Interactive visual analysis

insights into software comprehension

Roberto Therón

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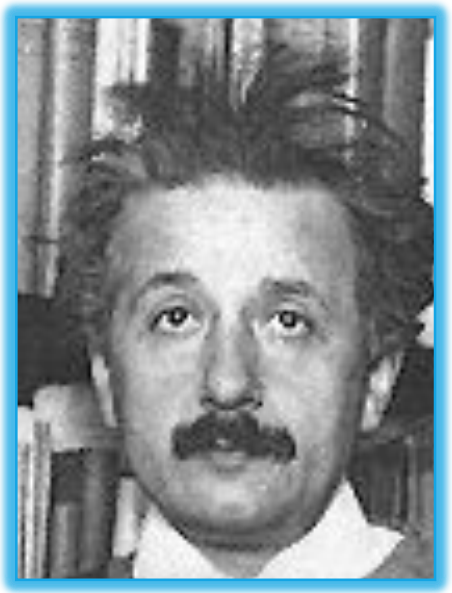
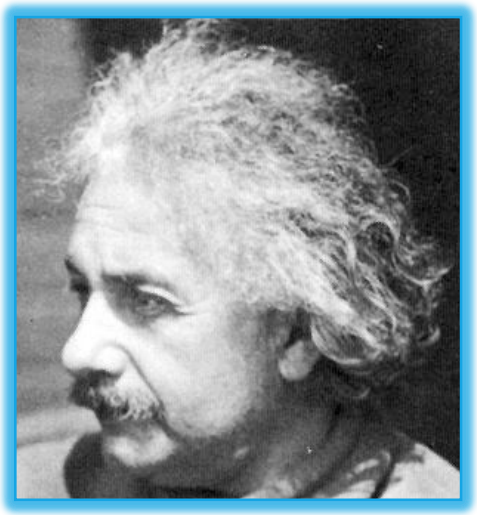
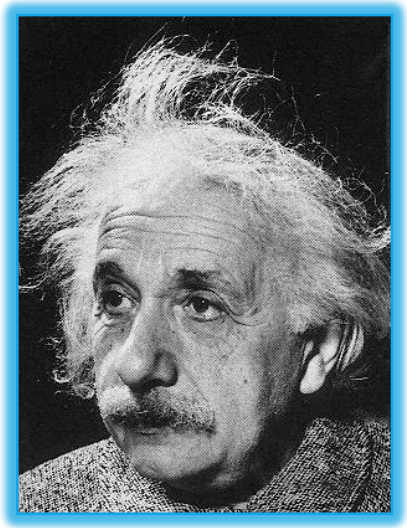
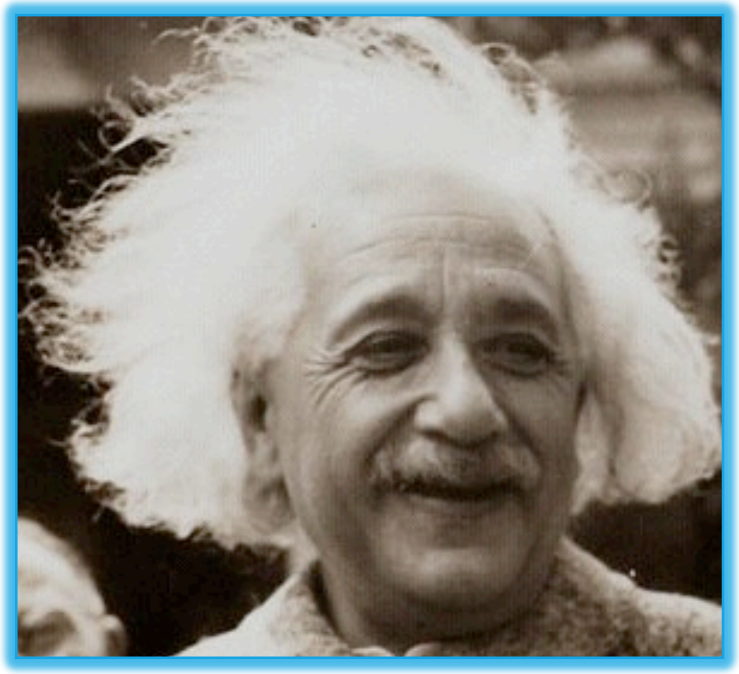
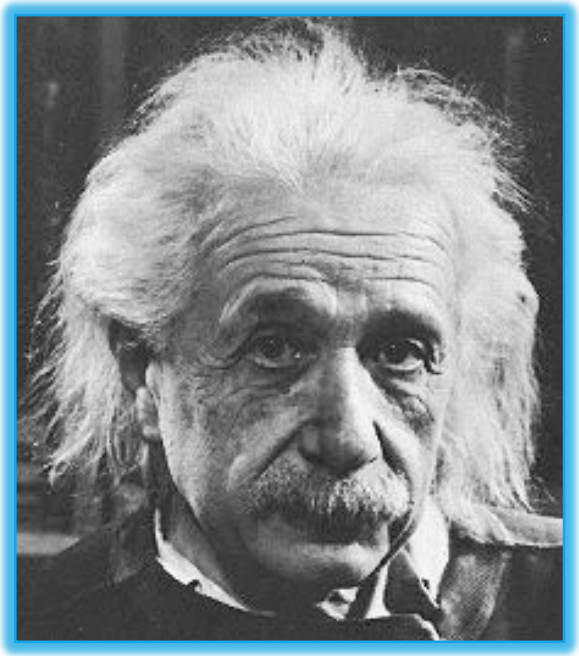
GIR MIDA information visualization and visual analytics

