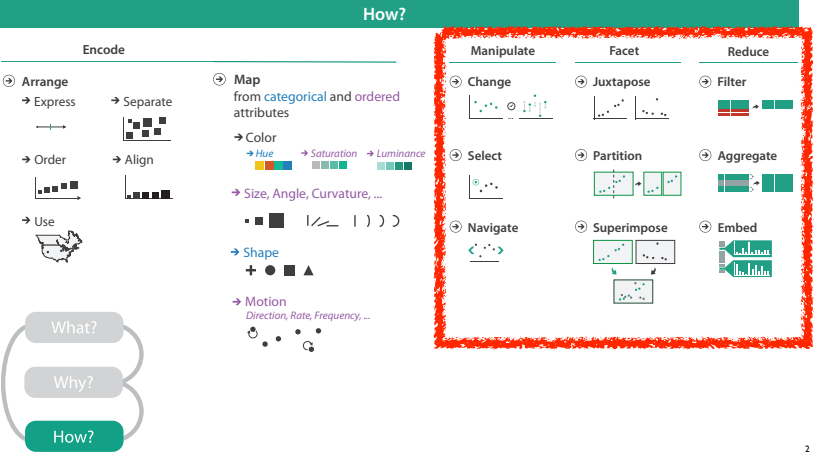## Slide 1

Lectures 3&4:
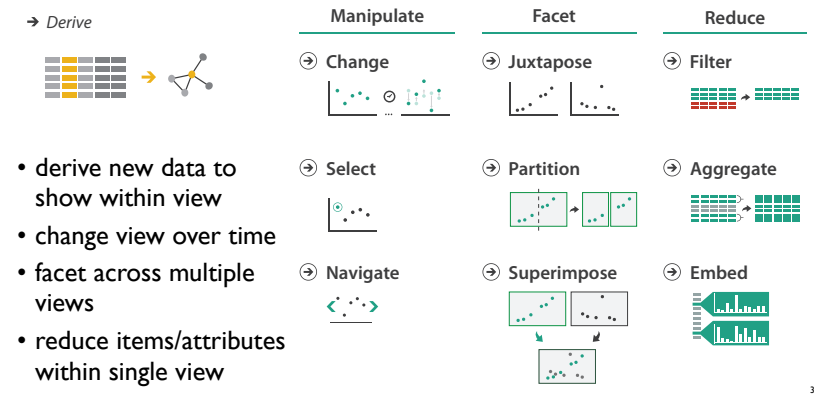# Facet into Multiple Views

Tamara Munzner
Department of Computer Science
University of British Columbia

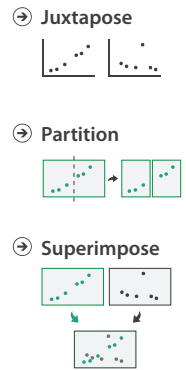*DSCI 532: Data Visualization II*
Lectures 3&4: 27 & 29 March 2017

https://github.ubc.ca/ubc-mds-2016/DSCI_532_viz-2_students

Slide 2

How?

Encode

Arrange
→ Express   → Separate
→ Order   → Align
→ Use

Map
from categorical and ordered attributes
→ Color
  → Hue → Saturation → Luminance
→ Size, Angle, Curvature, …
→ Shape
  + ● ■ ▲
→ Motion
  Direction, Rate, Frequency, …

Manipulate
- Change
- Select
- Navigate

Facet
- Juxtapose
- Partition
- Superimpose

Reduce
- Filter
- Aggregate
- Embed

What?
Why?
How?

