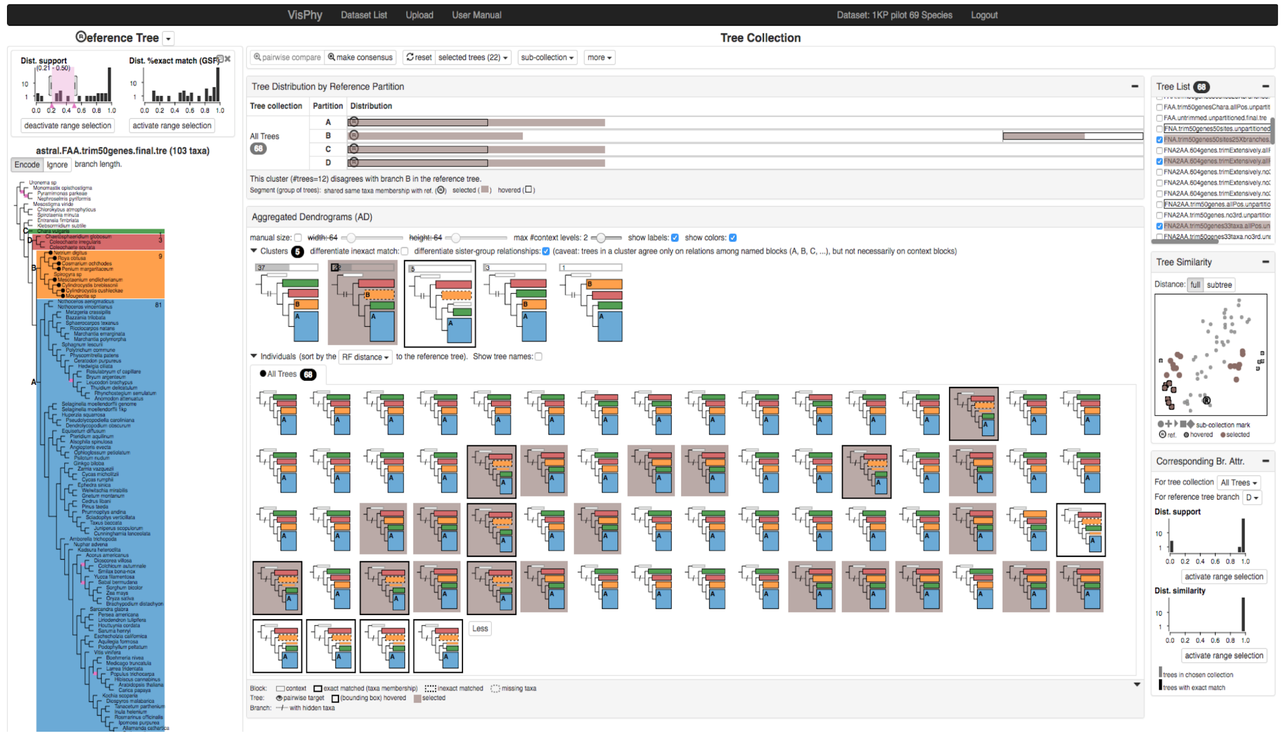


Contributions at abstraction, idiom, & algorithm levels

- data and task **abstractions** for comparison of phylogenetic trees
- new visual encoding **idiom**: Aggregated Dendrogram
  - compact tree representation that focuses on selected subtrees
  - **algorithm** that adapts to available screen space
- interactive multi-view tool: ADView
  - covers multiple levels of details for tree comparison

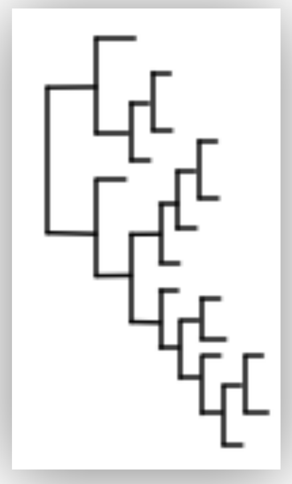


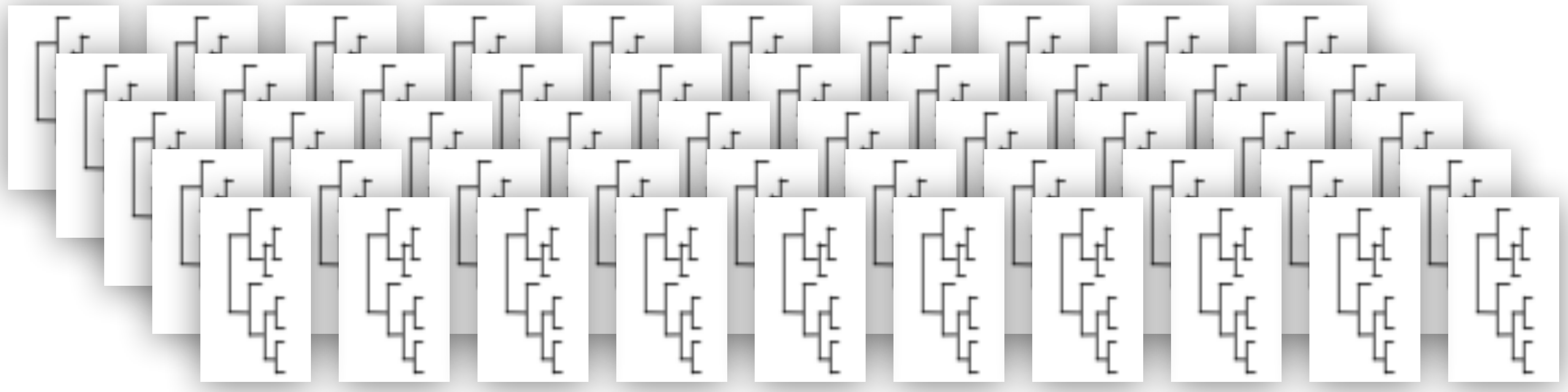




Data abstraction: Trees

Reference tree vs. Tree collection

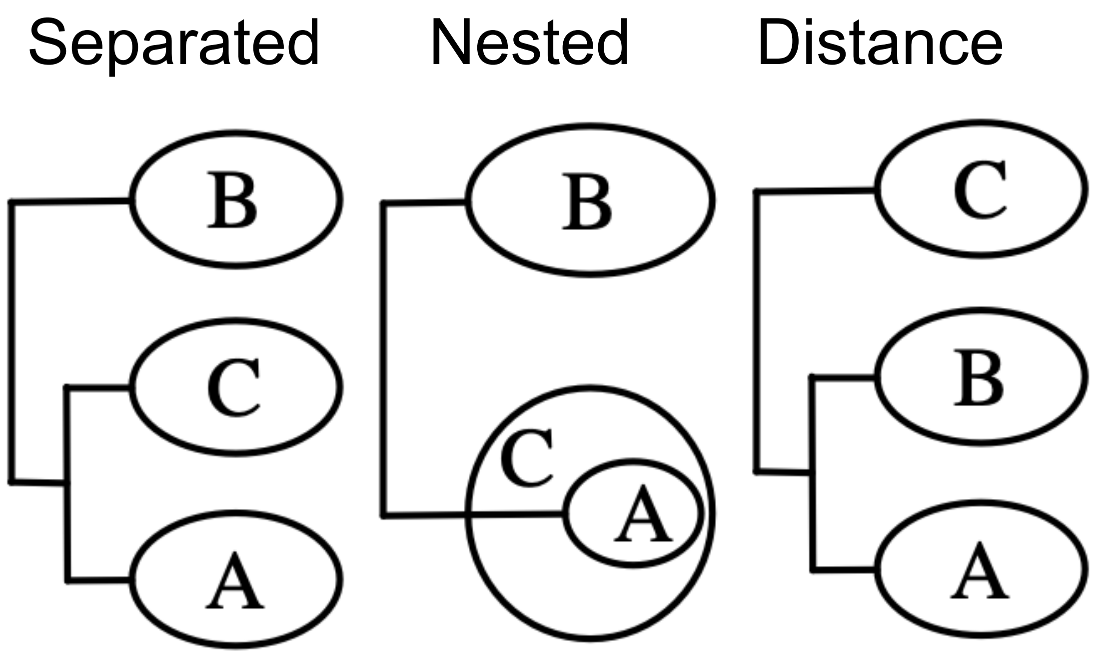




Task abstraction

Task abstraction

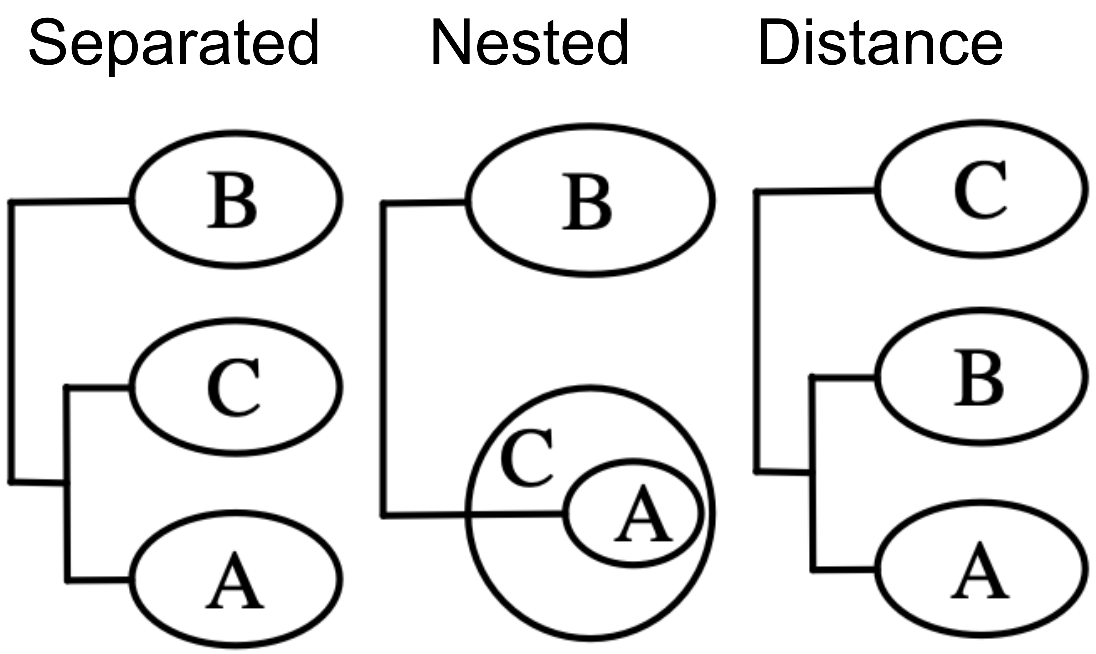
Topological relationships & distance
between subtrees / leaf nodes

