

COMP5048

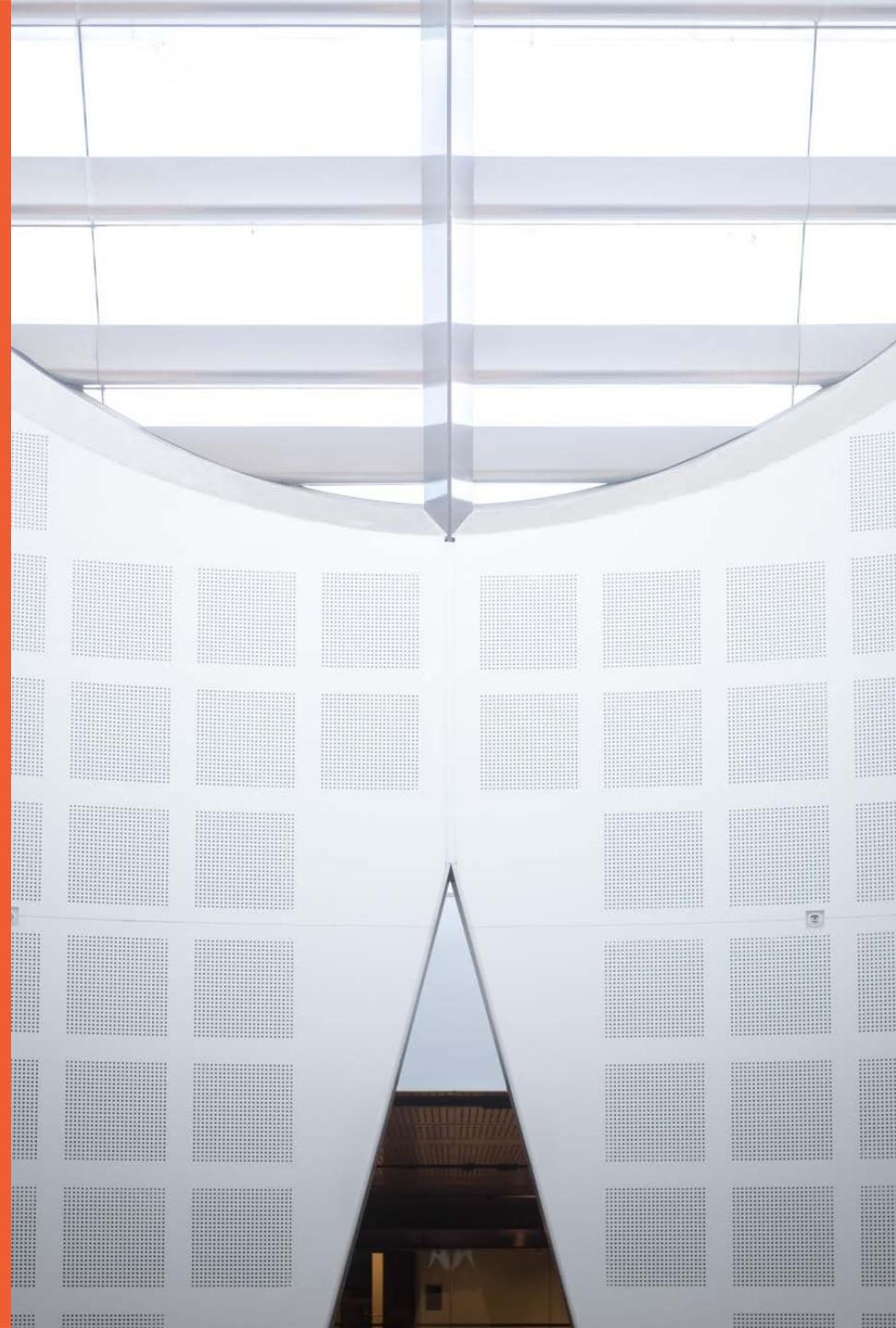
Visual Analytics

Week 1: Introduction

Professor Seokhee Hong
School of Information Technologies



THE UNIVERSITY OF
SYDNEY



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COMMONWEALTH OF AUSTRALIA

Copyright Regulations 1969

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Acknowledgement of Country

Before we begin the proceedings, I would like to acknowledge and pay respect to the traditional owners of the land on which we meet; the Gadigal people of the Eora Nation. It is upon their ancestral lands that the University of Sydney is built.

As we share our own knowledge, teaching, learning and research practices within this university may we also pay respect to the knowledge embedded forever within the Aboriginal Custodianship of Country.

Content:

- 1. COMP5048 Course Outline**
- 2. Visual Analytics**
- 3. Information Visualisation**
- 4. Graph Drawing**

1. COMP5048 Course Outline

- **Lectures: Thursday 6-8pm**

- **New Law School LT 101 Auditorium**
- **Coordinator/Lecturer: Prof. Seokhee Hong
(seokhee.hong@sydney.edu.au)**

- **Tutorial: Thursday 8-9pm**

- **New Law School LT 101 Auditorium (week 2-7)**
- **TA/Tutor: Dr. Quan Nguyen
(quan.nguyen@sydney.edu.au)**
- **Do your homework: Introduction/exercise using tools
(Tableaux, D3, Gephi, yed, Netminer...)**
- **Attend tutorial, if you have questions/difficulties**

COMP5048 Visual Analytics (CUSP)

- **Visual Analytics** aims to facilitate the data analytics process using **Information Visualisation**.
- **Information Visualisation** aims to make good pictures of **abstract information**, such as stock prices, health data, social networks, and software diagrams.
- The challenge for Visual Analytics is to design and implement effective **Visualisation methods** that produce geometric representation of complex data so that data analysts can carry out critical decision making.
- This unit will provide **Visualisation techniques and fundamental algorithms** to achieve good visualisation of abstract information.
- It will also provide opportunities for academic research and developing new methods for Visual Analytic methods.

Learning Outcomes (CUSP)

- **knowledge of basic concepts, techniques and algorithms to produce good visualization of abstract data effectively and efficiently**
- **understanding of geometric algorithms and visualization methods**
- **use of geometric algorithms and visualisation methods to solve new problems**
- **be able to apply and modify visualisation methods for application area such as social networks and biological networks**
- **experience academic research in Visual Analytics and Information Visualisation**

Assumed Knowledge

- **Basic Knowledge in**
 - **Data Structures:** trees, graphs
 - **Algorithms:**
 - Big O notation
 - Divide and Conquer Algorithm
 - **Programming:** Java, C++, Python

Assessment

- **Assignment 1 (20%) : individual report**
 - Week 7
- **Assignment 2 (40%): Group work (5 students)**
 - Programming assignment*: visual analytic system
 - Initial Report (10%): Semester Break
 - System Demo/Presentation (10%): Week 10-12
 - Final report (20%): Week 13
 - *students with no programming experience (contact Lecturer with academic records)
- **Exam (40%): student must achieve at least 40% in the written examination**

Topics Covered: Week 1-8

Approximate schedule: *topics are subject to change*

- Week 1: Introduction**
- Week 2: Visualisation of Hierarchical Data**
- Week 3: Visualisation of Network Data**
- Week 4: Visualisation of Directed Graphs**
- Week 5: Visualisation of Big Data**
- Week 6: Visualisation of Complex Data**
- Week 7: Examples: Visual Analytics**
- Week 8: Info Vis: Design/ Representations**

Topics Covered: Week 9-13

Approximate schedule: *topics are subject to change*

- **Week 9: Info Vis: Evaluation Methods**
- **Week 10: Student Presentation I**
- **Week 11: Student Presentation II**
- **Week 12: Student Presentation III**
- **Week 13 : Review**

References

- Giuseppe Di Battista, Peter Eades, Roberto Tamassia, Ioannis G. Tollis, "Graph Drawing: Algorithms for the Visualization of Graphs", Prentice-Hall, 1999.
- Tamara Munzner, Visualization Analysis and Design. CRC Press, 2014.
- Information Visualization : Perception for Design, Colin Ware, Morgan Kaufmann, 2012.
- *Illuminating the Path: The Research and Development Agenda for Visual Analytics* <http://nvac.pnl.gov/agenda.stm>
- Conference Proceedings: IEEE InfoVis, VAST, EuroVis, PacificVis, GD
- Journals:
 - IEEE Transactions on Visualization and Computer Graphics,
<http://www.computer.org/tvcg/>

COMP5048: resources

- eLearning
 - [LMS](#)
 - Login using Unikey and password
 - Link to CUSP
 - Official schedule, list of learning outcomes, etc
 - Copies of slides
 - Lecture videos
 - We intend to record the lectures, but sometimes the technology is not reliable
 - *Submit official assignment work here;*
 - See your grades; etc
 - Tutorial material
 - Link to edstem site

General Expectations

- Students attend scheduled classes(*), and devote an extra 5-8 hrs per week
 - watch videos if not able to attend lectures
 - doing assessments/homework
 - preparing and reviewing for classes
 - integrating the ideas
 - practice/exercise tools
- Students are responsible learners
 - Participate in classes, constructively
 - Check eLearning site at least once a week!
 - Notify academics whenever there are difficulties
 - Know and adhere to University policies

IMPORTANT:

POLICY RELATING TO ACADEMIC DISHONESTY AND PLAGIARISM

- All students must submit a cover sheet for all assessment work that declares that the work is original and not plagiarised from the work of others.

USYD/SIT Policies

- You are required to carefully read the policies on
 - Academic Honesty and Plagiarism
 - Special consideration due to illness and misadventure
- See the policies page of the faculty website at
<http://sydney.edu.au/engineering/student-policies/> for information regarding university policies and local provisions and procedures within the Faculty of Engineering and Information Technologies.

Special Consideration (University policy)

- If your performance on assessments is affected by *illness or misadventure*
- Follow proper bureaucratic procedures
 - Have professional *practitioner sign special USyd form*
 - Submit application for special consideration online, upload scans
 - <http://sydney.edu.au/students/special-consideration-and-arrangements.html>
 - If request is denied, consult coordinator immediately
- Notify coordinator by email as soon as *anything begins to go wrong*
- There is a similar process if you need special arrangements eg for religious observance, military service, representative sports

Late assessments

- For assignments (If you have not been granted special consideration or arrangements)
 - A penalty of 20% of the available marks will be taken, per day (or part) late
- *Eg your work would have scored 60% and is 1 hour late*
 - *you get 40%*
- *Eg your work would have scored 70% and is 28 hours late*
 - *you get 30%*
- Get something done early and submit it early; you can try to improve it and resubmit if there is time before the deadline

Academic honesty

- Please read the University policy on Academic Honesty carefully, from

<http://sydney.edu.au/students/academic-integrity.html>

“As a student of the University, you are responsible for taking part in your education in an honest and authentic manner.”

- There is a process and a centralized University system and database
- Offenses include:
 - Plagiarism – when you copy from another student, website or other source. This includes copying the whole assignment or only a part of it.
 - Academic dishonesty – when you make your work available to another student to copy (the whole assignment or a part of it). There are other examples of academic dishonesty.
 - Misconduct - when you engage another person to complete your assignment (or a part of it), for payment or not. This is a **very serious** matter and the Policy requires that your case is forwarded to the University Registrar for investigation.

Penalties

- The penalties are **severe** and include:
 - 1) a permanent record of academic dishonesty, plagiarism and misconduct in the University database and on your student file
 - 2) mark deduction, ranging from 0 for the assignment to Fail for the unit
 - 3) expulsion from the University and (for international students) cancelling of your student visa

Be smart and don't risk your future by engaging in plagiarism and academic dishonesty!

Detection

- We will use the similarity detection software TurnItIn and MOSS to compare your assignments with these of other students (current and previous) and the Internet
 - Turnitin is for text documents: http://www.turnitin.com/en_us/higher-education
 - MOSS is for programming code:
<https://theory.stanford.edu/~aiken/moss/>
- These tools are **extremely good!**
- If you cheat, the chances you will be caught are very high.

WHS INDUCTION

School of Information Technologies

General Housekeeping – Use of Labs

- Keep work area clean and orderly
- Remove trip hazards around desk area
- No food and drink near machines
- No smoking permitted within University buildings
- Do not unplug or move equipment without permission



EMERGENCIES – Be prepared



▪ www.sydney.edu.au/whs/emergency



THE UNIVERSITY OF
SYDNEY

SAFETY HEALTH & WELLBEING UNIVERSITY HOME STAFF INTRANET CONTACTS

Policy & strategy Responsibilities Managing WHS A-Z info Health and wellbeing Consultation Incident/hazard reporting Workers comp. Emergency

You are here: Home / WHS / Emergency

EMERGENCY

- [What to do in an emergency](#)
- [First aid](#)
- [Incident & accident reporting](#)
- [Chief building wardens](#)
- [Emergency management](#) +
- [Building emergency procedures](#) +
- [Handling of suspicious packages](#)
- [Chem Alert \(MSDS\)](#)
- [Mercury spills](#)

WHAT TO DO IN AN EMERGENCY

Emergencies can occur at any time, and can arise from a number of causes including fire, medical emergencies, chemical spills, gas leaks, bomb threats and physical threats. The first priority in any emergency situation is the safety of all people who may be in danger.

- [Be prepared](#)
- [Fire alarms](#)
- [Emergency response](#)
- [Medical emergencies](#)
- [People with disabilities](#)
- [Hazardous material incidents](#)
- [Gas leaks](#)
- [Phone threats](#)
- [Unattended bags or other suspicious items](#)
- [Emergency lockdown](#)
- [Personal safety on campus](#)
- [Personal threats](#)
- [Suspicious behaviour](#)

Be prepared

SAFETY HEALTH & WELLBEING

EMERGENCY CONTACT NUMBERS

POLICE, FIRE, AMBULANCE:

| Dial **0-000** from a University phone; if you are calling from an external line or mobile phone, dial **000**. Be prepared to give your name and location, and details of the emergency.

OTHER USEFUL NUMBERS

| **University Security Service:** 9351-3333 This is an emergency number only.

| **Chief fire wardens**

| **Nominated first aid officers**

EMERGENCIES

**WHERE IS YOUR
CLOSEST SAFE EXIT ?**

EMERGENCIES

Evacuation Procedures

ALARMS



BEEP... BEEP...

Prepare to evacuate

1. Check for any signs of immediate danger.
2. Shut Down equipment / processes.
3. Collect any nearby personal items.



WHOOP... WHOOP...

Evacuate the building

1. Follow the **EXIT** exit signs.
2. Escort visitors & those who require assistance.
3. DO NOT use lifts.
4. Proceed to the assembly area.

EMERGENCY RESPONSE

1. Warn anyone in immediate danger.
2. Fight the fire or contain the emergency, if safe & trained to do so.

If necessary...

3. Close the door, if safe to do so.
4. Activate the **"Break Glass"** Alarm  or 
5. Evacuate via your closest safe exit.  
6. Report the emergency to 0-000 & 9351-3333

MEDICAL EMERGENCY

- **If a person is seriously ill/injured:**

1. **call an ambulance 0-000**
2. **notify the closest Nominated First Aid Officer**

If unconscious— send for Automated External Defibrillator (AED) [AED locations.](#)

NEAREST to SIT Building (J12)

- Electrical Engineering Building, L2 (ground) near lifts
- Seymour Centre, left of box office
- Carried by all Security Patrol vehicles

3. **call Security - 9351-3333**
4. **Facilitate the arrival of Ambulance Staff (via Security)**



Nearest Medical Facility

University Health Service in Level 3, Wentworth Building

First Aid kit – SIT Building (J12)

- kitchen area adjacent to Lab 110

School of IT Safety Contacts



▪FIRST AID OFFICERS

Name: Will Calleja

Location: 1 West

Phone: 9036 9706

Name: Katie Yang

Location: 2E-227

Phone: 9351 4918

Orally REPORT all
INCIDENTS
& HAZARDS
to your SUPERVISOR

Undergraduates: to Katie Yang

9351 4918

SIT School Manager: Shari Lee

9351 4158

Support!

- See <http://sydney.edu.au/campus-life/safety-security.html>
- If you need to report an incident of sexual harassment or assault, or make a complaint about misconduct, or want assistance in any way, call our confidential helpline, **1800 SYD HLP (1800 793 457)**.
- There are a wide range of support services available for students
 - Please make contact, and get help

DISABILITY SERVICES

Do you have a disability?

- You may not think of yourself as having a ‘disability’ but the definition under the **Disability Discrimination Act** is broad and includes temporary or chronic medical conditions, physical or sensory disabilities, psychological conditions and learning disabilities.
- **The types of disabilities we see include:**
 - anxiety, arthritis, asthma, asperger's disorder, ADHD, bipolar disorder, broken bones, cancer, cerebral palsy, chronic fatigue syndrome, crohn's disease, cystic fibrosis, depression, diabetes, dyslexia, epilepsy, hearing impairment, learning disability, mobility impairment, multiple sclerosis, post traumatic stress, schizophrenia , vision impairment, and much more.
- **Students needing assistance must register with Disability Services –**
 - it is advisable to do this as early as possible.
- <http://sydney.edu.au/study/academic-support/disability-support.html>

Other support

- **Learning support**
 - <http://sydney.edu.au/study/academic-support/learning-support.html>
- **International students**
 - <http://sydney.edu.au/study/academic-support/support-for-international-students.html>
- **Aboriginal and Torres Strait Islanders**
 - <http://sydney.edu.au/study/academic-support/aboriginal-and-torres-strait-islander-support.html>
- **Student organization (can represent you in academic appeals etc)**
 - <http://srcusyd.net.au/> or <http://www.supra.net.au/>

2. Visual Analytics

Visual Analytics

- *the science of analytical reasoning facilitated by visual interactive interfaces*
- especially concerned with *sensemaking* and *reasoning*
- Visual analytics integrates new computational & theory-based tools with innovative interactive techniques and visual representations to enable human-information discourse

Reference:

Illuminating the Path: The Research and Development Agenda for Visual Analytics

<http://nvac.pnl.gov/agenda.stm>

- **Information visualisation amplifying human cognitive capabilities:**
 1. by **increasing cognitive resources**, such as by using a visual resource to expand human working memory,
 2. by **reducing search**, such as by representing a large amount of data in a small space,
 3. by enhancing the **recognition of patterns**, such as when information is organized in space by its time relationships,
 4. by supporting the easy **perceptual inference** of relationships that are otherwise more difficult to induce,
 5. by **perceptual monitoring** of a large number of potential events, and
 6. by providing a **manipulable medium** that, unlike static diagrams, enables the exploration of a space of parameter values.
- **Information visualization, combined with data analysis, can be applied to analytic reasoning to support the sense-making process.**

Visual Analytics Scope

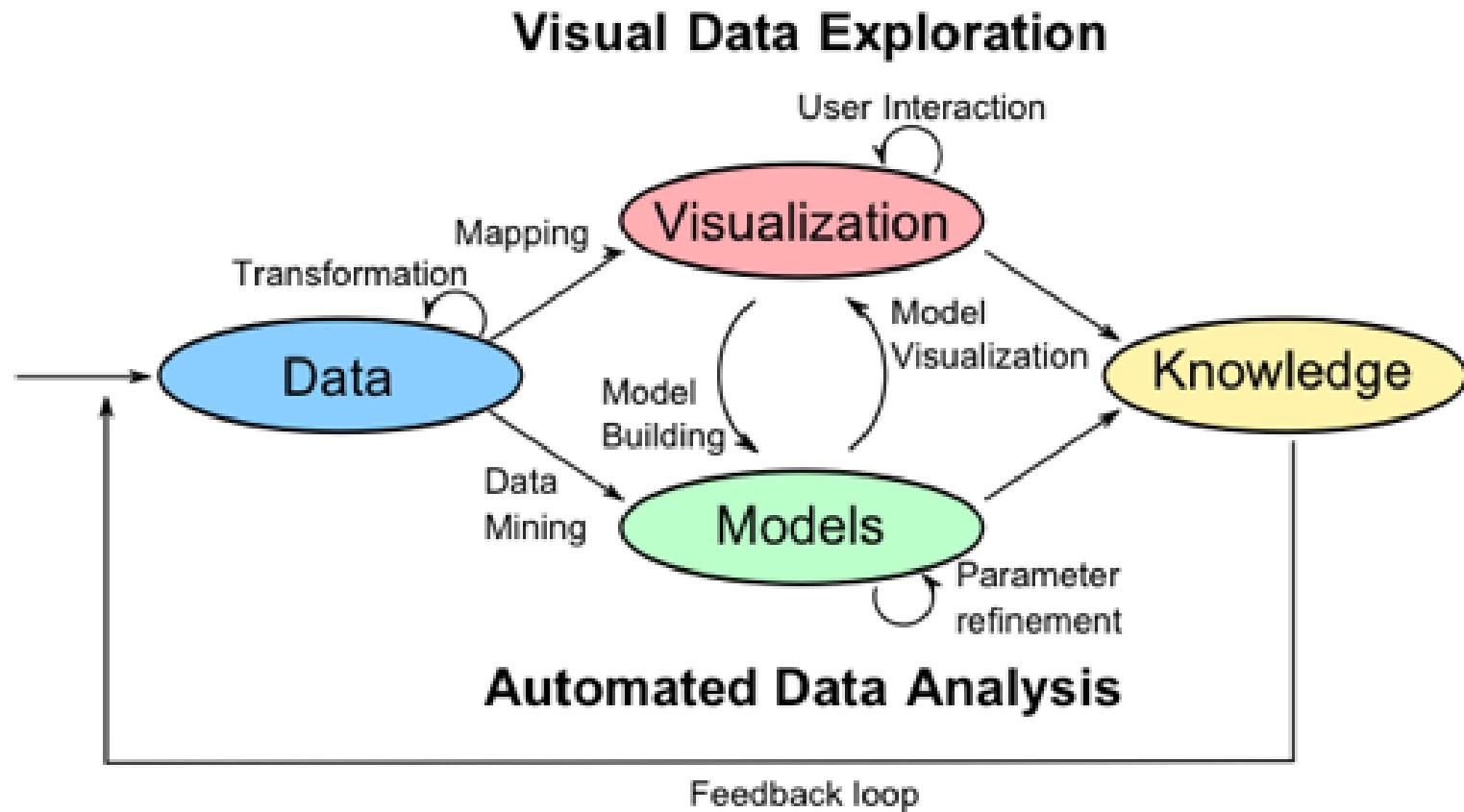


Scope: multidisciplinary field that includes:

- 1. Analytical reasoning techniques that enable users to obtain deep insights that directly support assessment, planning, and decision making**
- 2. Data representations and transformations that convert all types of conflicting and dynamic data in ways that support visualization and analysis**
- 3. Visual representations and interaction techniques that take advantage of the human eye's broad bandwidth pathway into the mind to allow users to see, explore, and understand large amounts of information at once**
- 4. Techniques to support production, presentation, and dissemination of the results of an analysis to communicate information in the appropriate context to a variety of audiences.**

- Visual analytics tools must enable diverse analytical tasks:
 1. Understanding past and present situations quickly, as well as the trends and events that have produced current conditions
 2. Identifying possible alternative **futures** and their warning signs
 3. Monitoring current events for **emergence** of warning signs as well as **unexpected** events
 4. Determining indicators of the intent of an action or an individual
 5. Supporting the **decision maker** in times of crisis.
- These tasks will be conducted through a combination of individual and **collaborative analysis**, often under **extreme time pressure**.
- Visual analytics must enable hypothesis-based and scenario-based analytical techniques, providing support for the analyst to reason based on the available evidence
- Visual analytics must facilitate high-quality human judgment with a limited investment of the analysts' time.

