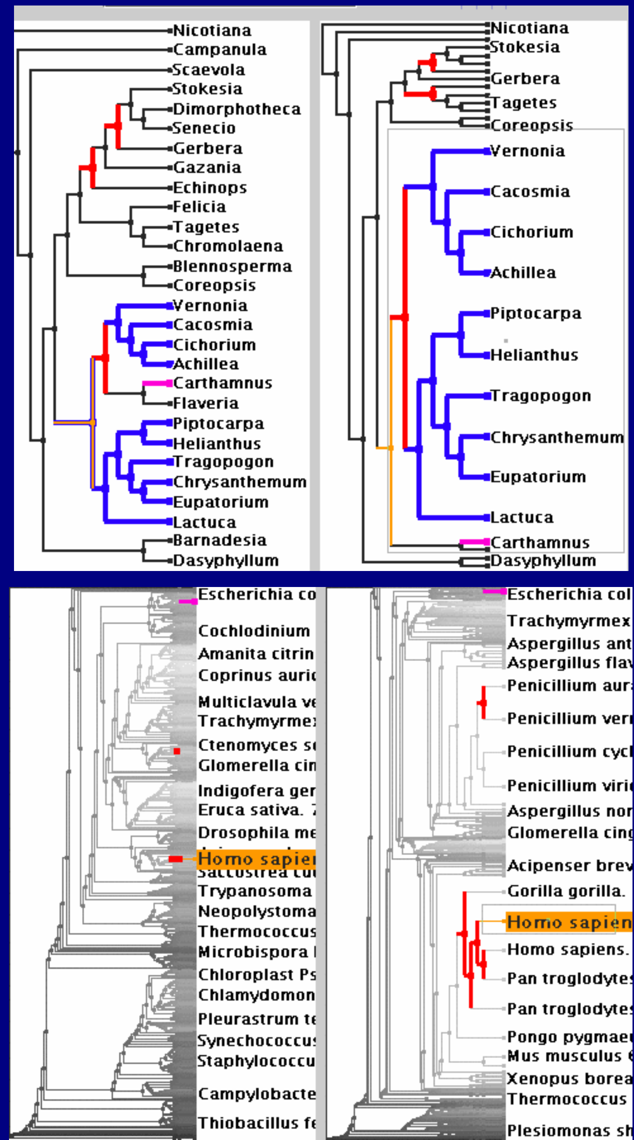
Information Visualization with Accordion Drawing

Tamara Munzner

University of British Columbia

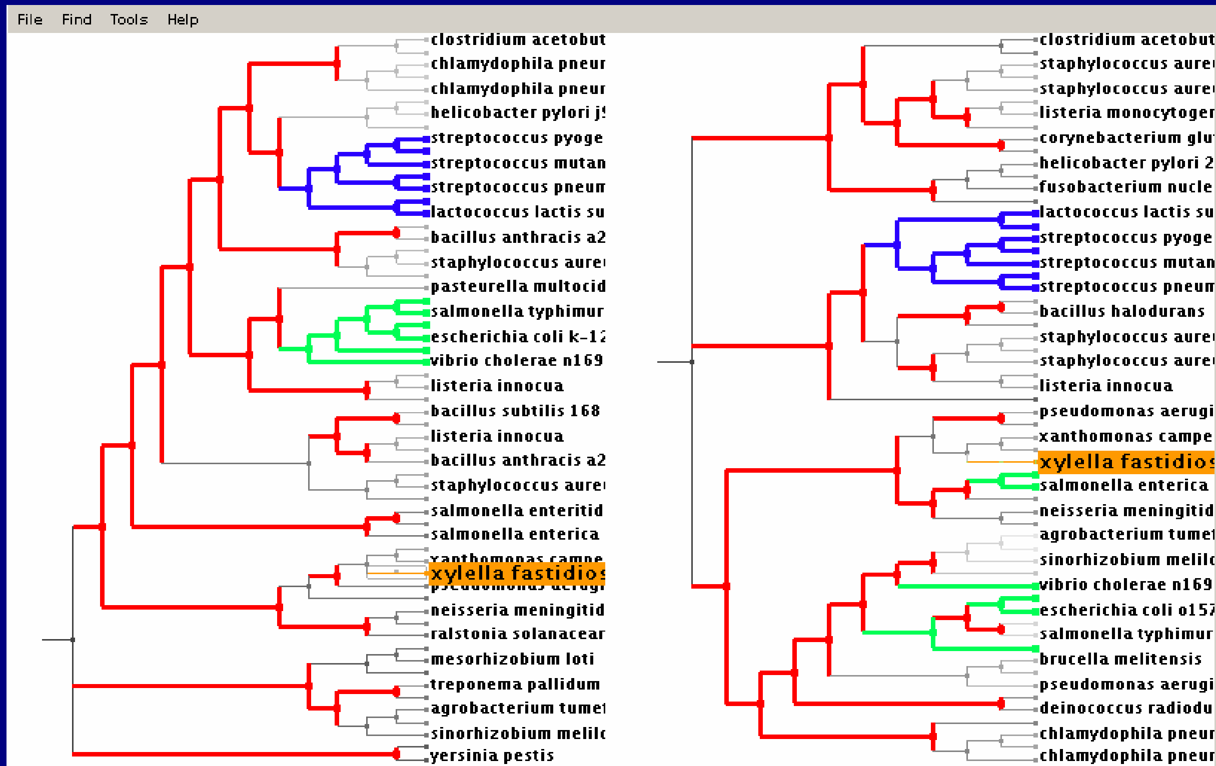
Accordion Drawing

- rubber-sheet navigation
  - stretch out part of surface, the rest squishes
  - borders nailed down
  - Focus+Context technique
    - integrated overview, details
  - old idea
    - [Sarkar et al 93], ...
- guaranteed visibility
  - marks always visible
  - important for scalability
  - new idea
    - [Munzner et al 03]



Guaranteed Visibility

- marks are always visible
- easy with small datasets



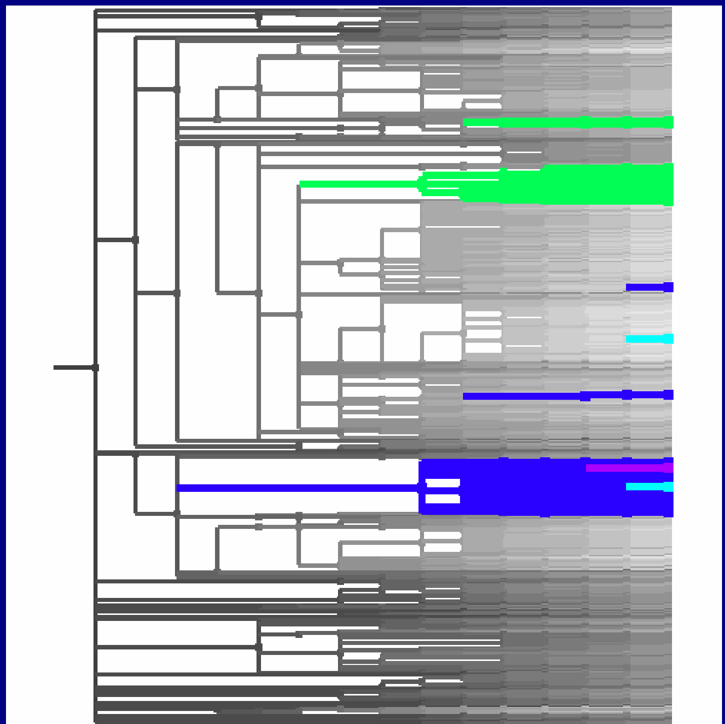
Guaranteed Visibility Challenges

- hard with larger datasets
- reasons a mark could be invisible
  - outside the window
    - AD solution: constrained navigation
  - underneath other marks
    - AD solution: avoid 3D
  - smaller than a pixel
    - AD solution: smart culling