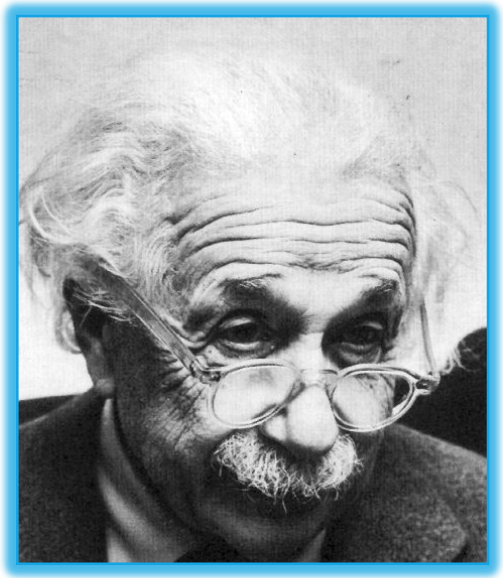


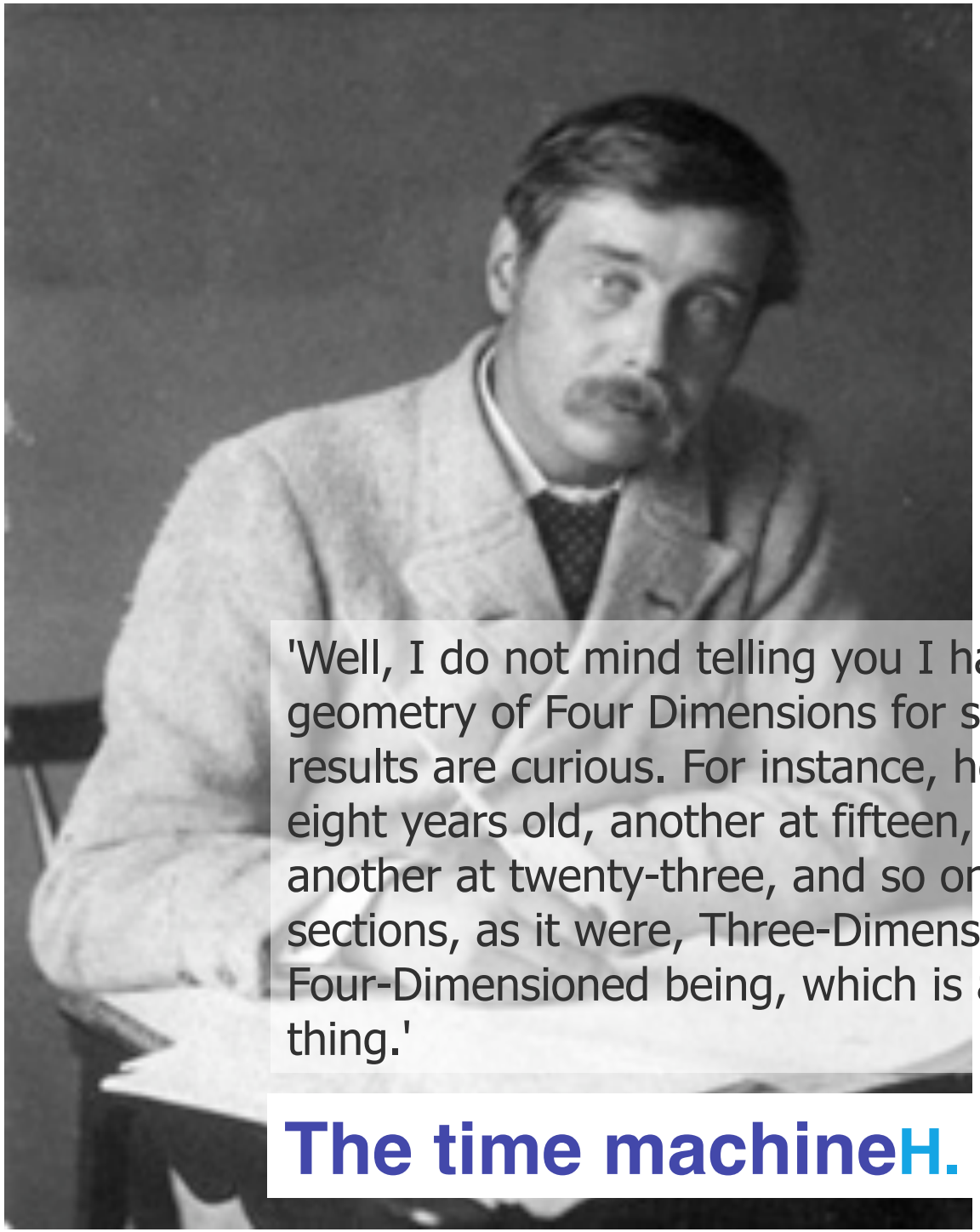












'Well, I do not mind telling you I have been at work upon this geometry of Four Dimensions for some time. Some of my results are curious. For instance, here is a portrait of a man at eight years old, another at fifteen, another at seventeen, another at twenty-three, and so on. All these are evidently sections, as it were, Three-Dimensional representations of his Four-Dimensioned being, which is a fixed and unalterable thing.'

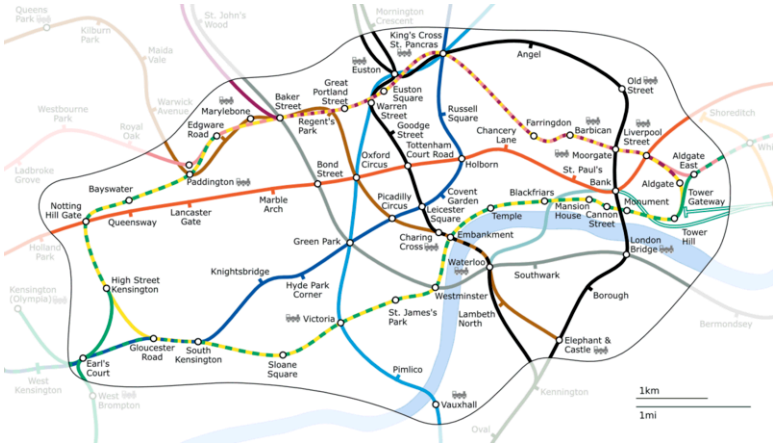
The time machine **H. G. Wells** **1895**

His

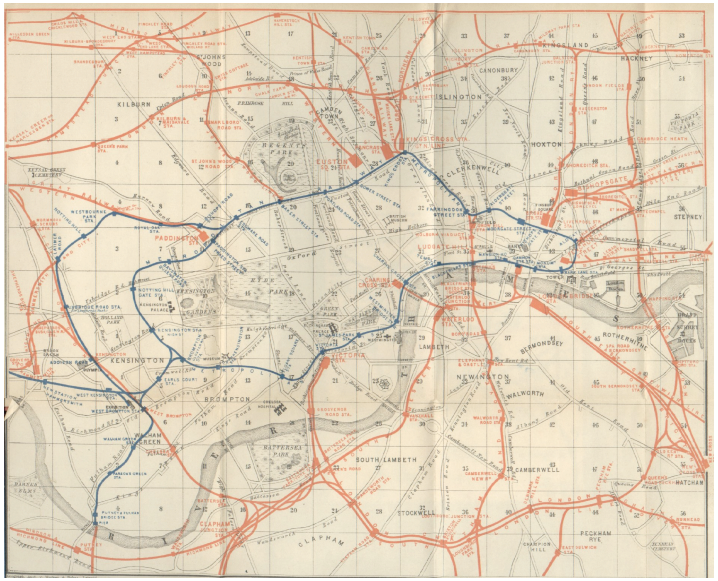
Redesign of the London underground map (1933). Harry Beck