Visual Analytics Framework [Keim]



Simple Example

Visualisation of Social Networks

- *email friends*

Email log files reflect relationships between people

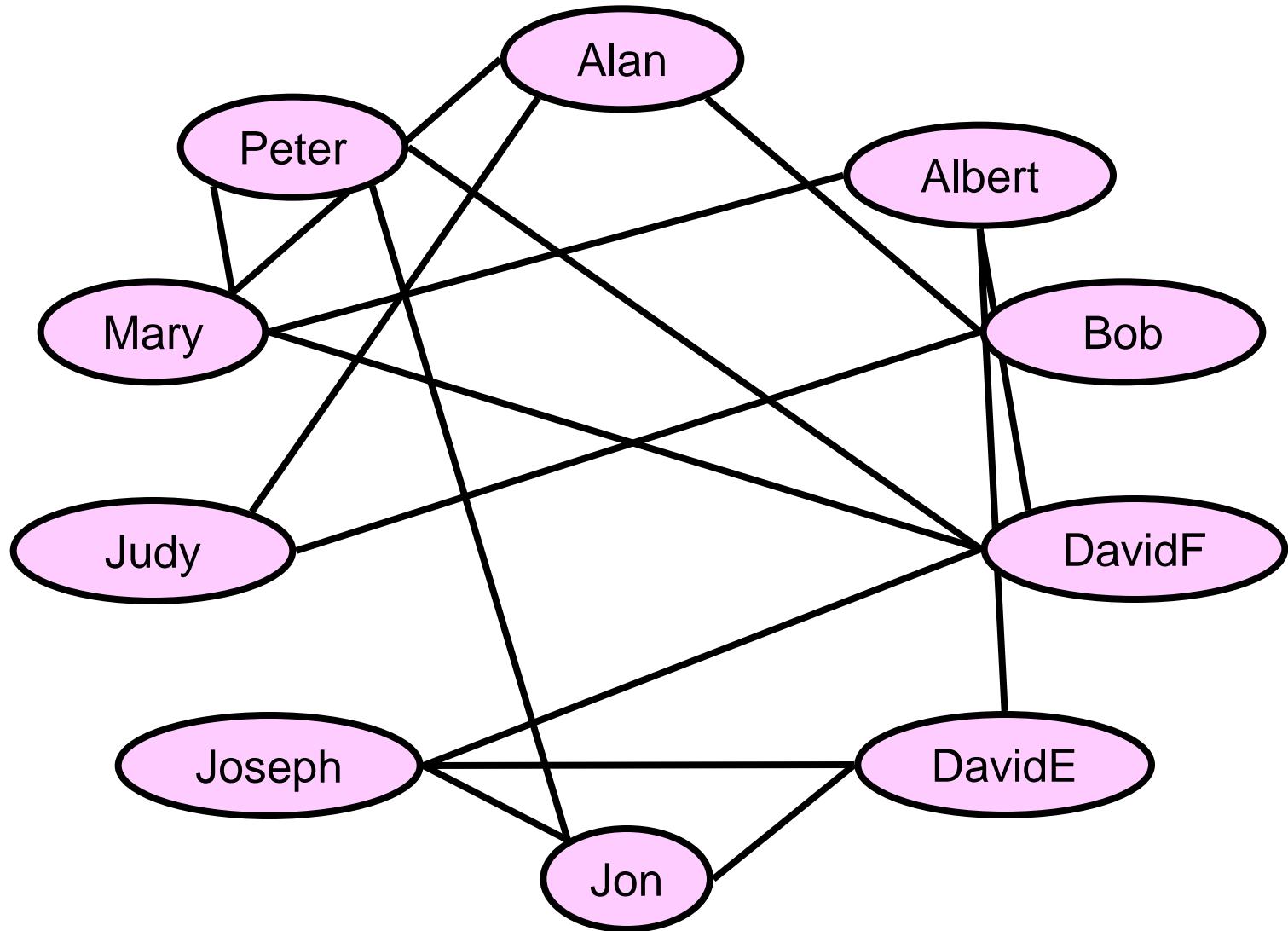
Definition: friends network

- X and Y are *email friends* if
 - X sends more than 5 messages per day to Y, and
 - Y sends more than 5 messages per day to X.

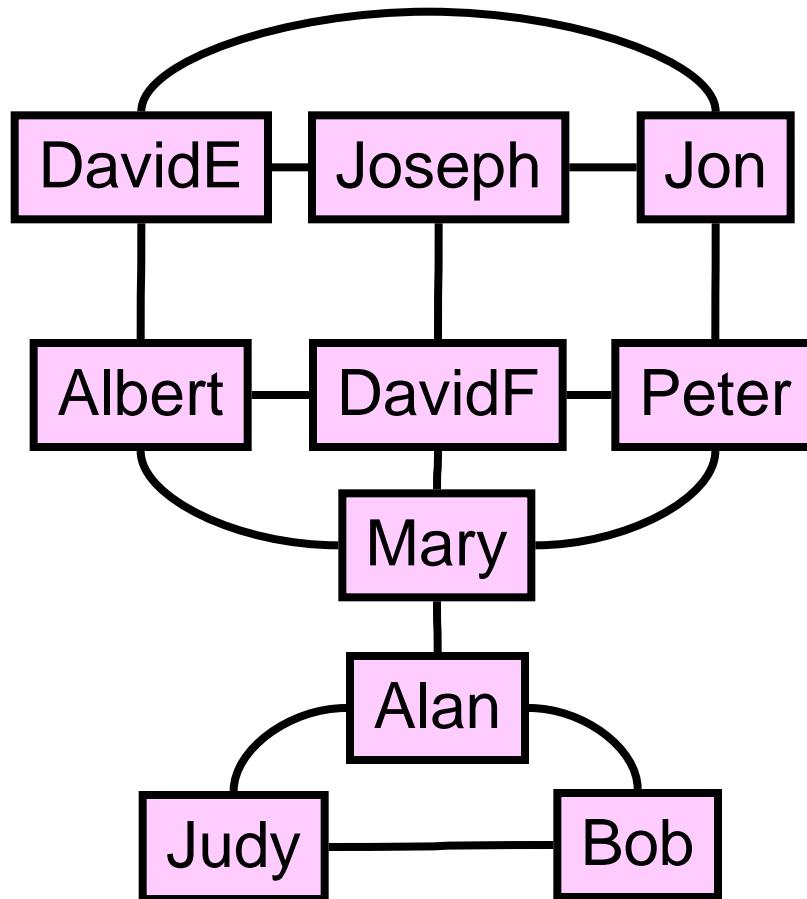
- The *email_friends* graph can be derived from email log files.

<i>X</i>	<i>Email_friends (X)</i>
Mary	Peter, Albert, DavidF, Alan
Judy	Bob, Alan
Peter	Mary, DavidF, Jon
DavidF	Albert, Joseph, Peter, Mary
Jon	Peter, Joseph, DavidE
DavidE	Jon, Joseph, Albert
Joseph	DavidE, Jon, DavidF
Bob	Judy, Alan
Alan	Bob, Mary, Judy
Albert	DavidF, Mary, DavidE