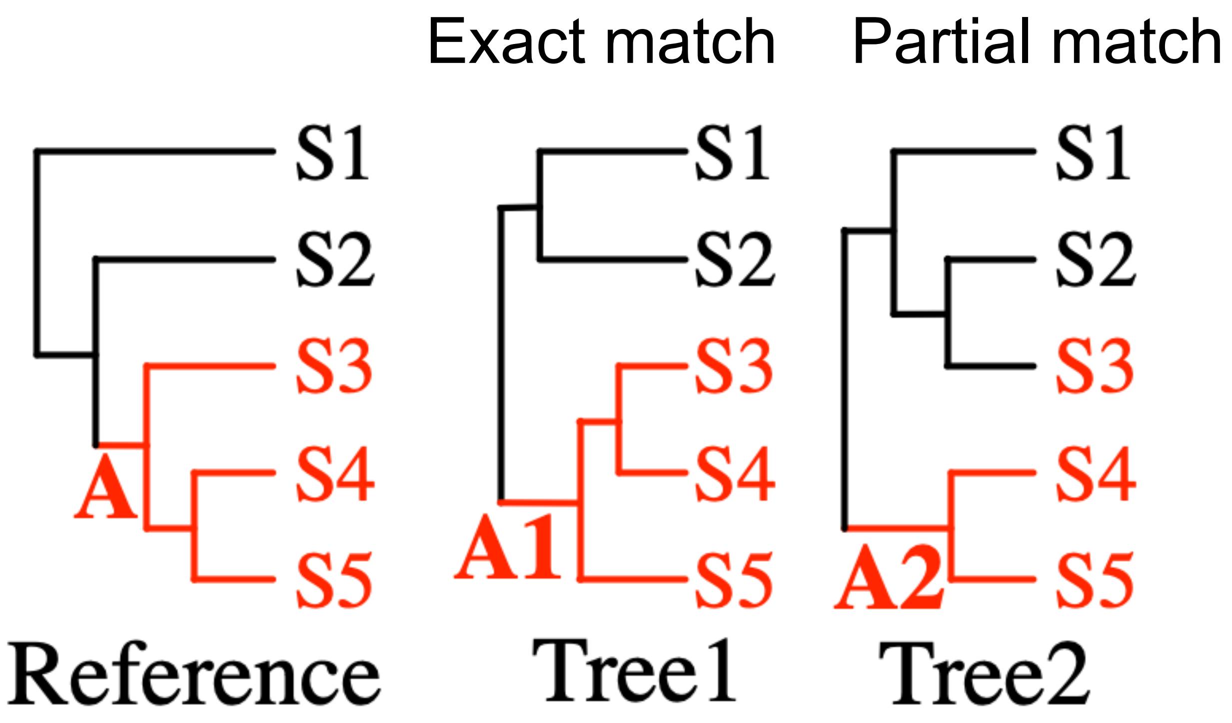


Task abstraction

Topological relationships & distance between subtrees / leaf nodes

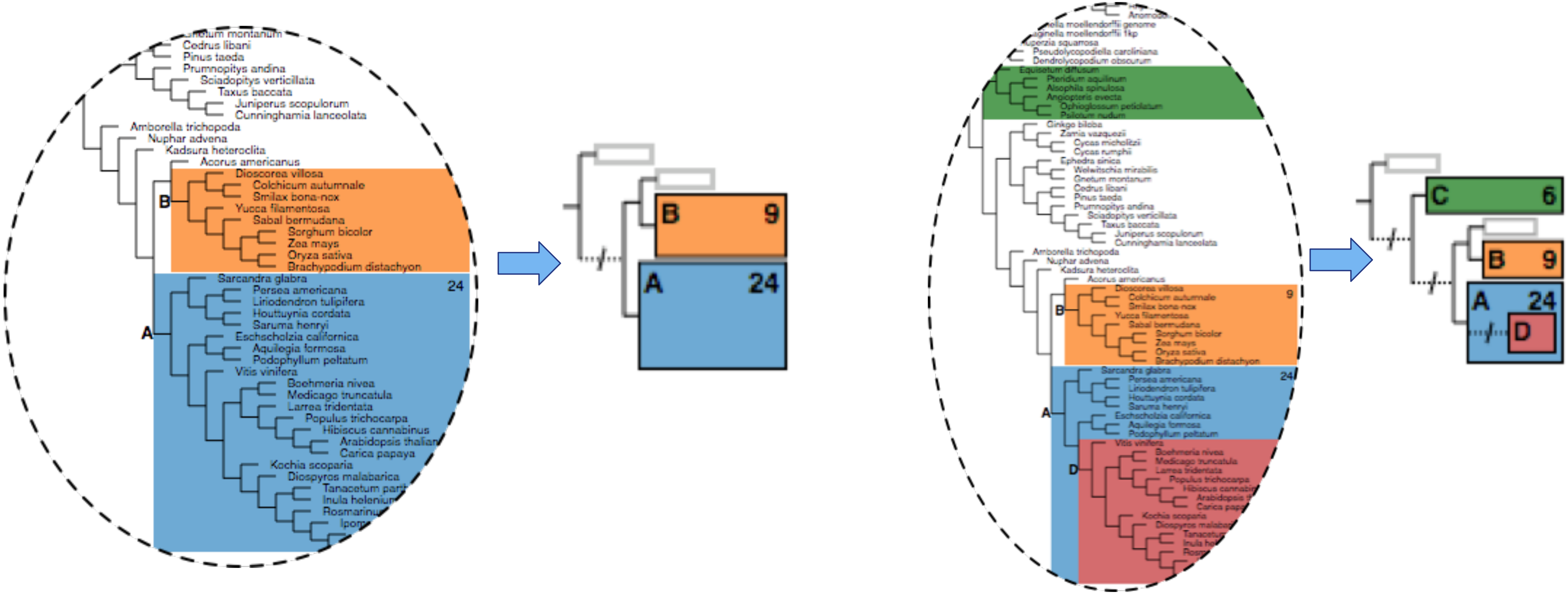
Leaf node memberships compared to reference tree





