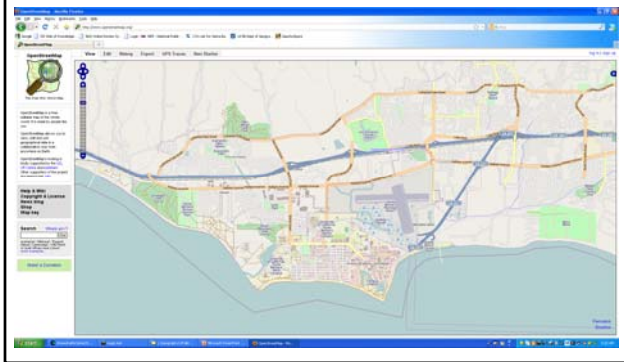


Geography 12: Maps and Spatial Reasoning  
**Lecture 20: Network Maps**

Professor Keith Clarke



## On-line Street Map



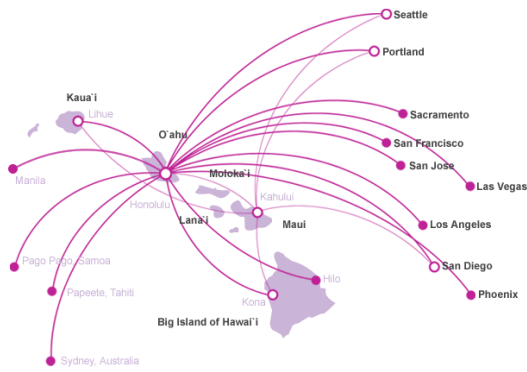
## London Underground



## Trams in Melbourne, Australia



## Airline Routes



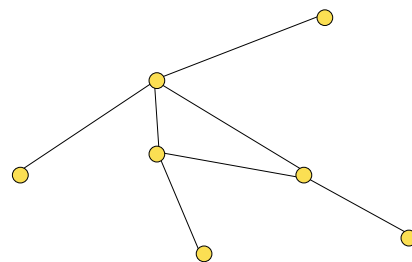
## Power Grid



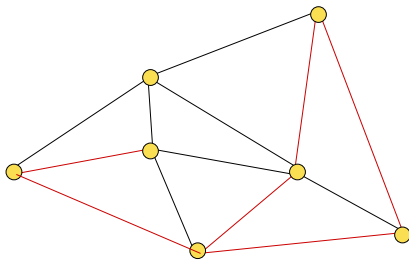
## Terminology of networks

- Topology
- Link or route
- Place or node
- Topological distance
- Diameter
- Accessibility
- Connectivity: connectivity index

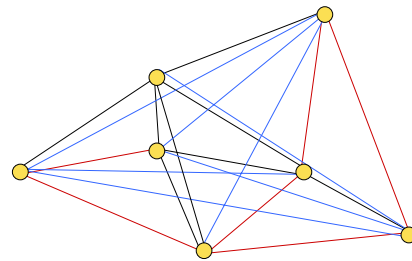
## Network graph



Fully connected planar graph



Fully connected non-planar graph



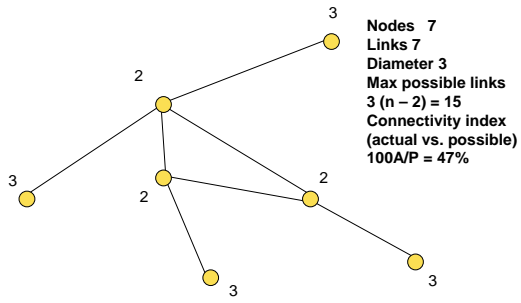
Non-planar graph



### Graph Theory $n = \# \text{ nodes}$

- Planar graph/Non-planar
- Symmetric/ Non-symmetric (one-way, two-way)
- Symmetric planar maximum # connections is:  $3(n - 2)$
- Symmetric non-planar maximum # connections is:  $[n(n - 1)] / 2$
- Non-symmetric non-planar maximum # connections is:  $n(n - 1)$
- Non-symmetric planar maximum # connections is:  $6(n - 2)$