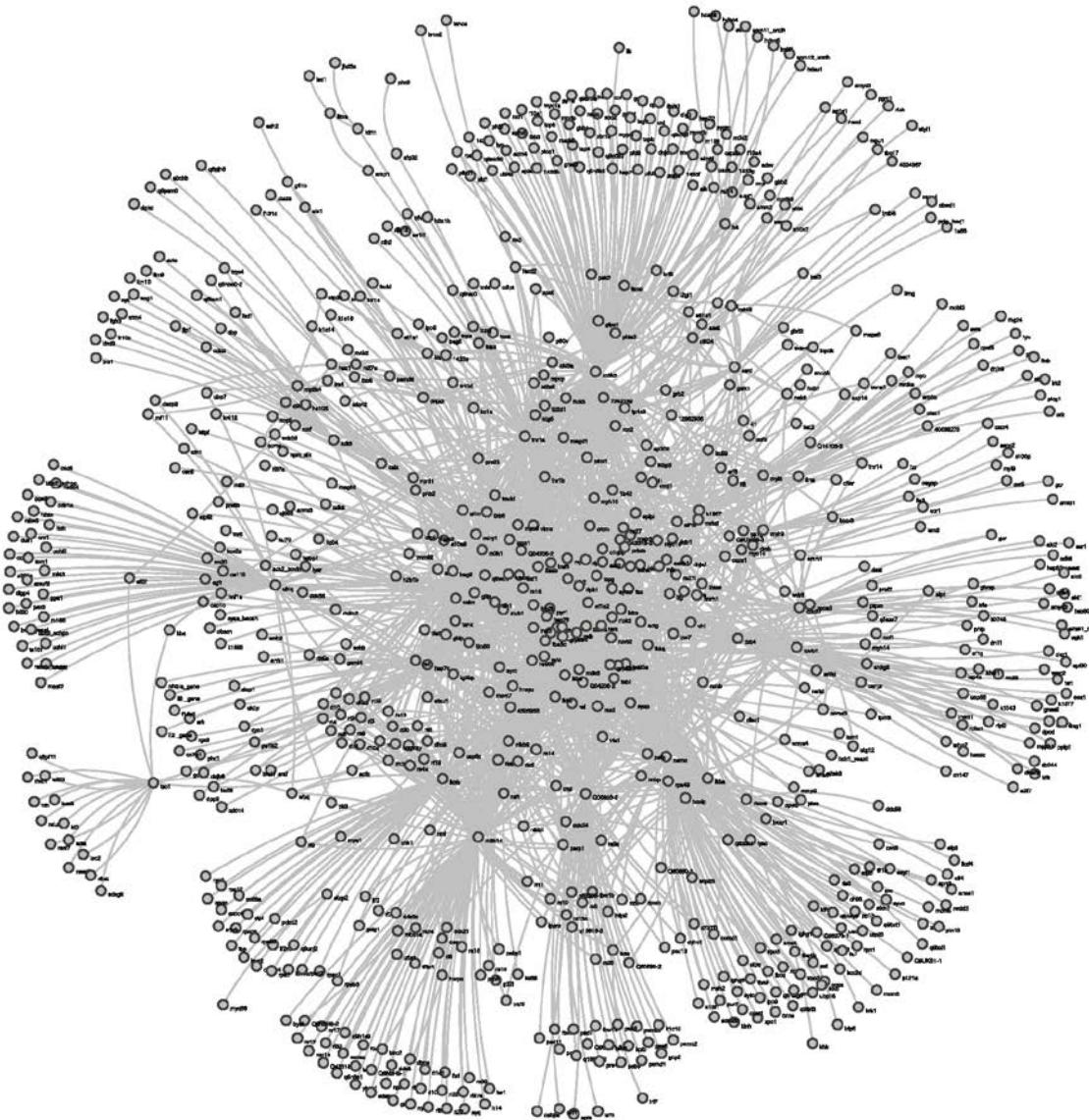
Visualisation A

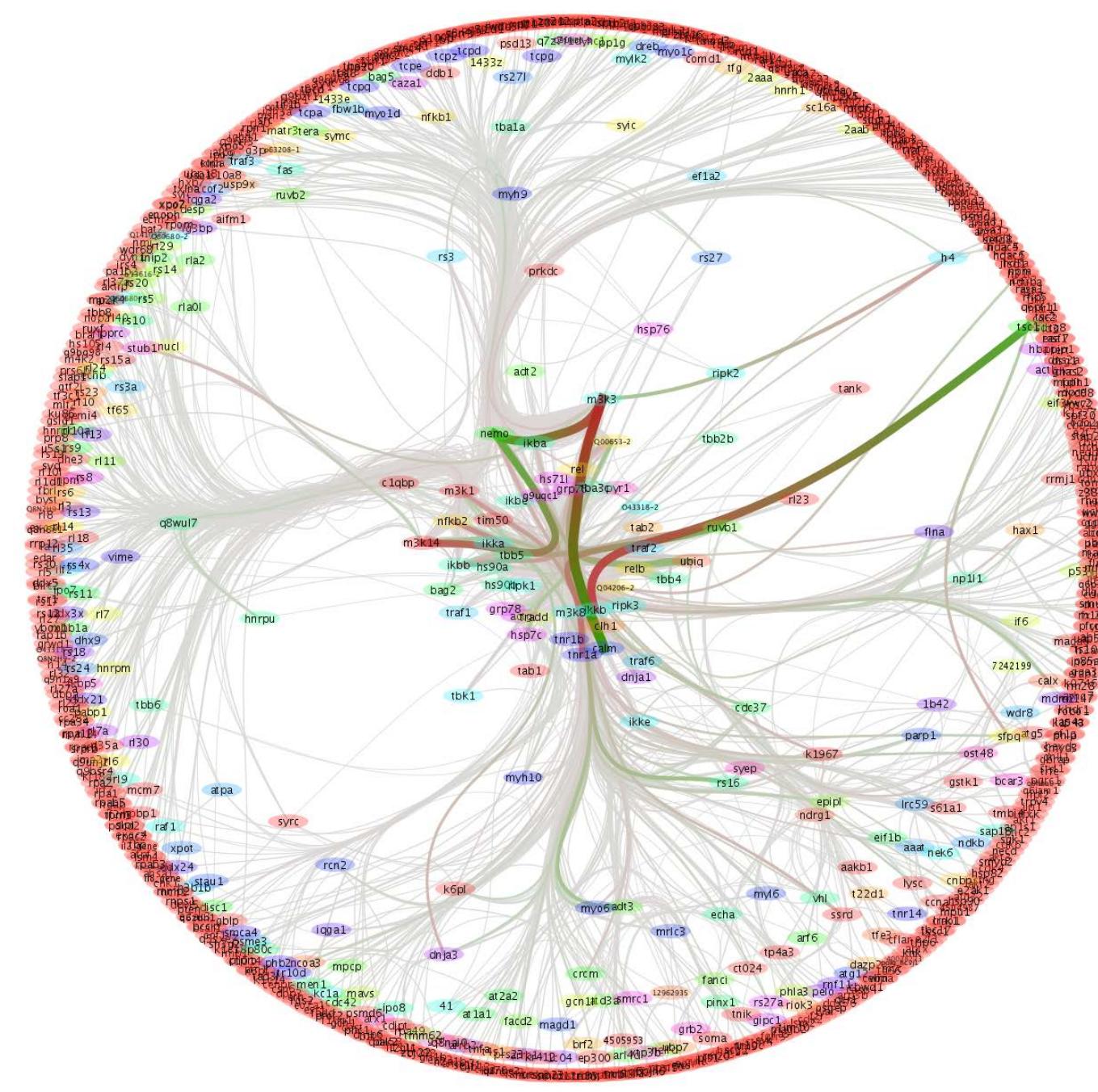


Visualisation B

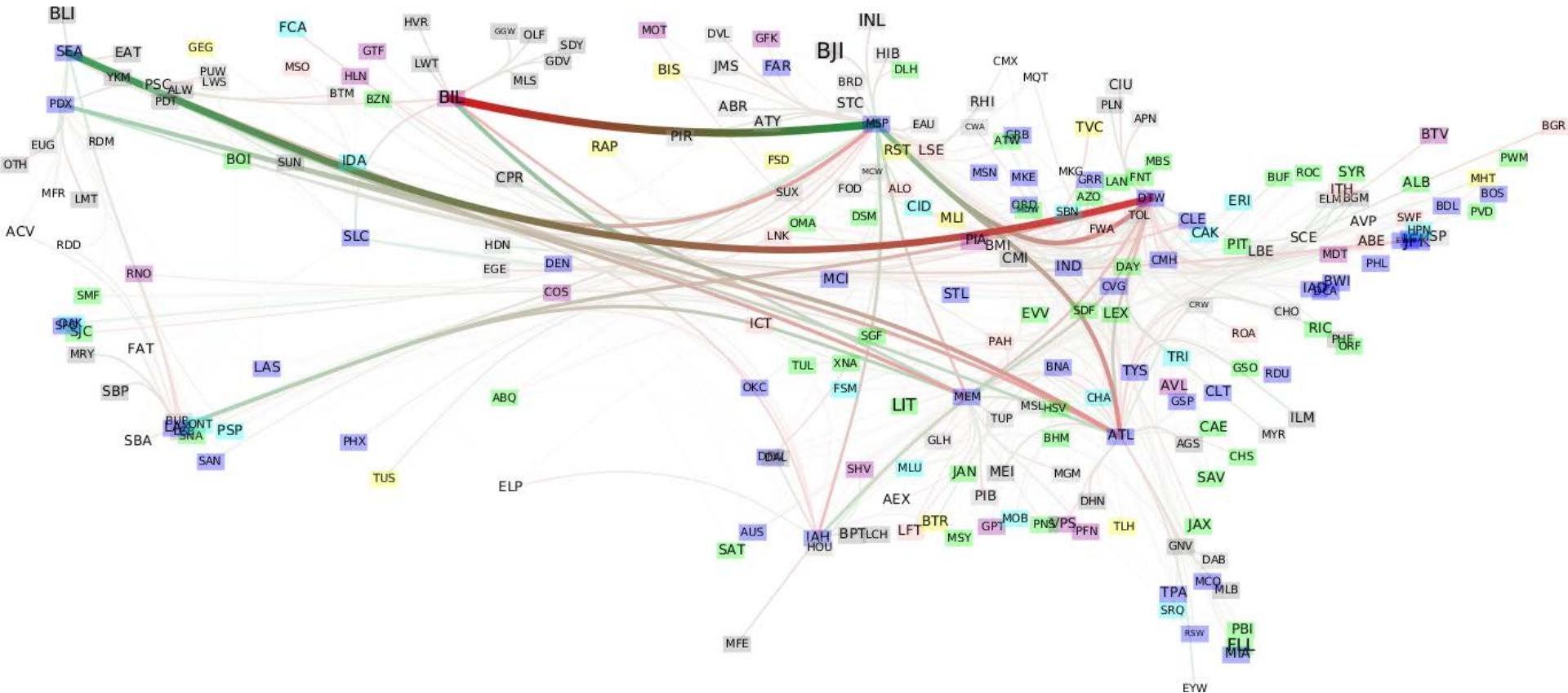


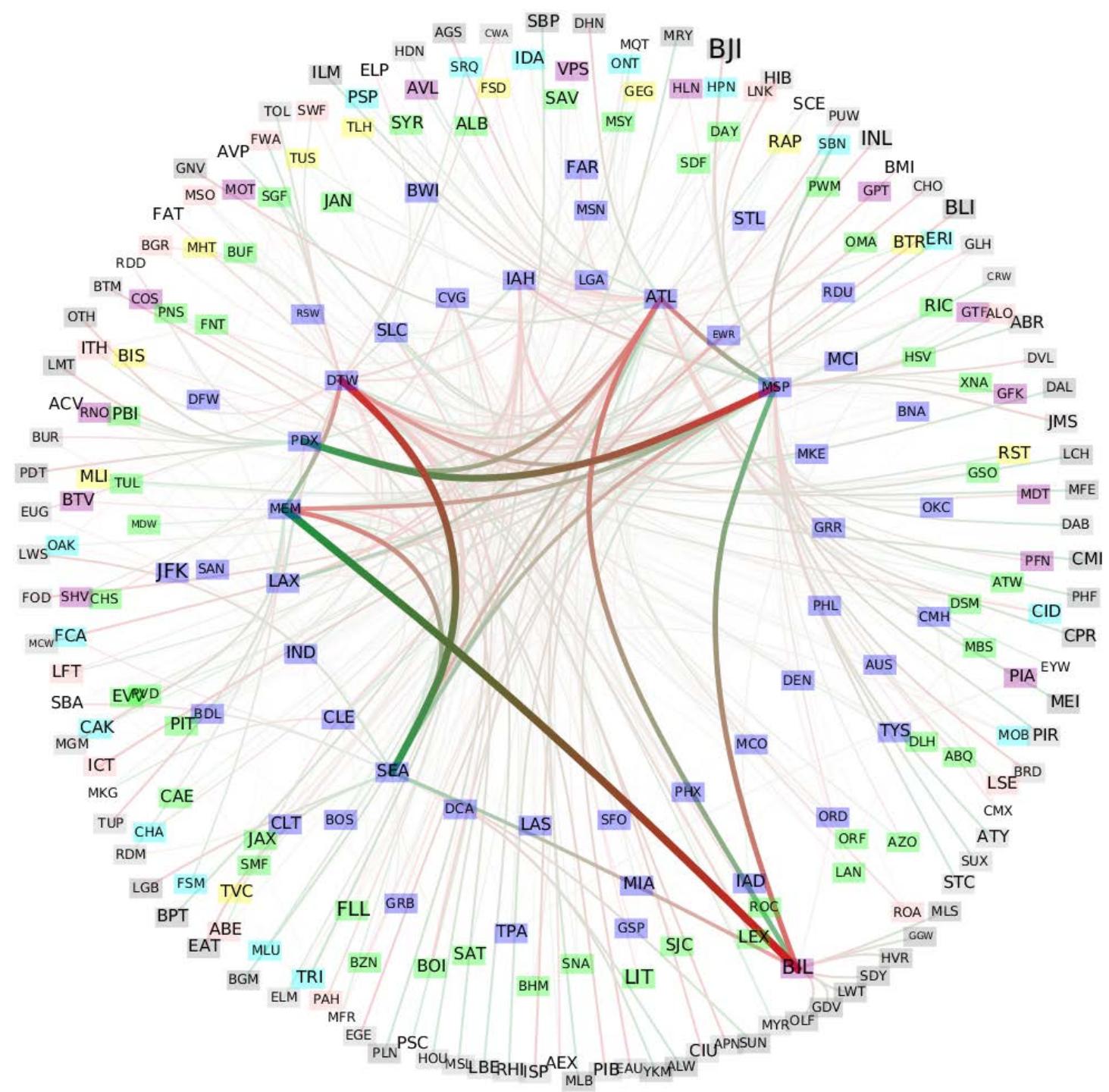
Protein-Protein Interaction Network



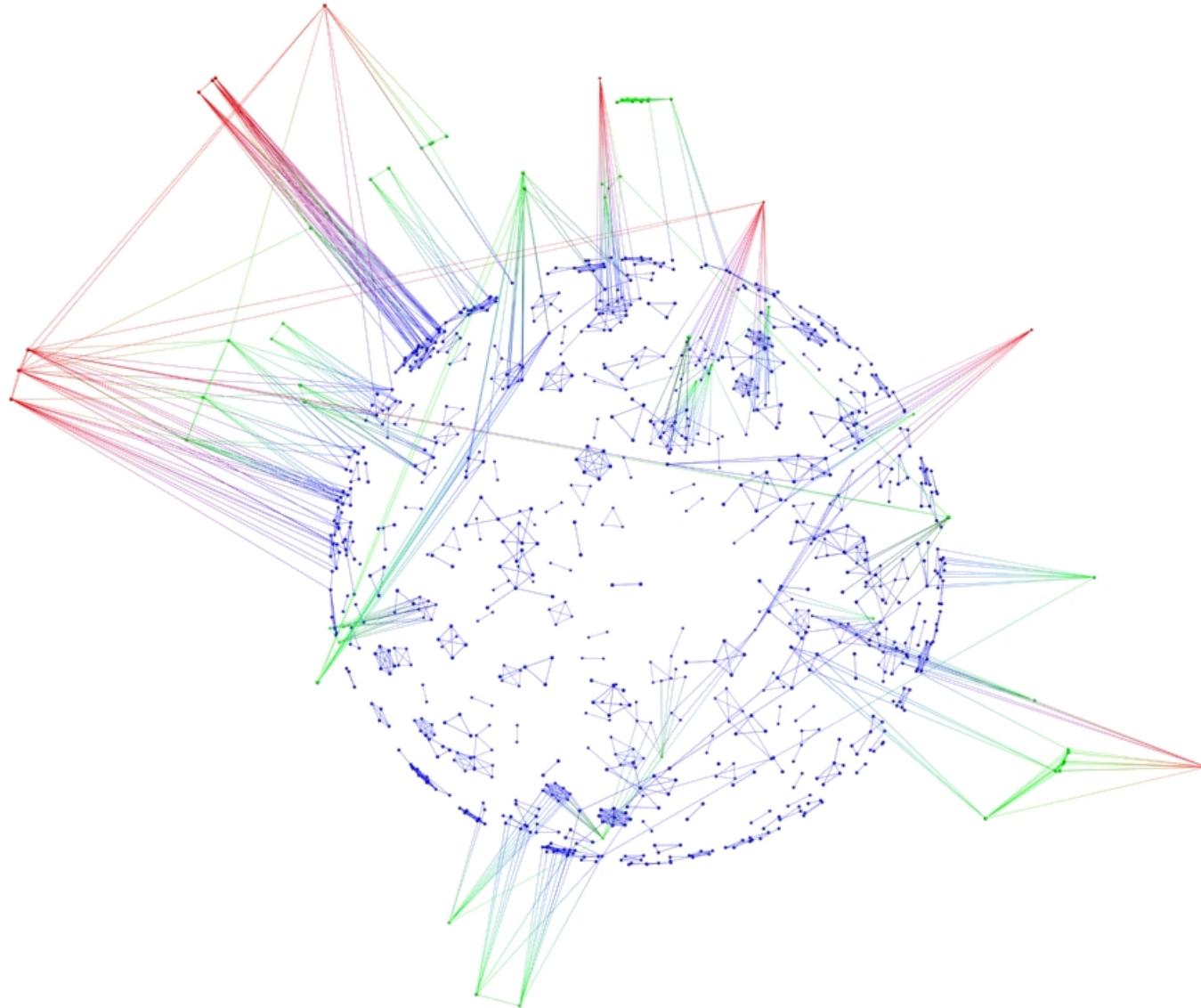


US Airline Network Traffic Analysis



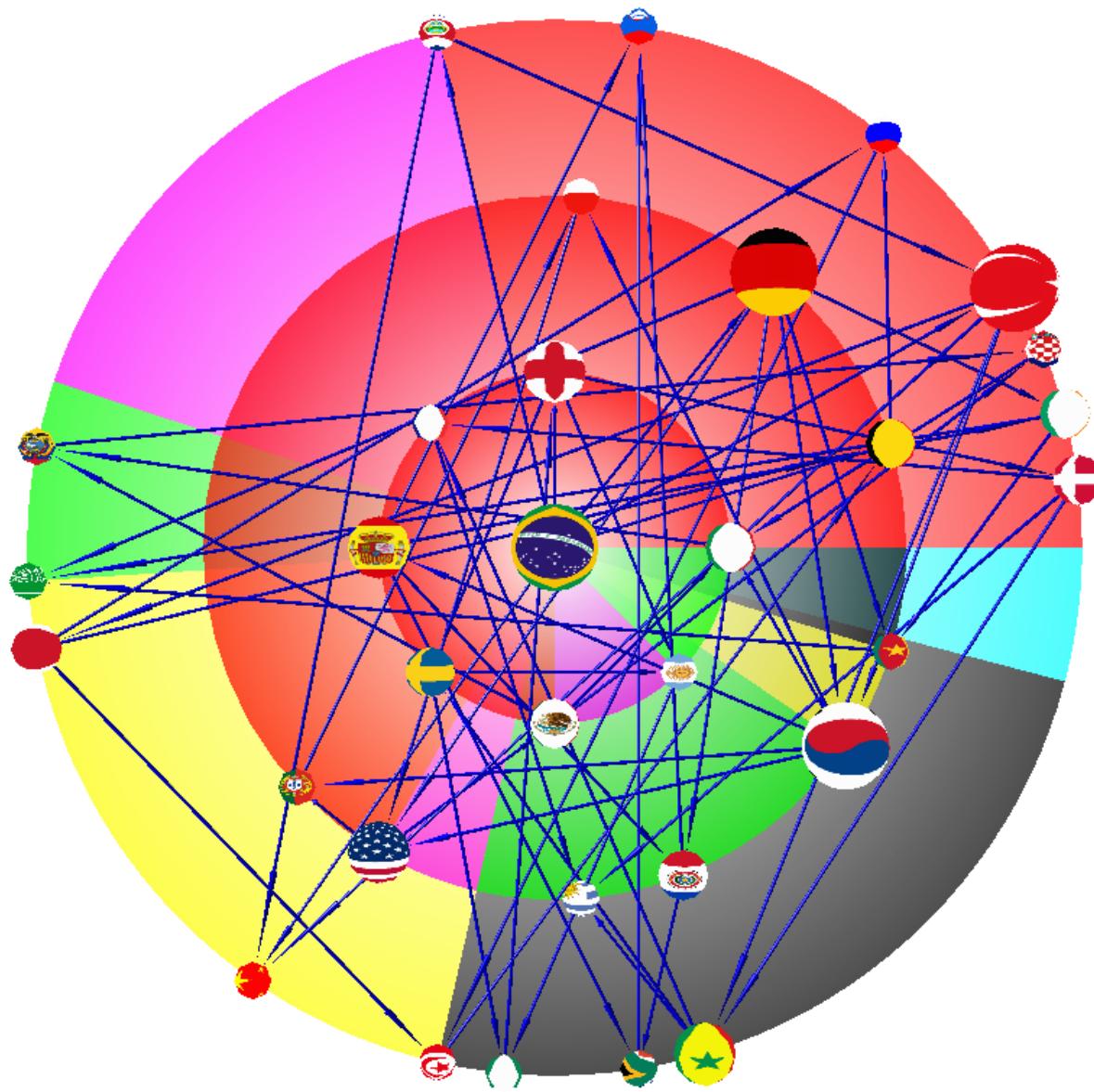


Scale-free Network: Collaboration Network

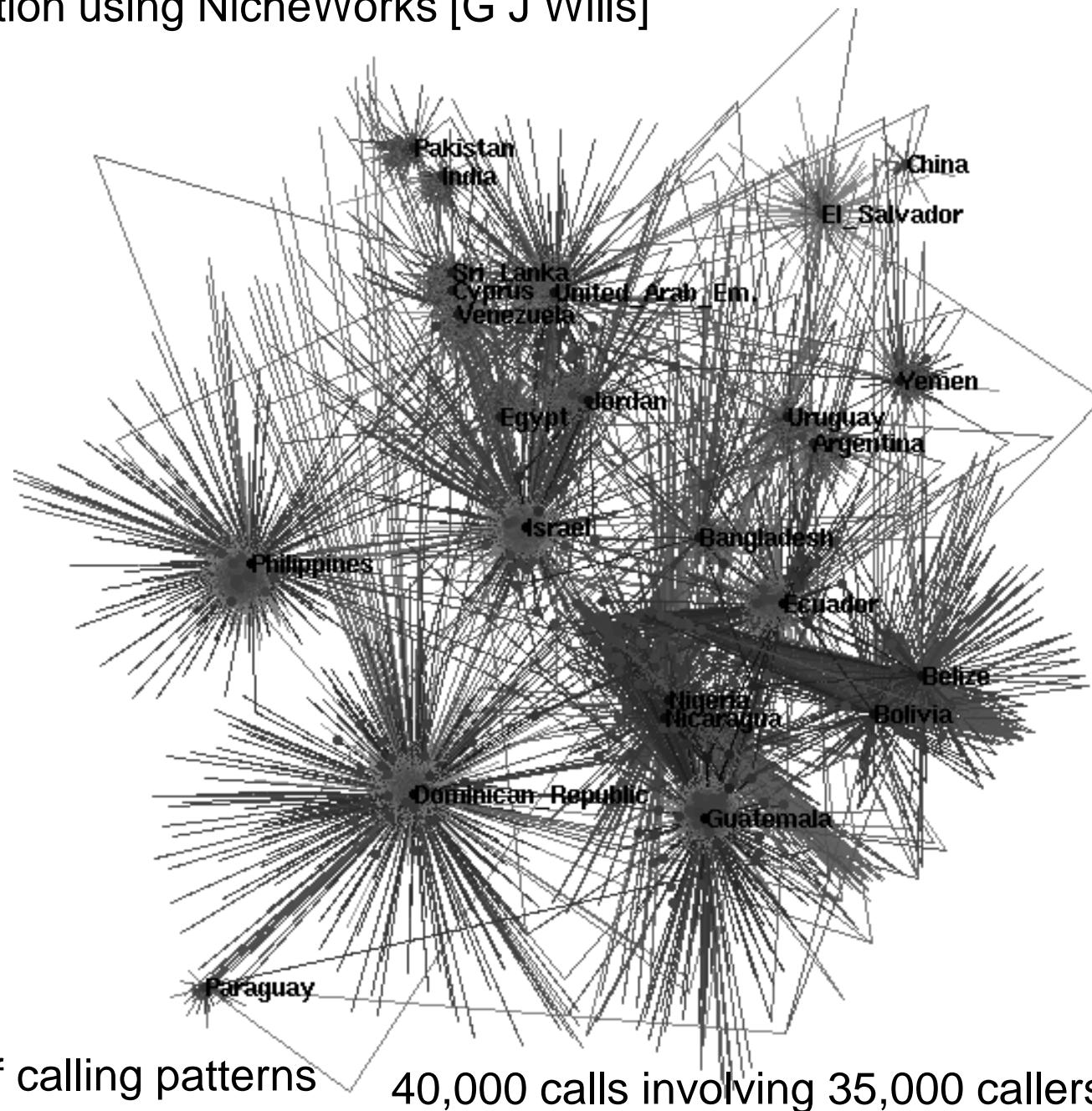


Apex: prominent researchers, $|V|=982$, $|E|=2012$
Research Empire: research clusters

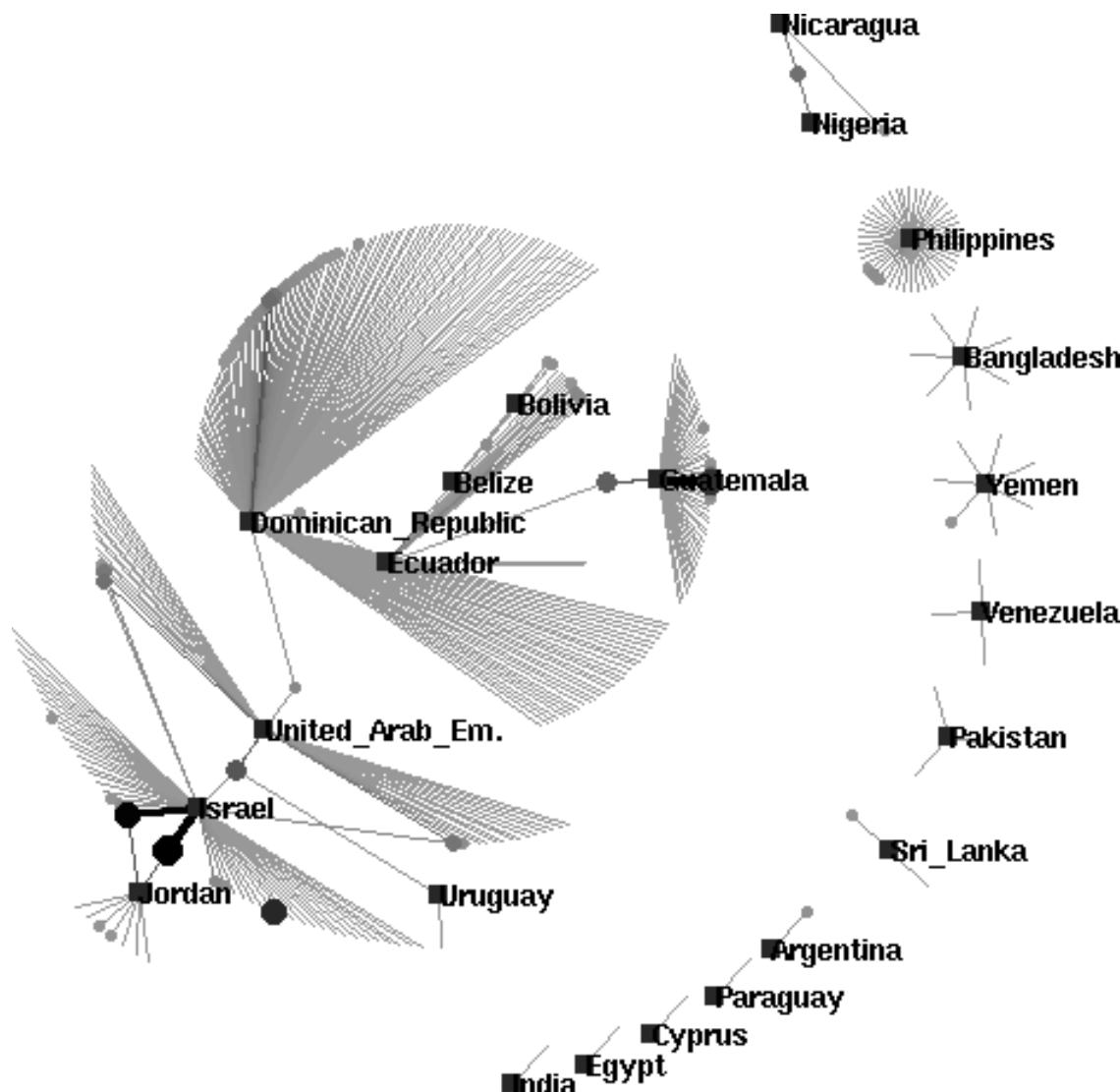
World Cup 2002



Fraud Detection using NicheWorks [G J Wills]

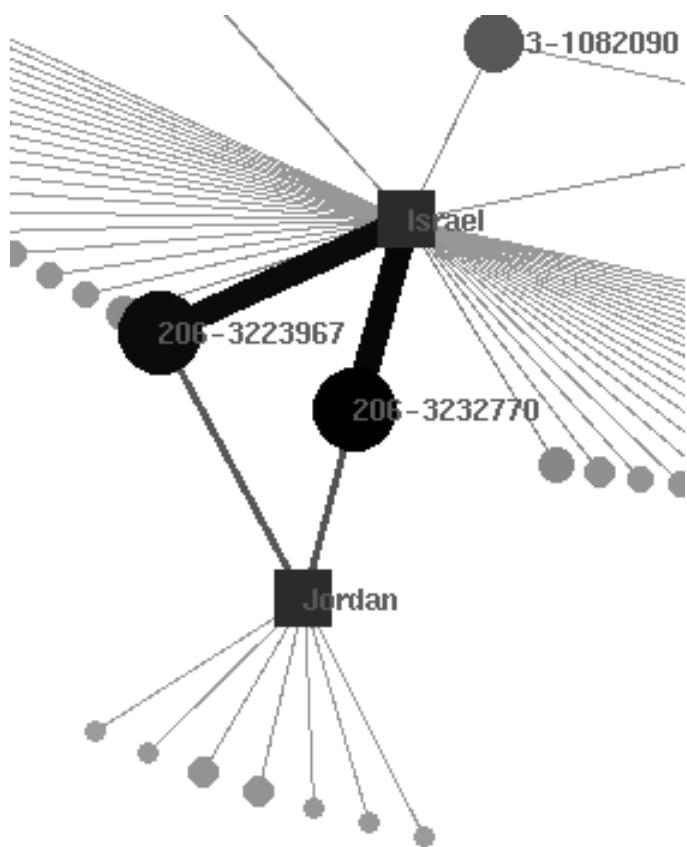


International Calling Fraud

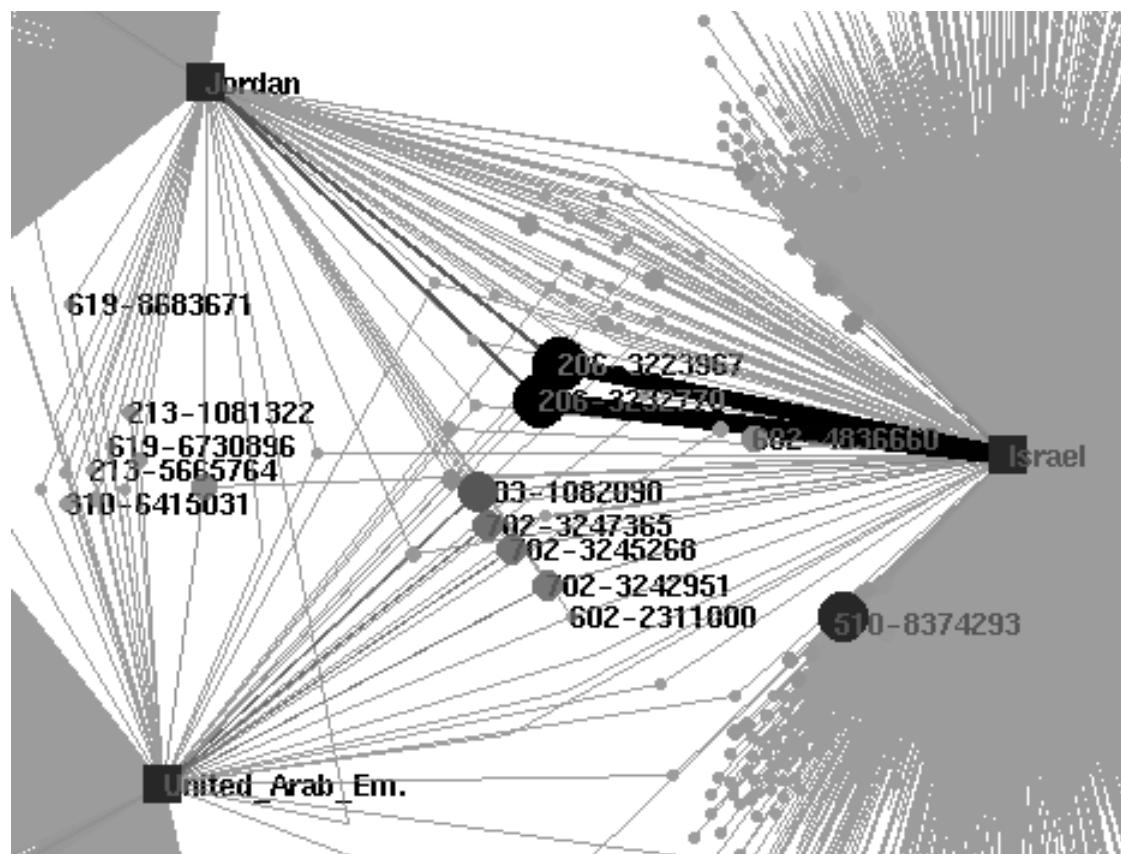


- High users' calling patterns

International Calling Fraud



■ possible fraud pattern



- The Israel-Jordan-UAE generated subset
- zooming in to those callers calling more than one country

3. Information Visualisation

Visualisation

- Visualisation:
the use of computer-supported, interactive, visual representations of data to amplify cognition.
 - **Scientific visualisation:**
the use of computer-supported, interactive, visual representations of **scientific data** to amplify cognition.
 - **Information visualisation:**
the use of computer-supported, interactive, visual representations of **abstract data** to amplify cognition.

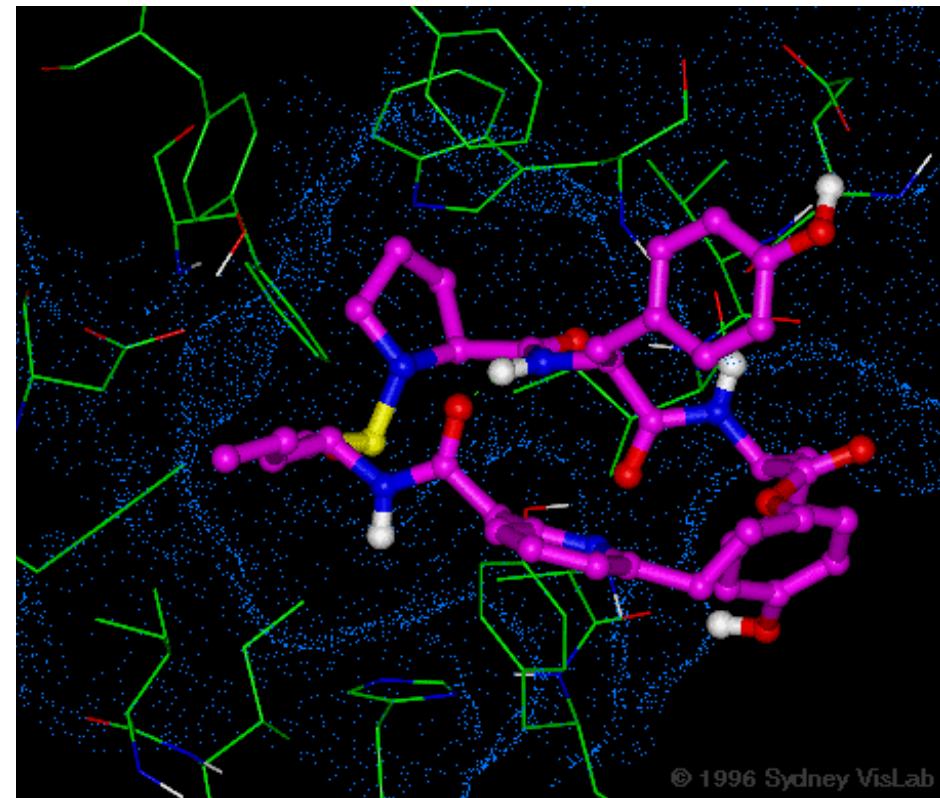
Scientific Visualisation

Astrophysics - Astronomy



- Visualisation of the Durham/UKST Galaxy Redshift Survey
- Andrew Ratcliffe,

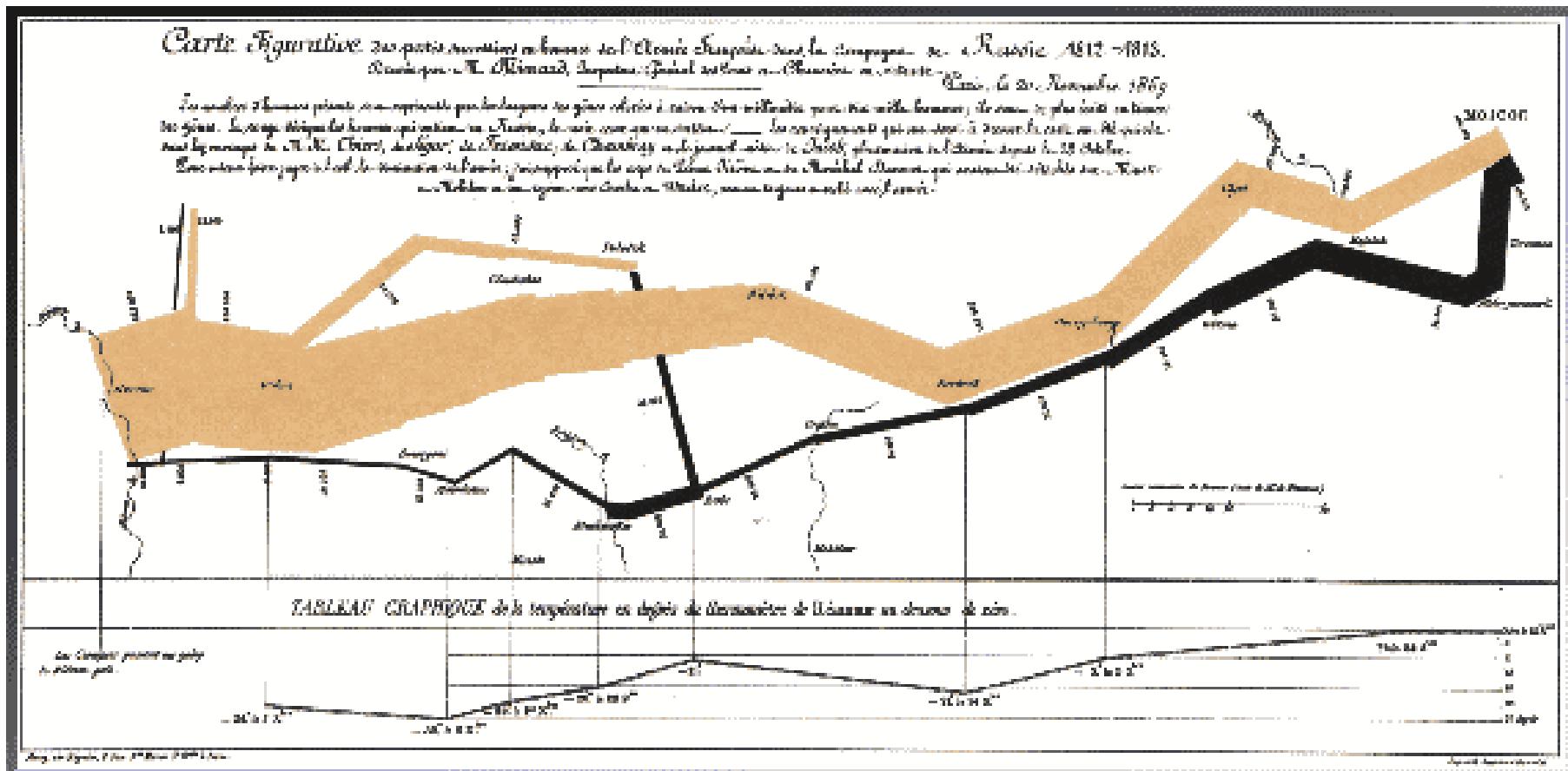
Chemistry – Biochemistry



- Molecular Modelling of Immunosuppressant Molecules Bound to an Enzyme
- Peter Karuso