2

Slide 3

How to handle complexity: 1 previous strategy + 3 more

→ Derive

Manipulate
- Change
- Select
- Navigate

Facet
- Juxtapose
- Partition
- Superimpose

Reduce
- Filter
- Aggregate
- Embed

- derive new data to show within view
- change view over time
- facet across multiple views
- reduce items/attributes within single view

3

Slide 4

Facet

- Juxtapose
- Partition
- Superimpose

4

Slide 5

Juxtapose and coordinate views

- linked views
  - simultaneously visible multiple views
  - linked together such that actions in one view affect the others

→ Share Encoding: Same/Different
  → *Linked Highlighting*

→ Share Data: All/Subset/None

→ Share Navigation

5

Slide 6
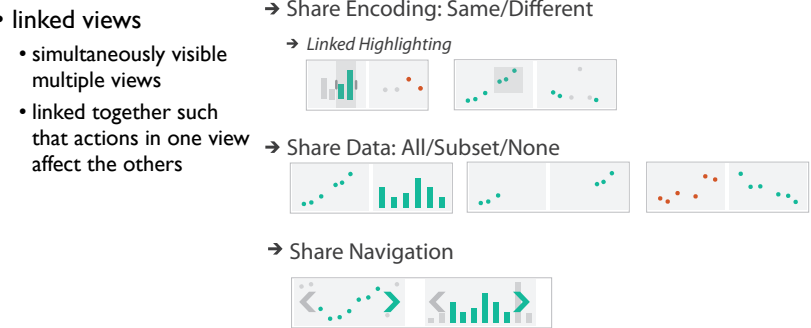
Idiom: **Linked highlighting**   System: **EDV**

- see how regions contiguous in one view are distributed within another
  – powerful and pervasive interaction idiom
- encoding: different
  – **multiform**
    - rationale: single monolithic view has strong limits on number of attributes that can be shown simultaneously
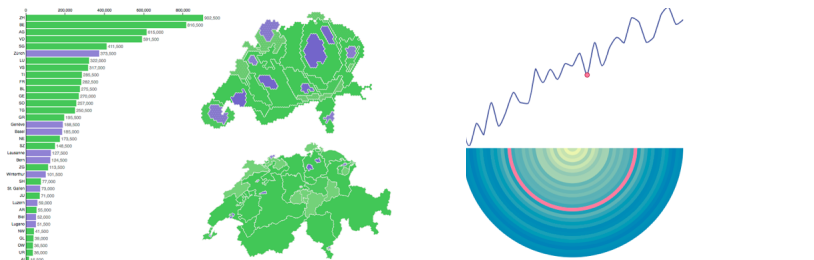- data: all shared

[Visual Exploration of Large Structured Datasets. Wills. Proc. New Techniques and Trends in Statistics (NTTS), pp. 237–246. IOS Press, 1995.]

6

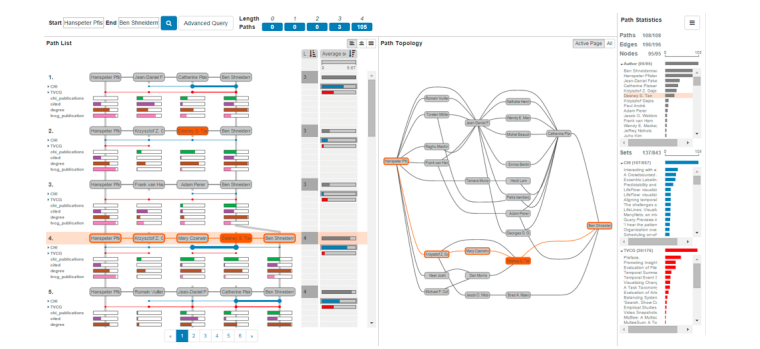## Slide 7

Linked views

- unidirectional vs bidirectional linking

http://www.ralphstraumann.ch/projects/swiss-population-cartogram/

http://peterbeshai.com/linked-highlighting-react-d3-reflux/

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Slide 8

Complex linked multiform views   System: **Pathfinder**

https://www.youtube.com/watch?v=aZF7AC8aNXo

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Slide 9

Idiom: **bird's-eye maps**   System: **Google Maps**

- encoding: same
- data: subset shared
- navigation: shared
  – bidirectional linking
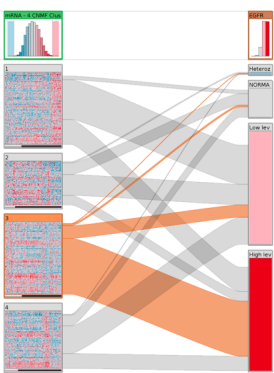
- differences
  – viewpoint
  – (size)

- *overview-detail*

[A Review of Overview+Detail, Zooming, and Focus+Context Interfaces. Cockburn, Karlson, and Bederson. ACM Computing Surveys 41:1 (2008), 1–31.]