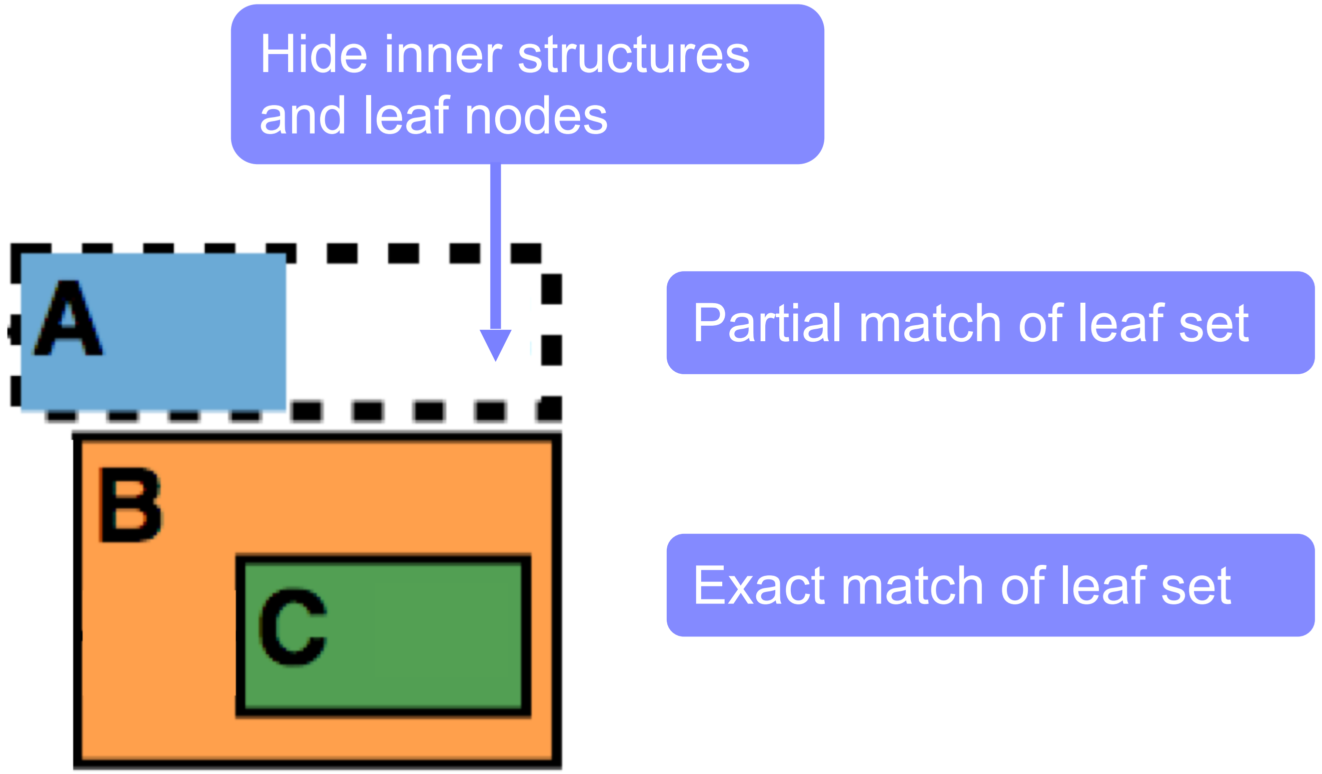
Aggregated Dendrogram: Intuition

Use glyphs to compress a tree according to user selections



Visual design: focus + context

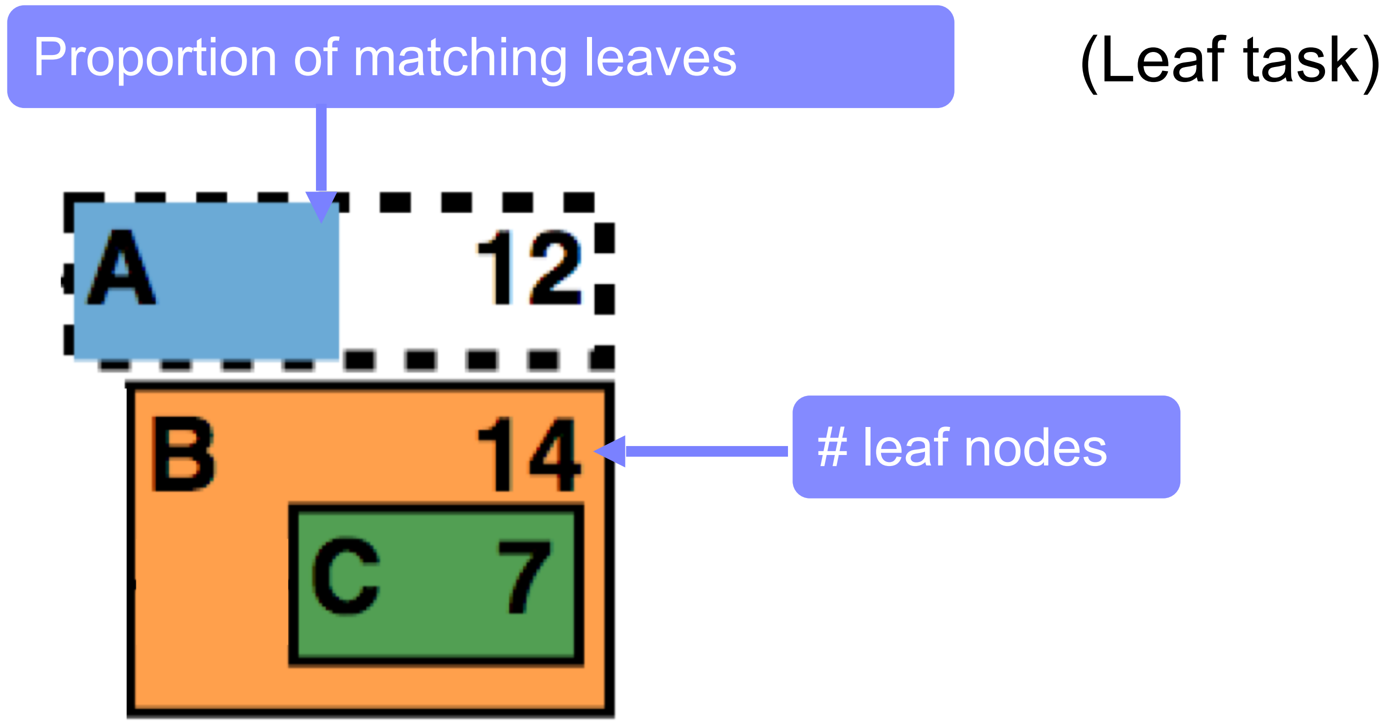
- focus
  - selected subtrees



(Leaf task)

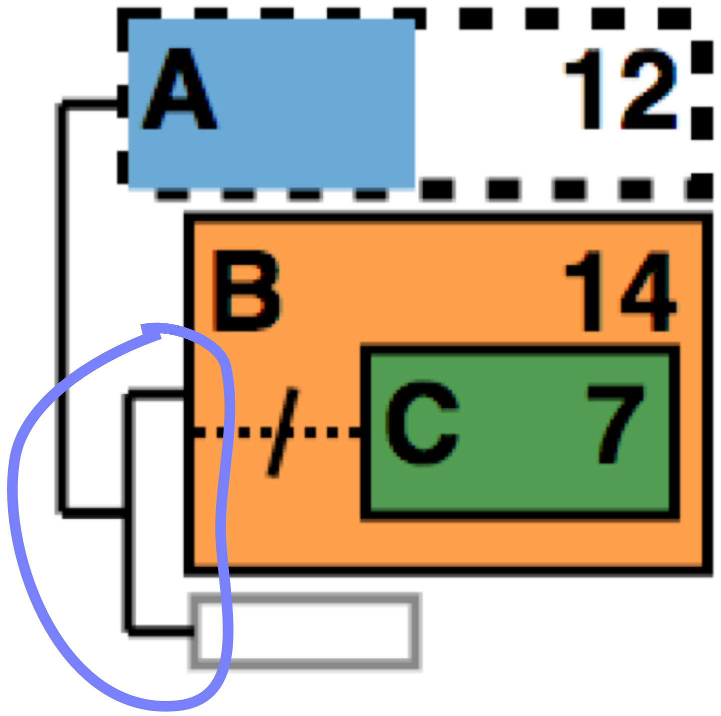
Visual design: focus + context

- focus
  - selected subtrees



Visual design: focus + context

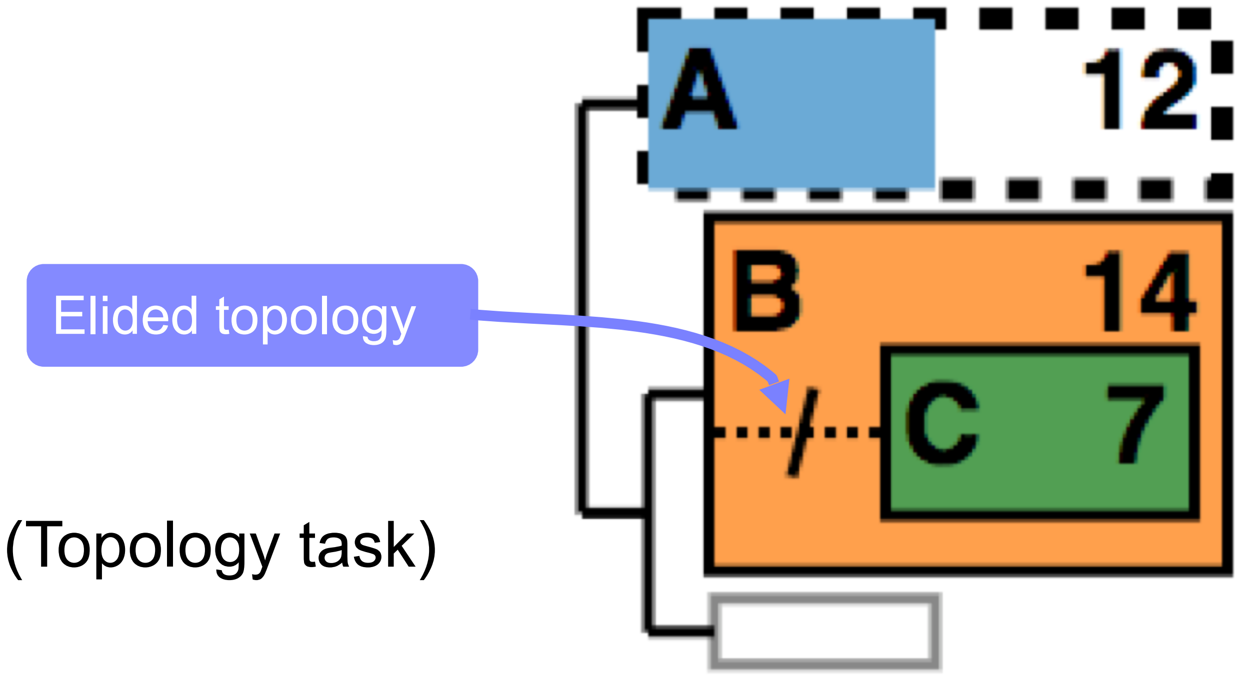
- focus
  - selected subtrees
  - topological relationships between them



(Topology task)