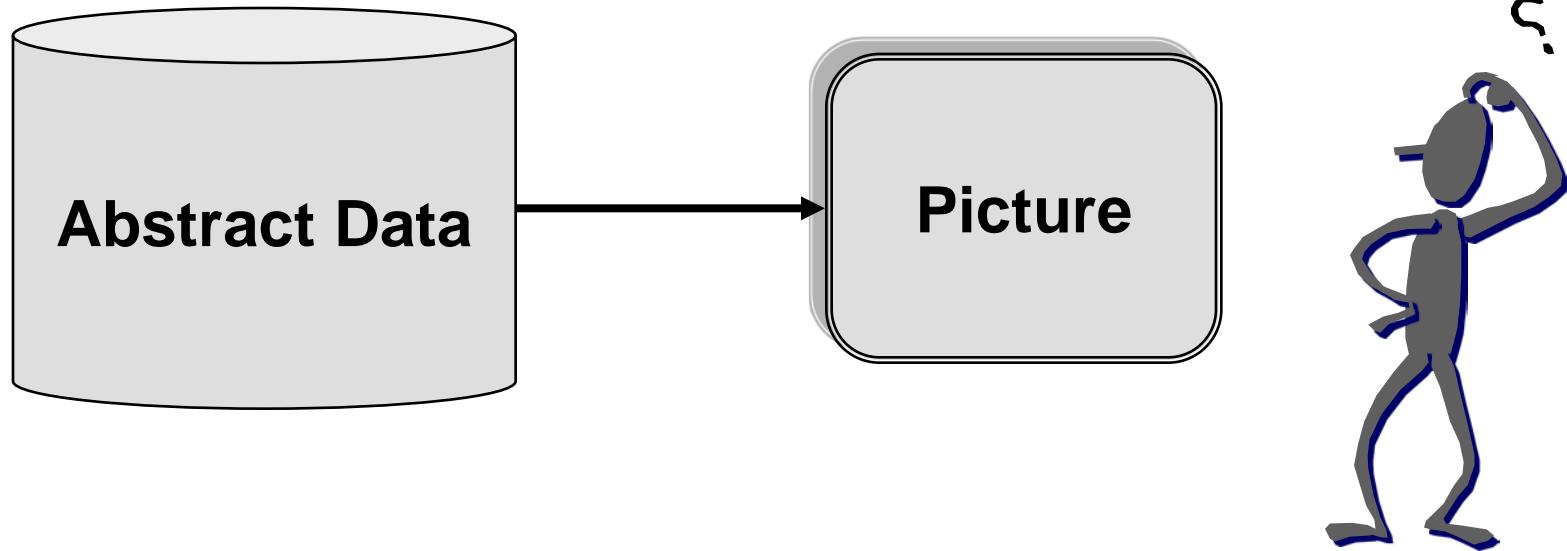
Information Visualisation

the loss of Napoleon's army



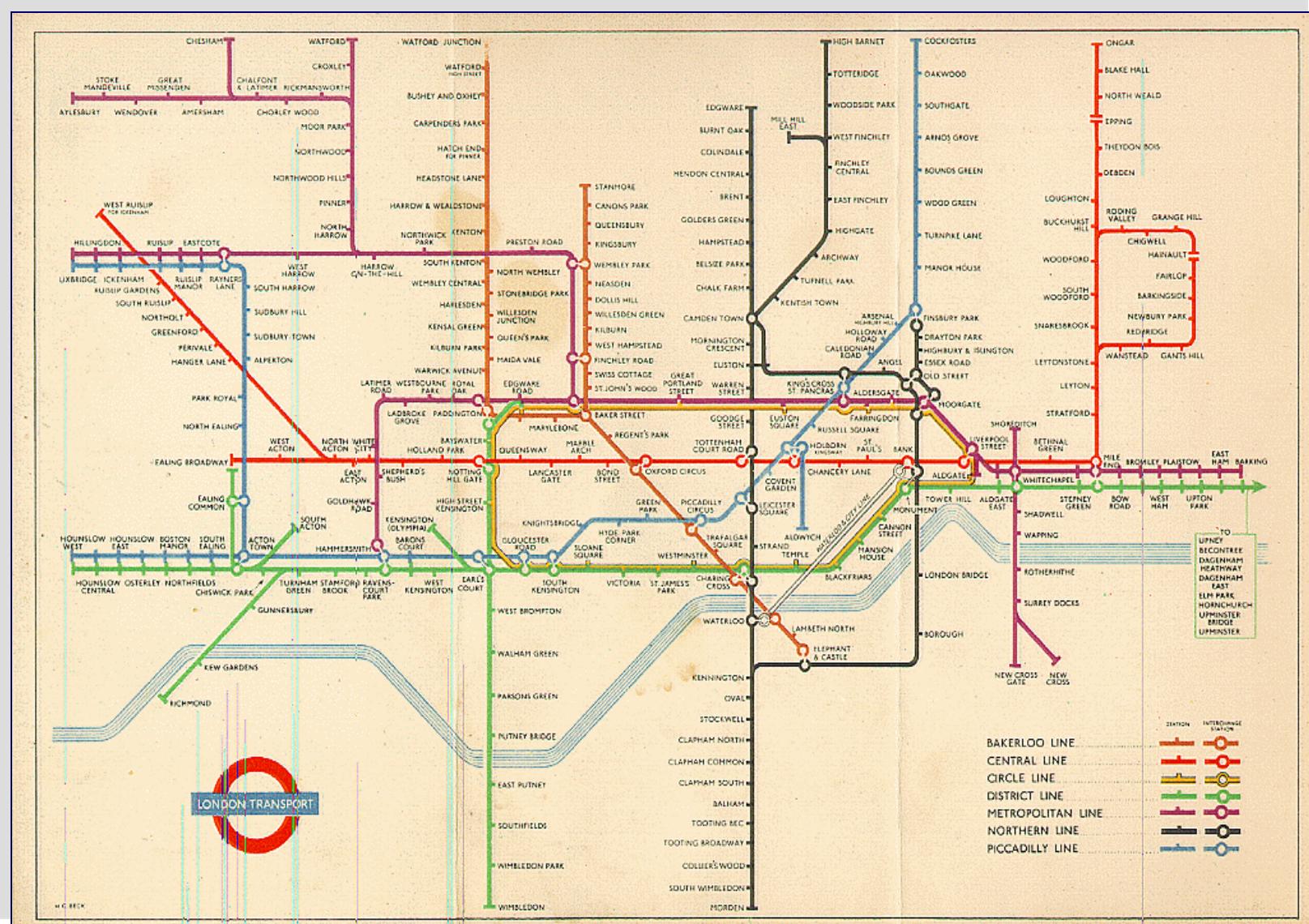
- Edward R. Tufte, The Visual Display of Quantitative Information
- by Charles Joseph Minard (1781-1870)
- Russian-Polish border 422,000 men / Moscow 100,000 men.

Information Visualisation



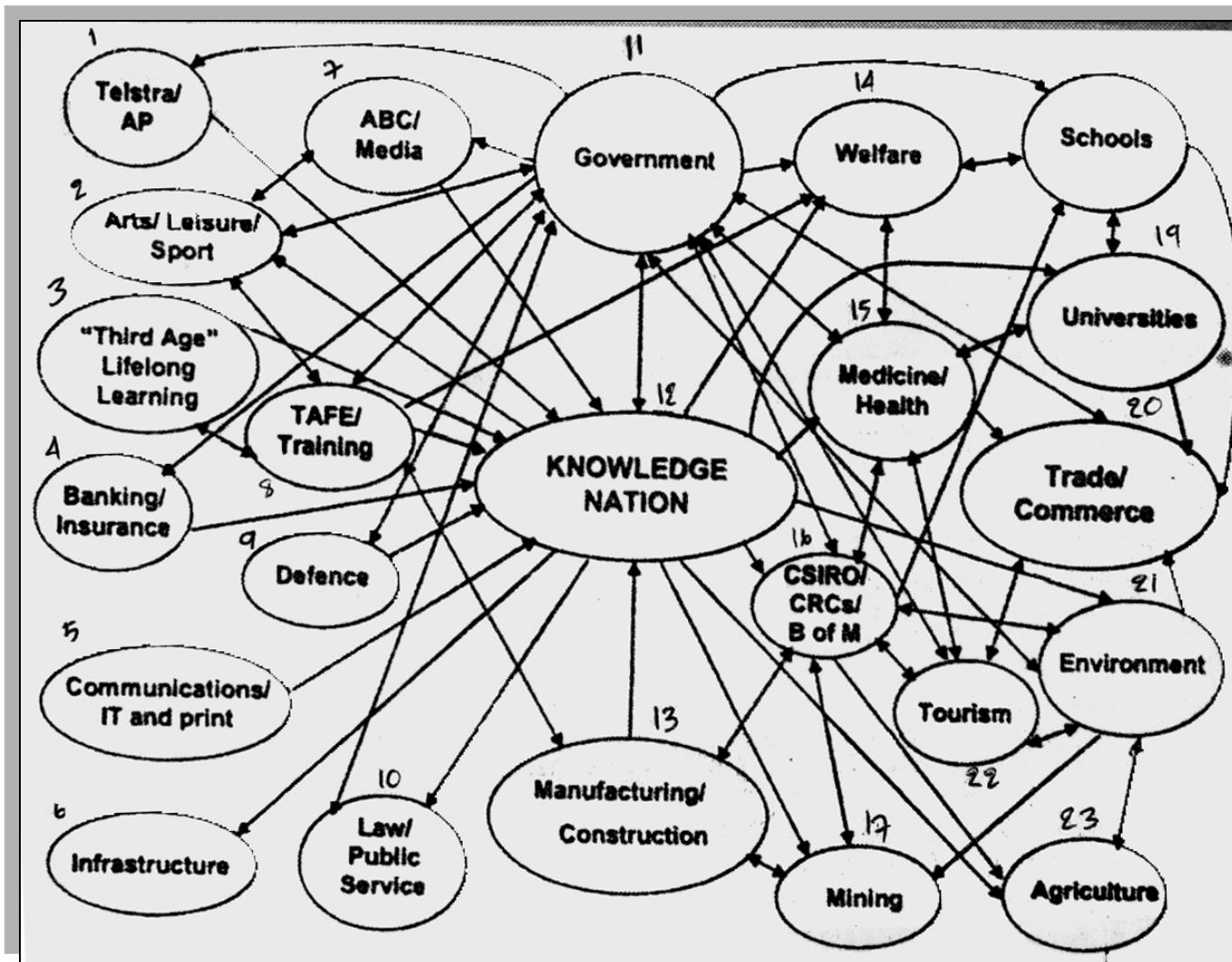
Information visualisation research aims to make pictures of abstract data so that humans can understand, navigate, and manipulate the data.

Good visualisation



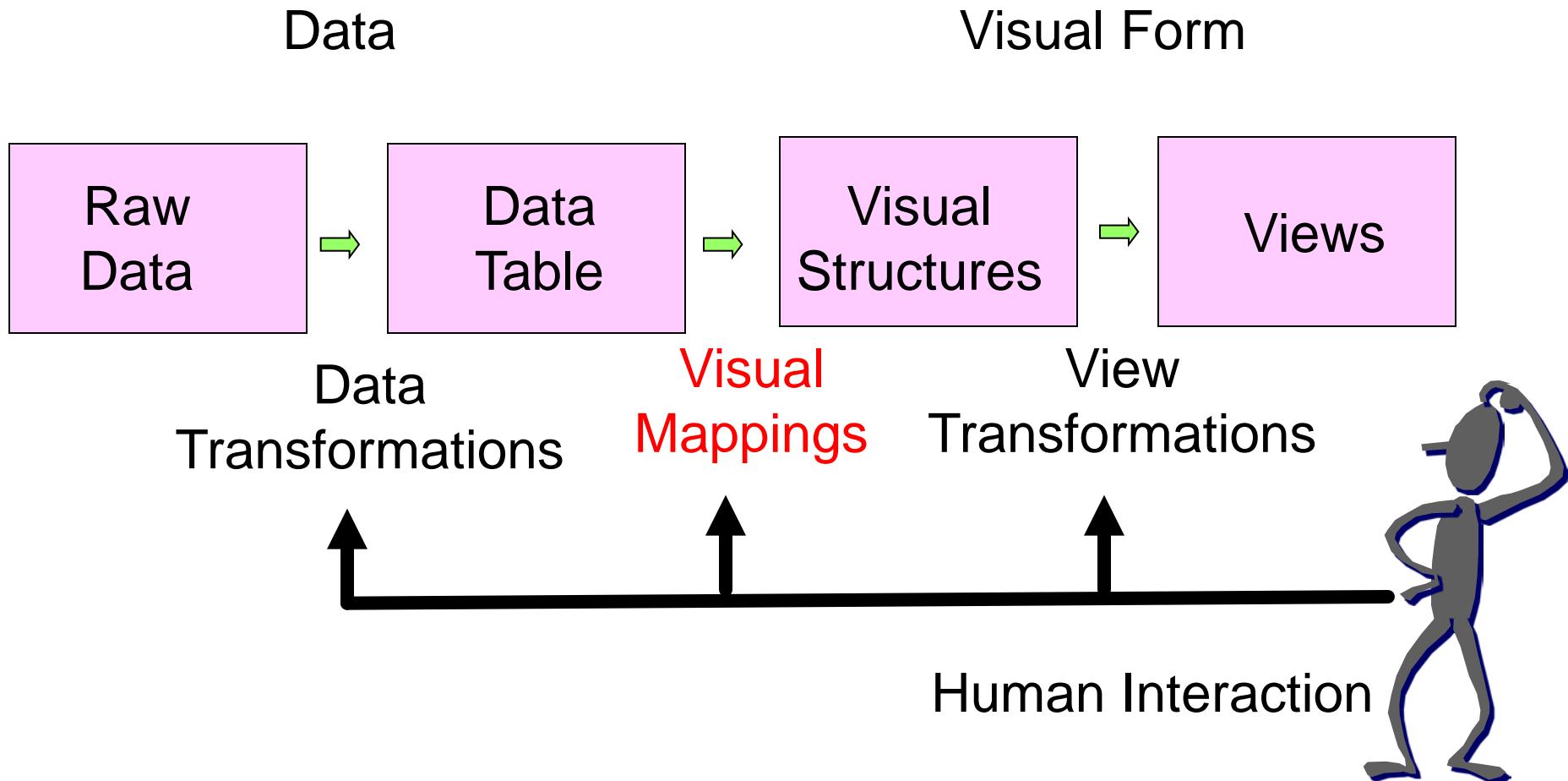
• H. Beck

Bad visualisation



■ ALP

Reference Model for Visualisation



Visualisation of football transfers



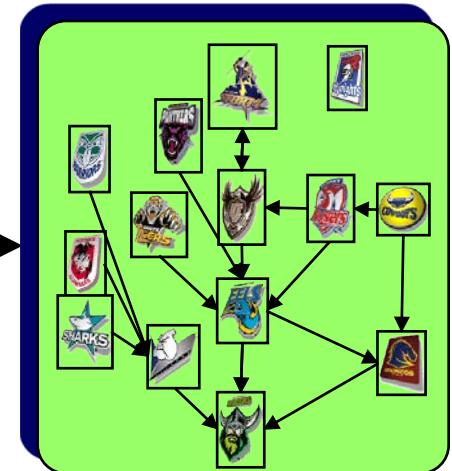
Analysis

- Drew moved from the Panthers to the Eels
 - Miles moved from the Roosters to the Eagles
 - Green moved from the Cowboys to the Roosters
 - O'Hara moved from the Bulldogs to the Raiders

Data

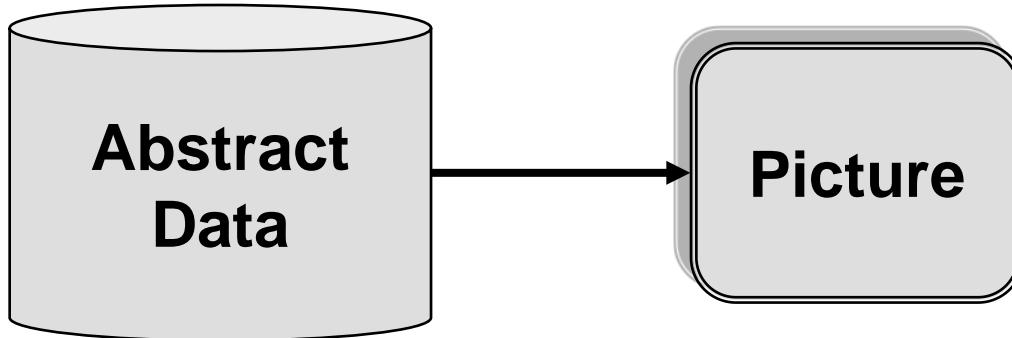
Graph

Visualisation



Picture

Representation and Techniques



Representation (Metaphor): how to represent the data

Techniques/Algorithms/Methods: how to construct such representation automatically using a computer efficiently and effectively

Data Types

Multi-dimensional/Muti-variate/Multi-attribute Data

eg. Student data =(Degree, Year, Academic records, International/local, Address, Phone number, email)

-> Nominal value, categorical, text format etc
+ time series, spatial information

Graph

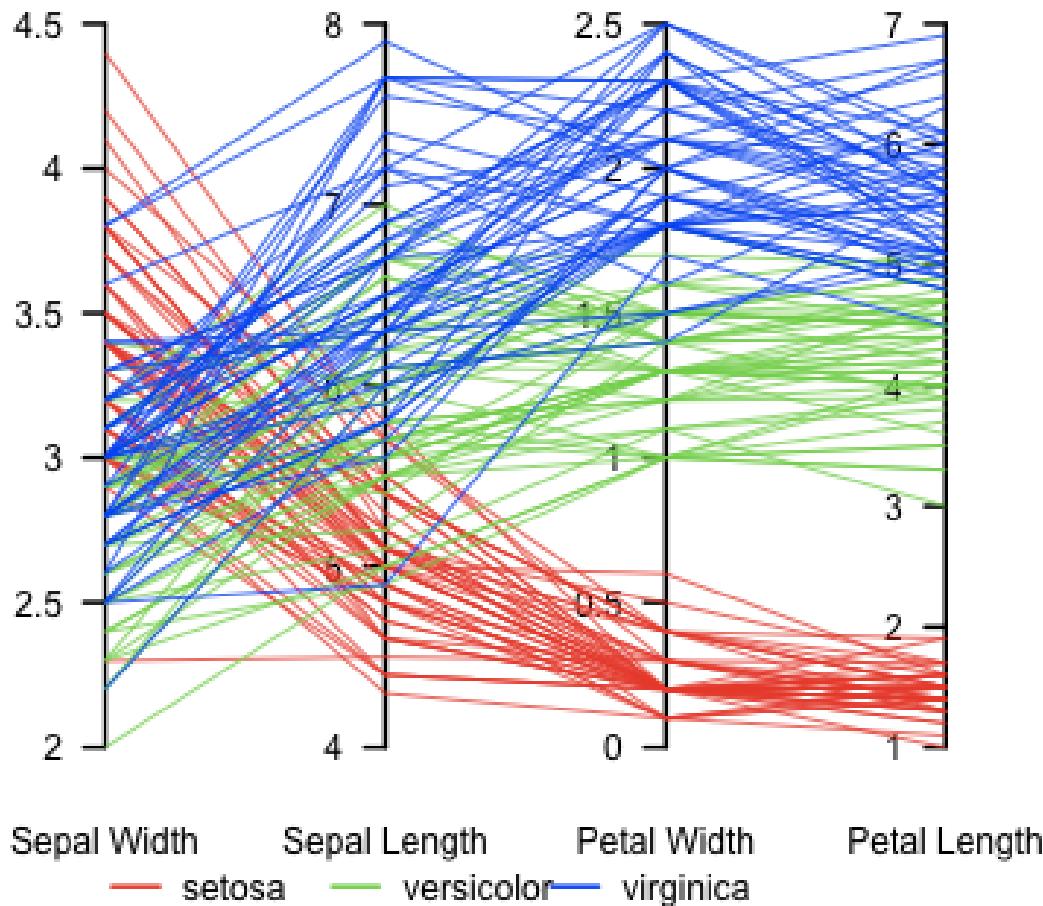
$G=(V, E)$, V: vertex (node) set , E: edge set

Social network, Twitter, facebook, linked-in etc

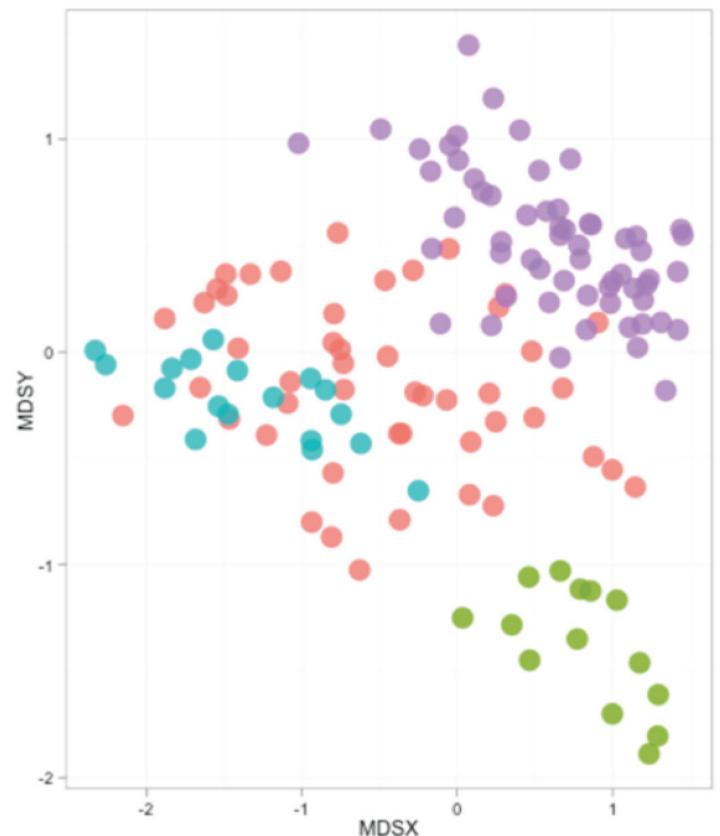
Multi-dimensional/Multi-variate Data

Paraeel Coordinates [Inselburg]

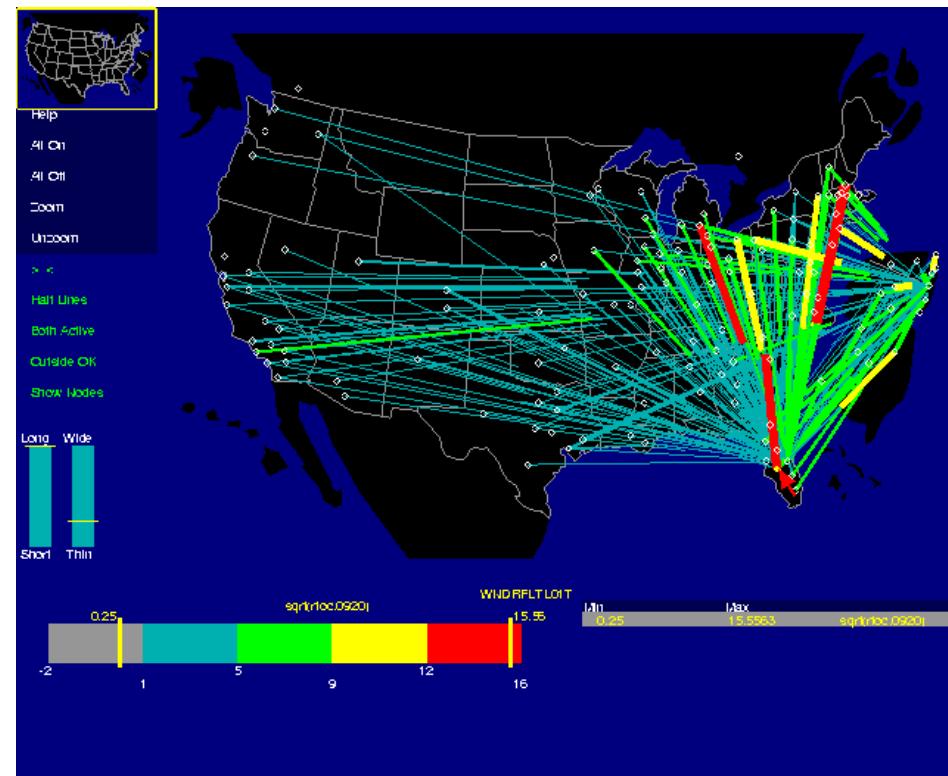
Parallel coordinate plot, Fisher's Iris data