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Slide 10

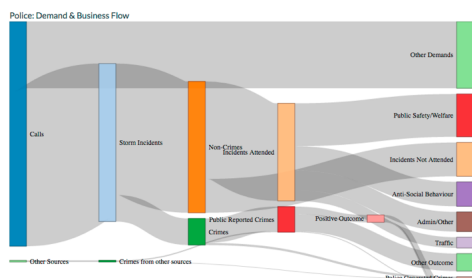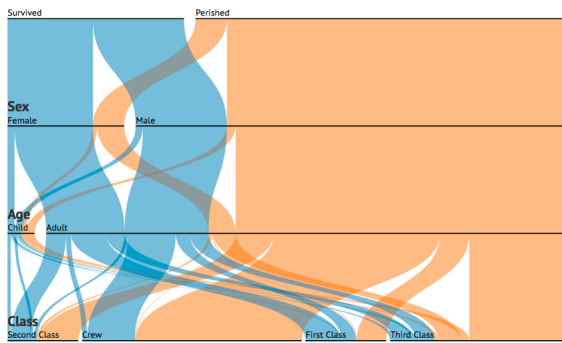## Overview-detail   System: **StratomeX**

https://www.youtube.com/watch?v=UcKDbGqHsdE

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Slide 11

Shiny example

Police: Demand & Business Flow

https://gallery.shinyapps.io/TSupplyDemand/

11

Slide 12

Idiom: **Parallel sets**

Survived   Perished

Sex
Female   Male

Age
Child   Adult

Class
Second Class   Crew   First Class   Third Class

https://www.jasondavies.com/parallel-sets/

https://eagereyes.org/parallel-sets

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Slide 13

Idiom: **Mosaic plots**   System: **Mondrian**

http://www.theusrus.de/blog/understanding-mosaic-plots/

http://www.theusrus.de/Mondrian/

http://www.theusrus.de/blog/making-movies/

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Slide 14
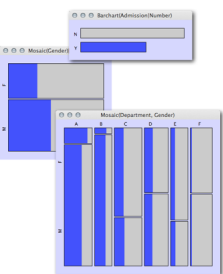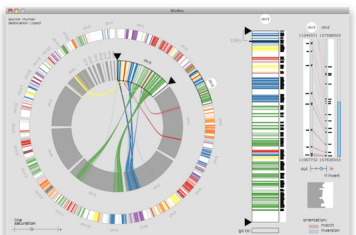
Overview-detail   System: **MizBee**

- multiscale: three viewing levels
  – tooling: processing (modern version: p5js.org)

https://www.youtube.com/watch?v=86p7brwuz2g

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Slide 15

Shiny example

- APGI genome browser
  – tooling: R/Shiny
  – interactivity
    - tooltip detail on demand on hover
    - expand/contract chromosomes
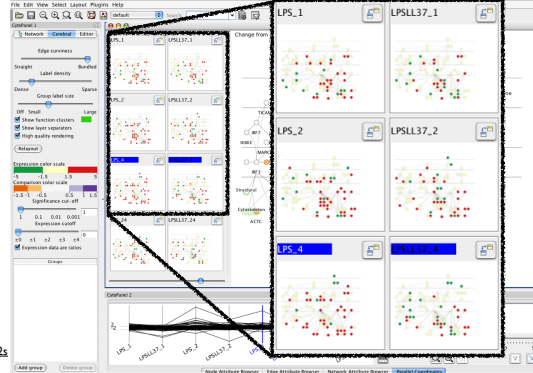   - expand/contract control panes