Visual design: focus + context

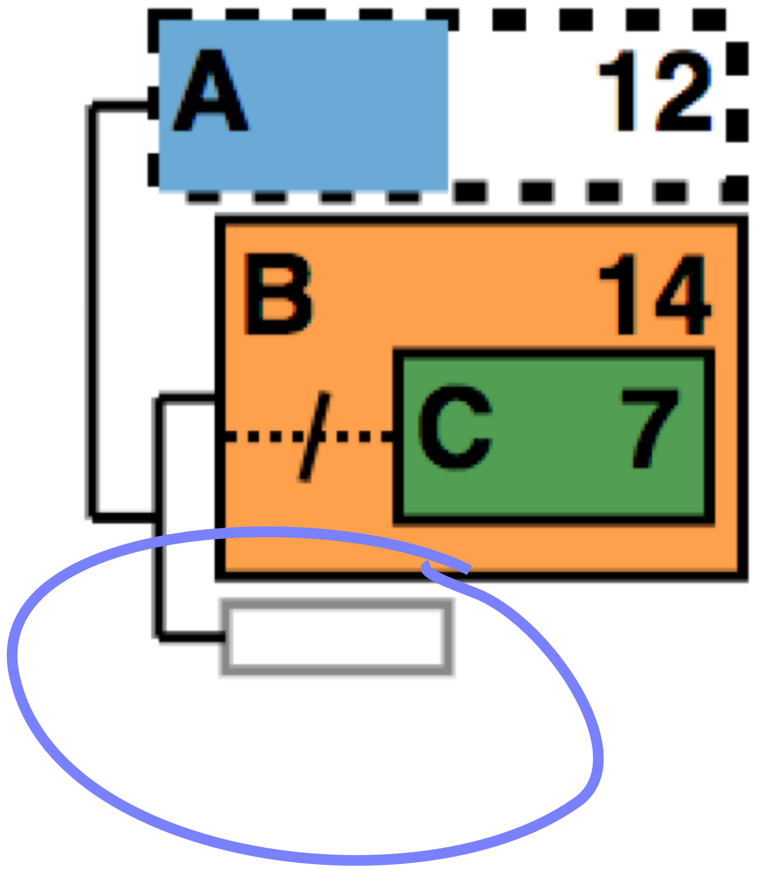
- focus
  - selected subtrees
  - topological relationships between them



(Topology task)

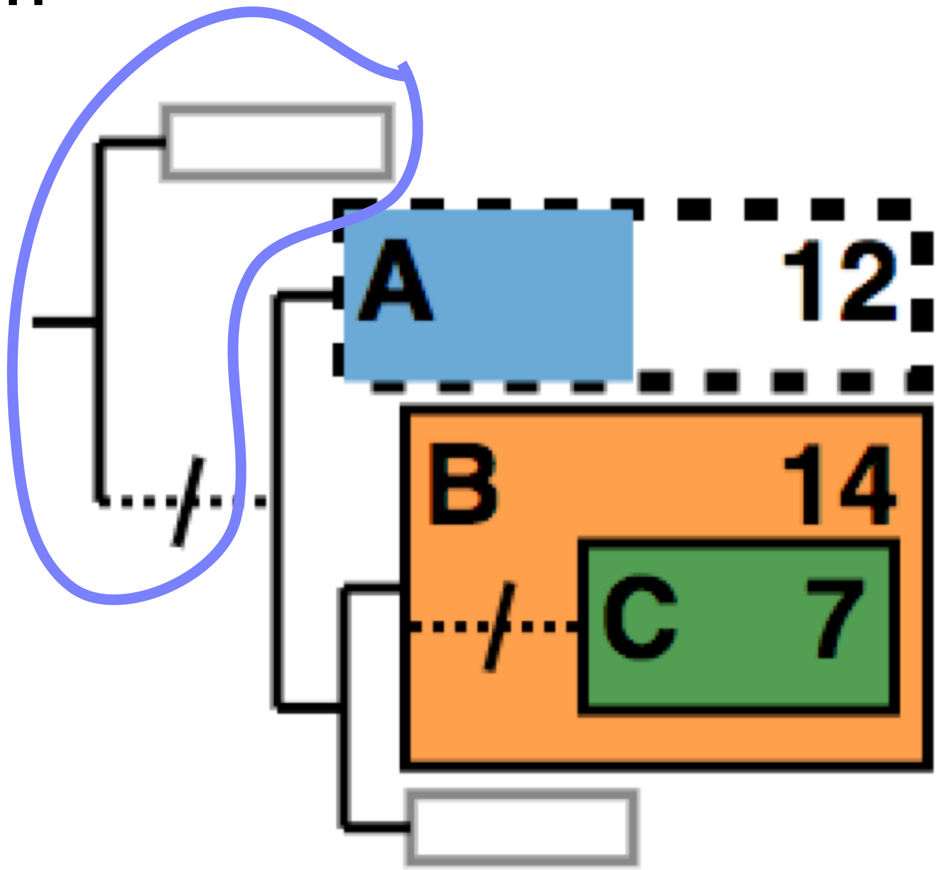
Visual design: focus + context

- focus
  - selected subtrees
  - topological relationships between them
- context
  - neighboring subtrees



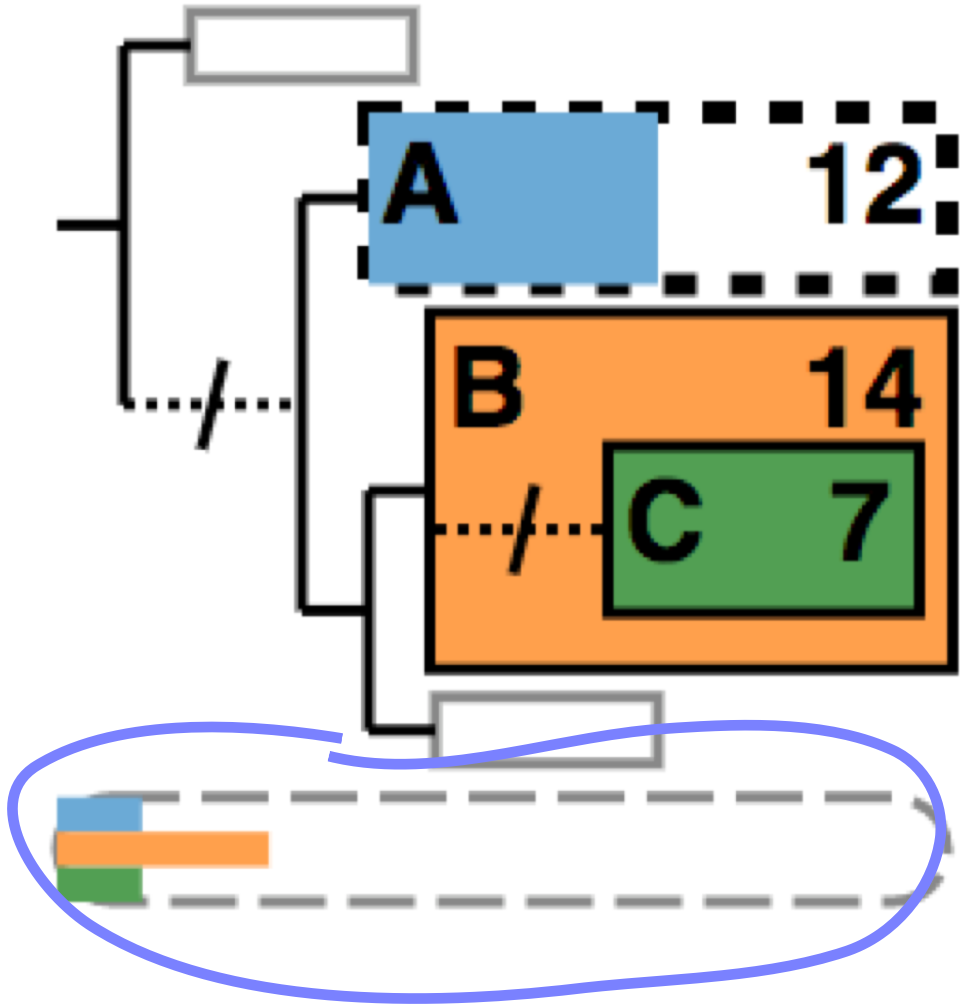
Visual design: focus + context

- focus
  - selected subtrees
  - topological relationships between them
- context
  - neighboring subtrees
  - upstream topology and root



Visual design: focus + context

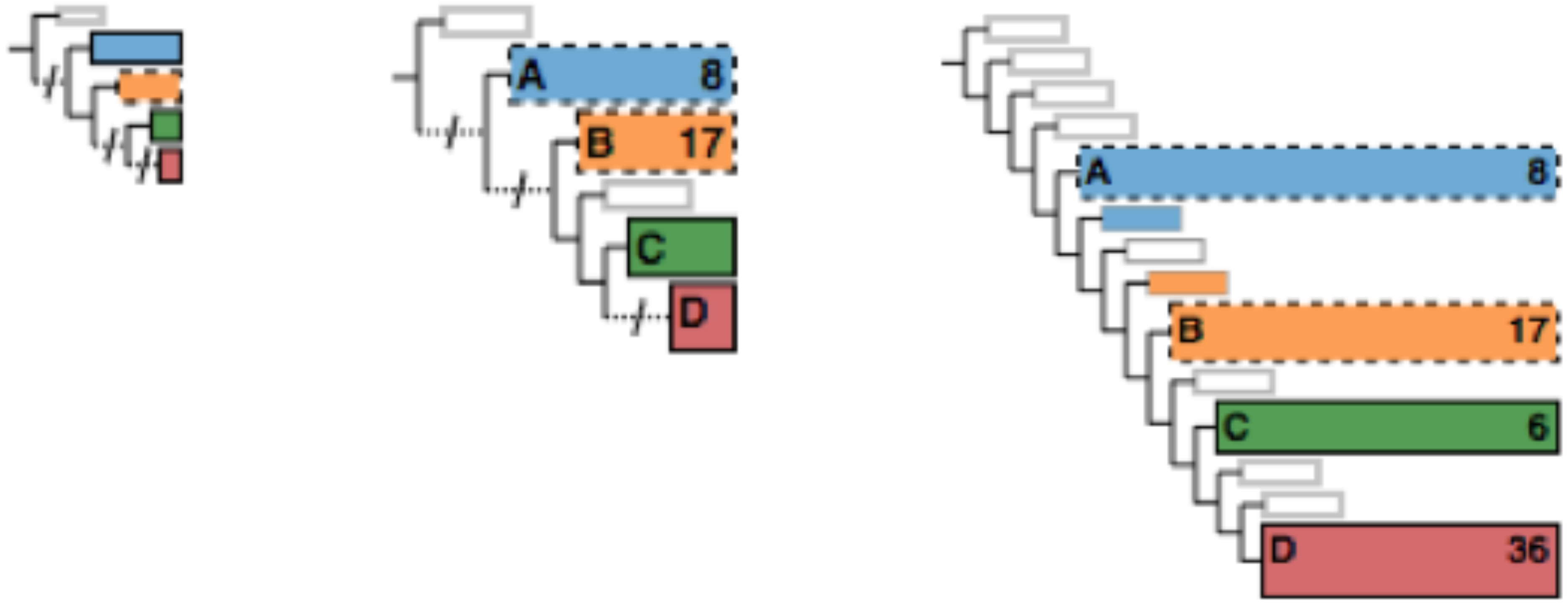
- focus
  - selected subtrees
  - topological relationships between them
- context
  - neighboring subtrees
  - upstream topology and root
  - missing leaf nodes