King's Cross St. Pancras
Euston
Angel
Great Portland Street
Euston Square
Old Street
Baker Street
Warren Street
Russell Square
Marylebone
Regent's Park
Goodge Street
Farringdon
Barbican
Liverpool Street
Edgware Road
Chancery Lane
Tottenham Court Road
Moorgate
Aldgate East
Oxford Circus
Holborn
St. Paul's
Bond Street
Bank
Aldgate
Tower Gateway
Paddington
Bayswater
Blackfriars
Monument
Picadilly Circus
Covent Garden
Marble Arch
Mansion House
Cannon Street
Notting Hill Gate
Lancaster Gate
Leicester Square
Temple
Queensway
Tower Hill
Charing Cross
Embankment
Green Park
London Bridge
Waterloo
Knightsbridge
High Street Kensington
Southwark
Hyde Park Corner
Westminster
Borough
St. James's Park
Victoria
Lambeth North
Elephant & Castle
Gloucester Road
South Kensington
Earl's Court
Sloane Square
Pimlico
Vauxhall
1km
1mi

History: work in progress



The problem



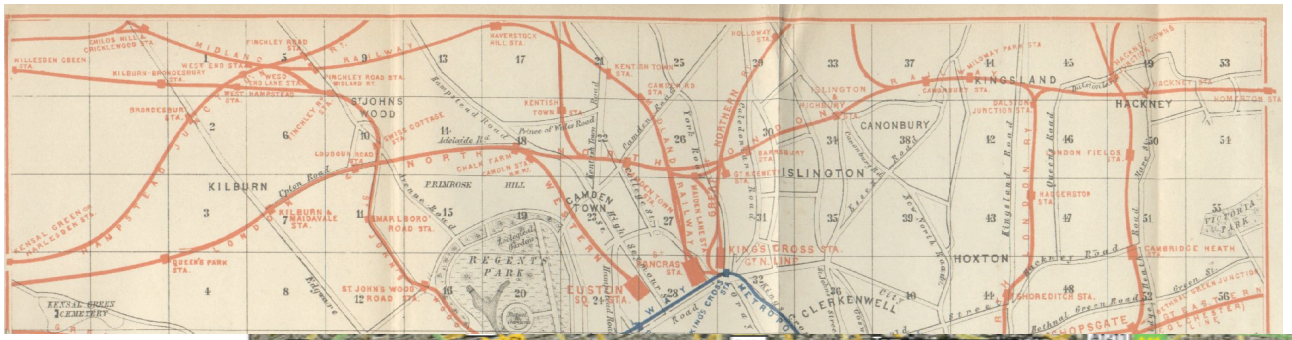
data transference

visualization

The big problem

data transference
interactive
visualization


Where do we go?
DETOUR



Avoid highways — Get reverse directions

From: Victoria Station
Westminster, London SW1V, UK
Via A202/Camberwell New Rd — Edit

Drive: 5.3 mi – about 19 mins

1.	Head **west** toward **A3213/Belgrave Rd**	226 ft
2.	Turn **right** at **A3213/Belgrave Rd**	282 ft
3.	Turn **left** at **A3214/Buckingham Palace Rd**	0.1 mi
4.	Turn **left** at **St George's Dr**	0.2 mi
5.	Turn **left** at **Eccleston Square**	0.1 mi
6.	Turn **right** at **A3213/Belgrave Rd** Continue to follow A3213	0.4 mi
7.	Turn **left** at **A3213/Bessborough St** Continue to follow A3213	0.2 mi
8.	Turn **right** at **A202/Vauxhall Bridge Rd**	0.4 mi
9.	Slight **left** at **A3036/Wandsworth Rd**	20 ft
10.	**A3036/Wandsworth Rd** turns slightly **right** and becomes **A202/Kennington Ln**	0.2 mi
11.	Turn **right** at **A202/Durham St**	0.1 mi
12.	Turn **left** at **A202/Harleyford Rd** Continue to follow A202	1.4 mi
13.	Turn **right** at **A215/Camberwell Green** Continue to follow A215	1.7 mi
14.	Turn **left** at **A2214/Half Moon Ln**	0.2 mi
15.	Turn **right** at **Burbage Rd**	0.3 mi

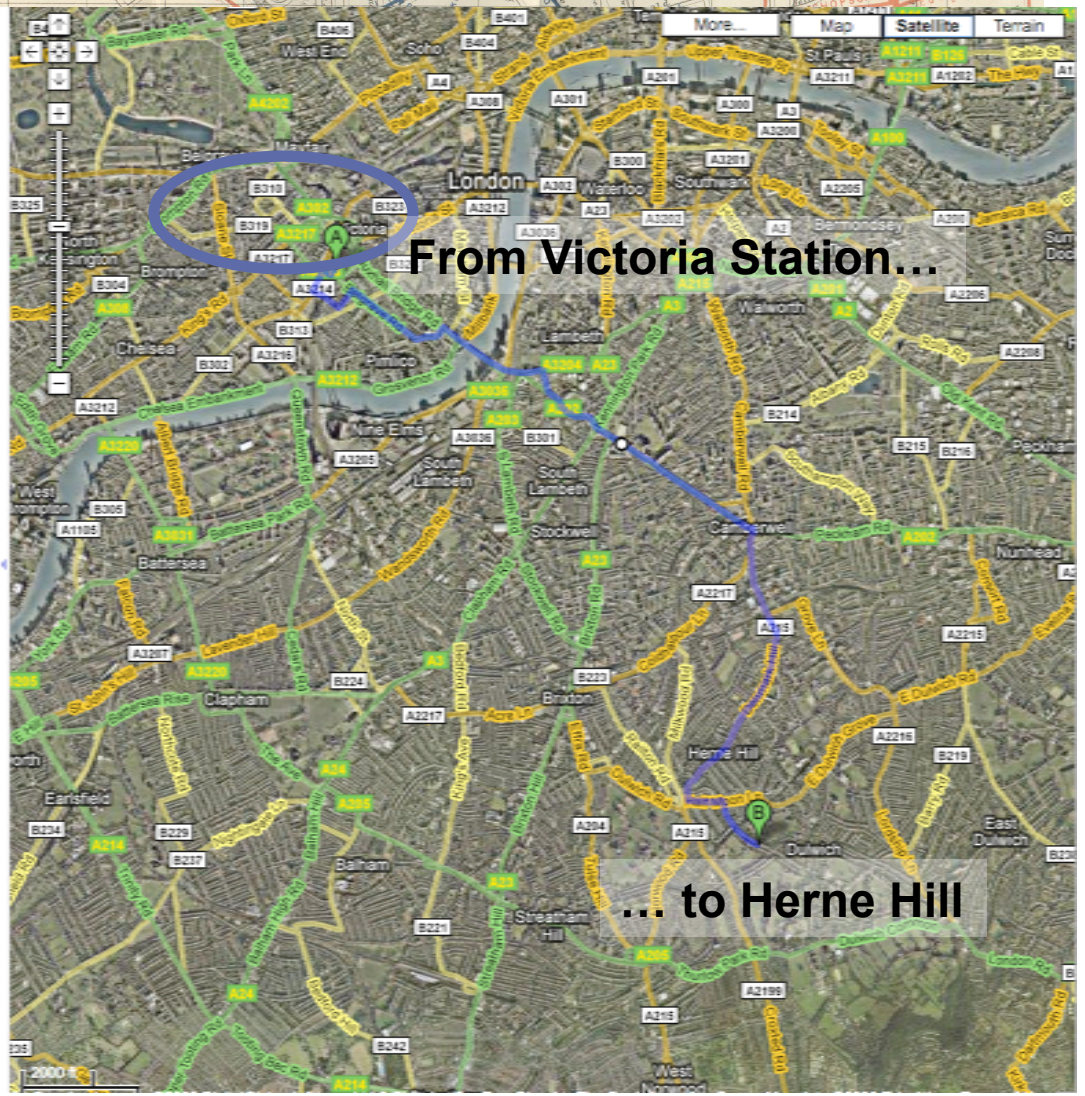
To: Burbage Rd
Southwark, London SE24, UK — Edit