ICGC PANCREATIC CANCER (DUCTAL ADENOCARCINOMA) - GENOME VIEWER
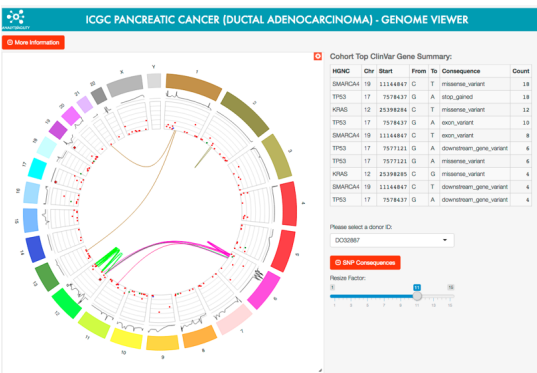
https://gallery.shinyapps.io/genome_browser/

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Slide 16

Idiom: **Small multiples**   System: **Cerebral**

- encoding: same
- data: none shared
  – different attributes for node colors
  – (same network layout)
- navigation: shared

https://www.youtube.com/watch?v=76HhG1FQngI&t=2s

[Cerebral: Visualizing Multiple Experimental Conditions on a Graph with Biological Context. Barsky, Munzner, Gardy, and Kincaid. IEEE Trans. Visualization and Computer Graphics (Proc. InfoVis 2008) 14:6 (2008), 1253–1260.]
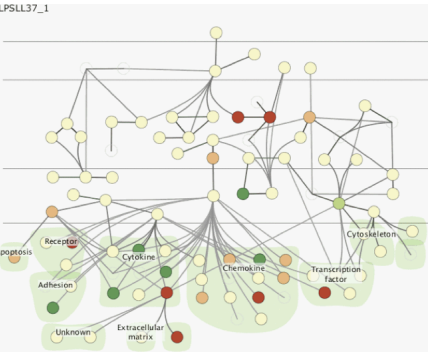
Coordinate views: Design choice interaction

Data

	All	Subset	None
Same	Redundant	Overview/Detail	Small Multiples
Different	Multiform	Multiform, Overview/Detail	No Linkage

Encoding

- why juxtapose views?
  - benefits: eyes vs memory
    - lower cognitive load to move eyes between 2 views than remembering previous state with single changing view
  - costs: display area, 2 views side by side each have only half the area of one view
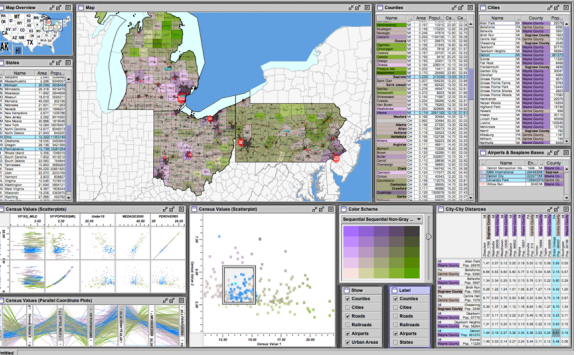
Why not animation?

- disparate frames and regions: comparison difficult
  - vs contiguous frames
  - vs small region
  - vs coherent motion of group

- safe special case
  - animated transitions
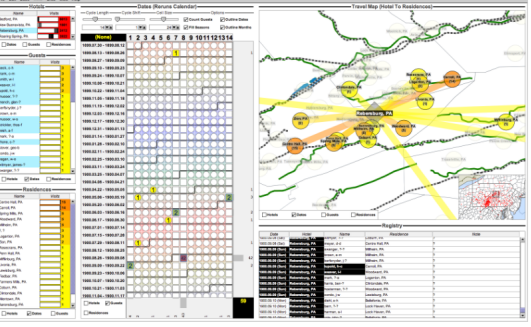
LPSLL37_1

System: **Improvise**

- investigate power of multiple views
  - pushing limits on view count, interaction complexity
  - how many is ok?
    - open research question
  - reorderable lists
    - easy lookup
    - useful when linked to other encodings

[Building Highly-Coordinated Visualizations In Improvise. Weaver. Proc. IEEE Symp. Information Visualization (InfoVis), pp. 159–166, 2004.]