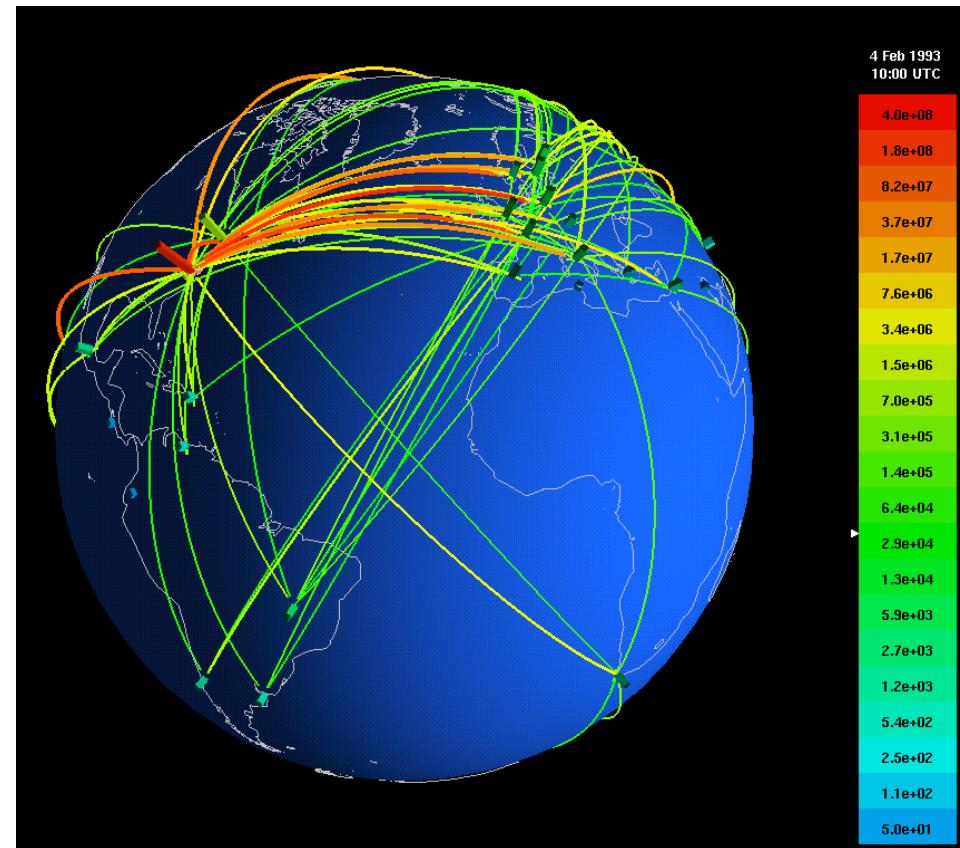
Scatterplot using MDS (Multi-Dimensional Scaling)



Geographic/Spatial Data



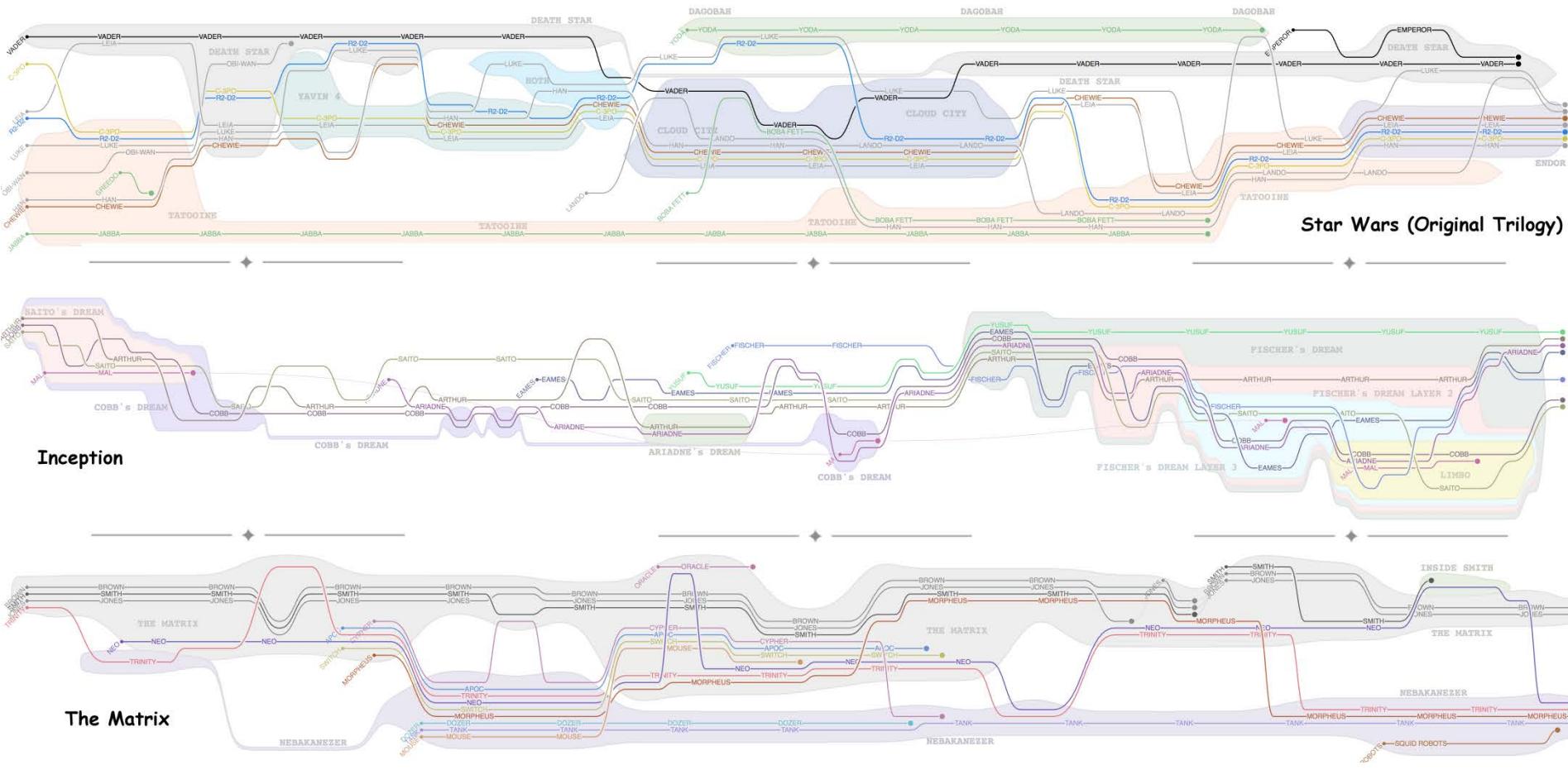
- [Becker, Eick, Wilks 95]
- SeeNet



- [Cox, Eick 95] 3D Displays of Network Traffic
- SeeNet3D

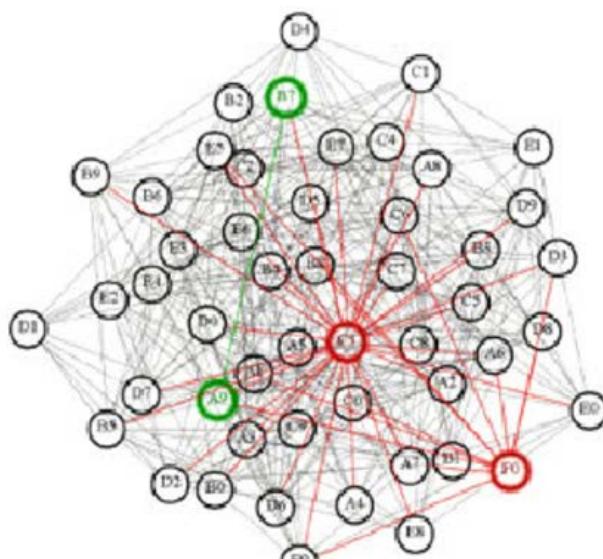
Time-series Data

Storyline [Tanahashi, Ma]



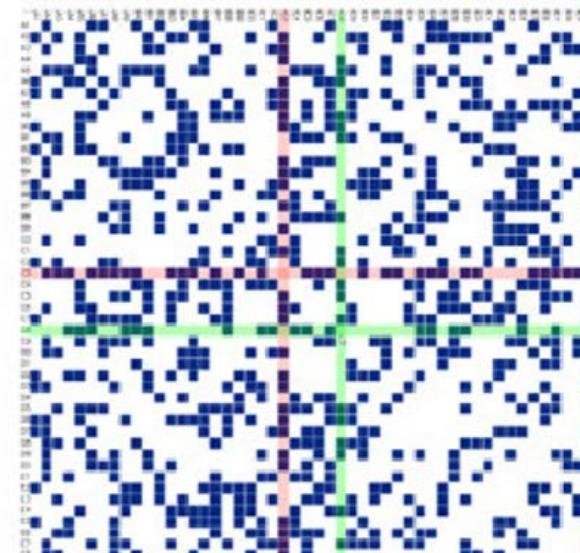
Graph Data Representation

Node-Link Diagram



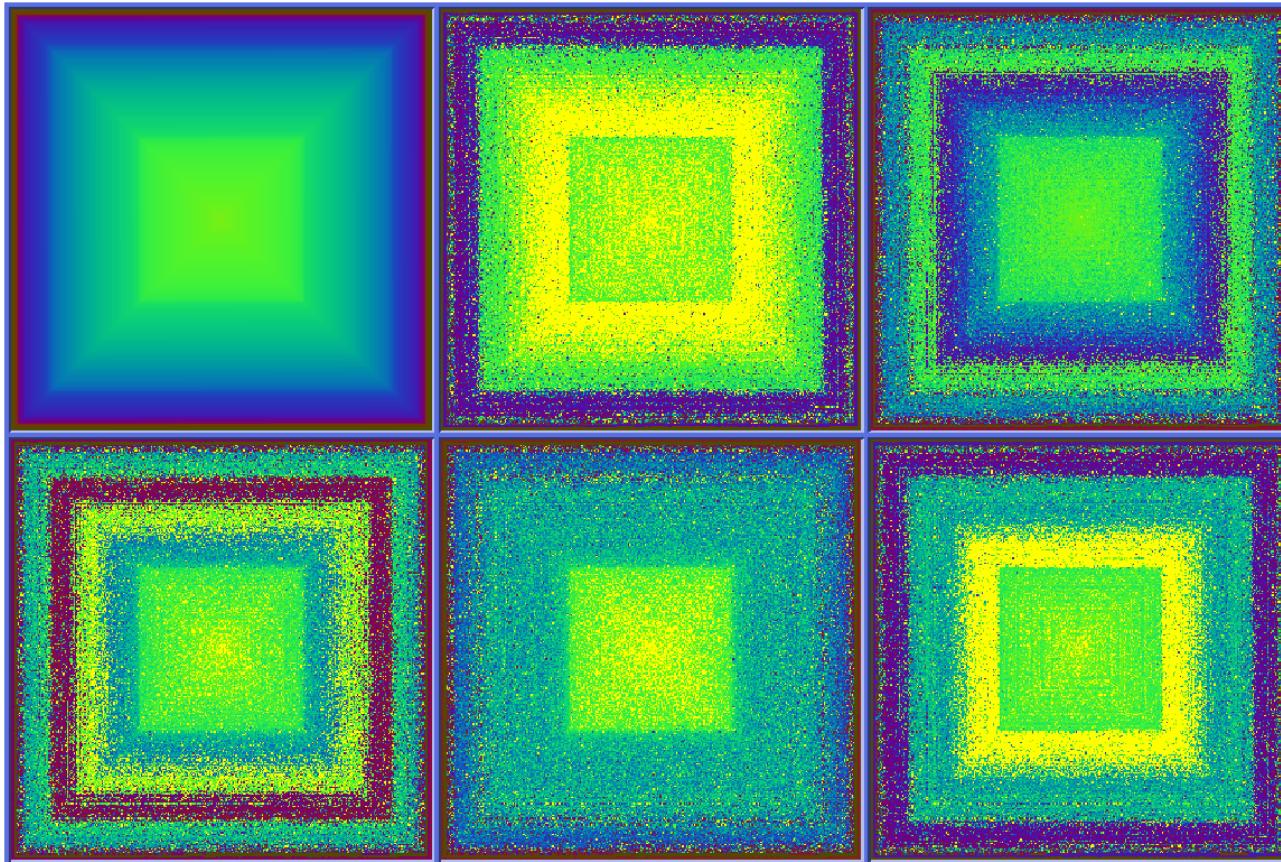
a)

Adjacency Matrix



b)

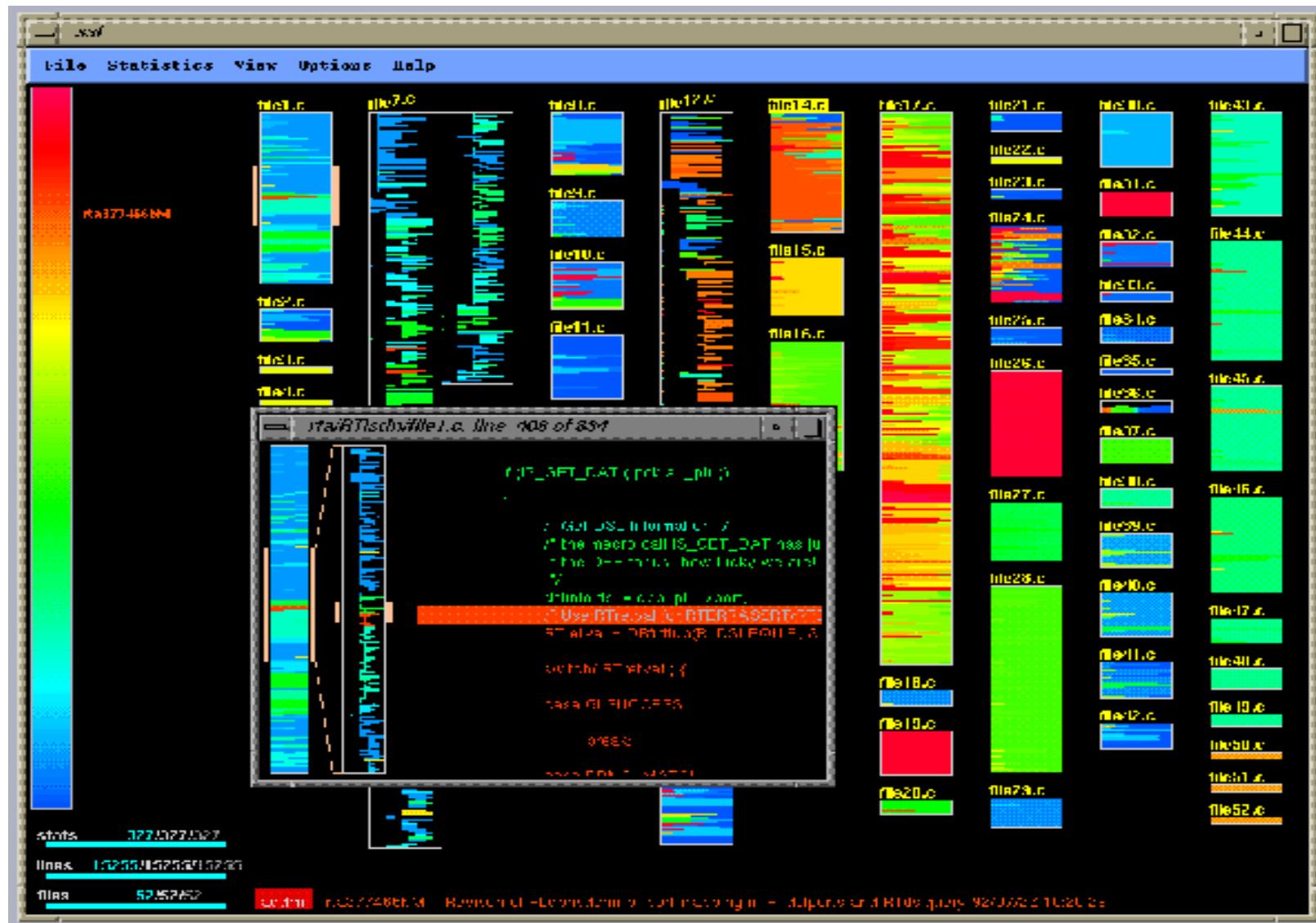
Database Visualisation



VISDB

Five-dimensional artificially generated data set (100,000 points) in simple configuration.

Software Visualisation

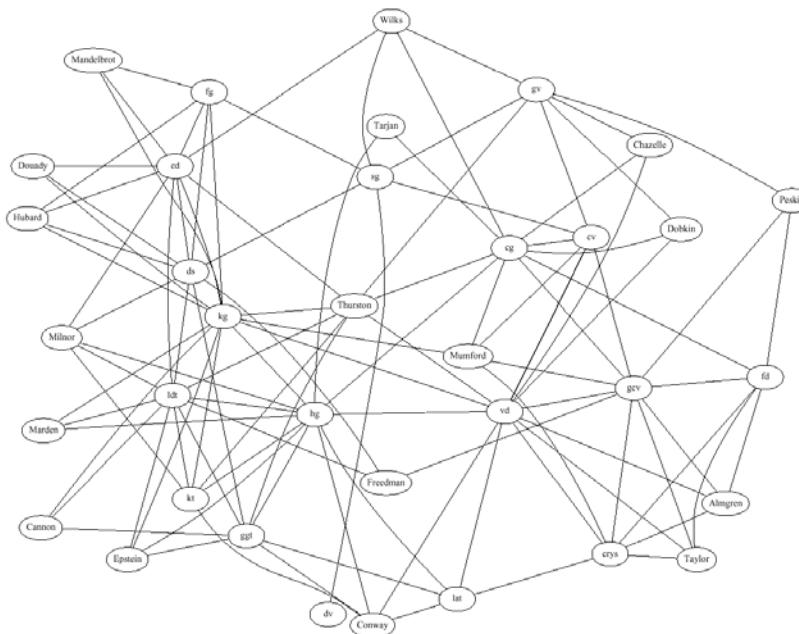


SeeSoft

4. Graph Drawing (Network Visualisation)

Graph Drawing

- **Graphs: abstract structure to model relational information.**
 - **Graph $G=(V,E)$**
 - **V: set of vertices (objects, entities)**
 - **E: set of edges connecting vertices(relationship)**
 - **Graph Drawing: automatic construction of good geometric representations of graphs in 2D or 3D.**



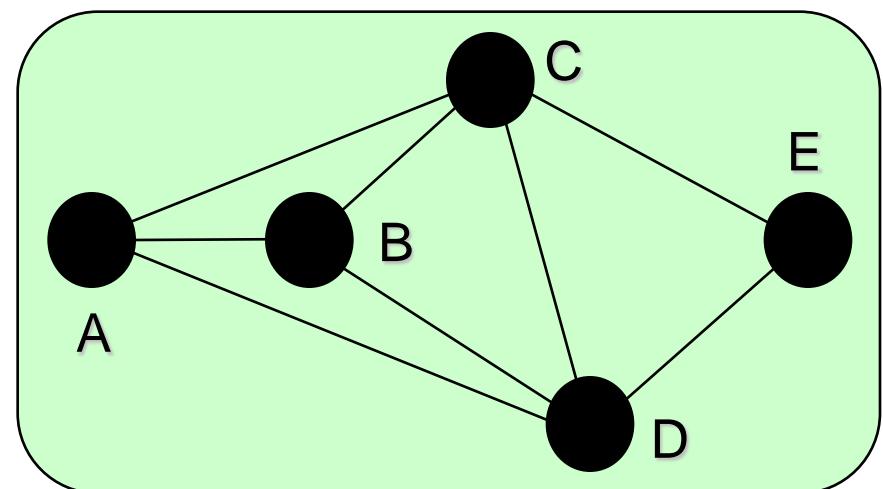
Graph Drawing

- The classical graph drawing problem is to develop algorithms to draw graphs.

The input is a graph with no geometry

The output is a drawing of the graph; the drawing should be easy to understand, easy to remember, beautiful.