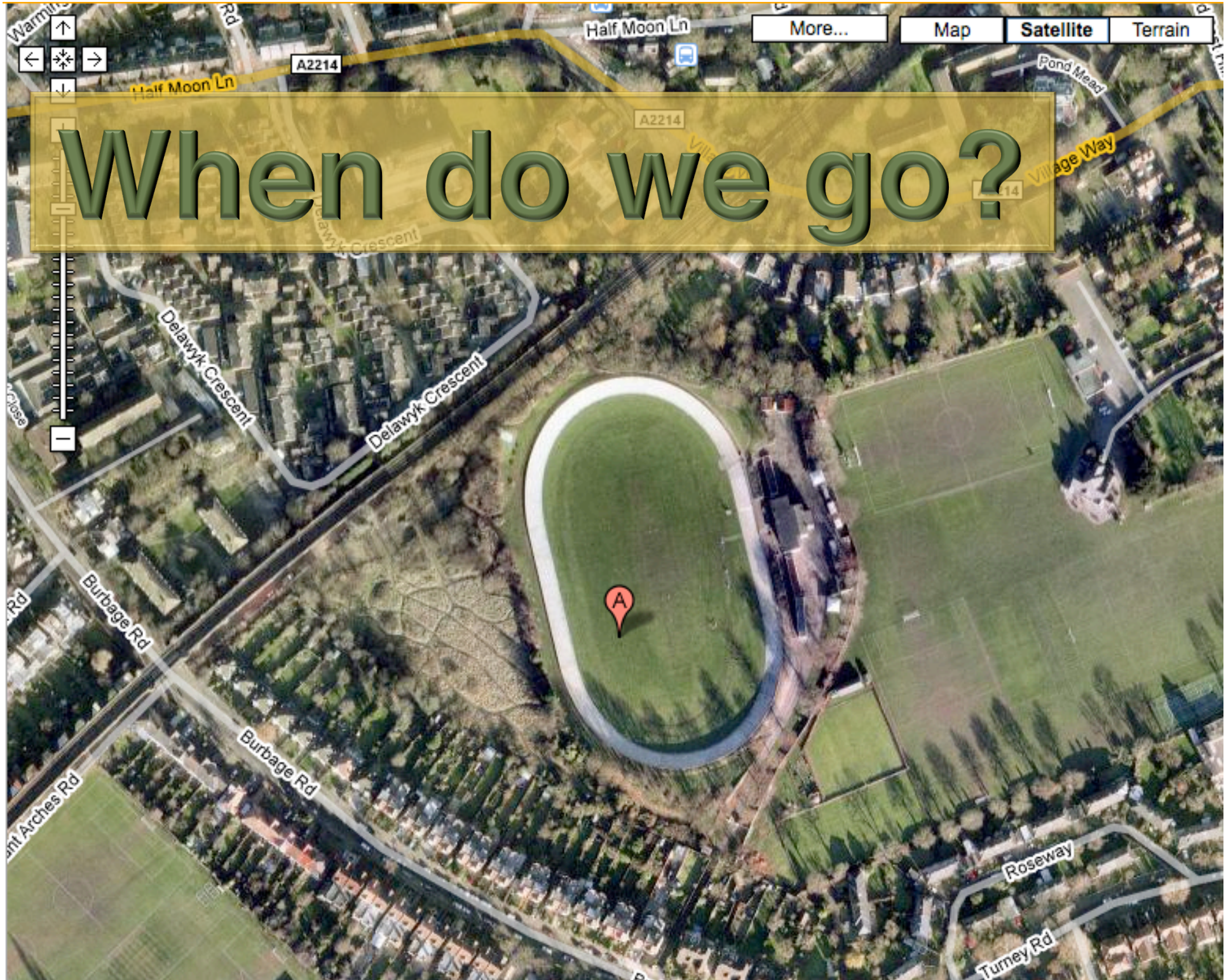
km | miles

Add destination ...