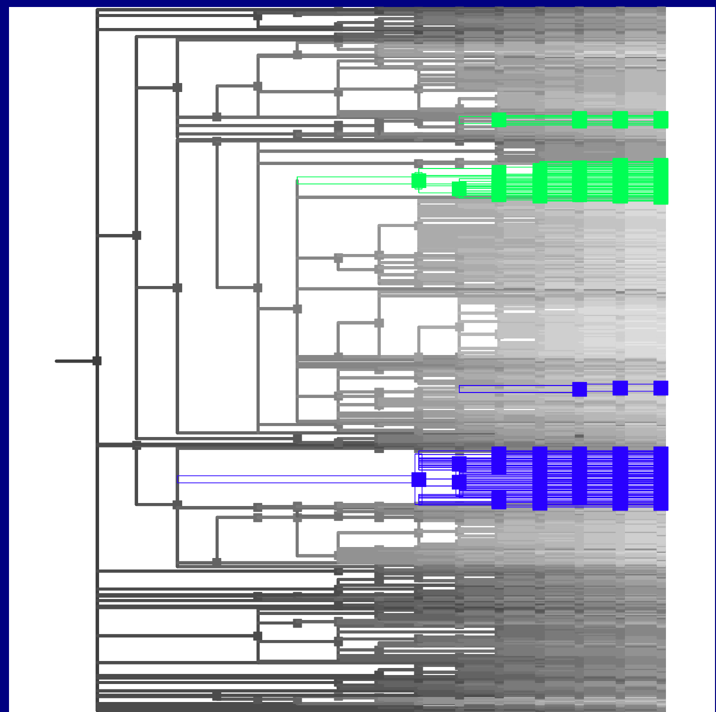
Guaranteed Visibility: Small Items

- naive culling may not draw all marked items

GV



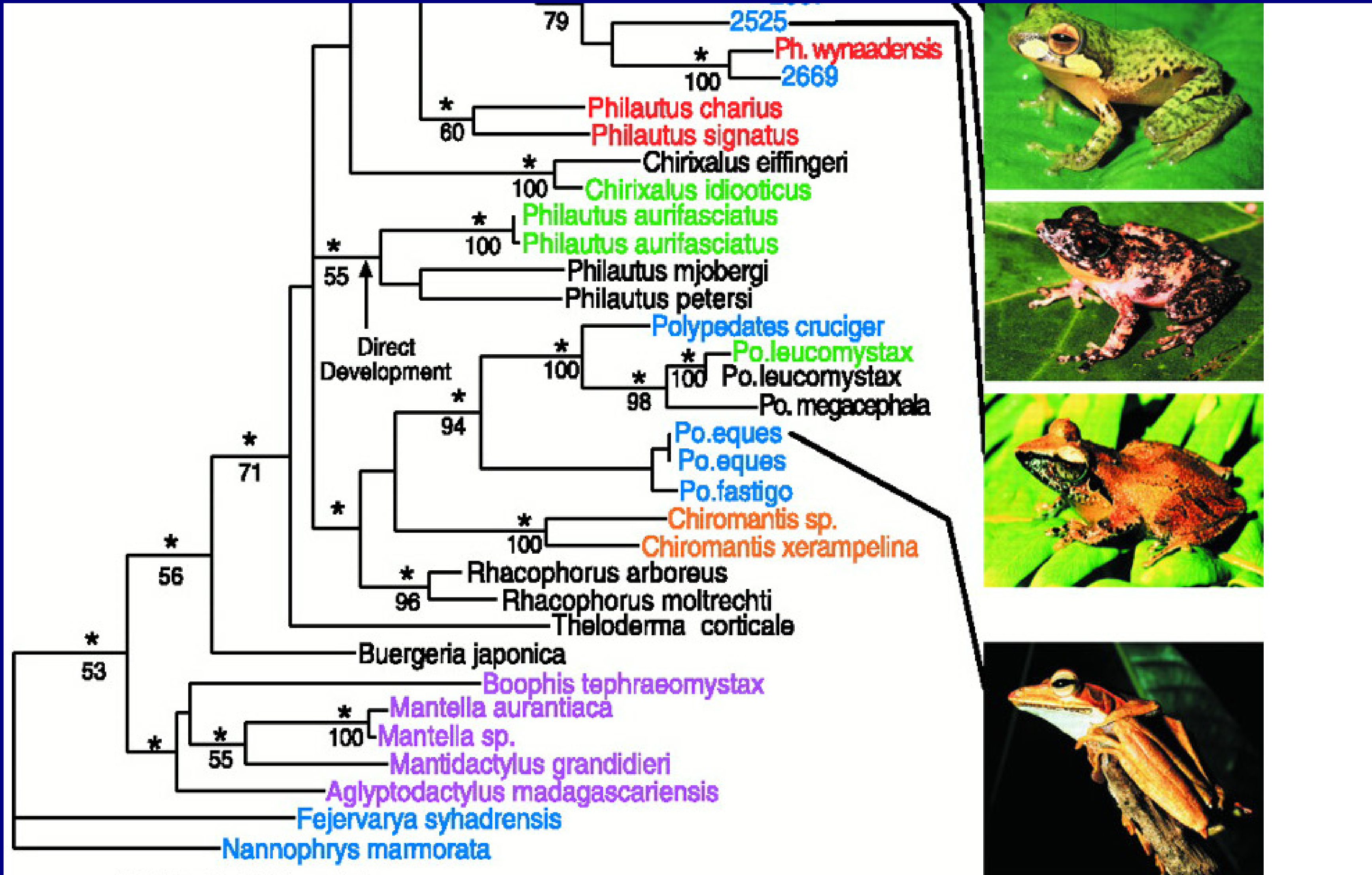
no GV



Outline

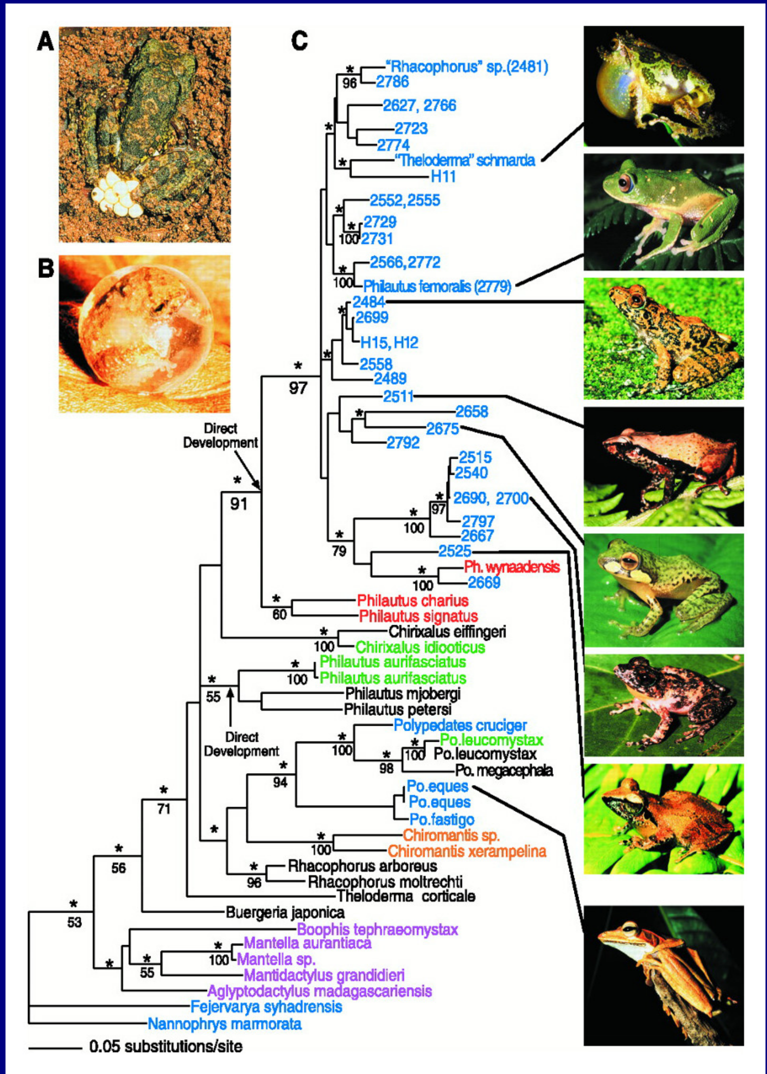
- trees
  - TreeJuxtaposer
- sequences
  - SequenceJuxtaposer
- scaling up trees
  - TJC
- general AD framework
  - PRISAD
- power sets
  - PowerSetViewer
- evaluation