A - B, C, D
B - A, C, D
C - A, B, D, E
D - A, B, C, E
E - C, D



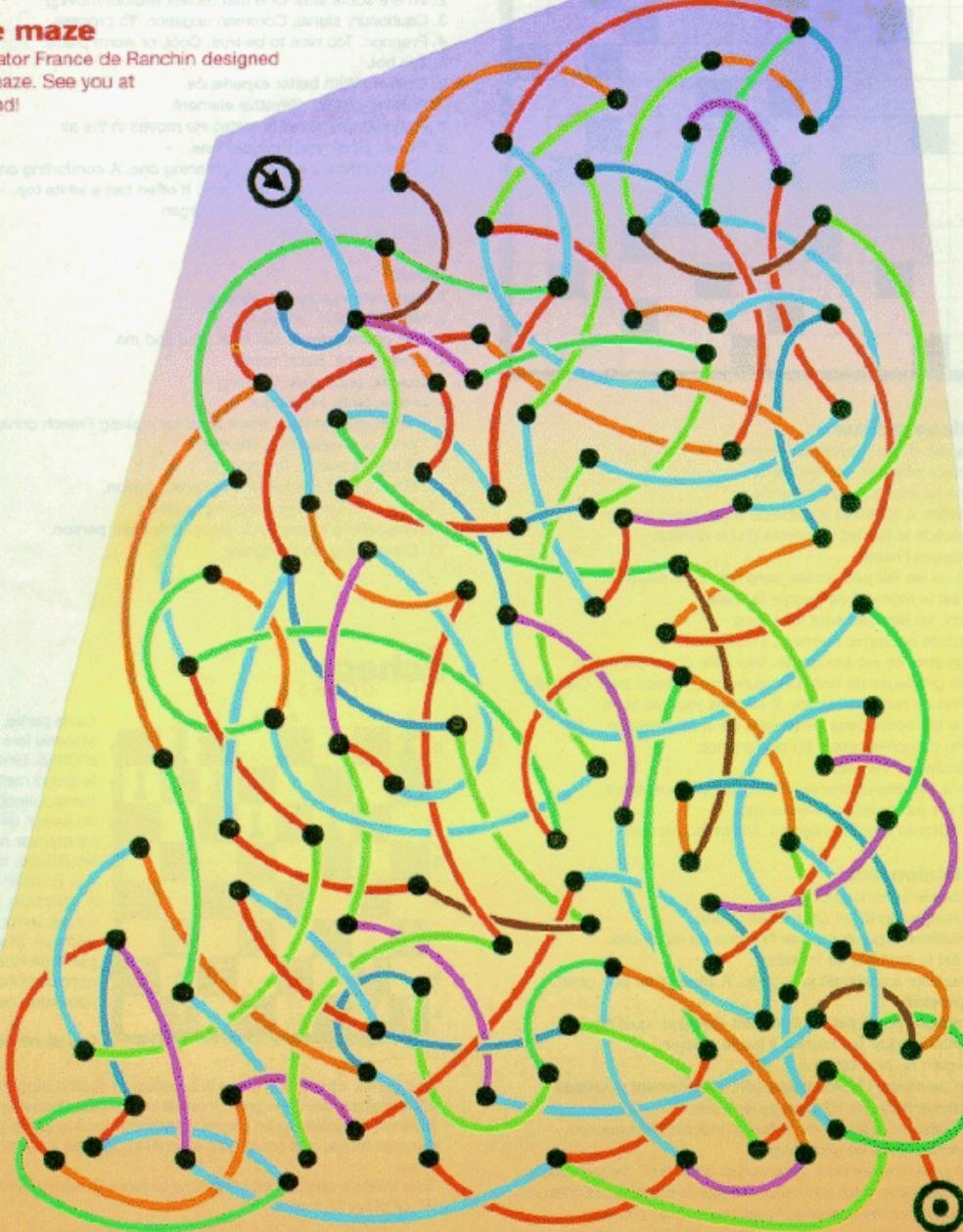
Tangled Drawing

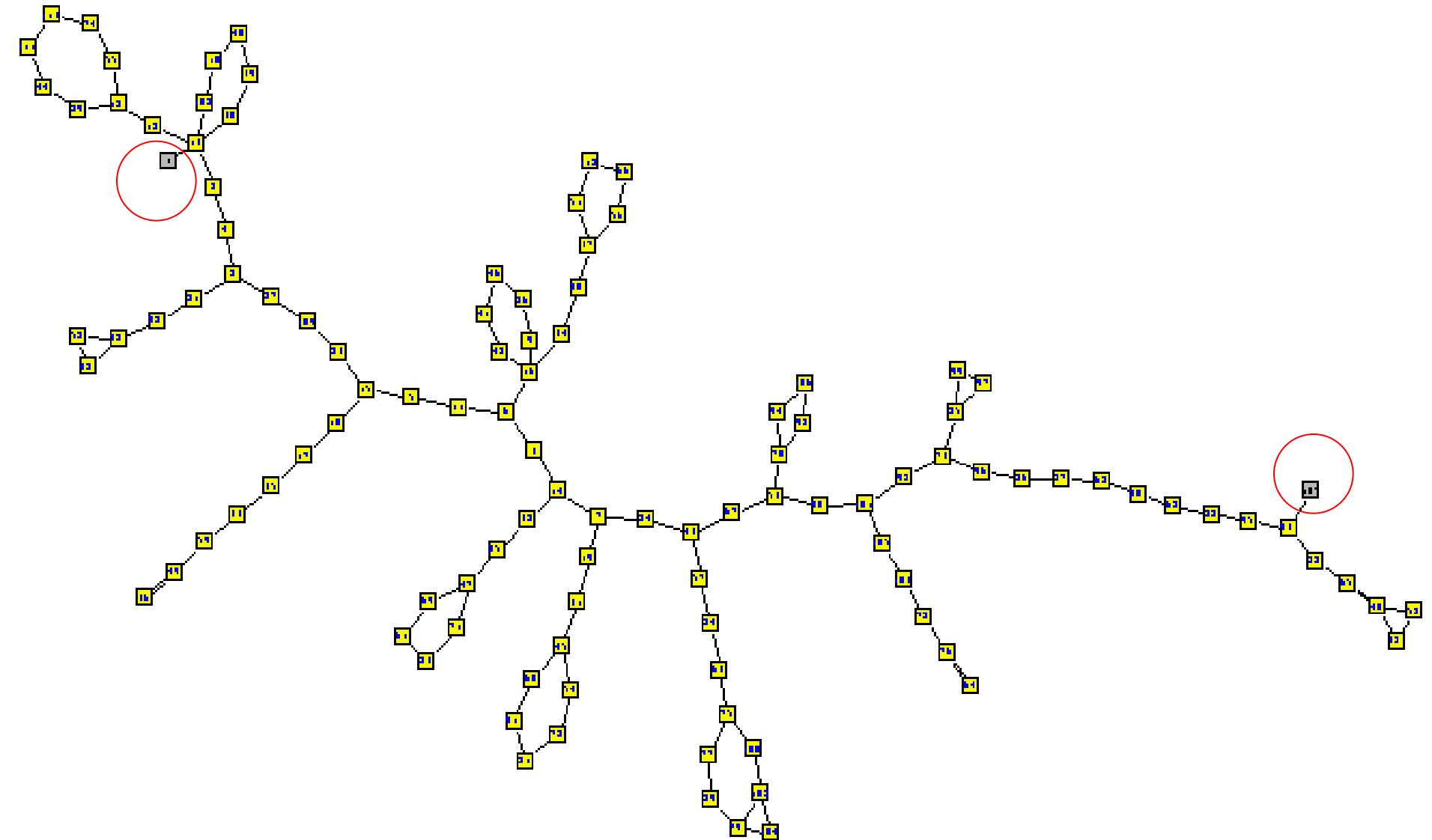
Le labyrinthe

La dessinatrice France de Ranchin a imaginé ce labyrinthe. Saurez-vous trouver la sortie ?

The maze

Illustrator France de Ranchin designed this maze. See you at the end!





Untangled Drawing

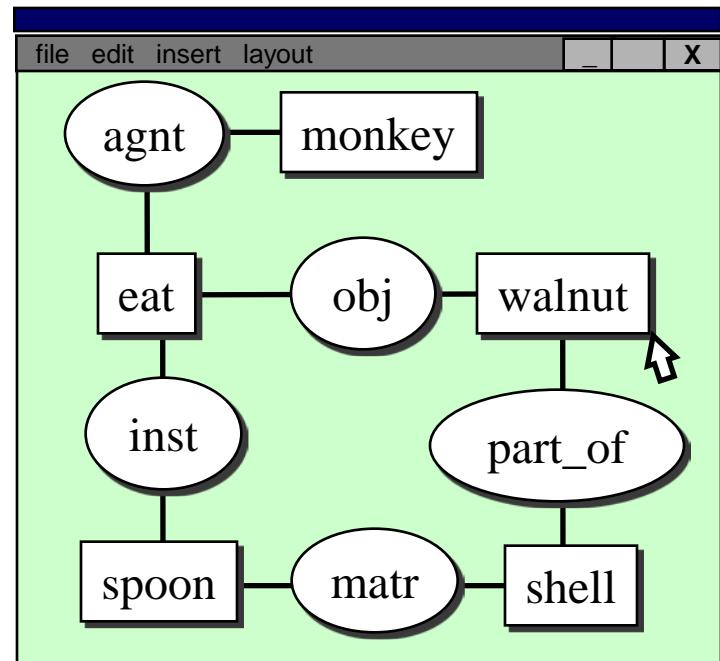
Graph Drawing

The input graph is usually some relational description of a software system.

```
agt(monkey, eat).  
inst(eat, spoon).  
obj(eat, walnut).  
part_of(walnut, shell).  
matr(spoon, shell).
```



The output picture is used in a system design/analysis tool.



The graph drawing problem is to design methods to give good drawings of graphs.

Graph Drawing

Software Engineering
- data flow diagram
- subroutine call graph
- program nesting trees
- object oriented class hierarchy

Information System
- organization charts

Data base
- entity relationship diagram

Real-time System
- Petri nets
- state transition diagrams

VLSI
- circuit schematics

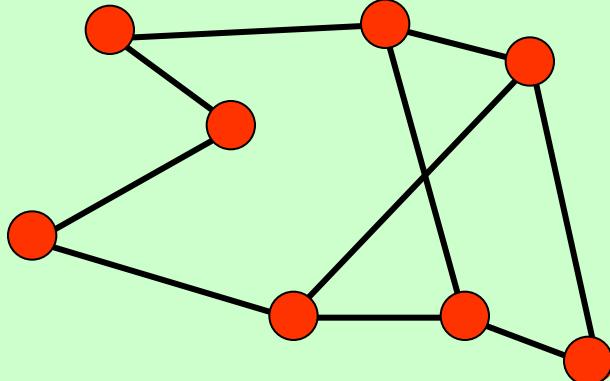
Decision Support System
- Pert network

Artificial intelligence
- knowledge representation diagram

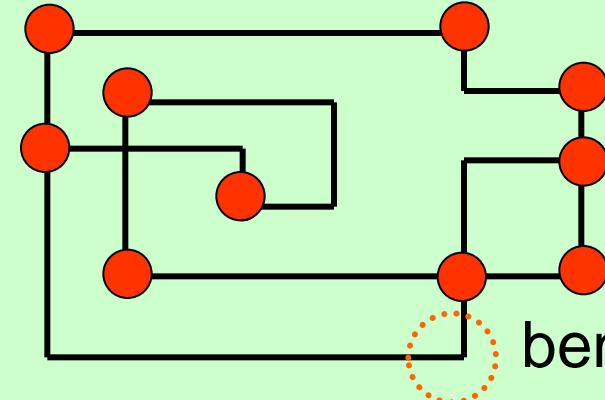
Graph Classes

- **tree**
 - **free tree**
 - **binary tree**
 - **rooted tree**
 - **ordered tree**
- **planar graphs**
- **general graphs**
- **directed graphs**
- **extended graph model**
 - **hierarchical graphs**
 - **clustered graphs**
 - **hyper graphs**
 - **higraphs**

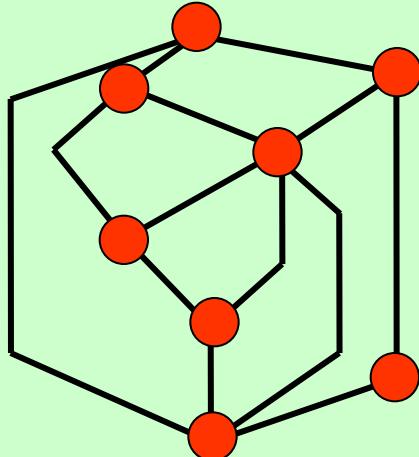
Drawing conventions



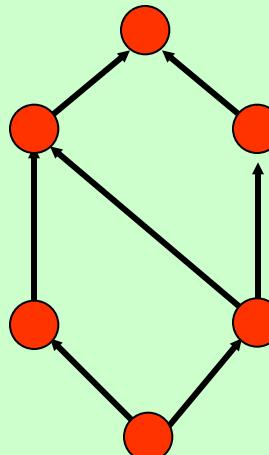
Straight-line drawing



Orthogonal drawing



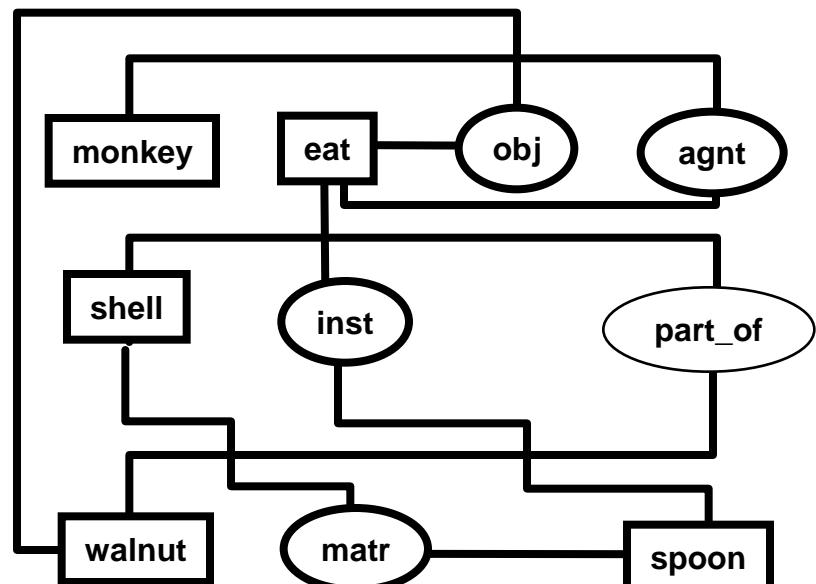
Polyline drawing



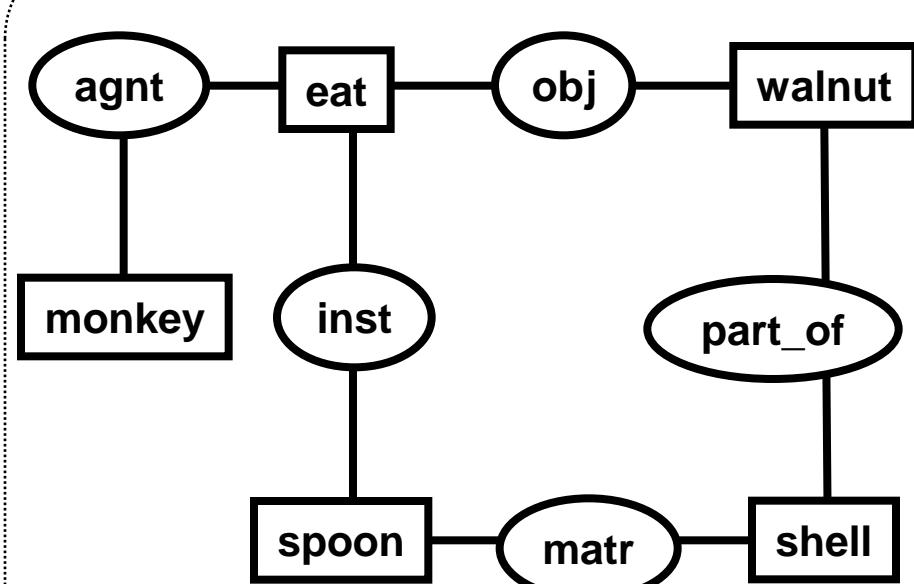
Upward drawing

Aesthetics

readability: the drawing should be easy to read, easy to understand, easy to remember, beautiful.



less readable



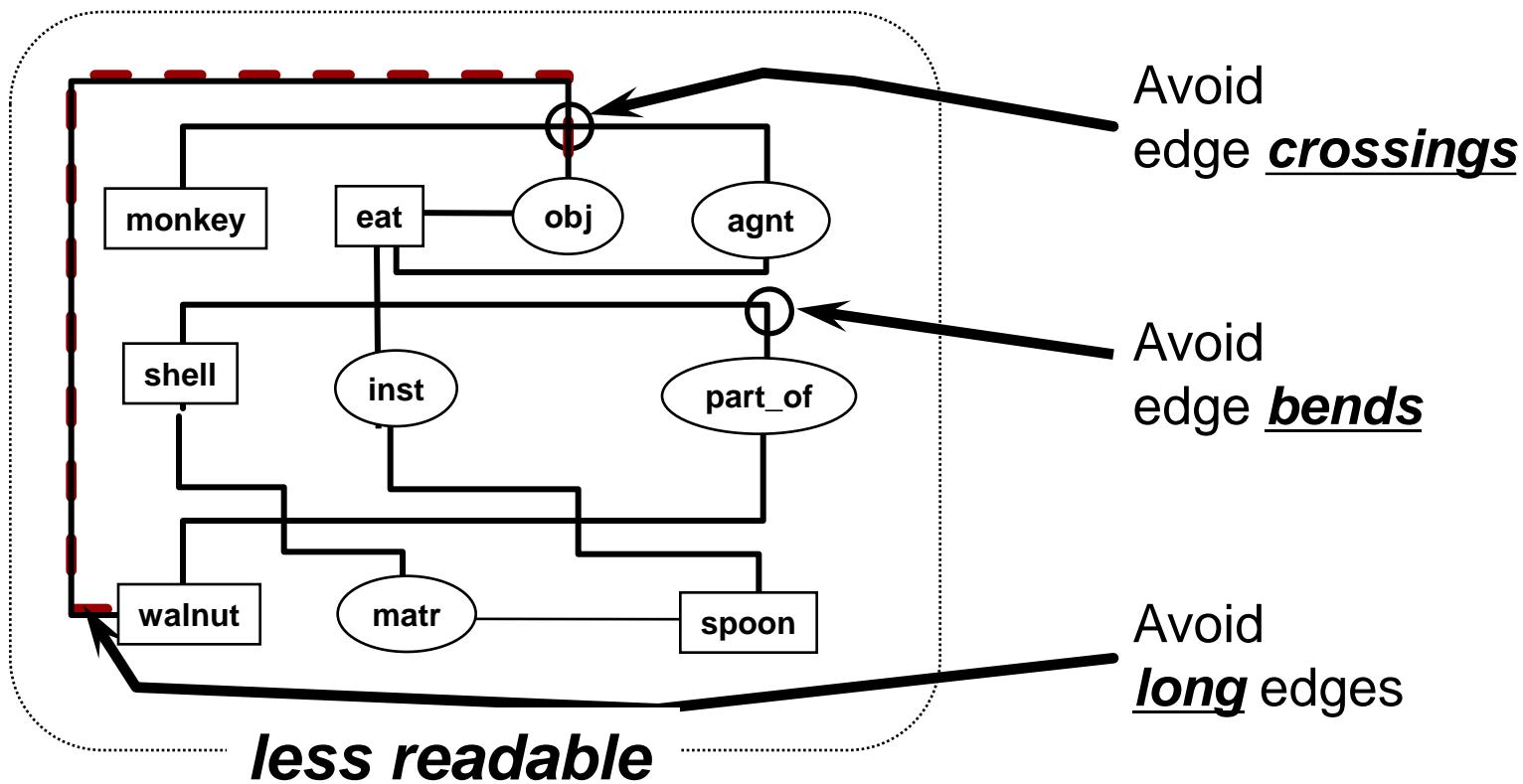
more readable

Aesthetics (quality metrics)

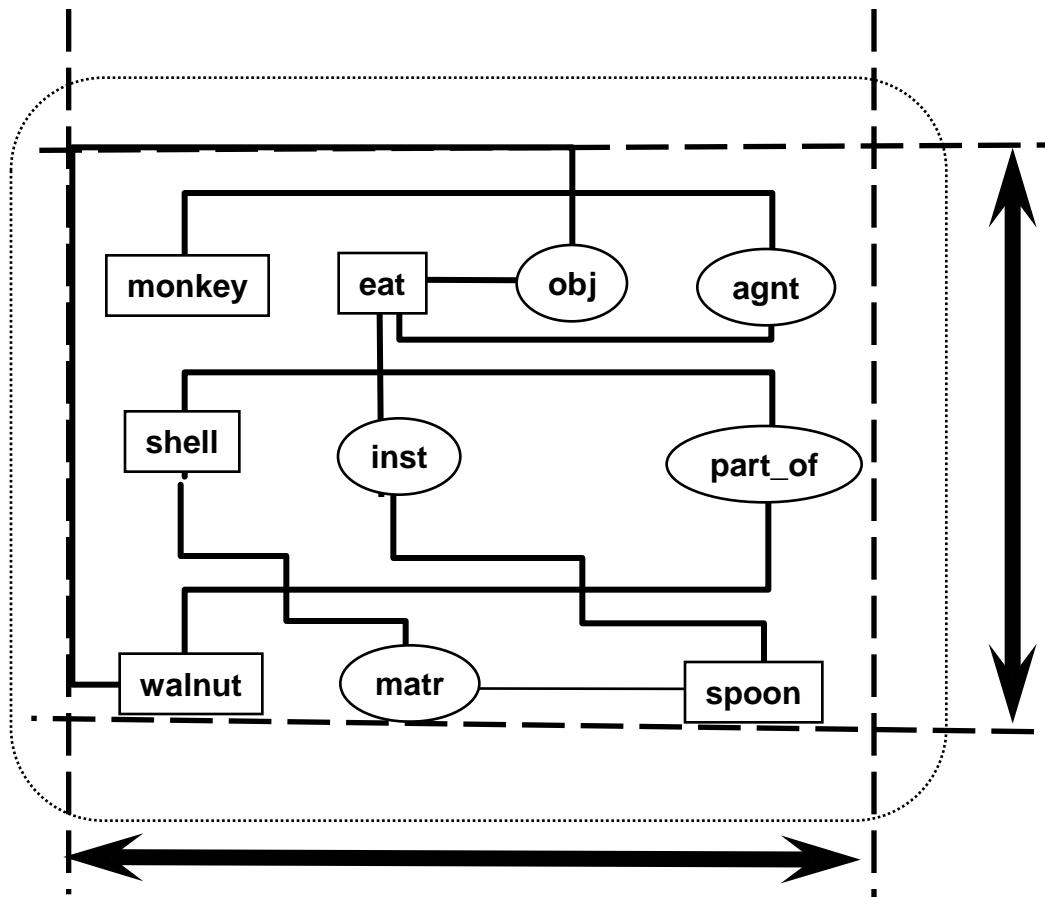
Readability is sometimes measured by aesthetic criteria

- **crossings**
- **area**
- **symmetry**
- **edge length**
 - **total edge length, maximum edge length, uniform edge length**
- **bends**
 - **total bends, maximum bends, uniform bends**
- **angular resolution**
- **aspect ratio**

Crossings and bends



Area and resolution



One should spread the nodes evenly over the page. This can be measured:

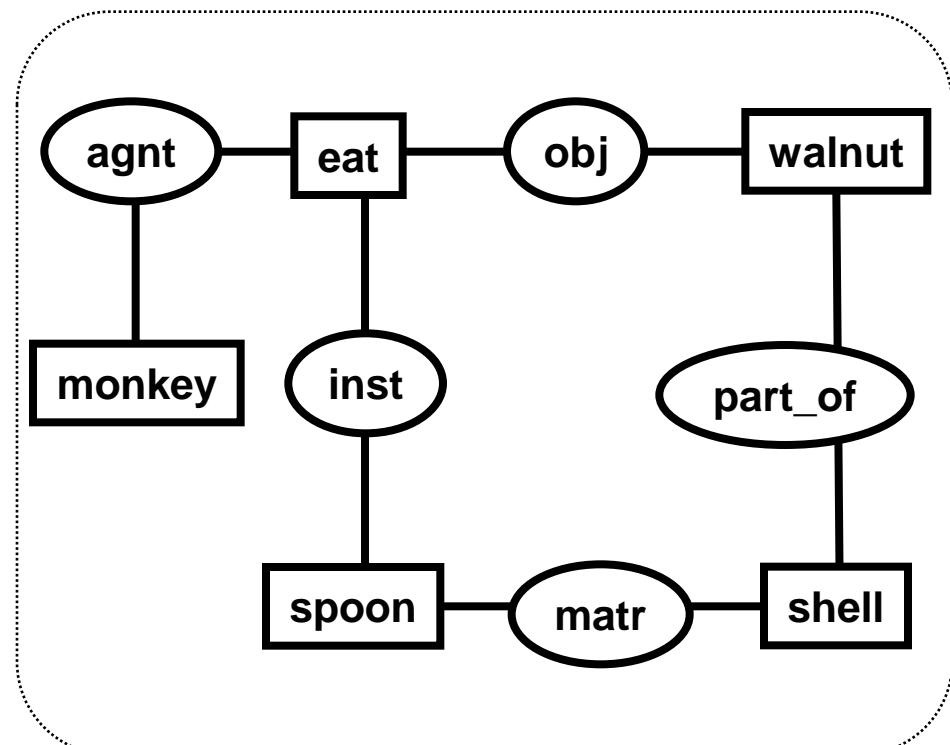
- minimise area (for fixed size nodes)
- or equivalently
- maximise resolution (for a fixed size screen).

Aesthetics (Quality Metrics)

There are many aesthetic criteria for good diagrams:

- minimum **edge crossings**,
- minimum **bends**,
- minimum **edge lengths**,
- maximum **resolution**,

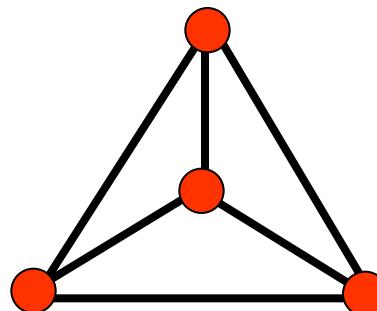
and **many more**.