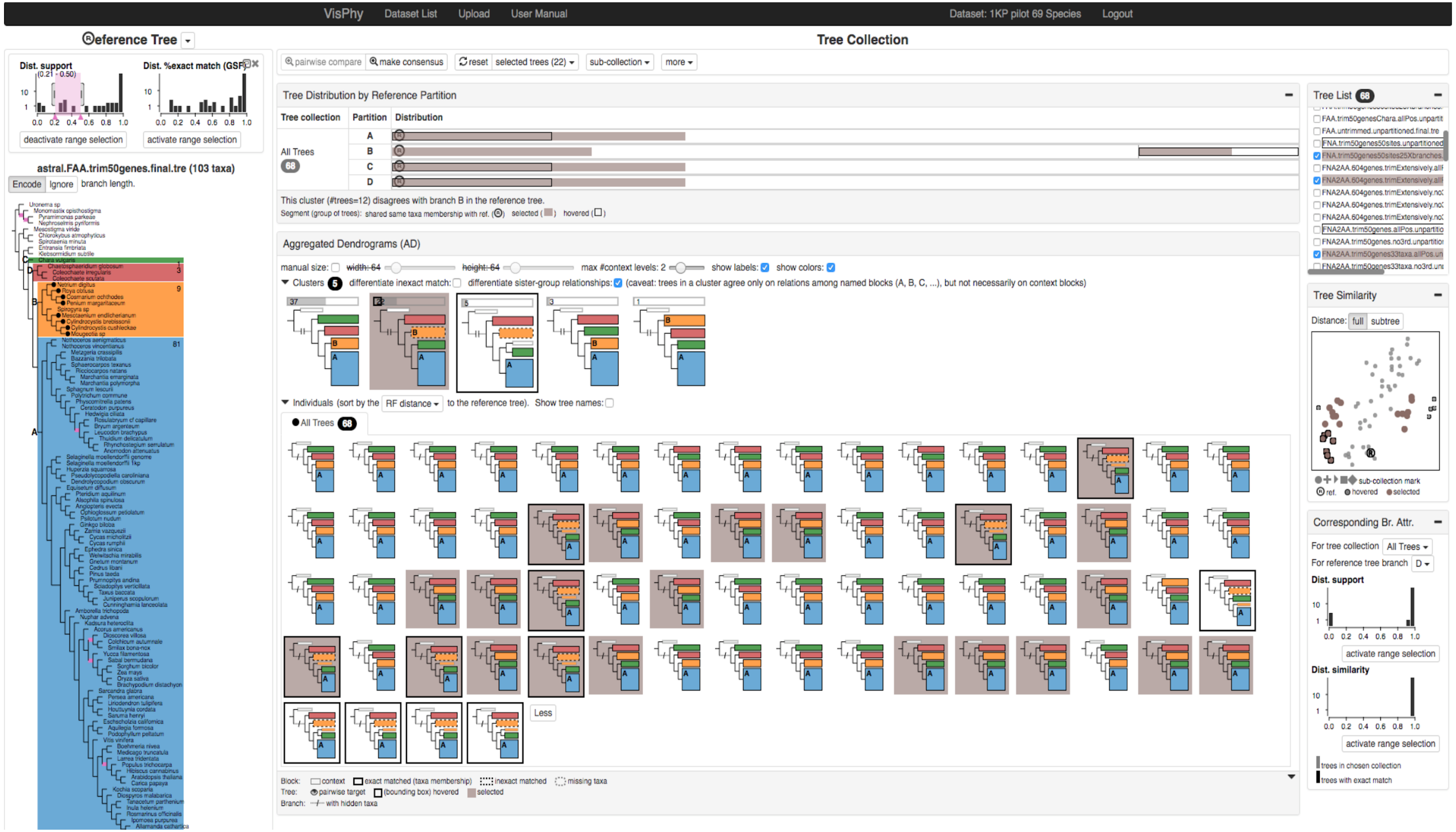
Visual design: algorithm adapts to space

- show more info when space permitted
  - labels
  - # leaf nodes
  - neighboring blocks