Phylogenetic/Evolutionary Tree



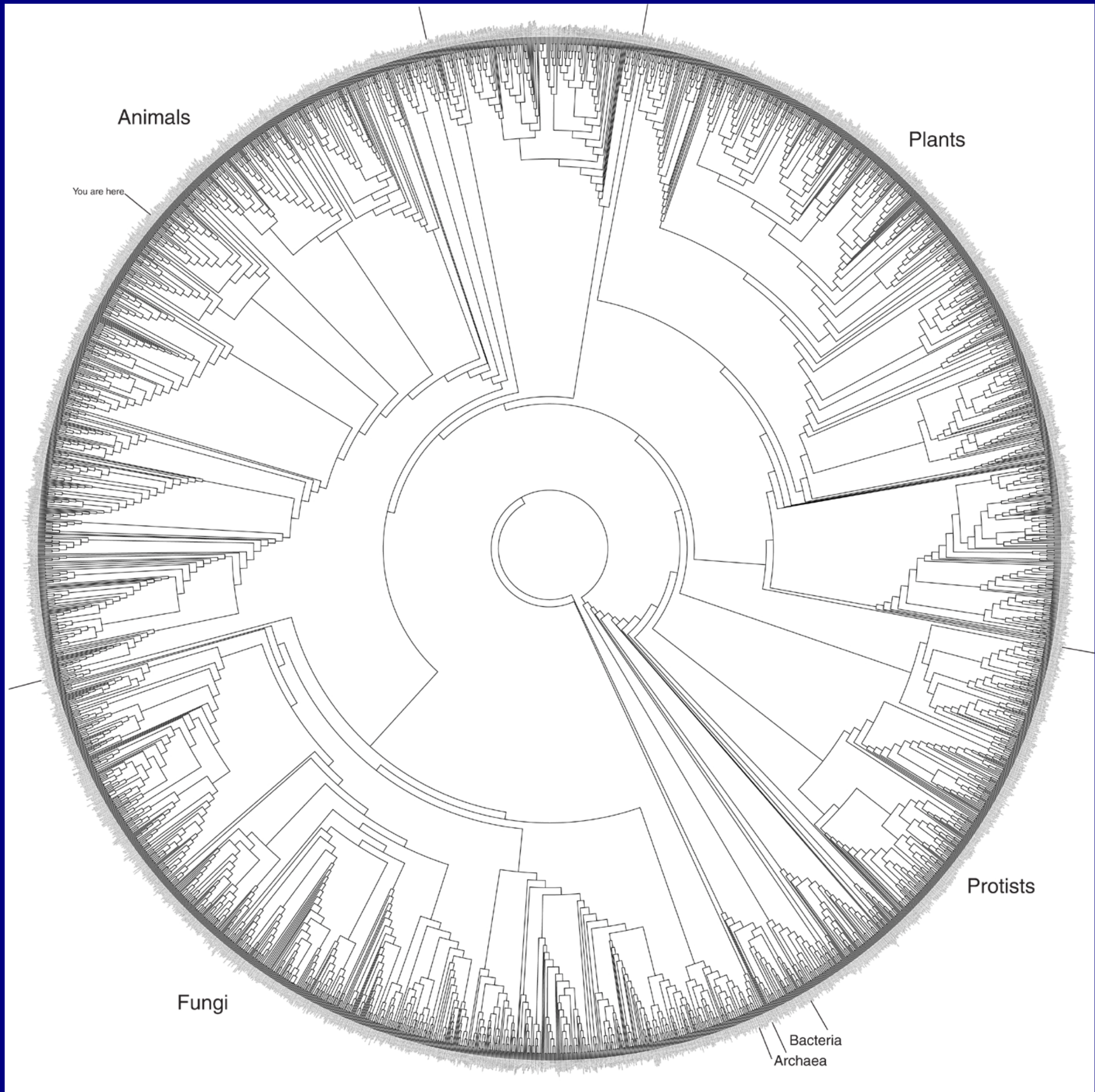
M Meegaskumbura et al., Science 298:379 (2002)

Common Dataset Size Today



M Meegaskumbura et al., Science 298:379 (2002)

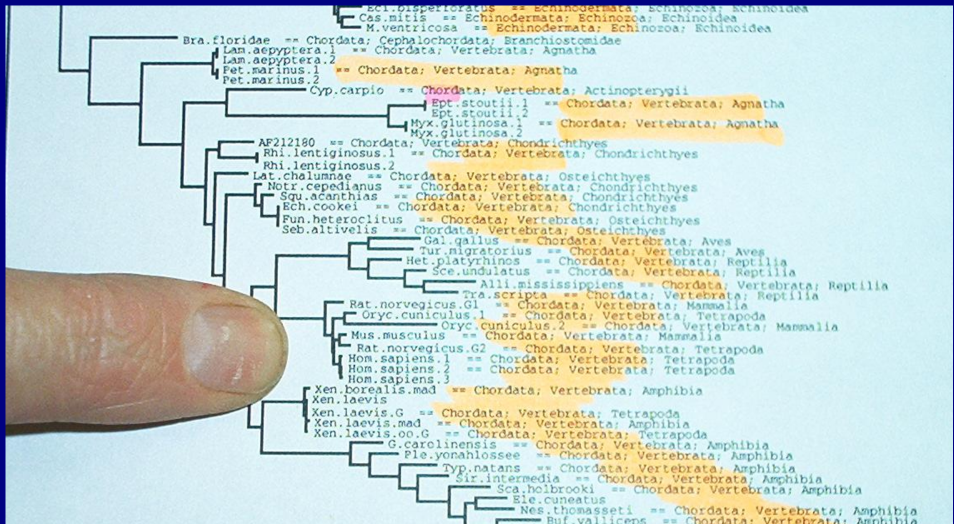
Future Goal: 10M Node Tree of Life

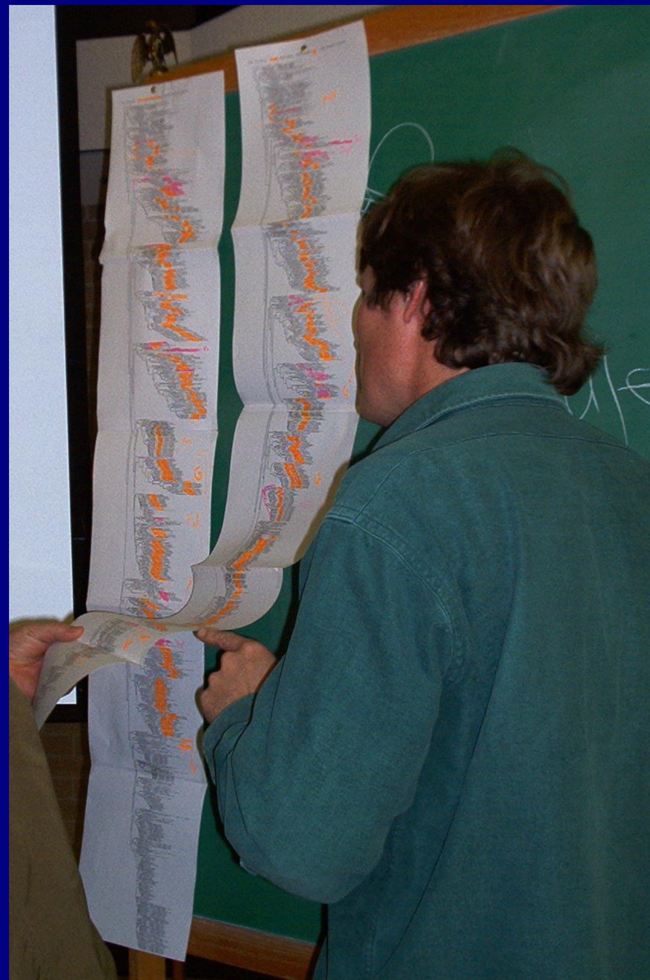


David Hillis, Science 300:1687 (2003)

Paper Comparison: Multiple Trees

focus

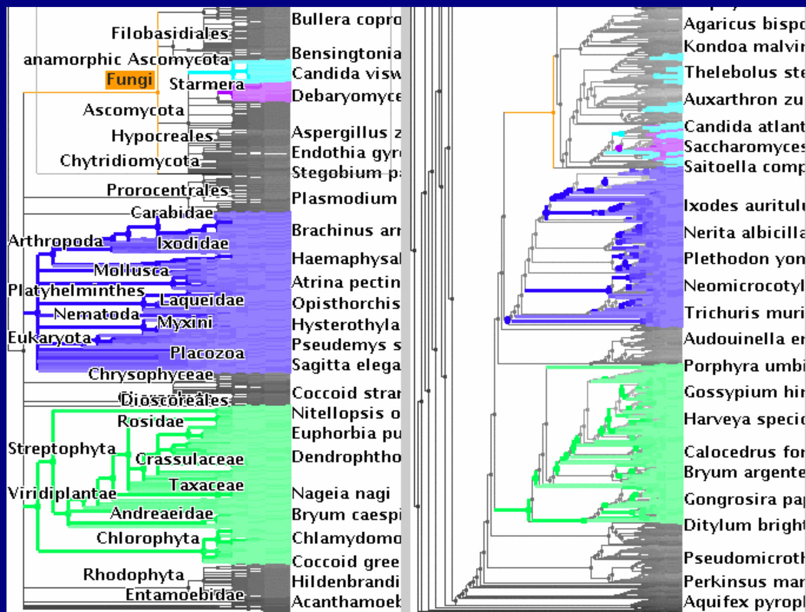




context

TreeJuxtaposer

- comparison of evolutionary trees
  – side by side
- demo
  – olduvai.sf.net/tj



TJ Contributions

- first interactive tree comparison system
  - automatic structural difference computation
  - guaranteed visibility of marked areas
- scalable to large datasets
  - 250,000 to 500,000 total nodes
  - all preprocessing subquadratic
  - all realtime rendering sublinear
- introduced accordion drawing (AD)
- introduced guaranteed visibility (GV)

Joint Work: TJ Credits

Tamara Munzner, Francois Guimbretiere, Serdar Tasiran, Li Zhang, and Yunhong Zhou.