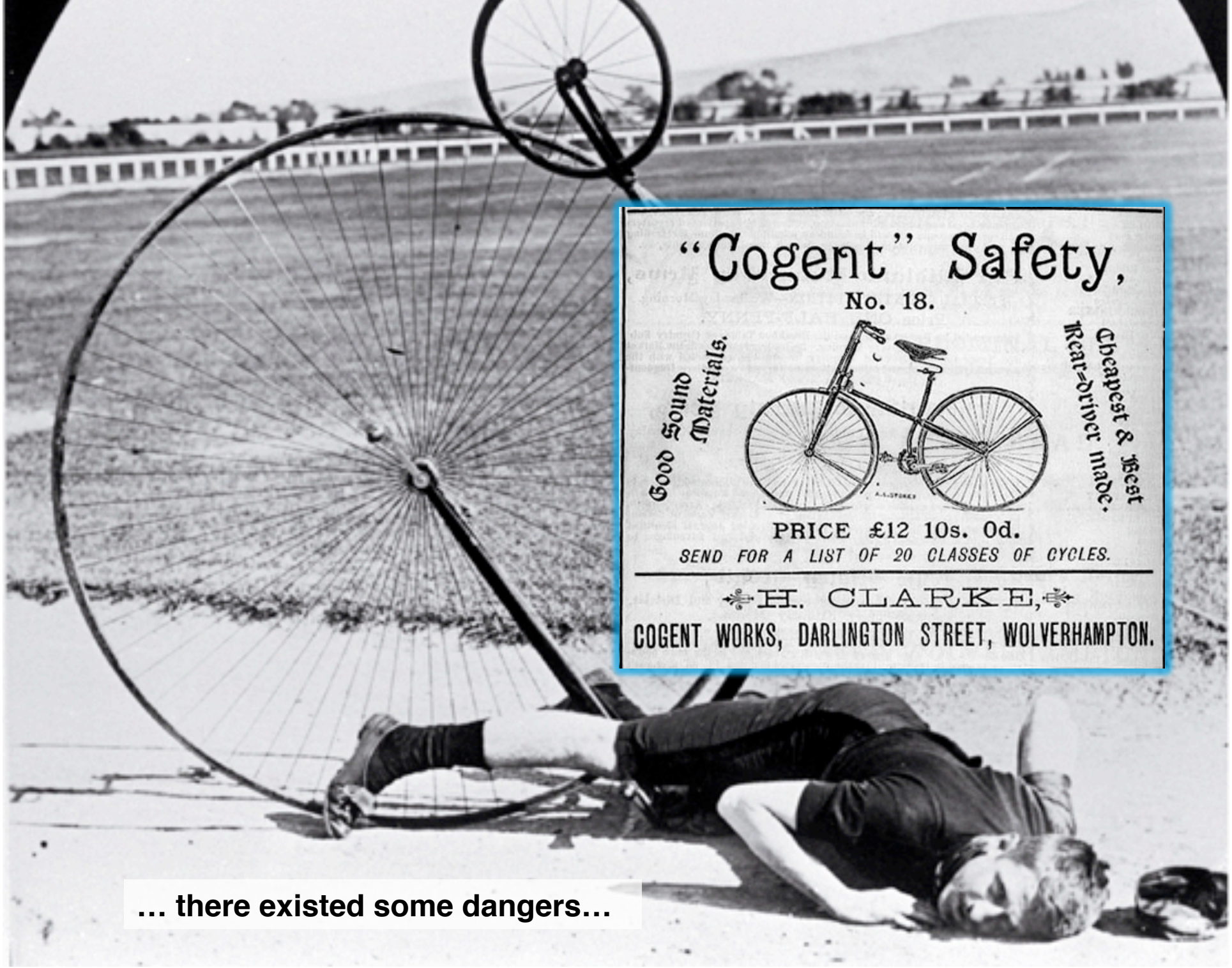
These directions are for planning purposes only. You may find that construction projects, traffic, or other events may cause road conditions to differ from the map results.

Map data ©2008 Tele Atlas




When do we go?
More...
Map
Satellite
Terrain
Half Moon Ln
A2214
Pond Mead
Village Way
Delawyk Crescent
Burbage Rd
Roseway
Turney Rd

7th September 1932: A group of elderly cycling enthusiasts on their Victorian-style penny farthings, training for the 'ordinary' race at Herne Hill track… Funny!, but…



… there existed some dangers…

PENNY FARTHING

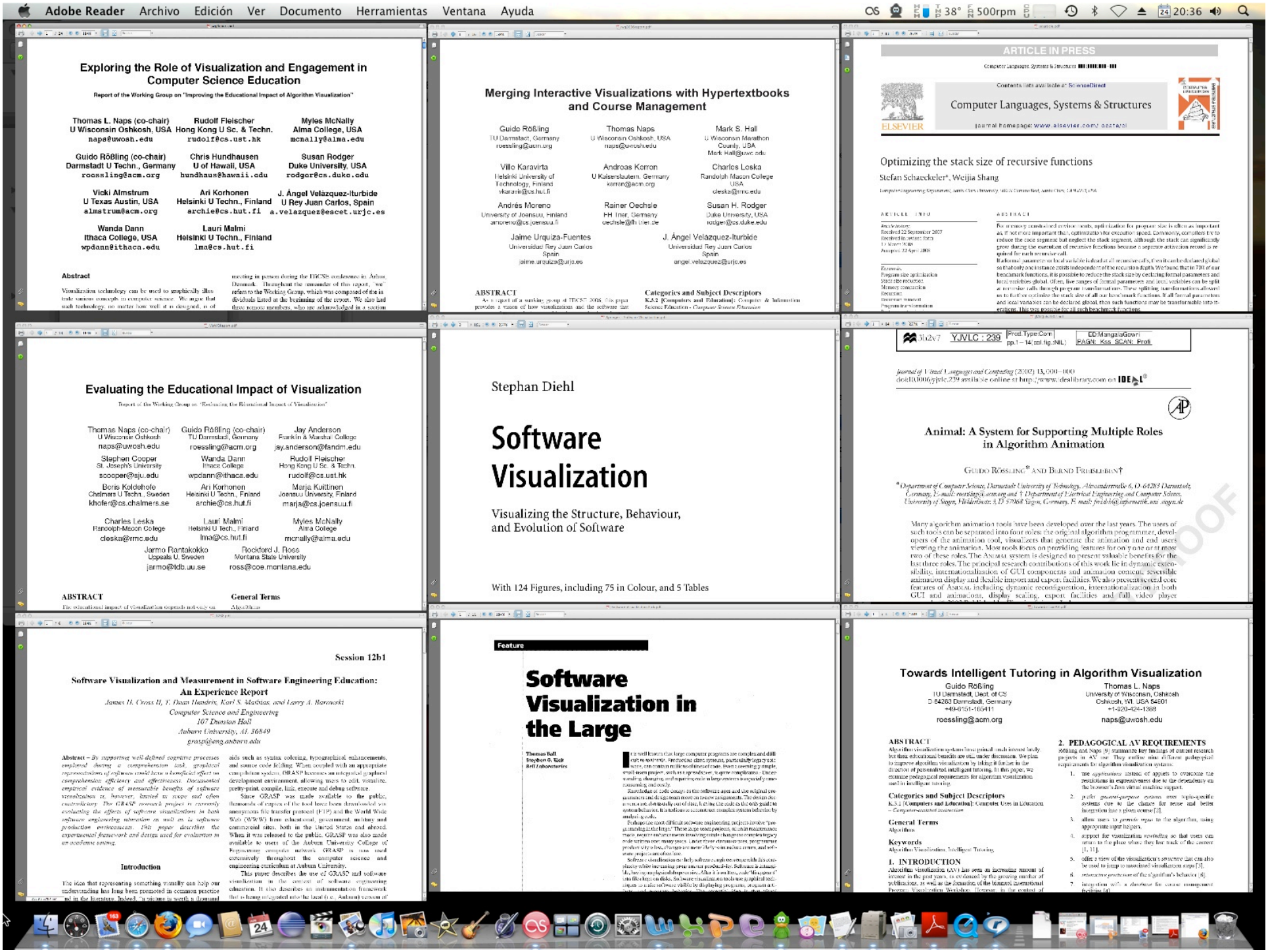
Vs.