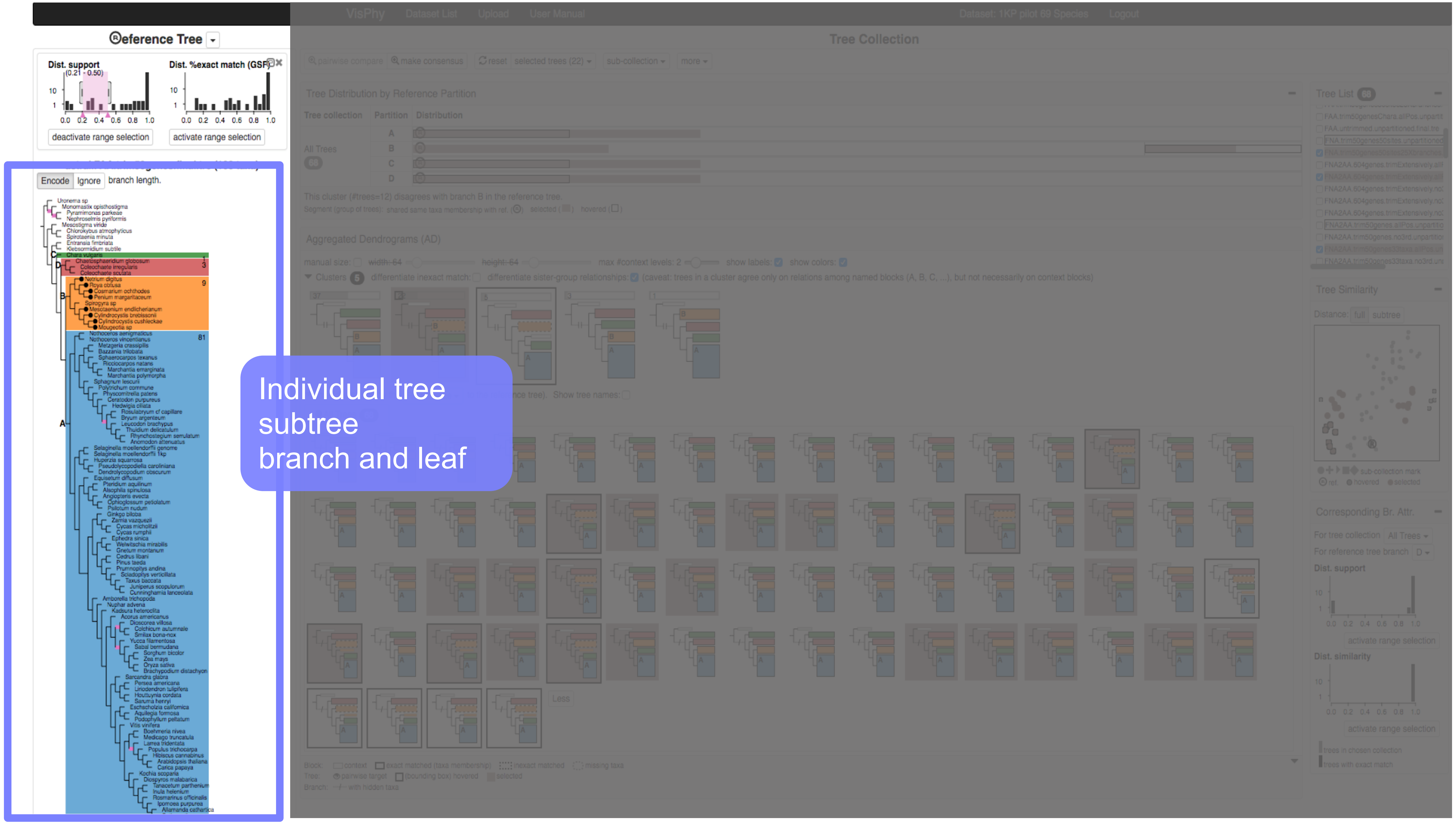
40x40 px **80x80 px** **160x160 px**



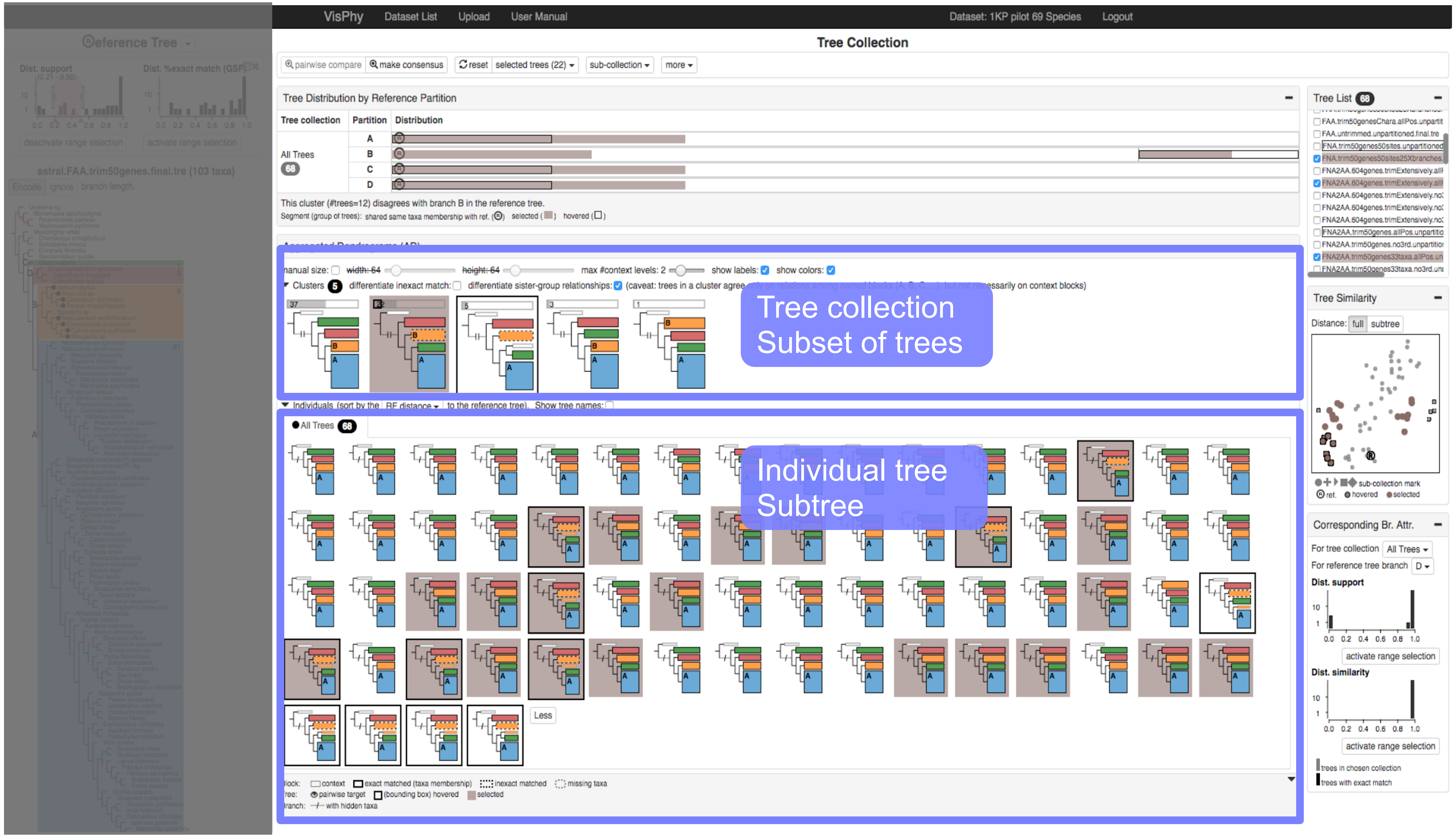
ADView interface: Multi-level structure across views



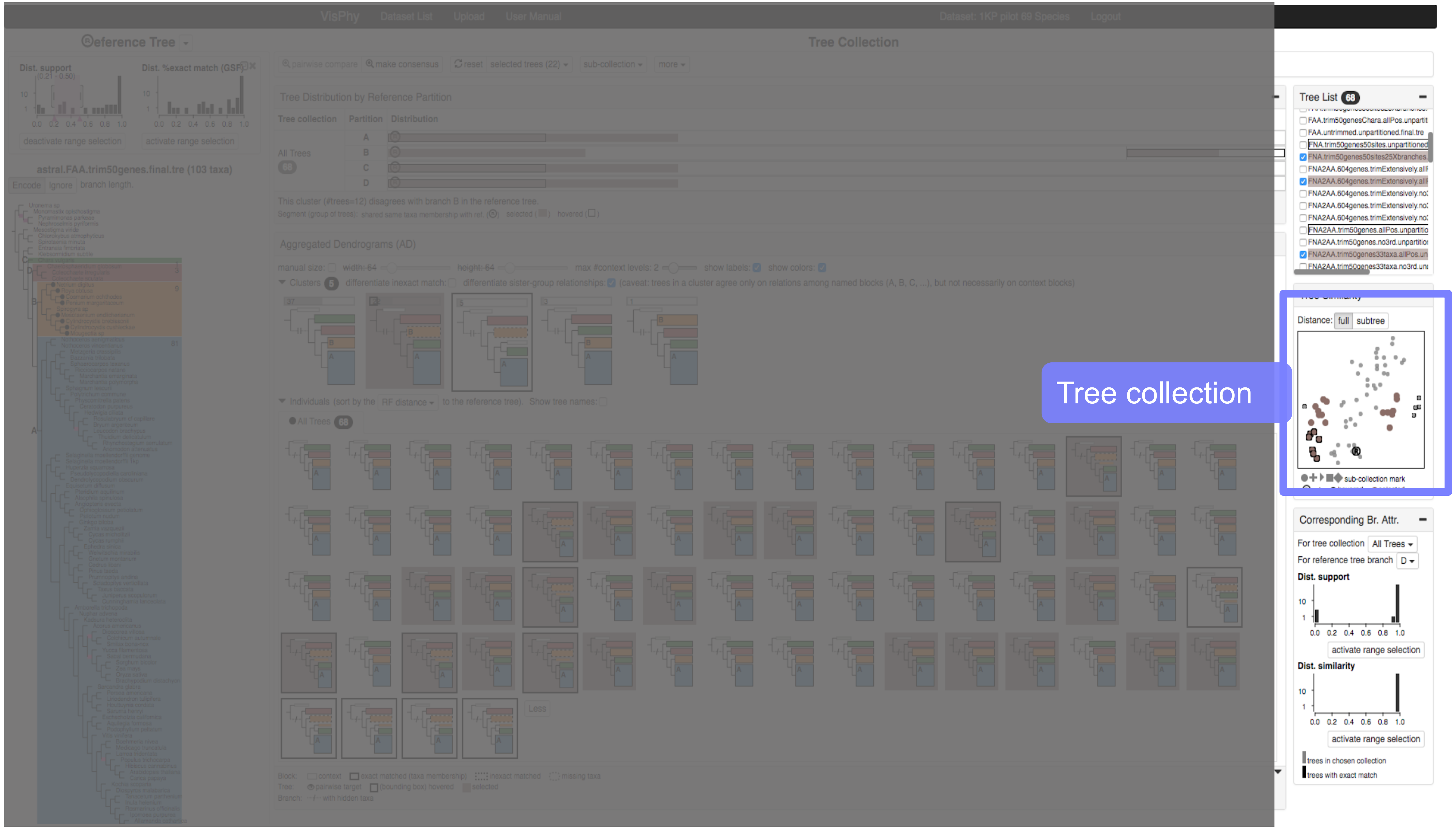
Interface walkthrough: reference tree



Interface walkthrough: individual & cluster ADs



Interface walkthrough: treespace



Validation with many biologists

- worked closely with a biology PhD student (second author)

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  - 10 biologists at different times throughout project