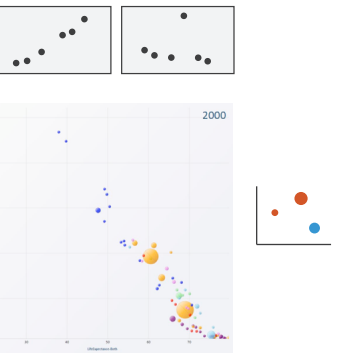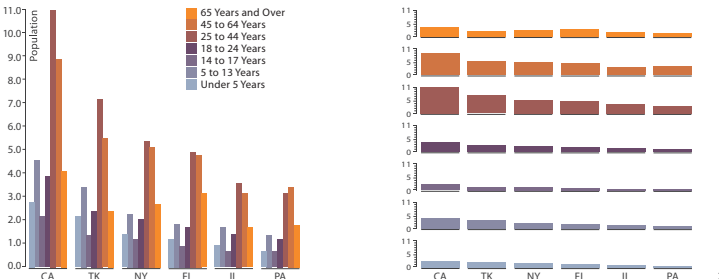## Video: Visual Analysis of Historical Hotel Visitation Patterns

https://www.youtube.com/watch?v=Tzsv6wkZoiQ

http://www.cs.ou.edu/~weaver/improvise/examples/hotels/

Partition into views

- how to divide data between views → **Partition into Side-by-Side Views**
  - split into regions by attributes
  - encodes association between items using spatial proximity
  - order of splits has major implications for what patterns are visible
- no strict dividing line
  - *view: big/detailed*
    - contiguous region in which visually encoded data is shown on the display
  - *glyph: small/iconic*
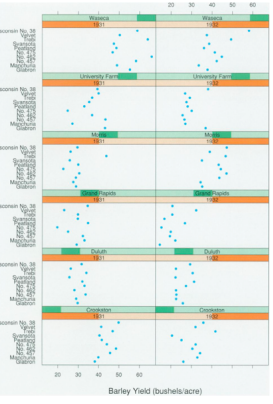   - object with internal structure that arises from multiple marks

2000

Partitioning: List alignment

- single bar chart with grouped bars
  - split by state into regions
    - complex glyph within each region showing all ages
  - compare: easy within state, hard across ages

- small-multiple bar charts
  - split by age into regions
  - one chart per region
  - compare: easy within age, harder across states

Legend:
- 65 Years and Over
- 45 to 64 Years
- 25 to 44 Years
- 18 to 24 Years
- 14 to 17 Years
- 5 to 13 Years
- Under 5 Years
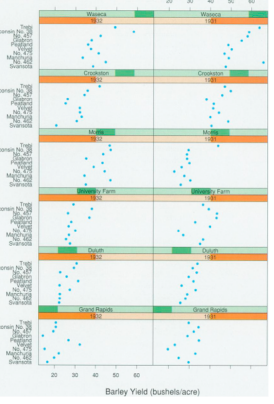
Population

CA TK NY FL IL PA

Idiom: **Trellis plots**

- matrix alignment for small multiple plots
  - same issues as alignment for marks within plot!
- partition by
  - year for columns
  - site for rows (alphabetical)
- within pane
  - variety for vertical axis
  - yield for vertical position
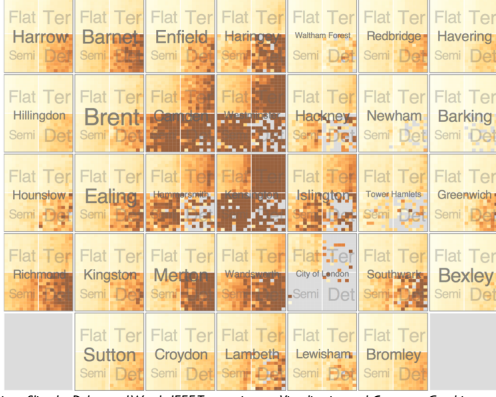
Barley Yield (bushels/acre)

Idiom: **Trellis plots**

- main effects ordering
  - order small-multiples plots based on derived data to see trends
  - order plots by median values
  - shared vertical axis within each plot ordered by median values within varieties