SAFETY BICYCLE

For Dunlop and the other protagonists of the air tire, originally the air tire meant a solution to the vibration problem. However, the group of sporting cyclists riding their high-wheelers did not accept that as a problem at all. Vibration presented a problem only to the (potential) users of the low-wheeled bicycle. Three important social groups were therefore opposed to the air tire. But then the air tire was mounted on a racing bicycle. When, for the first time, the tire was used at the racing track, its entry was hailed with derisive laughter. This was, however, quickly silenced by the high speed achieved, and there was only astonishment left when it outpaced all rivals (Croon 1939). Soon handicappers had to give racing cyclists on high-wheelers a considerable start if riders on air-tire low-wheelers were entered. After a short period no racer of any pretensions troubled to compete on anything else (Grew 1921).

The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other

Trevor J. Pinch and Wiebe E. Bijker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Exploring the Role of Visualization and Engagement in Computer Science Education
Report of the Working Group on "Improving the Educational Impact of Algorithm Visualization"
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Abstract
Merging Interactive Visualizations with Hypertextbooks and Course Management
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ABSTRACT
Categories and Subject Descriptors
ARTICLE IN PRESS
Computer Languages, Systems & Structures
ELSEVIER
Optimizing the stack size of recursive functions
Stefan Schaeckeler*, Weijia Shang
Evaluating the Educational Impact of Visualization
Report of the Working Group on "Evaluating the Educational Impact of Visualization"
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ABSTRACT
General Terms
Stephan Diehl
Software Visualization
Visualizing the Structure, Behaviour, and Evolution of Software
With 124 Figures, including 75 in Colour, and 5 Tables
YJVLC : 239
Animal: A System for Supporting Multiple Roles in Algorithm Animation
Guido Rößling* and Bernd Freisleben†
Session 12b1
Software Visualization and Measurement in Software Engineering Education: An Experience Report
Introduction
Feature
Software Visualization in the Large
Thomas Ball Stephen G. Eick Bell Laboratories
Towards Intelligent Tutoring in Algorithm Visualization
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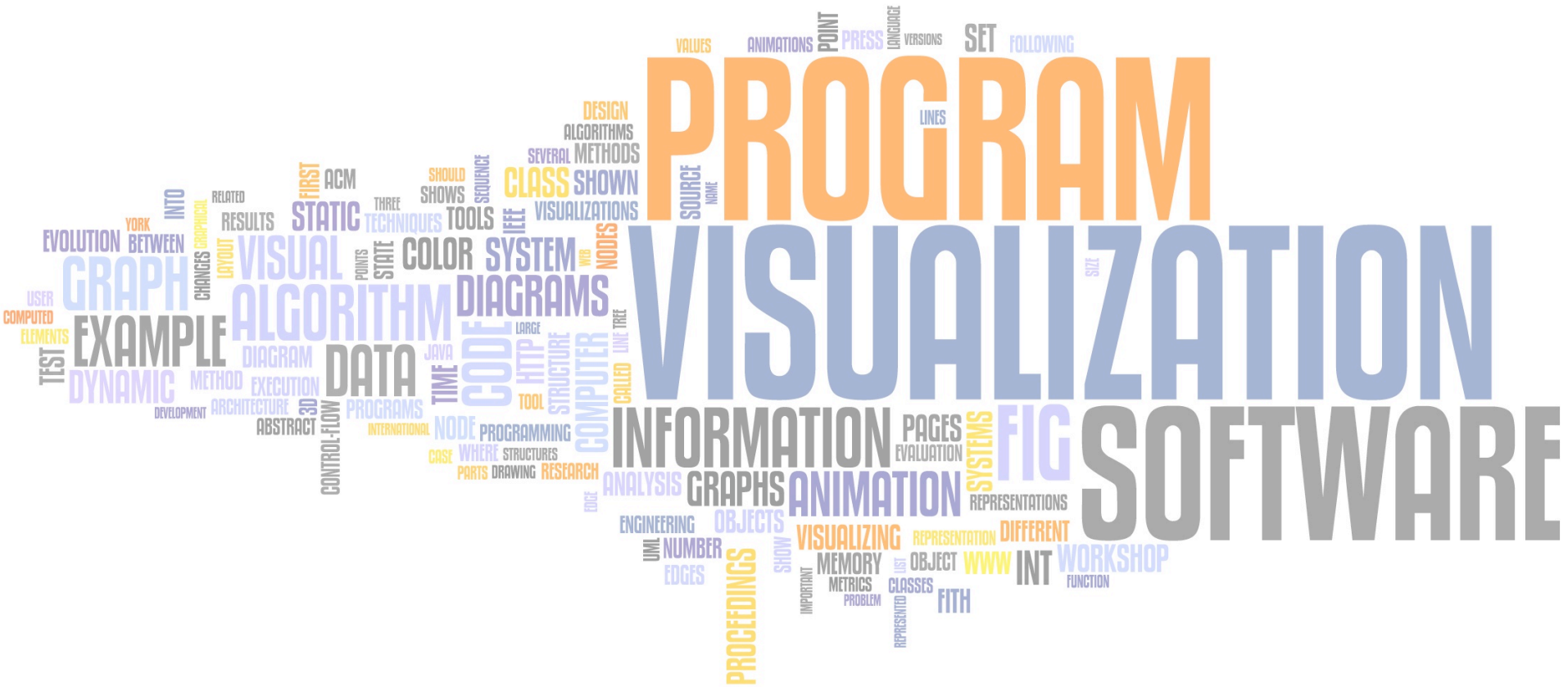
ABSTRACT
1. INTRODUCTION
2. PEDAGOGICAL AV REQUIREMENTS


PROGRAM
VISUALIZATION
SOFTWARE
INFORMATION
ALGORITHM
GRAPH
EXAMPLE
DIAGRAMS
DATA
VISUAL
ANIMATION
GRAPHS
FIG
SYSTEM
COLOR
STATIC
CLASS
CODE
COMPUTER
PROCEEDINGS
VISUALIZING
OBJECTS
NUMBER
MEMORY
WORKSHOP
INT
FITH
DYNAMIC
DIAGRAM
ANALYSIS
PAGES
EVALUATION
SYSTEMS
REPRESENTATIONS
DIFFERENT
REPRESENTATION
OBJECT
WWW
FUNCTION
METRICS
CLASSES
PROBLEM
ENGINEERING
UML
EDGES
SHOW
IMPORTANT
REPRESENTED
EVOLUTION
BETWEEN
RESULTS
TECHNIQUES
TOOLS
SHOWN
METHODS
ALGORITHMS
DESIGN
SET
POINT
PRESS
ANIMATIONS
VALUES
LANGUAGE
VERSIONS
FOLLOWING
LINES
SOURCE
NAME
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VISUALIZATIONS
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SEQUENCE
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RELATED
GRAPHICAL
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LAYOUT
YORK
STATE
POINTS
USER
COMPUTED
ELEMENTS
TEST
LARGE
TREE
CALLED
HTTP
STRUCTURE
TOOL
JAVA
TIME
METHOD
EXECUTION
ARCHITECTURE
DEVELOPMENT
3D
ABSTRACT
CONTROL-FLOW
PROGRAMS
INTERNATIONAL
NODE
PROGRAMMING
CASE
WHERE
STRUCTURES
PARTS
DRAWING
RESEARCH
EDGE
LIST