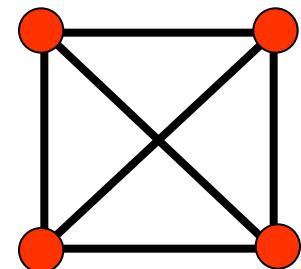
Optimisation Problem

- minimize crossings
 - minimize area
 - maximize symmetry
 - minimize total edge length
 - minimize number of bends
 - maximize angular resolution
- > NP-hard problem

Conflicts



Minimize
edge
crossings

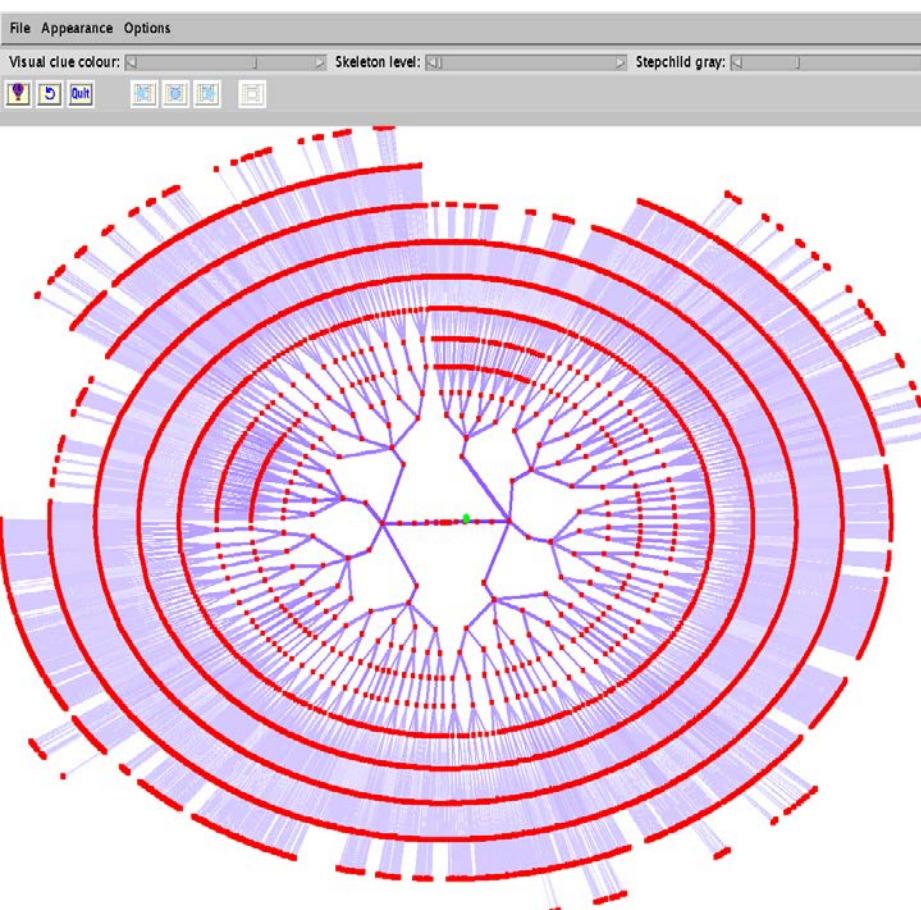


Maximize
symmetry

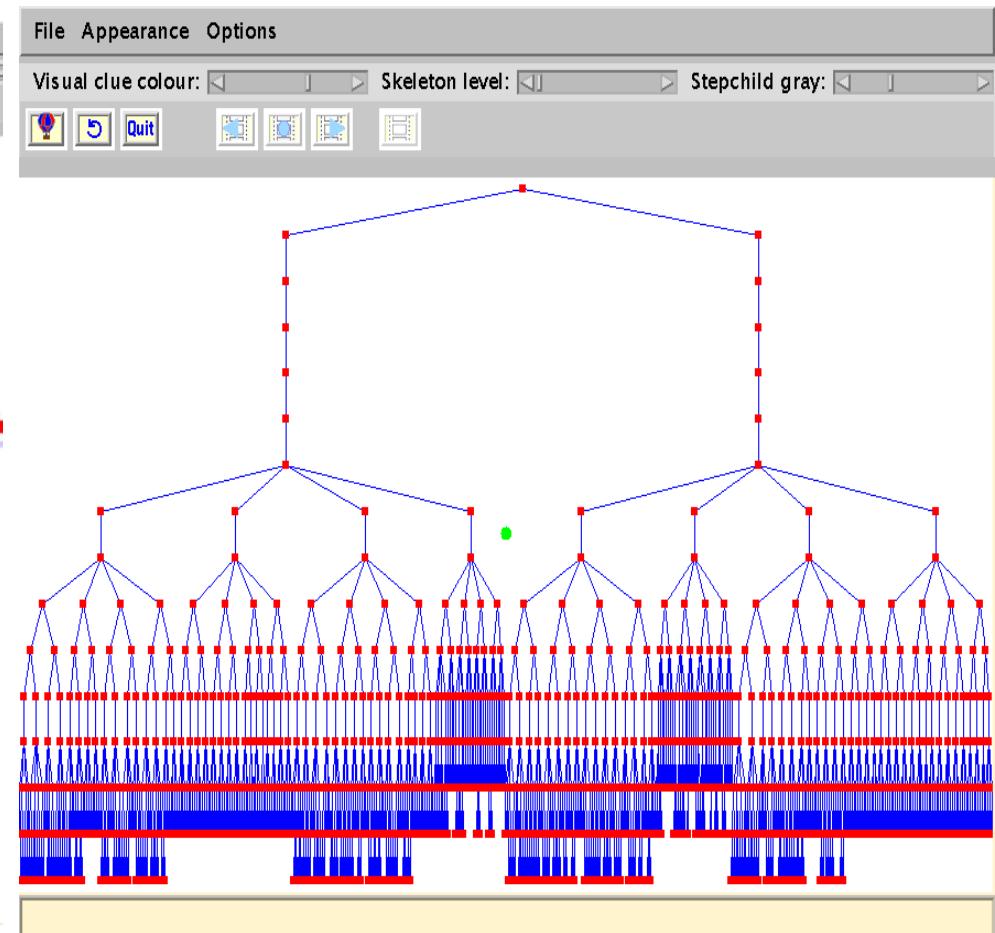
Graph Drawing Algorithms

- **Tree Drawing**
 - Tidy drawing (rooted binary trees)
 - Free tree drawing
- **Planar Graphs**
 - Straight-line drawing
 - Orthogonal (grid) Drawing
- **Undirected graphs:** Spring algorithm (force directed methods)
- **Directed graphs :** Sugiyama method (Layered/Hierarchical drawing)
- **Clustered graphs ...**

Tree visualisation

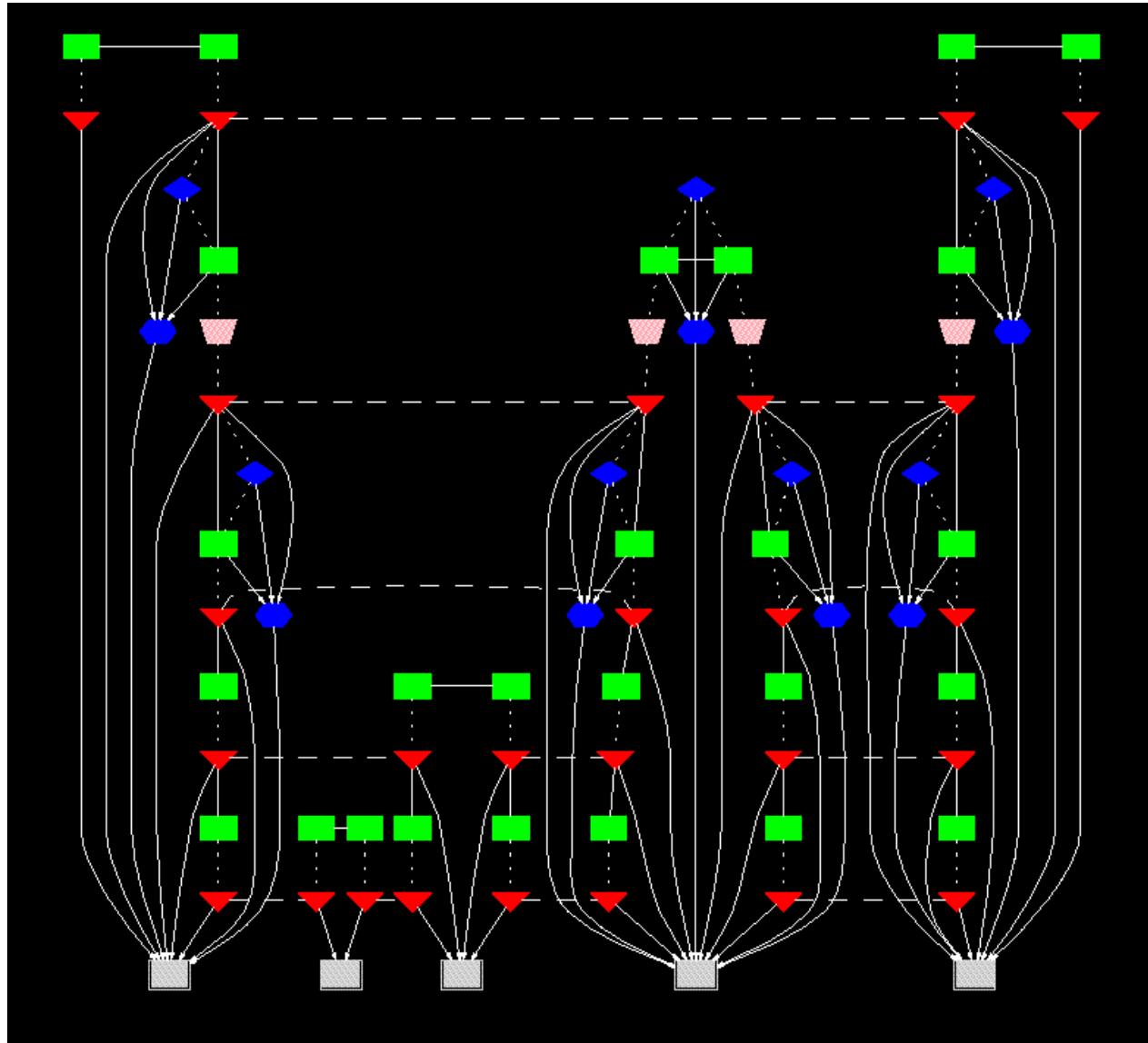


Radial layout of
29773 nodes

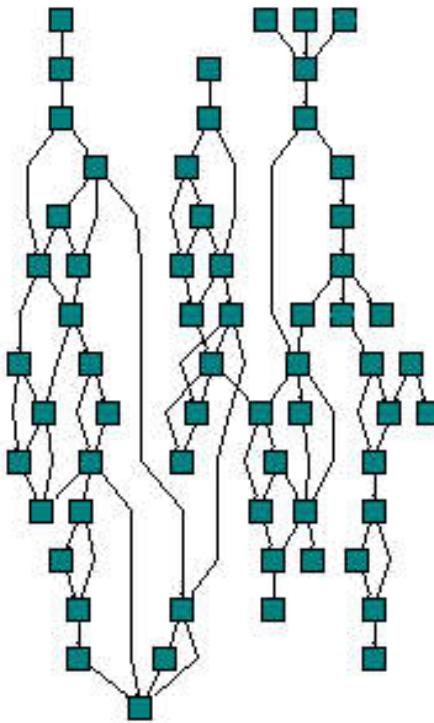


Reingold-Tilford layout of
3255 nodes

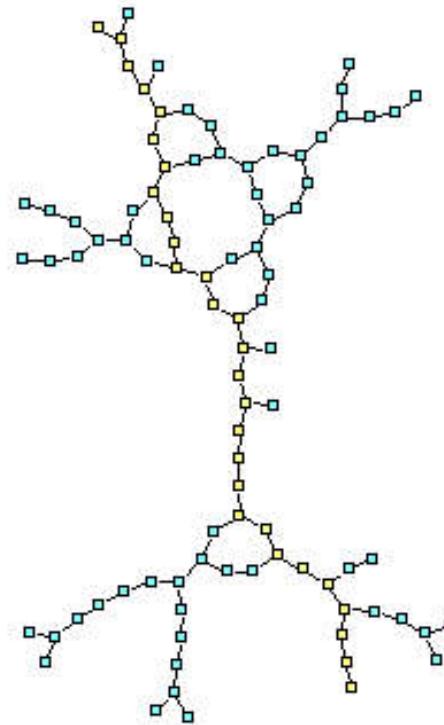
Graphviz, AT&T, USA



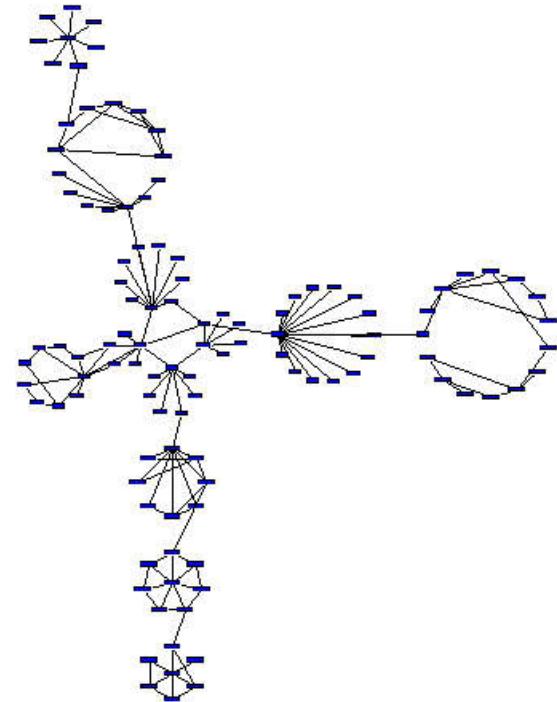
Tom Sawyer Software, USA



Hierarchical layout



Symmetric layout

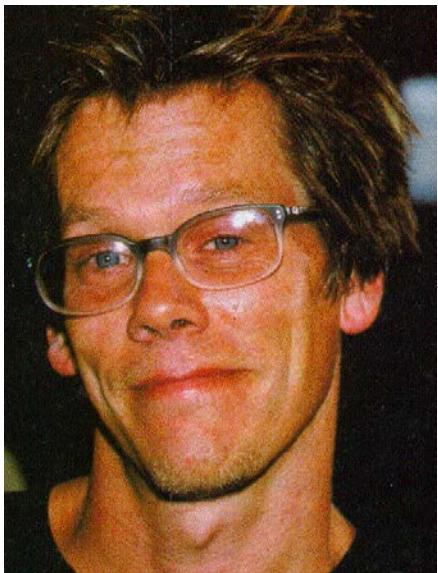


Circular layout

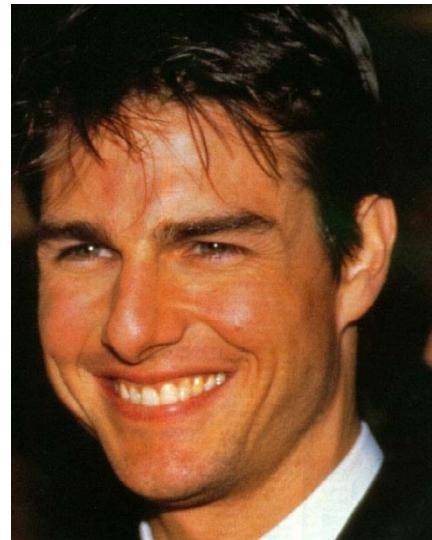
Applications: Network Visualization



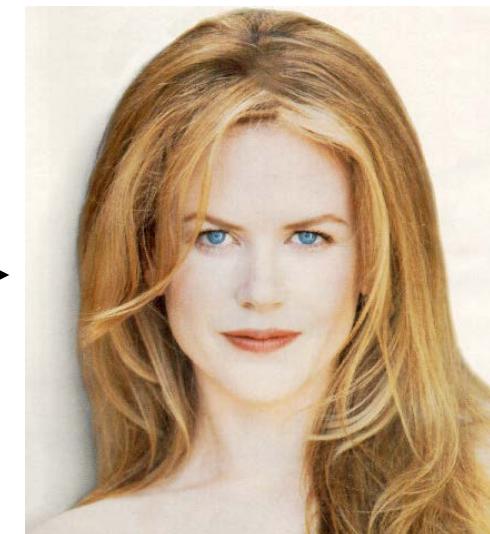
Social Network: Movie Actor Collaboration Network



A Few Good Man

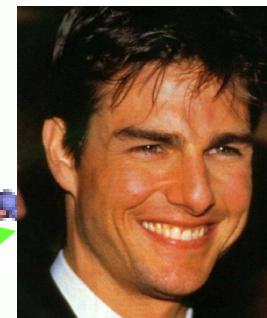
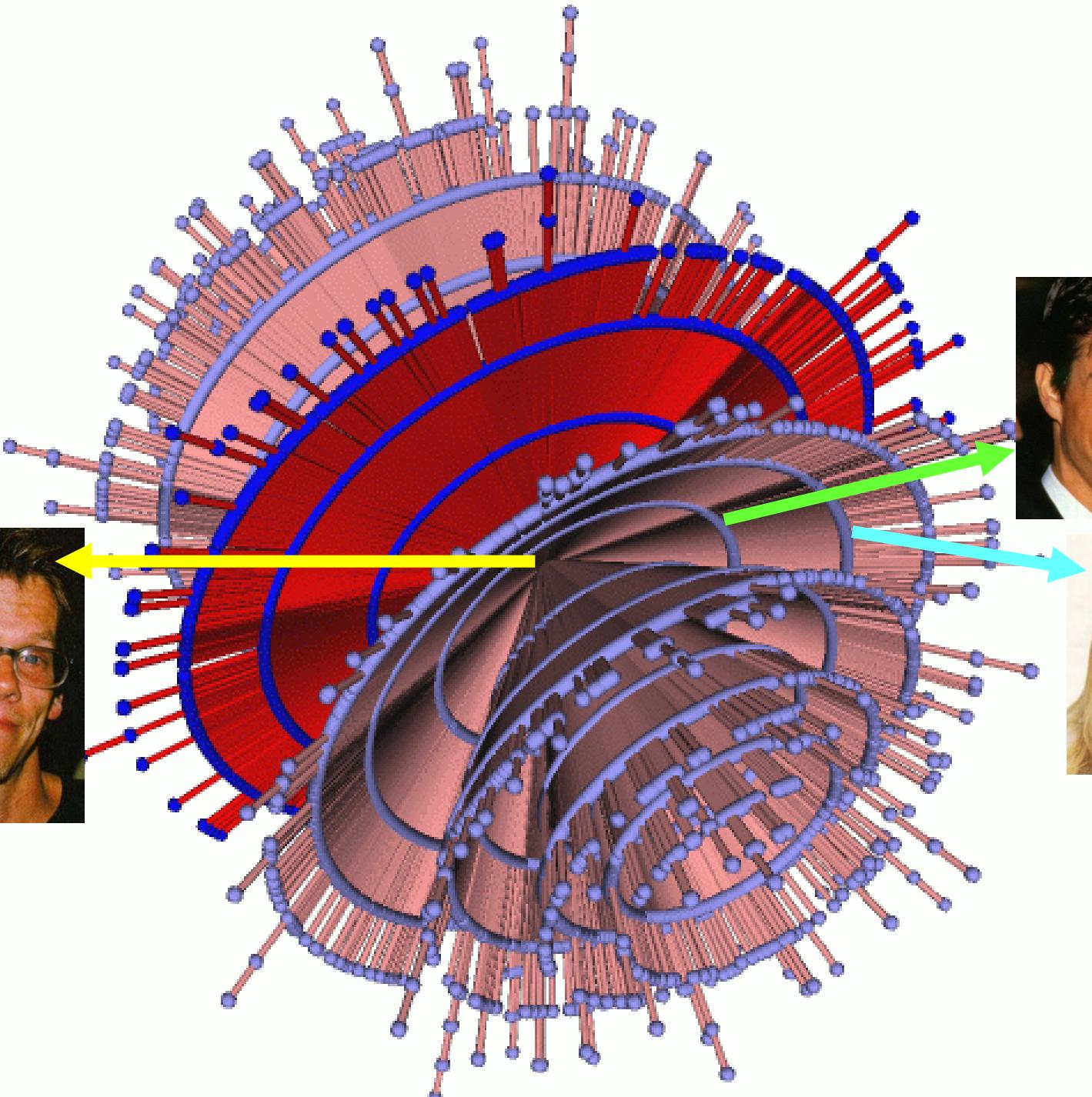


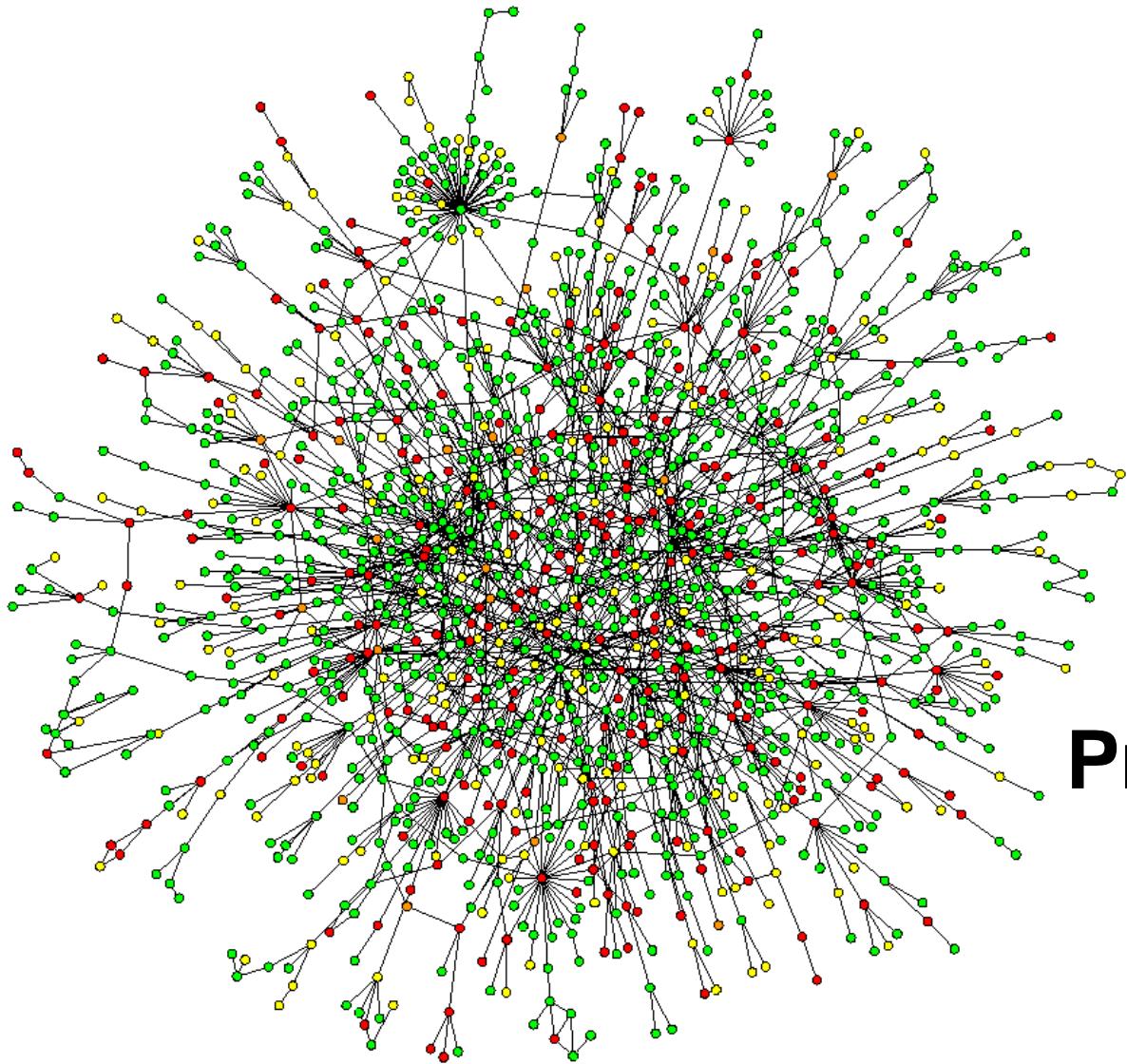
Days of Thunder (1990)
Far and Away (1992)
Eyes Wide Shut (1999)