TreeJuxtaposer: Scalable Tree Comparison using Focus+Context with Guaranteed Visibility.

SIGGRAPH 2003

www.cs.ubc.ca/~tmm/papers/tj

James Slack, Tamara Munzner, and Francois Guimbretiere.

TreeJuxtaposer: InfoVis03 Contest Entry. (Overall Winner)

InfoVis 2003 Contest

www.cs.ubc.ca/~tmm/papers/contest03

Outline

- trees
  - TreeJuxtaposer
- sequences
  - SequenceJuxtaposer
- scaling up trees
  - TJC
- general AD framework
  - PRISAD
- power sets
  - PowerSetViewer
- evaluation

Genomic Sequences

- multiple aligned sequences of DNA
- now commonly browsed with web apps
  - zoom and pan with abrupt jumps
- check benefits of accordion drawing
  - smooth transitions between states
  - guaranteed visibility for globally visible landmarks

SequenceJuxtaposer

- dense grid, following conventions
  - rows of sequences partially correlated
  - columns of aligned nucleotides
  - videos

SJ Contributions

- accordion drawing for gene sequences
- paper results: 1.7M nucleotides
  – current with PRISAD: 40M nucleotides
- joint work: SJ credits

James Slack, Kristian Hildebrand, Tamara Munzner, and Katherine St. John.

SequenceJuxtaposer: Fluid Navigation For Large-Scale Sequence Comparison In Context.

Proc. German Conference on Bioinformatics 2004

www.cs.ubc.ca/~tmm/papers/sj

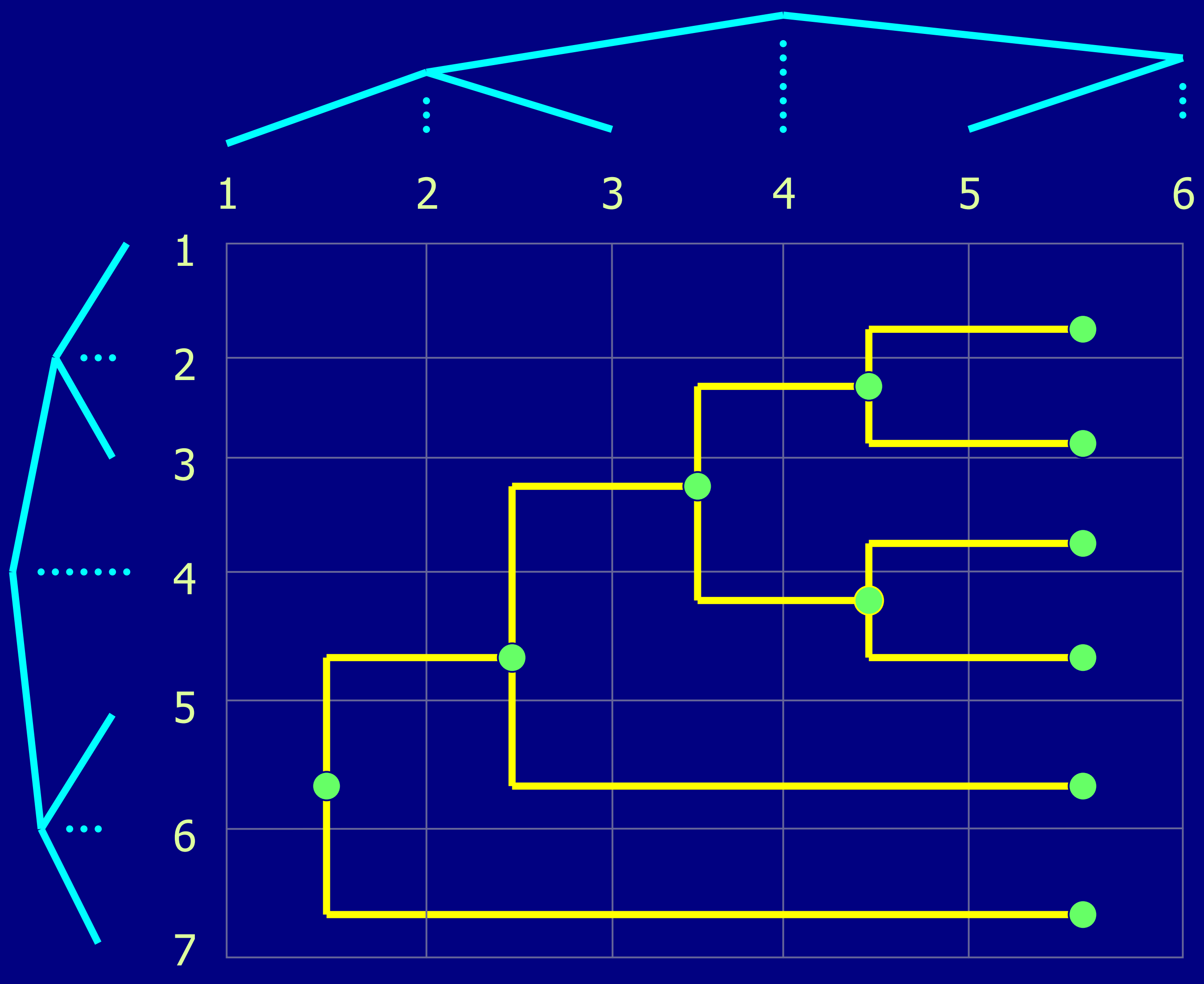
Outline

- trees
  - TreeJuxtaposer
- sequences
  - SequenceJuxtaposer
- scaling up trees
  - TJC
- general AD framework
  - PRISAD
- power sets
  - PowerSetViewer
- evaluation

Scaling Up Trees

- TJ limits
  - large memory footprint
  - CPU-bound, far from achieving peak rendering performance of graphics card
- quadtree data structure used for
  - placing nodes during layout
  - drawing edges given navigation
  - culling edges with GV
  - selecting edges during interaction