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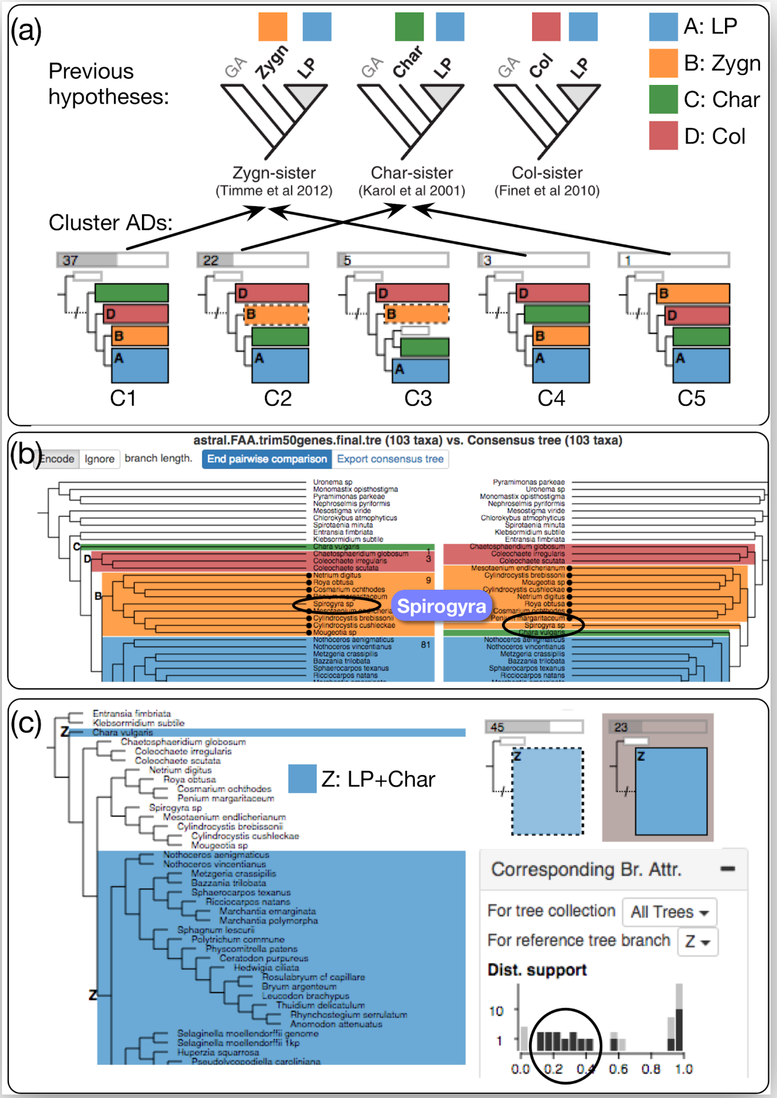
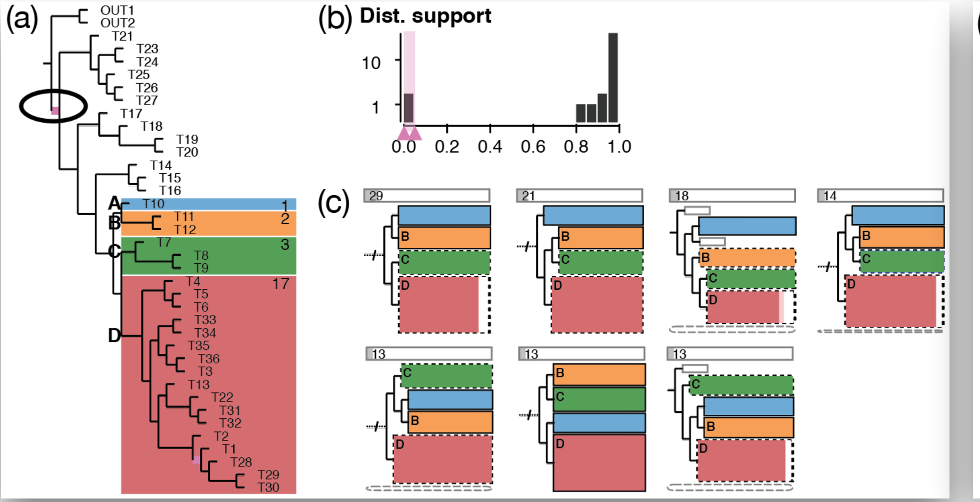
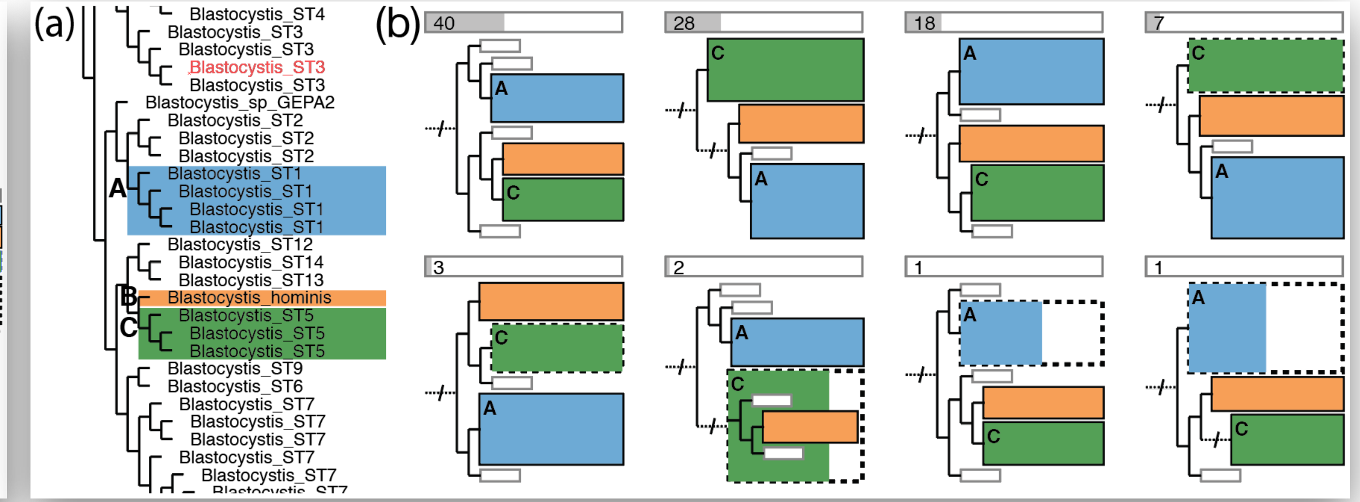
  - 5 biologists, using their own datasets