The Future of software visualization

Among other challenges:

> *Integration* Software visualization will be doomed to remain an academic endeavor if we do not succeed in integrating it into working environments and thus into the work flow of programmers, designers and project managers. [. . .]
>
> *3D visualization* In modern computer games, 3D graphics and narrative elements help the user to find her way through the virtual worlds. Recently, for every major operating system, 3D desktops have been released, or at least some animated 3D effects have been added to the old 2D desktop. Today's software visualization tools do not even exploit the graphics power of an average PC or laptop. 3D visualization may fulfill its promises (see
>
> *End-user visualization:* Today, software visualization tools are used by software developers. Some kinds of visualizations may be helpful for end-users who want to get some information about an application that they are using. For example, they may want to know what components are required

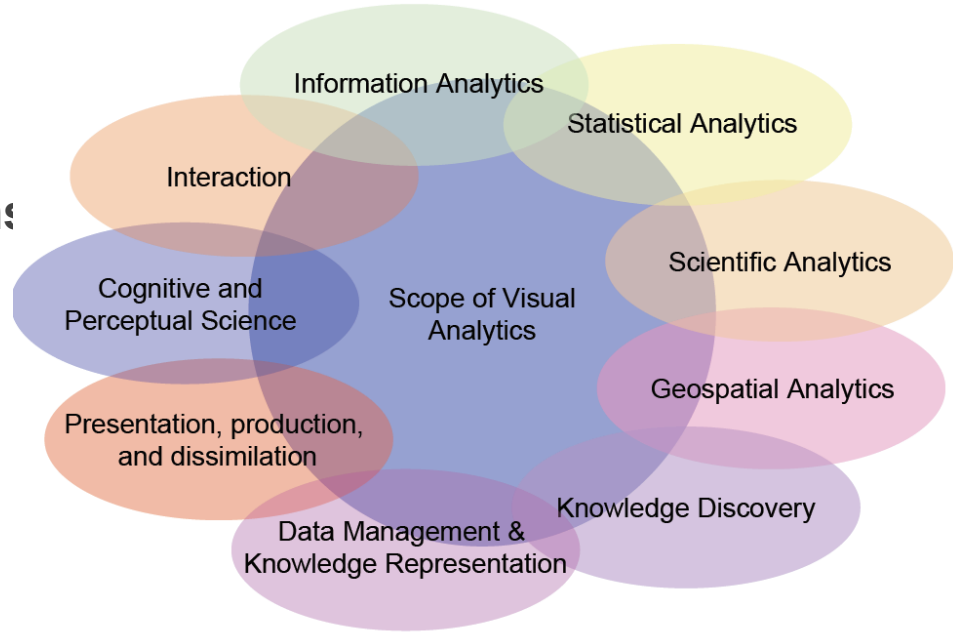
(Diehl, 2007)

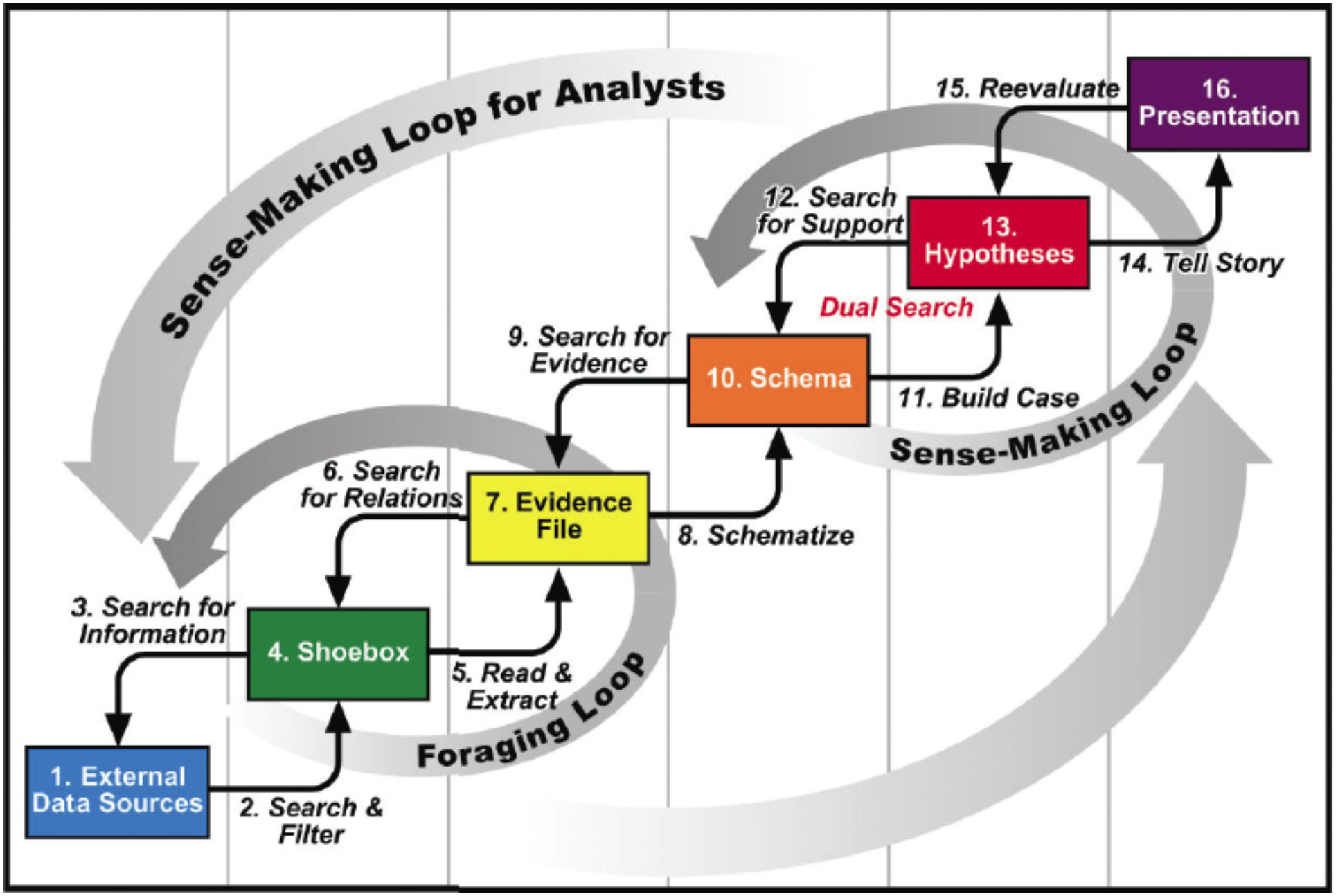
The interactive visual approach

Visual Analytics is the science of analytical reasoning facilitated by highly interactive visual interfaces.