Navigation Without Quadtrees

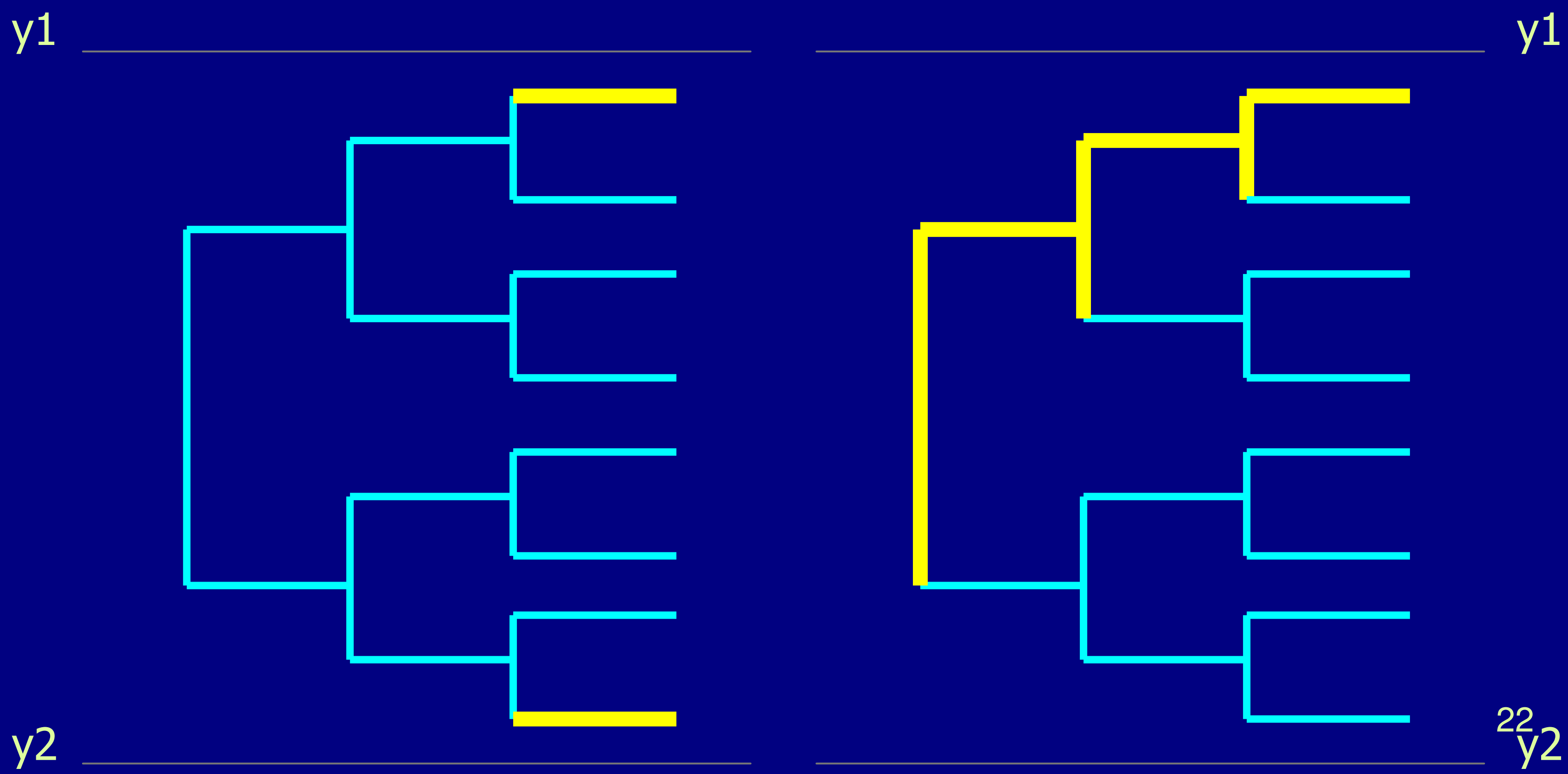


Eliminating the Quadtree

- new drawing algorithm
  - addresses both ordering and culling
- new way to pick edges
  - uses advances in recent graphics hardware
- find a different way to place nodes
  - modification of O-buffer for interaction

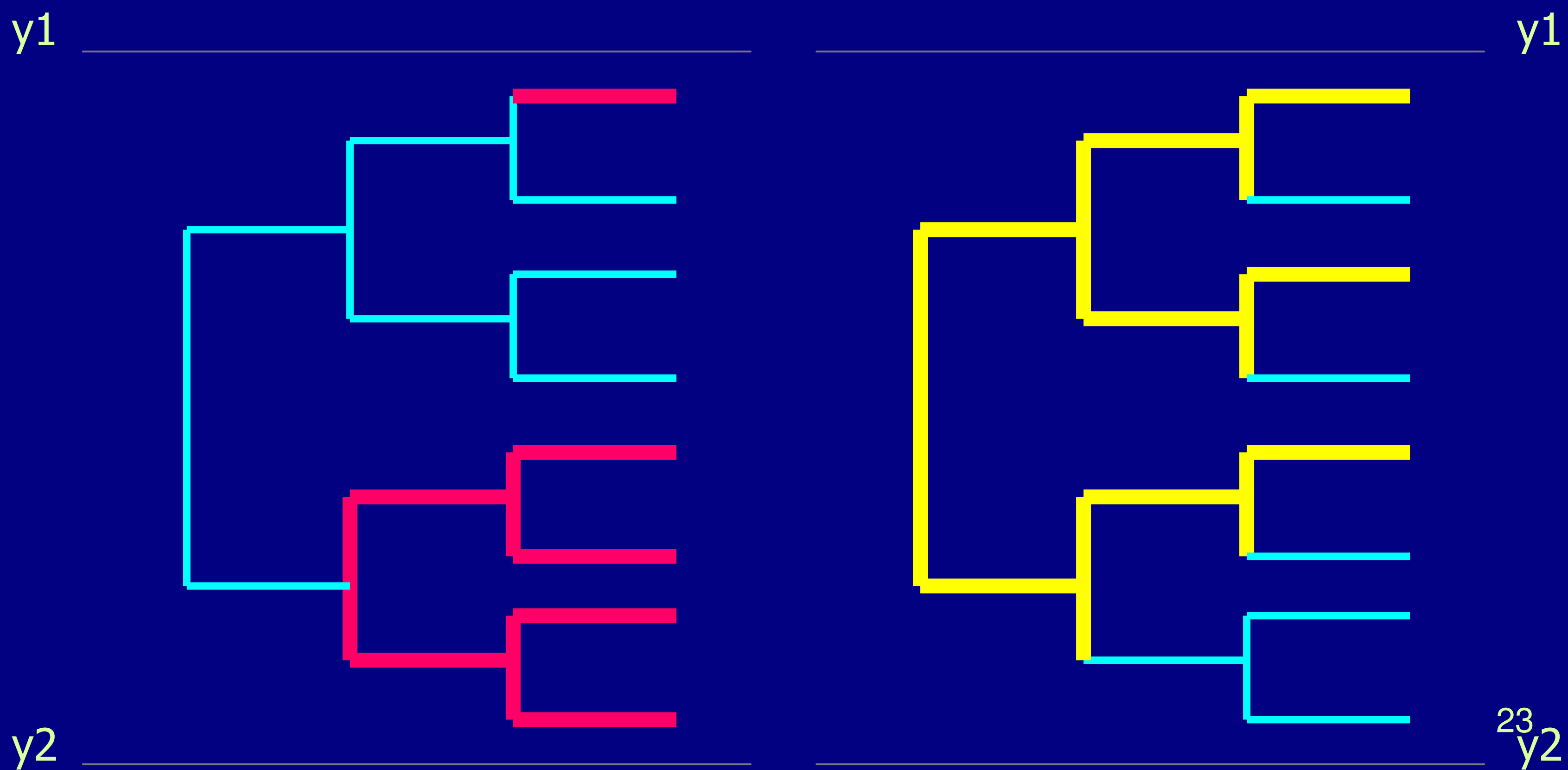
Drawing the Tree

- continue recursion only if sub-tree vertical extent larger than apixel
  - otherwise draw flattened path



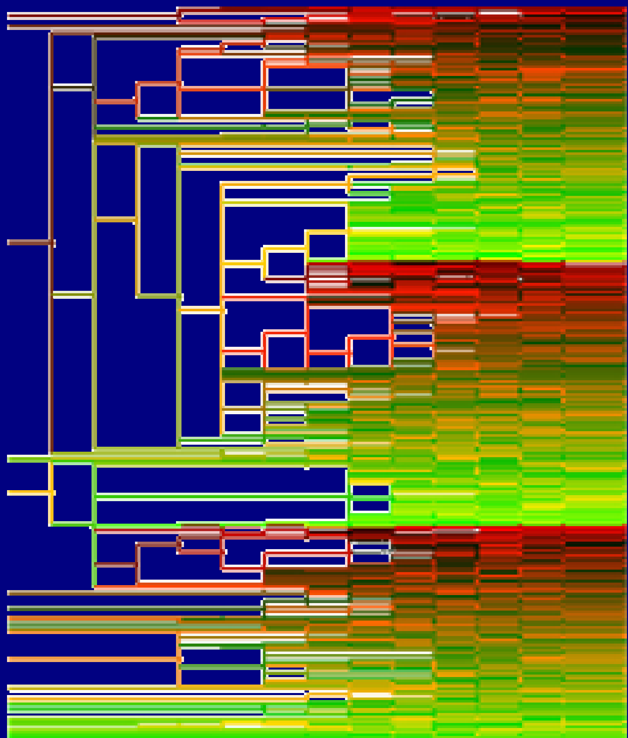
Guaranteed Visibility

- continue recursion only if subtree contains both marked and unmarked nodes



Picking Edges

- Multiple Render Targets
  - draw edges to displayed buffer
  - encoding edge identifier information in auxiliary buffer



TJC/TJC-Q Results

- TJC
  - no quadtree
  - requires HW multiple render target support
  - 15M nodes
- TJC-Q
  - lightweight quadtree
  - 5M nodes
- both support tree browsing only
  - no comparison data structures

Joint Work: TJC, TJC-Q Credits

Dale Beermann, Tamara Munzner, and Greg Humphreys.
Scalable, Robust Visualization of Large Trees.
Proc. EuroVis 2005
www.cs.virginia.edu/~gfx/pubs/TJC

Outline

- trees
  - TreeJuxtaposer
- sequences
  - SequenceJuxtaposer
- scaling up trees
  - TJC
- general AD framework
  - PRISAD
- power sets
  - PowerSetViewer
- evaluation