Barley Yield (bushels/acre)

Partitioning: Recursive subdivision — System: **HIVE**

- split by neighborhood
- then by type
- then time
  - years as rows
  - months as columns
- color by price

- neighborhood patterns
  - where it's expensive
  - where you pay much more for detached type

[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

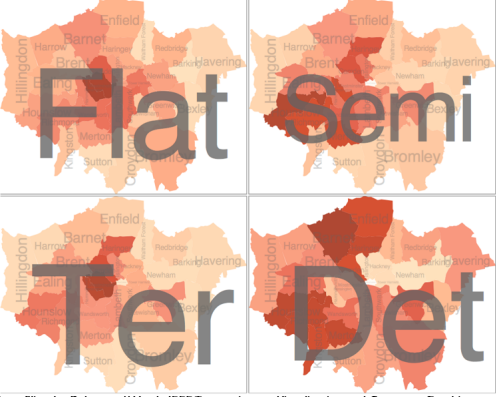## Partitioning: Recursive subdivision — System: **HIVE**

- switch order of splits
  - type then neighborhood
- switch color
  - by price variation

- type patterns
  - within specific type, which neighborhoods inconsistent

[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

Partitioning: Recursive subdivision — System: **HIVE**

- different encoding for second-level regions
  - choropleth maps

[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

Partitioning: Recursive subdivision — System: **HIVE**

- size regions by sale counts
  - not uniformly
- result: treemap

[Configuring Hierarchical Layouts to Address Research Questions. Slingsby, Dykes, and Wood. IEEE Transactions on Visualization and Computer Graphics (Proc. InfoVis 2009) 15:6 (2009), 977–984.]

Superimpose layers

- *layer*: set of objects spread out over region
  - each set is visually distinguishable group
  - extent: whole view   → **Superimpose Layers**
- design choices
  - how many layers, how to distinguish?
    - encode with different, nonoverlapping channels
    - two layers achieveable, three with careful design
  - small static set, or dynamic from many possible?

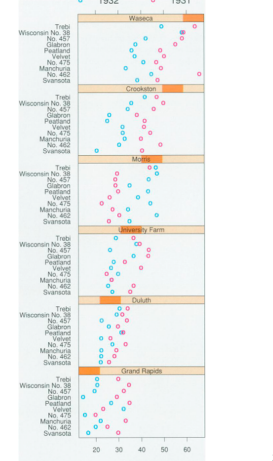## Static visual layering

- foreground layer: roads
  - hue, size distinguishing main from minor
  - high luminance contrast from background
- background layer: regions
  - desaturated colors for water, parks, land areas
- user can selectively focus attention
- "get it right in black and white"
  - check luminance contrast with greyscale view

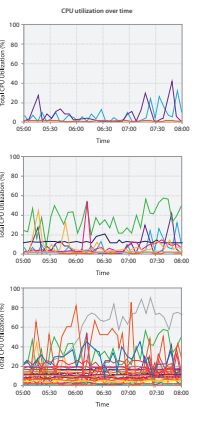[Get it right in black and white. Stone. 2010. http://www.stonesc.com/wordpress/2010/03/get-it-right-in-black-and-white]

Idiom: **Trellis plots**

- superimpose within same frame
  - color code by year

Barley Yield (bushels/acre)

Superimposing limits

- few layers, but many lines
  - up to a few dozen
  - but not hundreds
- superimpose vs juxtapose: empirical study
  - superimposed for local, multiple for global
  - tasks
    - local: maximum, global: slope, discrimination
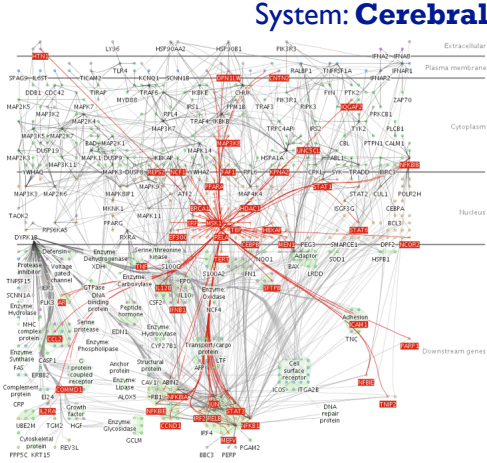 - same screen space for all multiples vs single superimposed