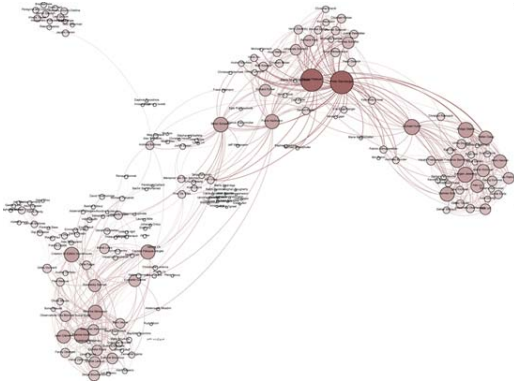
## Graph measures



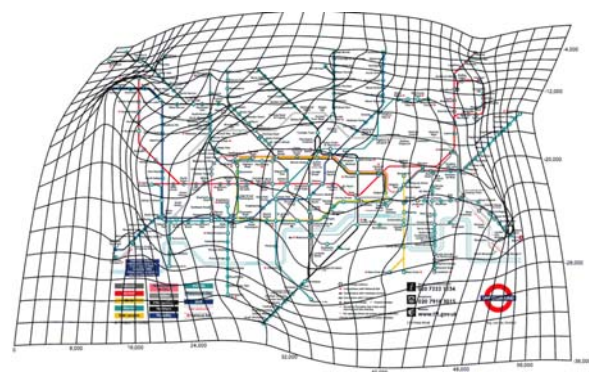
## LA Metro Rail network



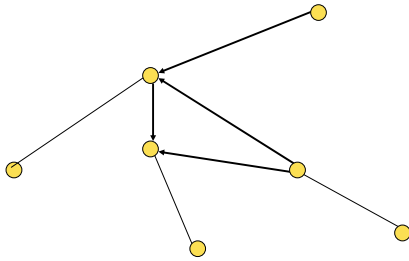
## Netvizz on facebook



## Distortion



## Directed graph



## Connectivity: Directed network

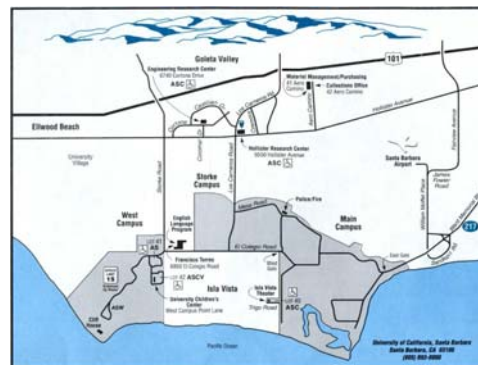


## Trees

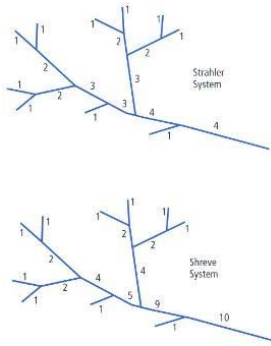
- Hierarchic order
- Strahler stream order
- Bifurcation ratio: ratio of links at one order to links at the next order



## Street network: "Pruning"

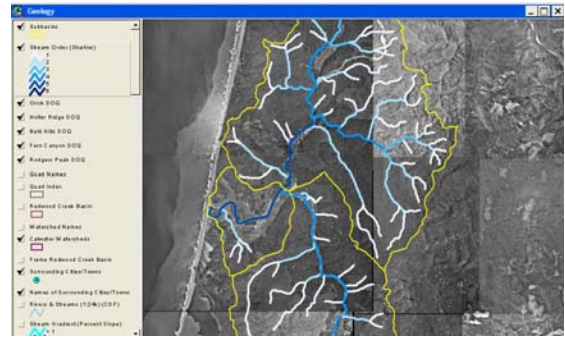


## Stream order

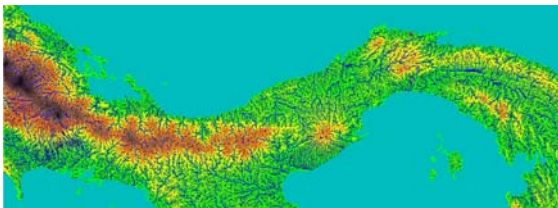


## Strahler order in GIS

[http://www.krisweb.com/krisredwoodck/krisdb/html/krisweb/maps/order\\_ortho.gif](http://www.krisweb.com/krisredwoodck/krisdb/html/krisweb/maps/order_ortho.gif)