PRISAD

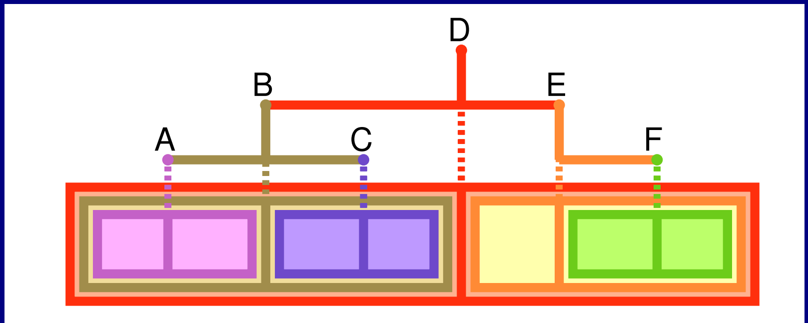
- generic accordion drawing infrastructure
  – handles many application types
- efficient
  – guarantees of correctness: no overculling
  – tight bounds on overdrawing
    - handles dense regions efficiently
  – new algorithms for rendering, culling, picking
    - exploit application dataset characteristics instead of requiring expensive additional data structures

PRISAD vs Application Interplay

	Application		PRISAD
World-space discretization	Layout	(x, y) size	Initialize
		$\{S_X, S_Y\}$	
	Gridding	S, node	Mapping
Screen-space rendering	Render	S, τ	Partition
		S ranges	
	Seed	Queue	Progressive Rendering
		Object	
	Draw		

PRISAD Responsibilities

- initializing a generic 2D grid structure
  - split lines: both linear ordering and recursive hierarchy



- mapping geometric objects to world-space structures
- partitioning a binary tree data structure into adjacent ranges
- controlling drawing performance for progressive rendering

Application Responsibilities

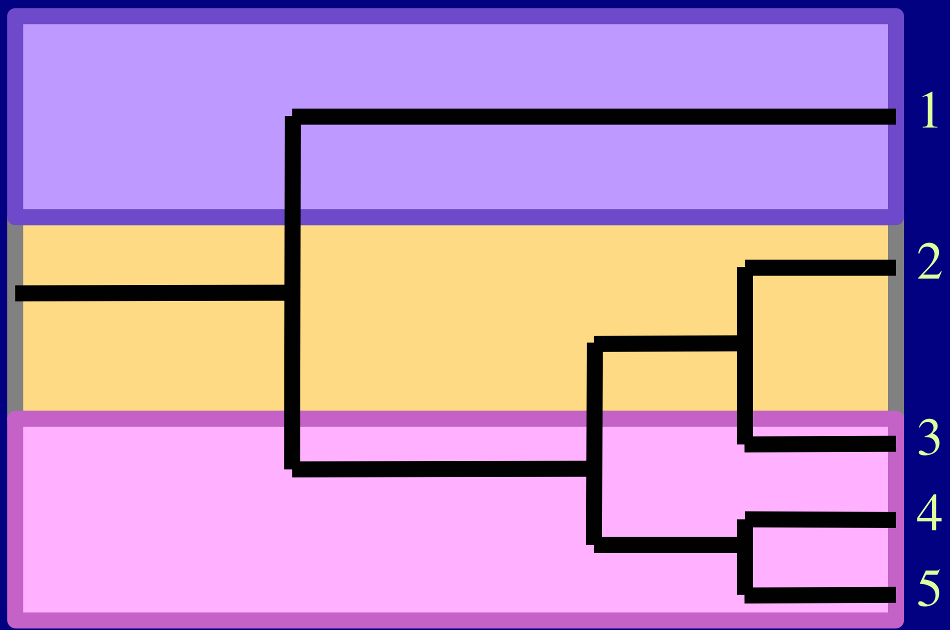
- calculating the size of underlying PRISAD structures
- assigning dataset components to PRISAD structures
- initiating a rendering action with two partitioning parameters
- ordering the drawing of geometric objects through seeding
- drawing individual geometric objects

Example: PRITree

- rendering with generic infrastructure
  - partitioning
    - rendering requires sub-pixel segments
    - partition split lines into leaf ranges
  - seeding
    - 1st: roots of marked sub-trees, marked nodes
    - 2nd: interaction box, remainder of leaf ranges
  - drawing
    - ascent rendering from leaves to root

Tree Partitioning

- divide leaf nodes by screen location
  - partitioning follows split line hierarchy
  - tree application provides stopping size criterion
  - ranges [1,1]; [2,2]; [3,5] are partitions



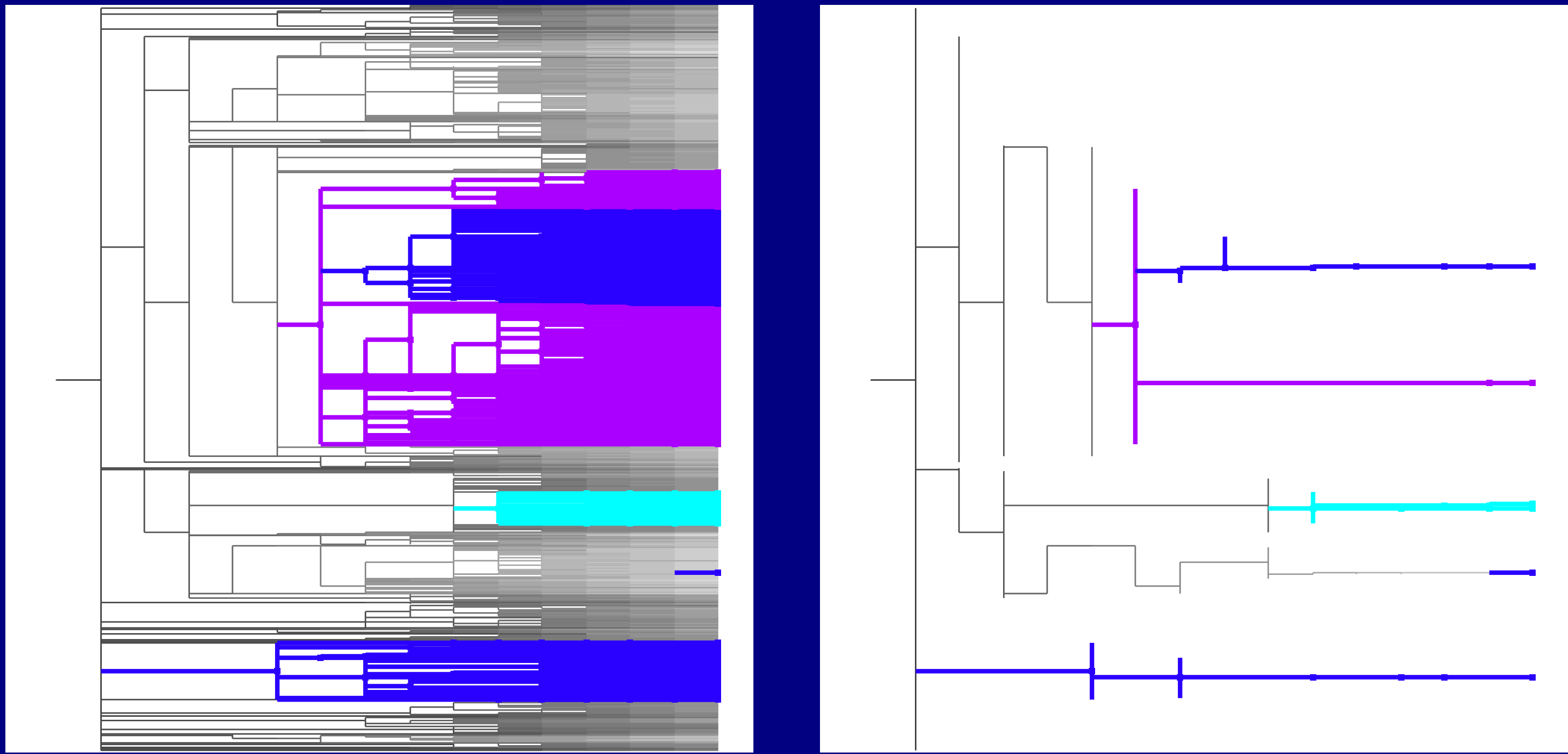
$L_0 = [1,1]$

$L_1 = [2,2]$

$L_2 = [3,5]$

Tree Seeding

- marked subtrees not drawn completely in first frame
  - draw “skeleton” of marks for each subtree for landmarks
  - solves guaranteed visibility of small subtree in big dataset