[Graphical Perception of Multiple Time Series. Javed, McDonnel, and Elmqvist. IEEE Transactions on Visualization and Computer Graphics (Proc. IEEE InfoVis 2010) 16:6 (2010), 927–934.]
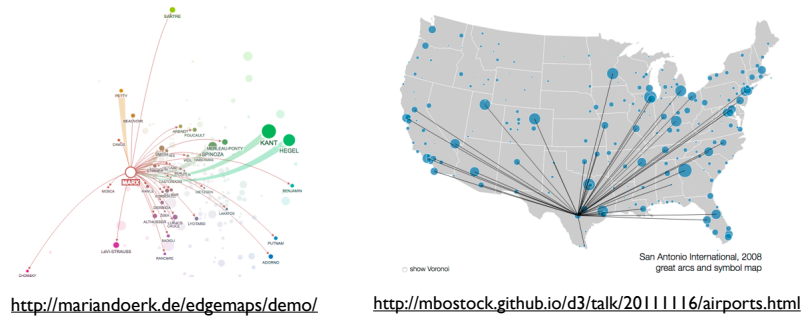
Dynamic visual layering

- interactive, from selection
  - lightweight: click
  - very lightweight: hover

- ex: 1-hop neighbors

[Cerebral: a Cytoscape plugin for layout of and interaction with biological networks using subcellular localization annotation. Barsky, Gardy, Hancock, and Munzner. Bioinformatics 23:8 (2007), 1040–1042.]

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Dynamic visual layering

- one-hop neighbour highlighting demos: click vs hover

http://mariandoerk.de/edgemaps/demo/

San Antonio International, 2008
great arcs and symbol map

http://mbostock.github.io/d3/talk/20111116/airports.html

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Further reading

- Visualization Analysis and Design. Munzner. AK Peters Visualization Series, CRC Press, 2014.
  - Chap 12: Facet Into Multiple Views
- A Review of Overview+Detail, Zooming, and Focus+Context Interfaces. Cockburn, Karlson, and Bederson. ACM Computing Surveys 41:1 (2008), 1–31.
- A Guide to Visual Multi-Level Interface Design From Synthesis of Empirical Study Evidence. Lam and Munzner. Synthesis Lectures on Visualization Series, Morgan Claypool, 2010.
- Zooming versus multiple window interfaces: Cognitive costs of visual comparisons. Plumlee and Ware. ACM Trans. on Computer-Human Interaction (ToCHI) 13:2 (2006), 179–209.
- Exploring the Design Space of Composite Visualization. Javed and Elmqvist. Proc. Pacific Visualization Symp. (PacificVis), pp. 1–9, 2012.
- Visual Comparison for Information Visualization. Gleicher, Albers, Walker, Jusufi, Hansen, and Roberts. Information Visualization 10:4 (2011), 289–309.
- Guidelines for Using Multiple Views in Information Visualizations. Baldonado, Woodruff, and Kuchinsky. In Proc. ACM Advanced Visual Interfaces (AVI), pp. 110–119, 2000.
- Cross-Filtered Views for Multidimensional Visual Analysis. Weaver. IEEE Trans. Visualization and Computer Graphics 16:2 (Proc. InfoVis 2010), 192–204, 2010.
- Linked Data Views. Wills. In Handbook of Data Visualization, Computational Statistics, edited by Unwin, Chen, and Härdle, pp. 216–241. Springer-Verlag, 2008.
- Glyph-based Visualization: Foundations, Design Guidelines, Techniques and Applications. Borgo, Kehrer, Chung, Maguire, Laramee, Hauser, Ward, and Chen. In Eurographics State of the Art Reports, pp. 39–63, 2013.

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