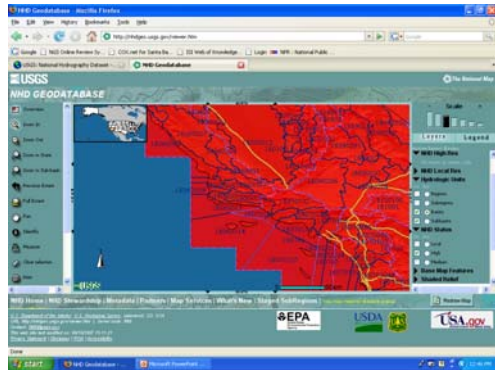
## Panama: Streams from SRTM



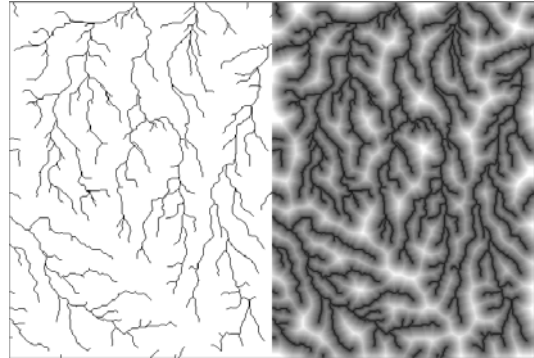
## Terrain: stream network



## National Hydrographic Database



## Distance to network



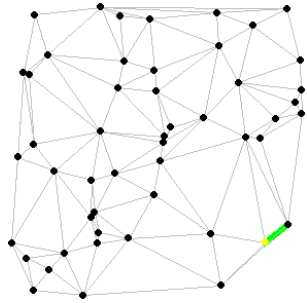
## Connections between networks: SkyWest: Spoke and hub



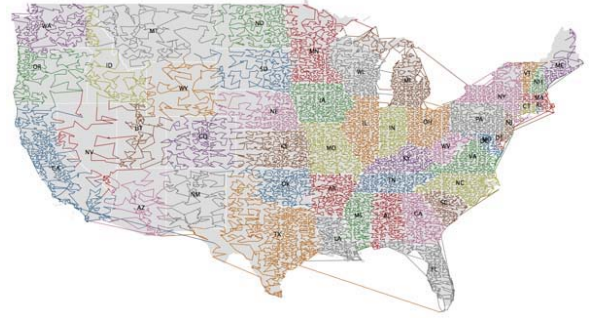
## Directions: MapQuest



### Shortest path: Dijkstra's algorithm

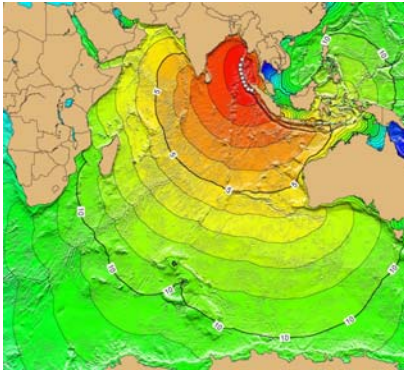


### Visit all nodes, shortest path

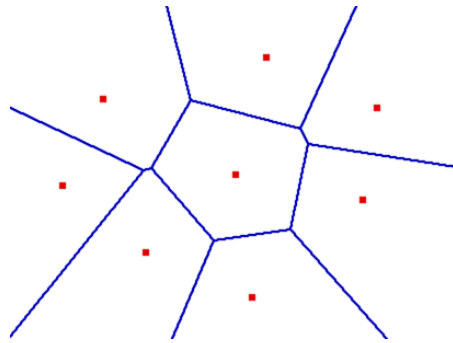


Robert Kosara: EagerEyes.org

### Isochrone



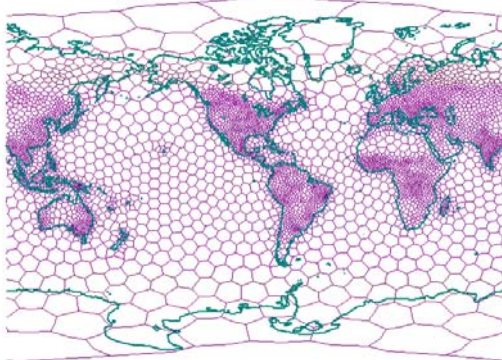
### Voronoi diagram





## Voronoi World Population

(equal cells)



## Network maps

- Terminology from topology: node, link, directed, planar
- Simple measures possible e.g. diameter, connectivity index
- Tree networks have orders, e.g. Strahler and measures e.g. branching ratio
- Algorithms can compute shortest path
- Isochrones