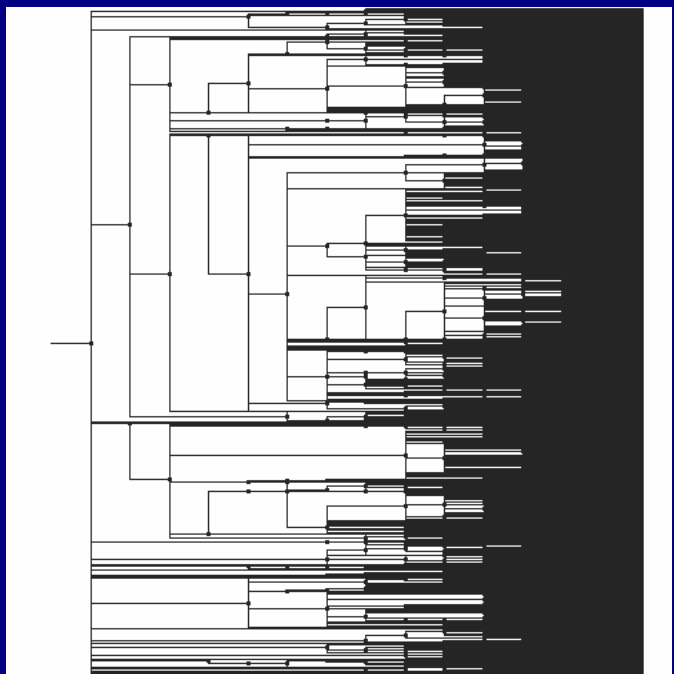


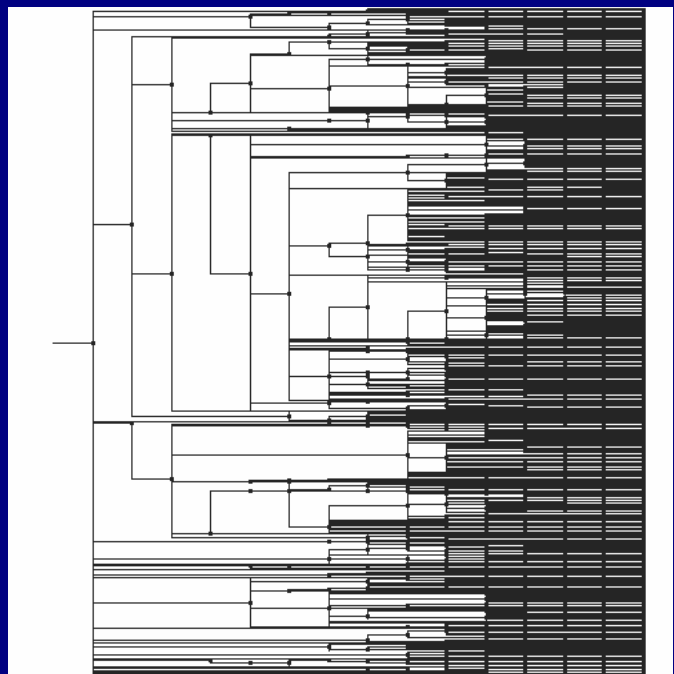
Tree Drawing Traversal

- ascent-based drawing
  - partition into leaf ranges before drawing
    - TreeJuxtaposer partitions during drawing
  - start from 1 leaf per range, draw path to root
  - carefully choose starting leaf
    - 3 categories of misleading gaps eliminated
      - leaf-range gaps
      - horizontal tree edge gaps
      - ascent path gaps

Leaf-range Gaps

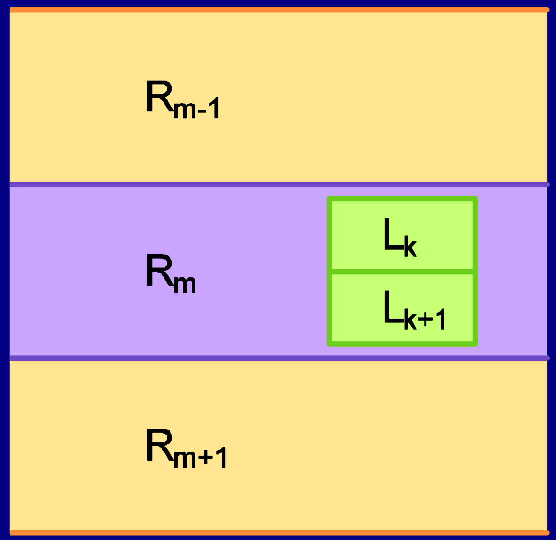
- number of nodes rendered depends on number of partitioned leaf ranges
  - maximize leaf range size to reduce rendering
  - too much reduction results in gaps

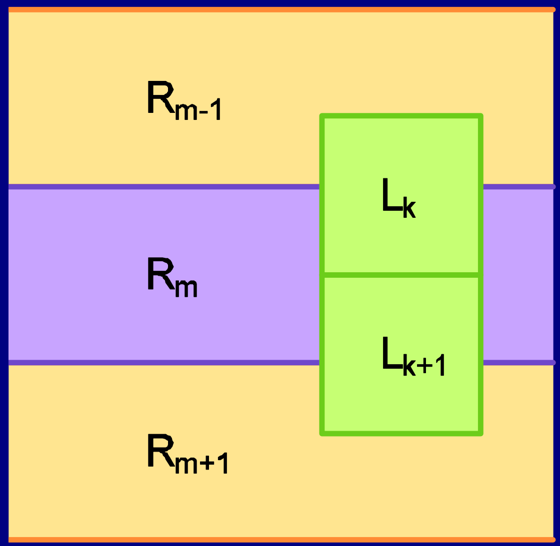




Eliminating Leaf-range Gaps

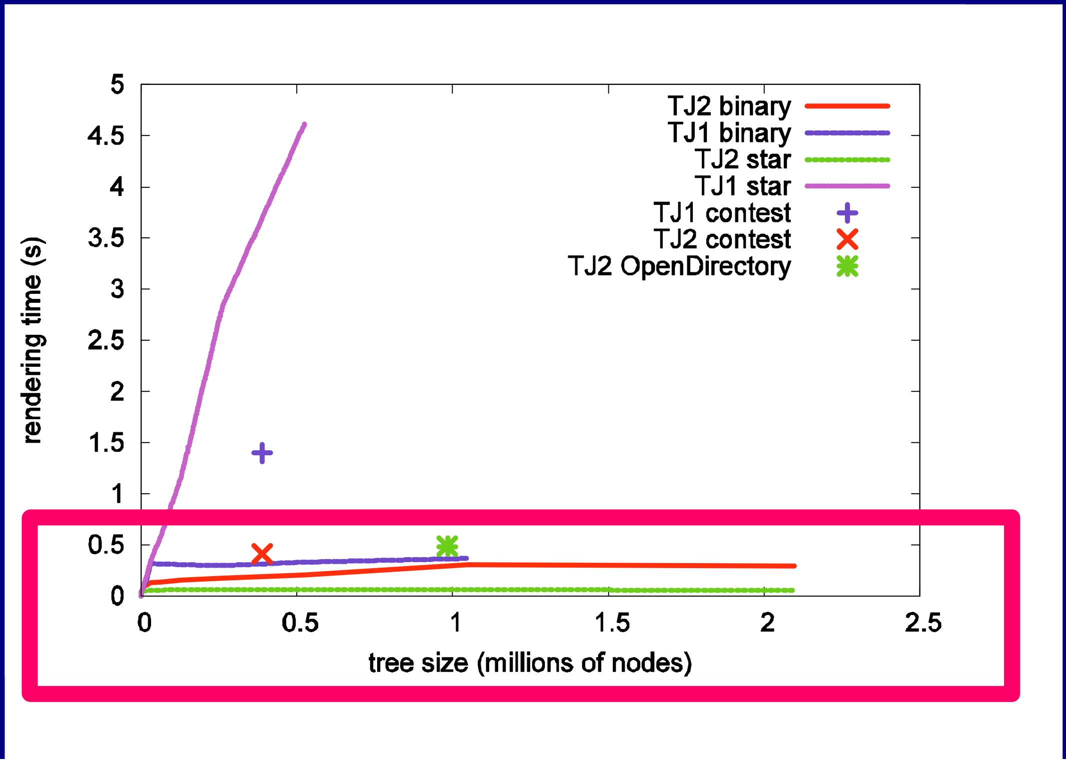
- eliminate by rendering more leaves
  - partition into smaller leaf ranges