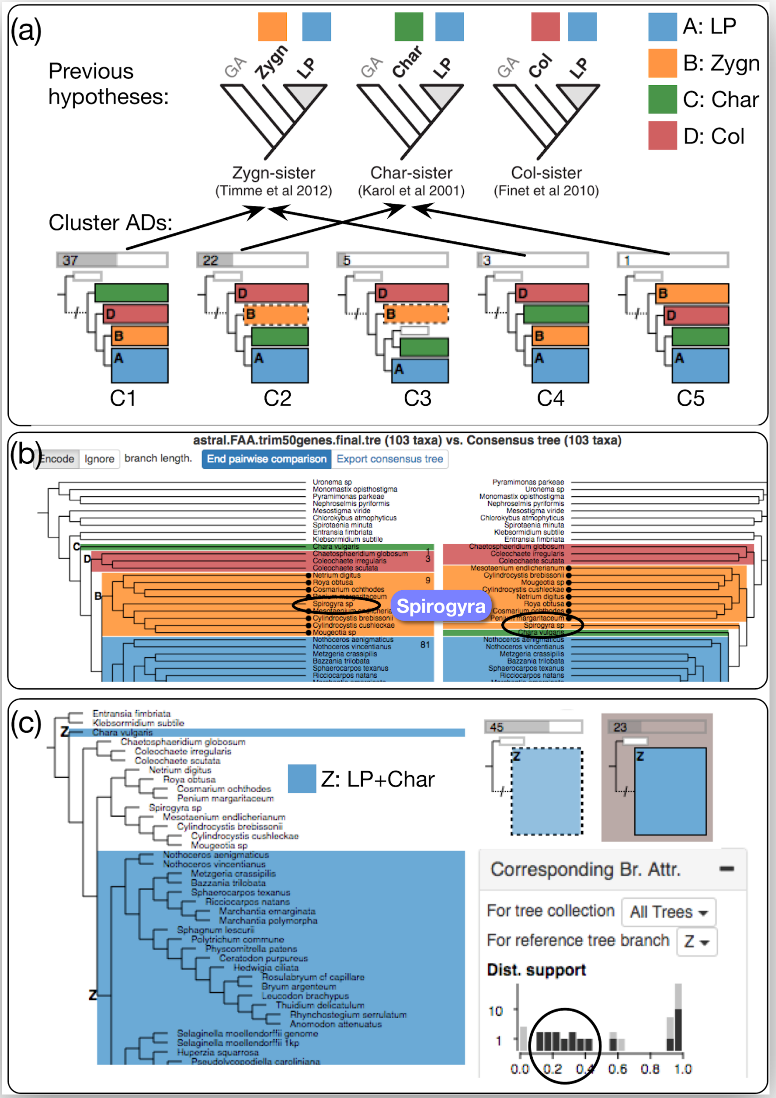


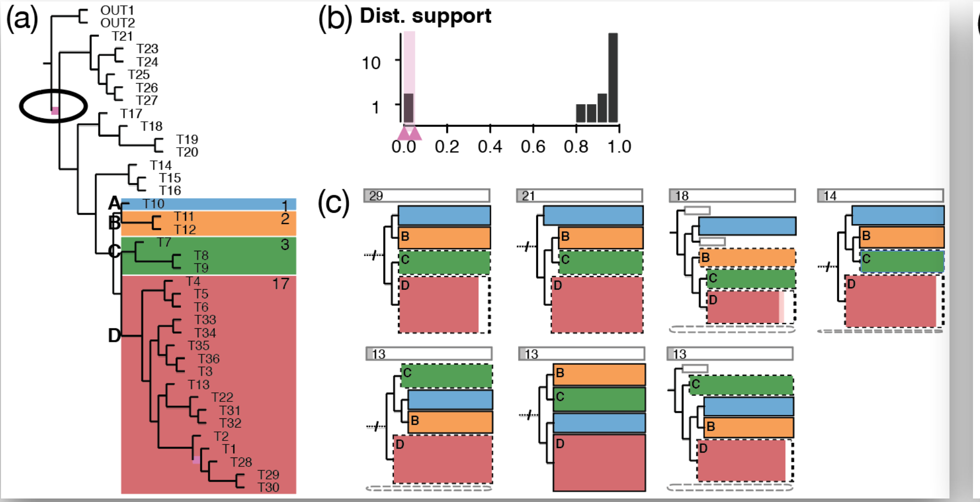


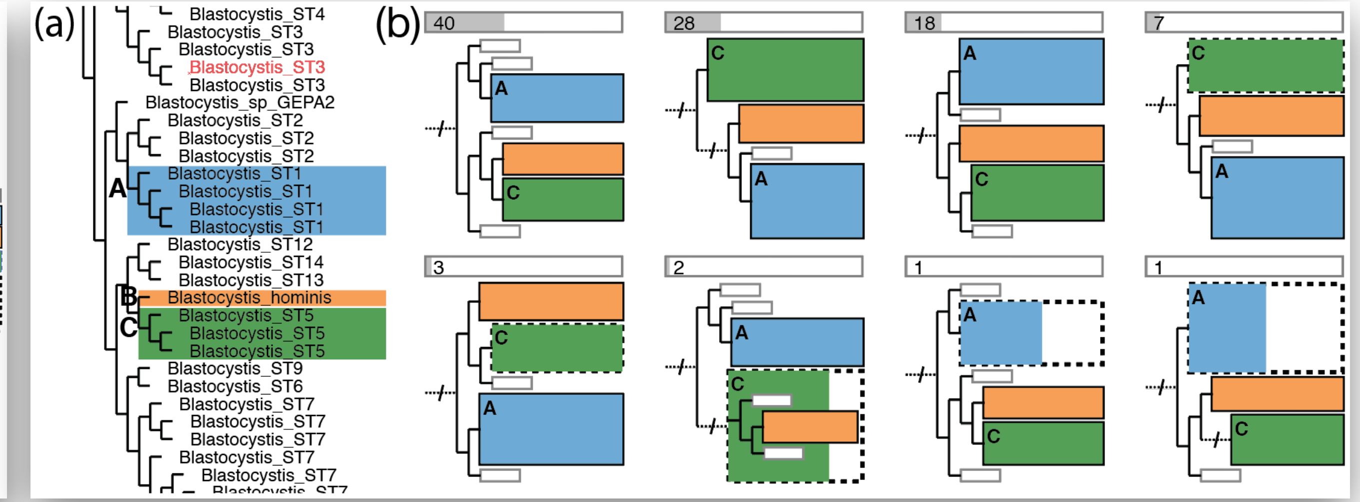


Validation with many biologists

- worked closely with a biology PhD student (second author)
- demos, interviews and discussions
  - 10 biologists at different times throughout project
- user study sessions
  - 5 biologists, using their own datasets
- biologists confirmed
  - validity of data and task abstractions
  - utility of ADView





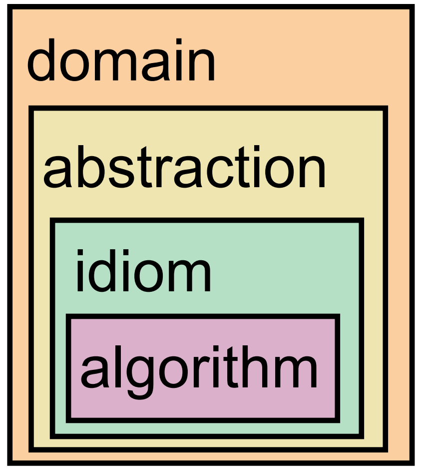


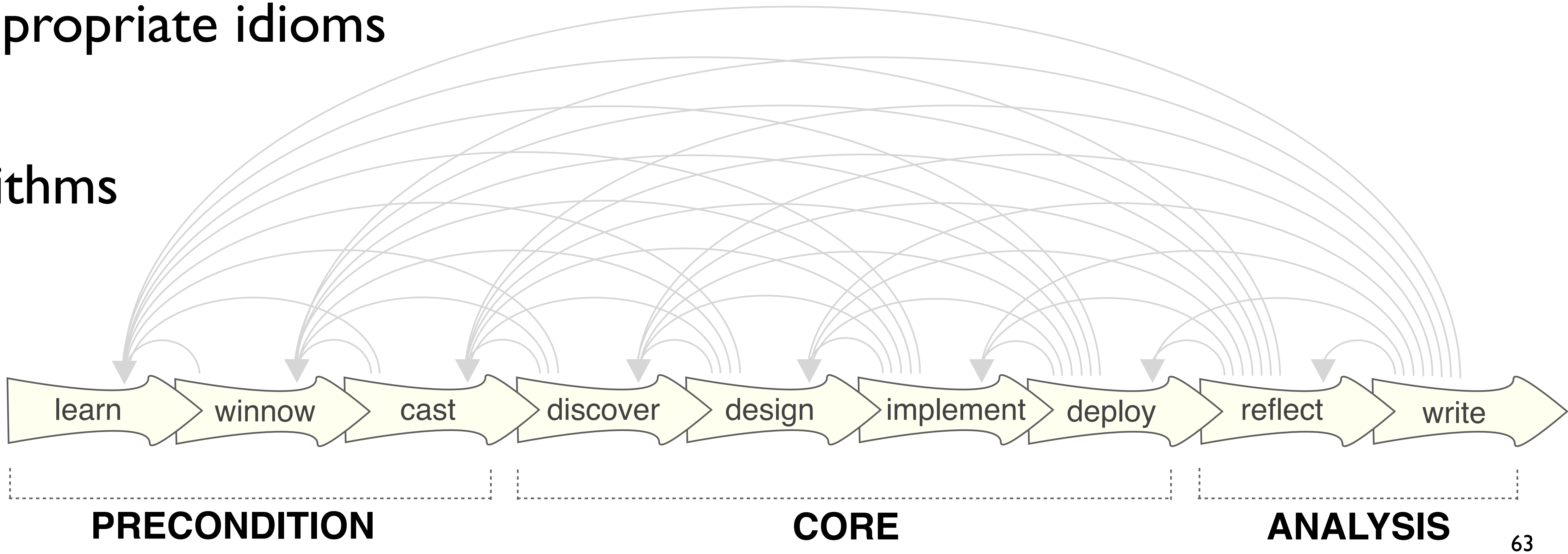
Video

https://www.youtube.com/watch?v=2SLcz7KNLJw

Problem-driven visualization with design study methodology

- work through all four levels of nested model
  - investigate domain
  - identify abstractions
    - crucial -- & difficult -- iterative process
  - select or create appropriate idioms
  - develop new algorithms
    - if need be



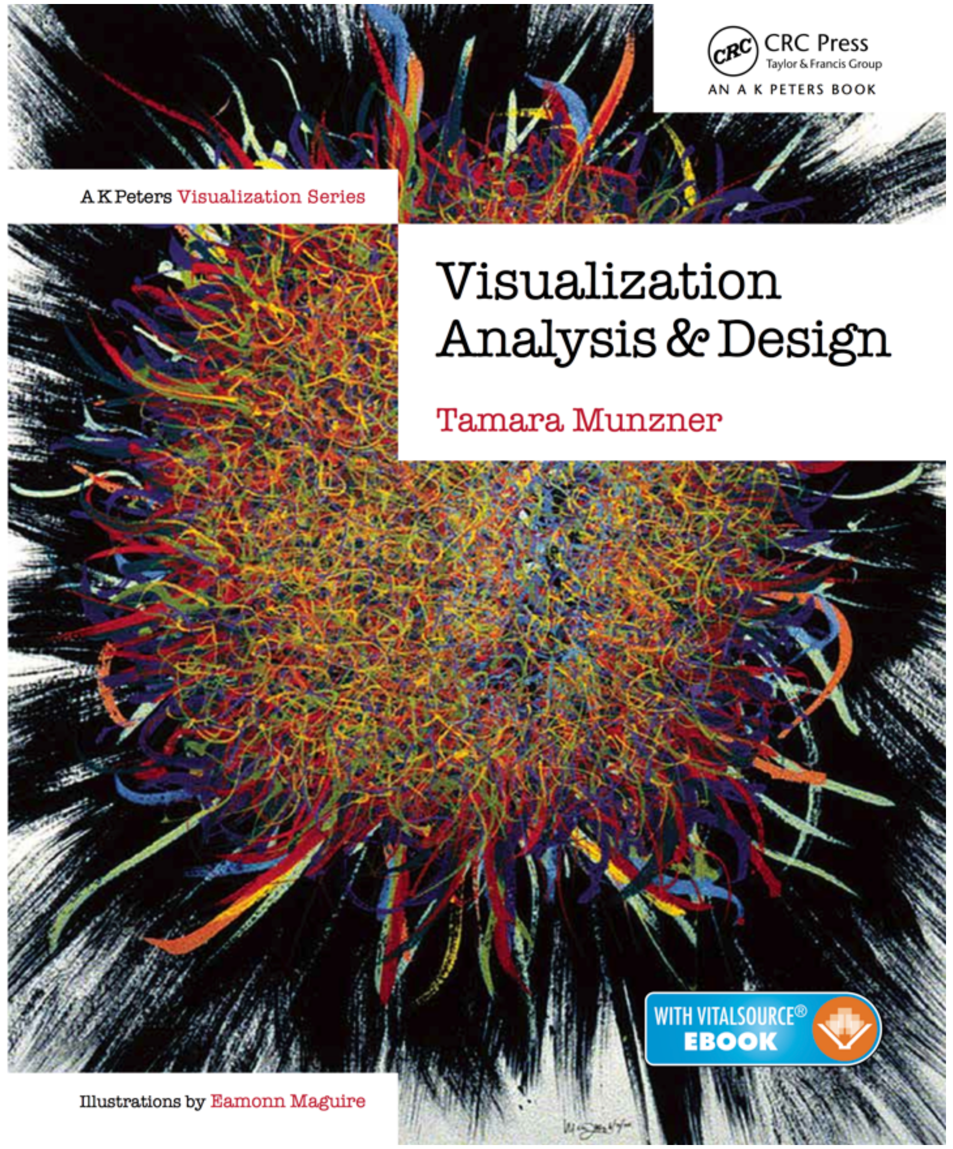


More information

- this talk
  http://www.cs.ubc.ca/~tmm/talks.html#amw24

- book
  http://www.cs.ubc.ca/~tmm/vadbook
  (hardcopy on demo/stuff table)

- full courses, papers, videos, software, talks
  http://www.cs.ubc.ca/group/infovis
  http://www.cs.ubc.ca/~tmm



Visualization Analysis and Design. Munzner. *CRC Press, AK Peters Visualization Series, 2014.*

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