Kevin Bacon Number 1

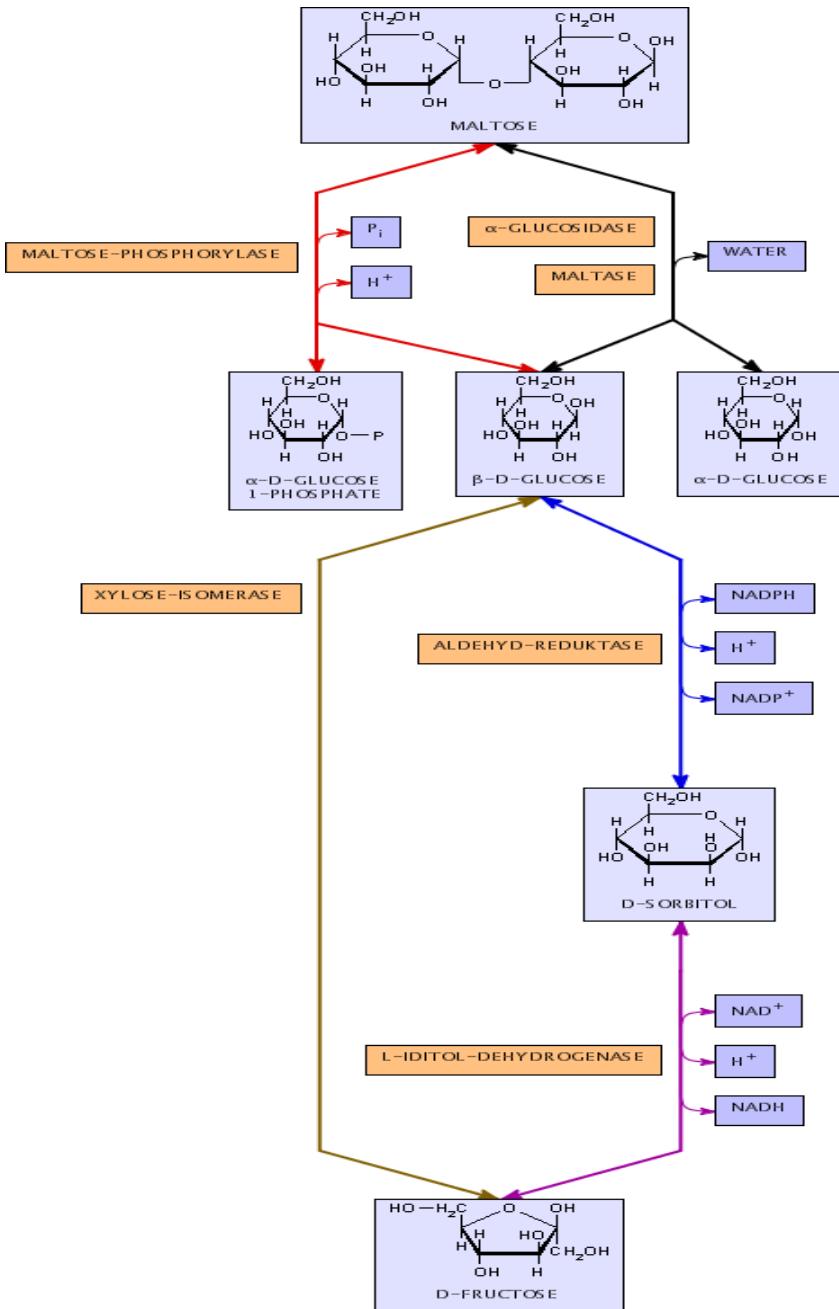
Kevin Bacon Number 2





Visualization of Protein Interaction Network

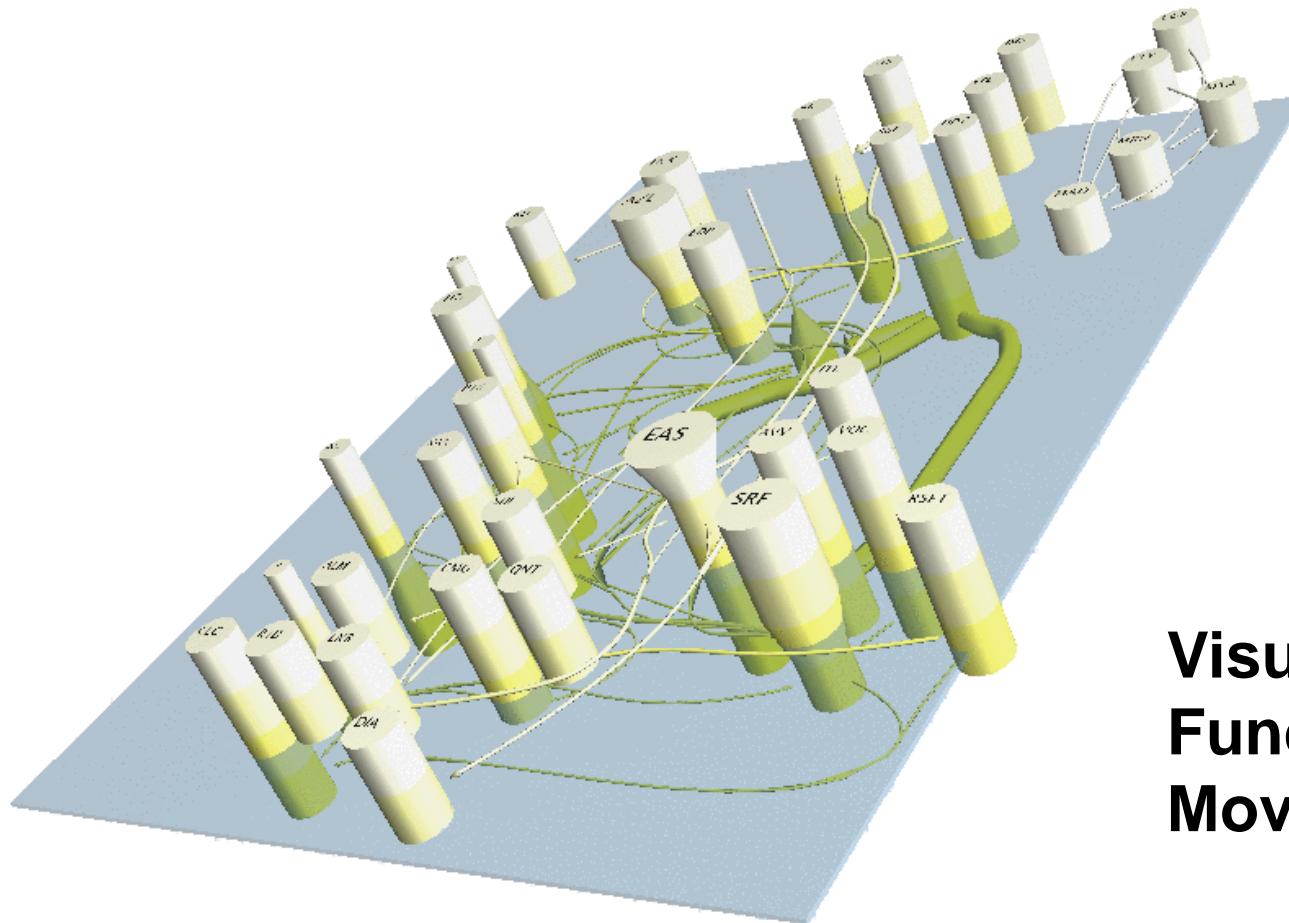
Map of protein-protein interactions. The colour of a node signifies the phenotypic effect of removing the corresponding protein (red, lethal; green, non-lethal; orange, slow growth; yellow, unknown). By **Hawoong Jeong**



Visualization of Biochemical Pathways

[Schreiber]

Visualisation of Finance Data



**Visualisation of
Fund Manager
Movement Graph**

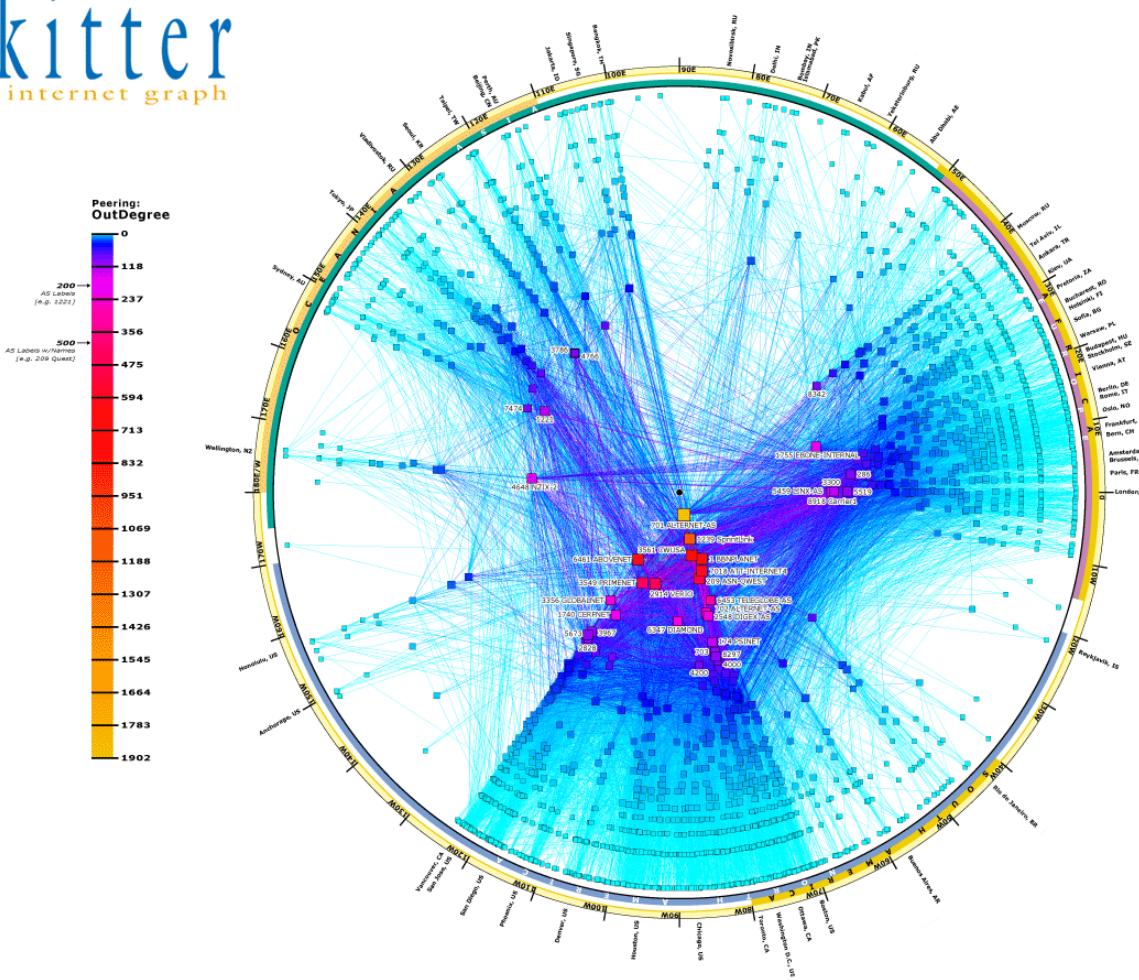
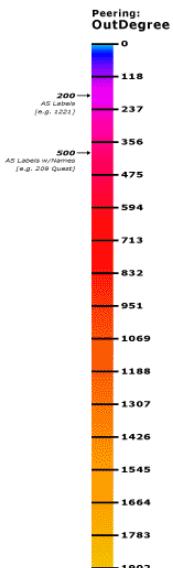
[Dwyer]

The AS Internet graph

A Macroscopic Visualisation of the Internet During October, 2000

skitter
AS internet graph

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cooperative association for internet data analysis O san diego supercomputer center O university of california, san diego
9500 gillman drive, mc0505 O la jolla, ca 92093-0505 O tel. 858-534-5000 O http://www.caida.org

CAIDA is a program of the University of California's San Diego Supercomputer Center (UCSD/SDSC)
skitter is supported by DARPA NGI Cooperative Agreement N66001-98-2-8922, NSF ANIR Grant NCR-9711092 and CAIDA members

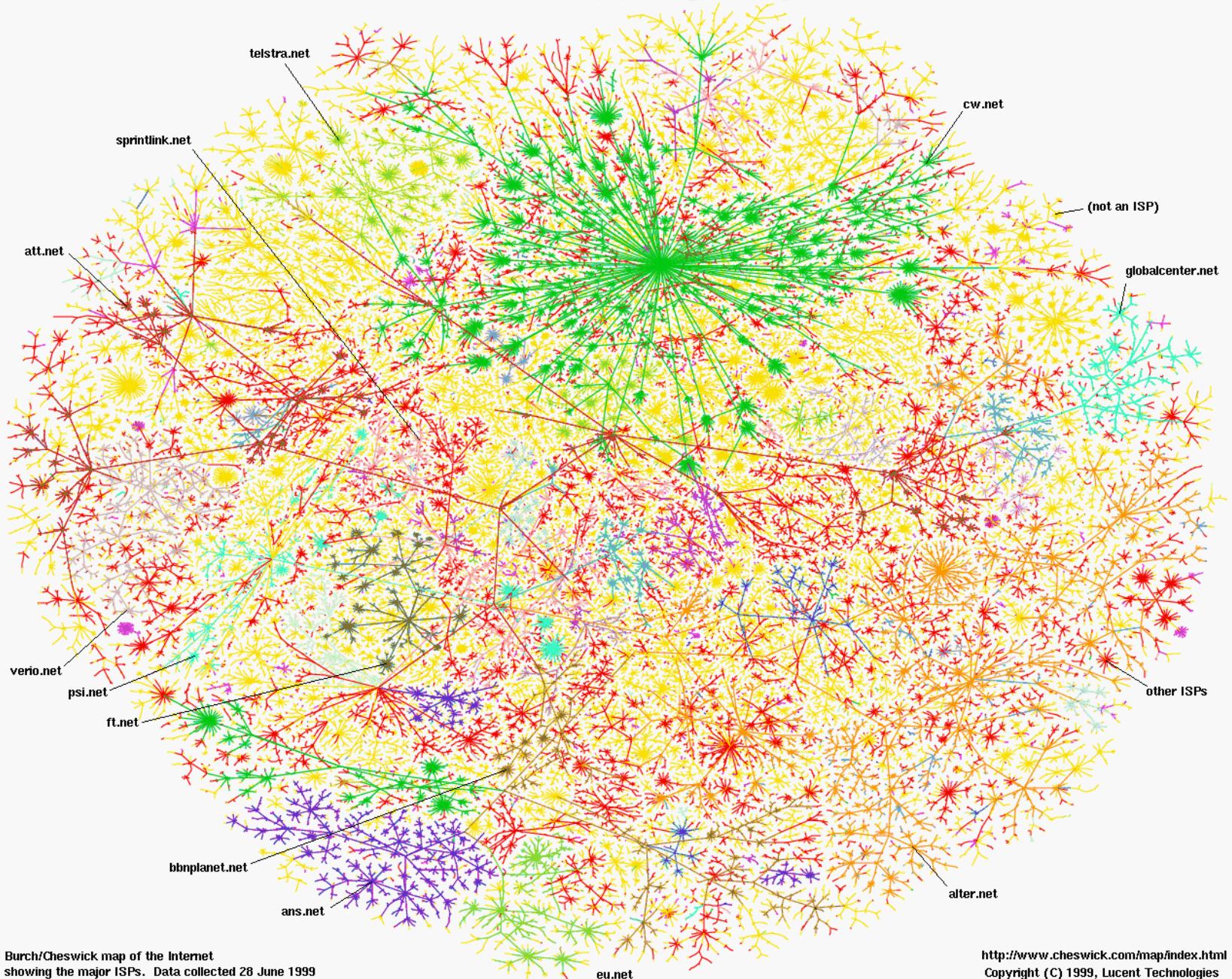
Research Challenges:

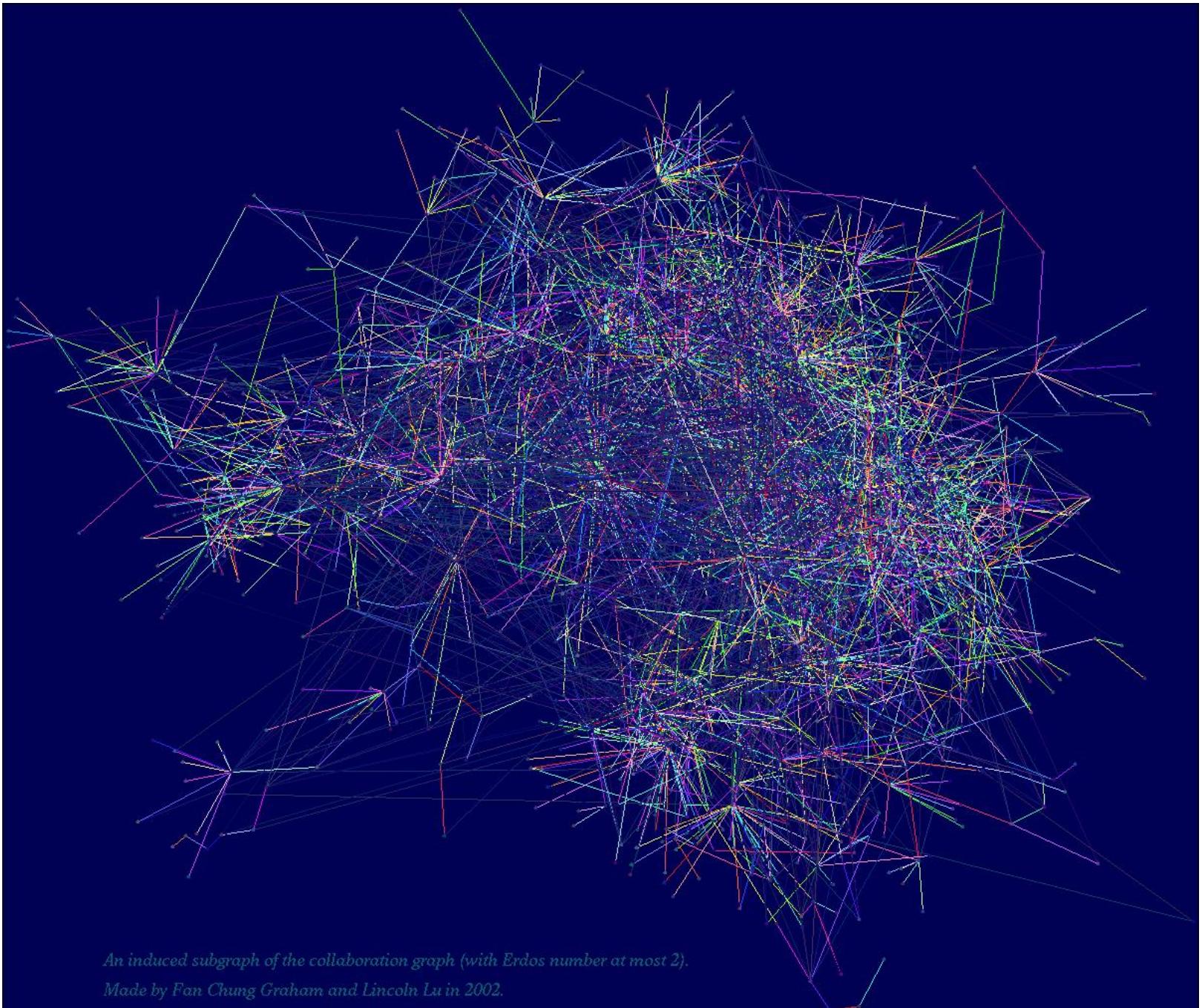
Big Complex Data

The Scale Problem

- Data sets are growing much faster than computing systems/tools to analyse them.
- Existing algorithms/methods do not scale well enough to be *efficient/effective* on the big data sets.

Internet Mapping Project





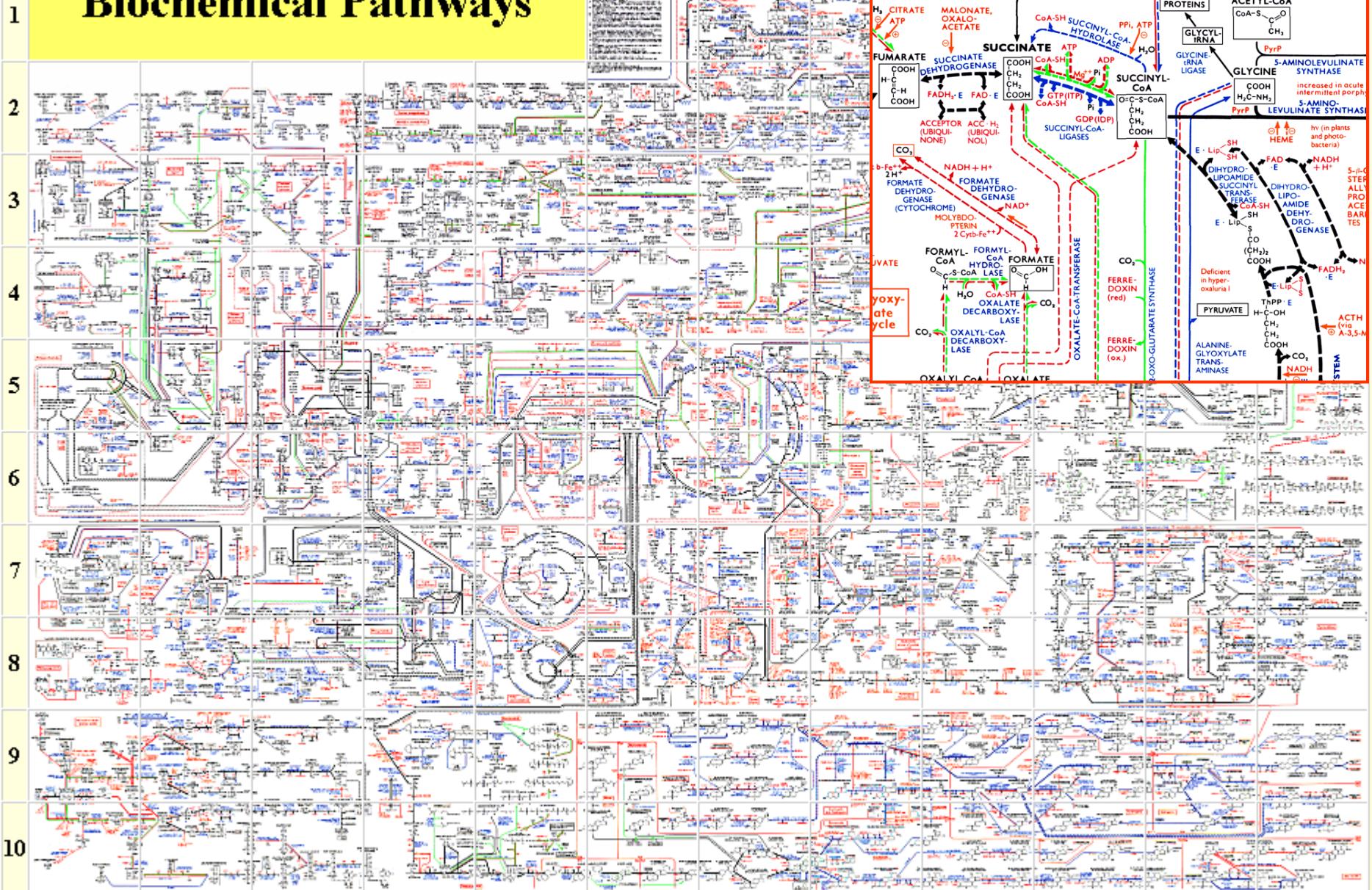
An induced subgraph of the collaboration graph (with Erdos number at most 2).

Made by Fan Chung Graham and Lincoln Lu in 2002.

Erdos network: mathematician collaboration network (co-authorship network)

A B C D E F G H I J K L

Biochemical Pathways



Visualisation Challenge

- 1. Computational complexity
 - *Efficiency*
 - Runtime
 - We need more efficient algorithms
- 2. Visual complexity
 - *Effectiveness*
 - Readability
 - We need better untangling
- 3. Domain complexity

Homework: Tutorial 1

Assumed Knowledge:

- Big O notation: $O(n)$ time etc
- Divide and Conquer Algorithm
- Trees: definition, terminology
- Tree Traversal: Inorder traversal etc