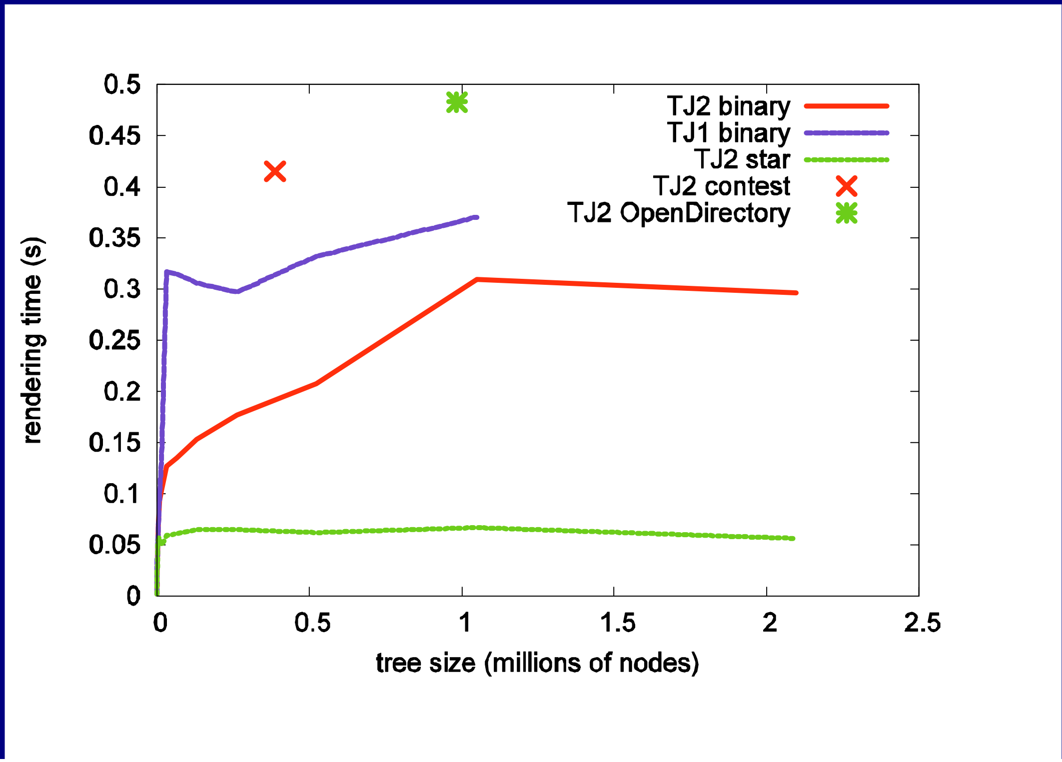
Rendering Time Performance

- TreeJuxtaposer renders **all** nodes for star trees
  - branching factor k leads to O(k) performance
- we achieve 5x rendering improvement with contest comparison dataset
- constant time, after threshold, for large binary trees



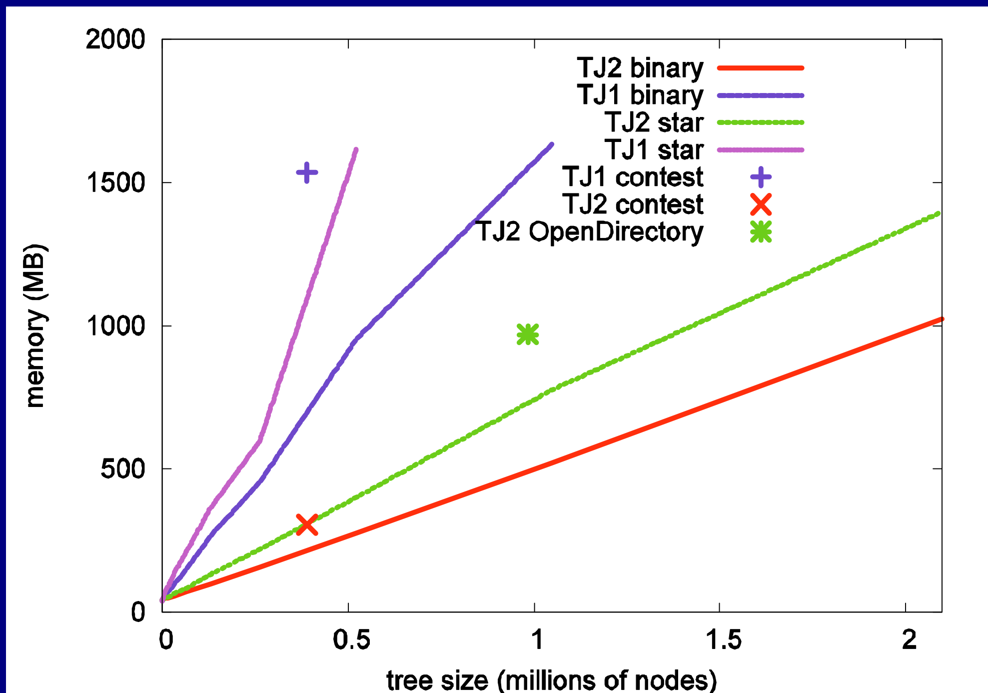
Rendering Time Performance

- constant time, after threshold, for large binary trees
  - we approach rendering limit of screen-space
- contest and OpenDirectory comparison render 2 trees
  - comparable to rendering two binary trees



Memory Performance

- linear memory usage for both
  - generic AD approach 5x better
- marked range storage changes improve scalability
  - 1GB difference for contest comparison



PRISAD Results

- video

- joint work: PRISAD credits

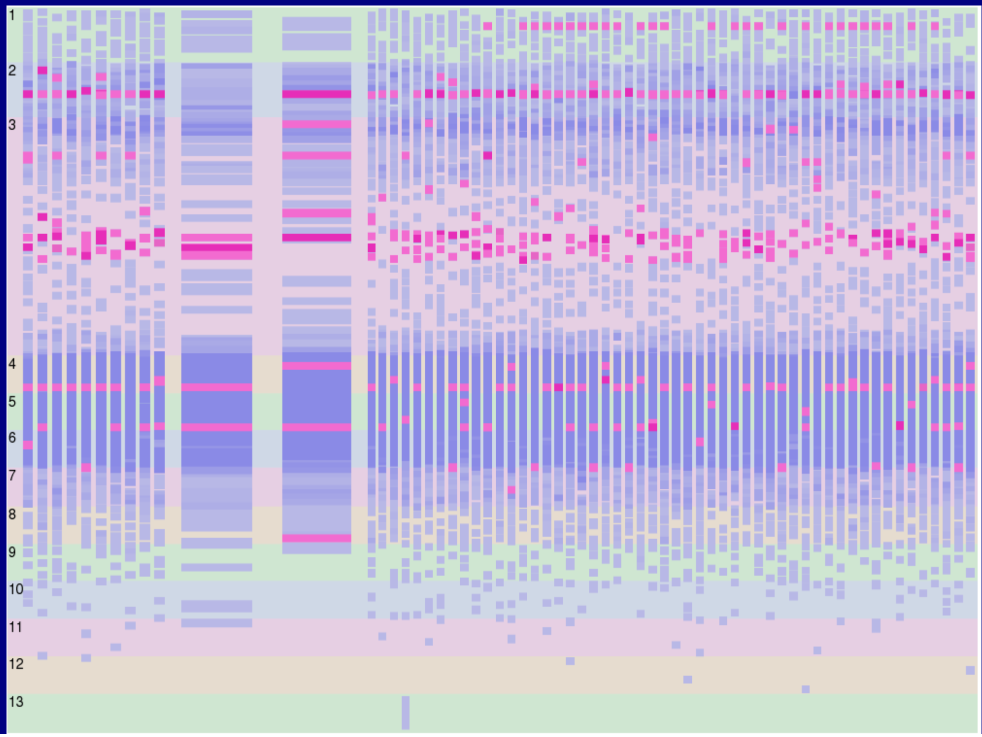
James Slack, Kristian Hildebrand, and Tamara Munzner.
PRISAD: A Partitioned Rendering Infrastructure for Scalable Accordion Drawing.
Proc. InfoVis 2005, to appear

Outline

- trees
  - TreeJuxtaposer
- sequences
  - SequenceJuxtaposer
- scaling up trees
  - TJC
- general AD framework
  - PRISAD
- power sets
  - PowerSetViewer
- evaluation

PowerSetViewer

- data mining market-basket transactions
  - items bought together make a set
  - space of all possible sets is power set
    - place logged sets within enumeration of power set



PSV Results

- dynamic data
  - show progress of steerable data mining system with constraints
  - all other AD applications had static data
- handles alphabets of up to 40,000
- handles log files of 1.5 to 7 million items
- joint work in progress with
  - Qiang Kong, Raymond Ng

Outline

- trees
  - TreeJuxtaposer
- sequences
  - SequenceJuxtaposer
- scaling up trees
  - TJC
- general AD framework
  - PRISAD
- power sets
  - PowerSetViewer
- evaluation

Evaluation

- how focus and context are used with
  - rubber sheet navigation vs. pan and zoom
  - integrated scene vs. separate overview
- user studies of TJ
  - tasks based on biologist interviews
- joint work in progress, with
  - Adam Bodnar, Dmitry Nekrasovski, Joanna McGrenere

Conclusion

- accordion drawing effective for variety of application datasets
  – trees, sequences, sets
- guaranteed visibility is powerful technique
  – computational expense can be handled by generic algorithms

More Information

- papers, videos, images
  - www.cs.ubc.ca/~tmm
- free software
  - olduvai.sourceforge.net/tj
  - olduvai.sourceforge.net/sj