The visual analytics process aims at tightly coupling automated analysis methods and interactive representations and combines the strengths of machines with those of humans

(Keim, 2006)

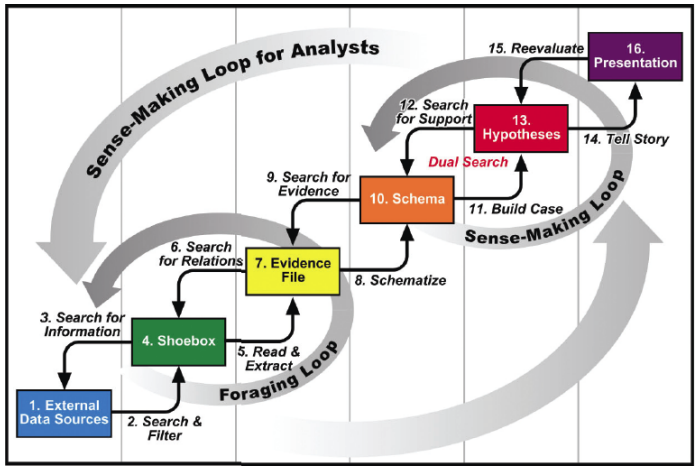


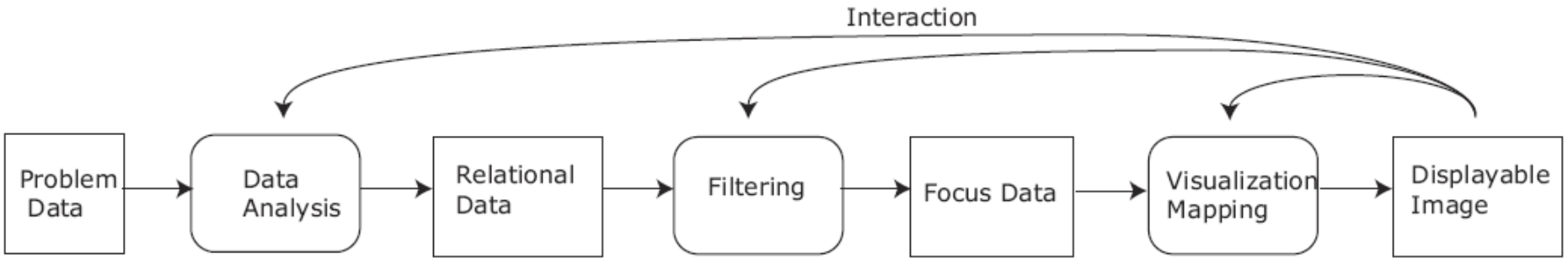


J. Thomas – Visual Analytics Initiative

Visualization mantras

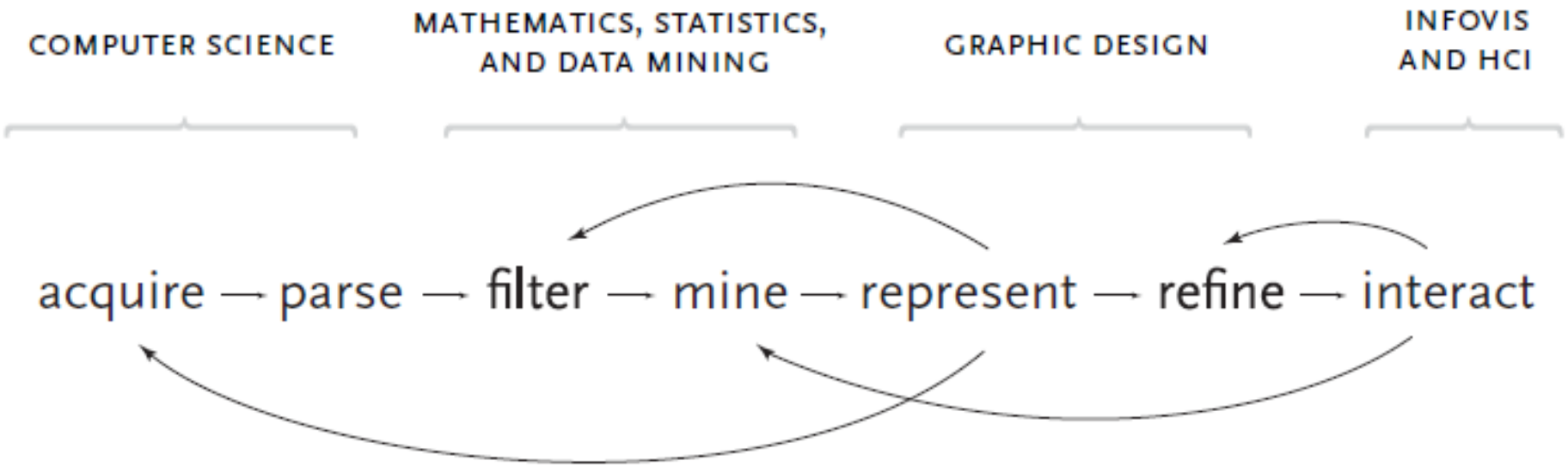
- Visual Information Seeking Mantra
  - Overview, Zoom-in / Filter, and Details on Demand (Shneiderman, 1996)
- Visual Analytics Mantra
  - Analyse first, Show the Important, Zoom, filter and analyse, Details on demand (Keim 2006)





Computacional Información Design

(Ben Fry, 2004)



Example: Evolution of Software

- Visualization of the collaboration history in the development of software items
- Source: Repositories of Software Configuration Management tools
  - relationships between the programmers and software items
  - creation of baselines, branches and revisions
  - Temporal information

Aim

- First contribution to the SCM tool (PlasticSCM) developed by Códice Software
  - Revision Tree: an interactive 2D visualization
    - Visualiation of the contributions of the team members, through several revisions, baselines and long periods of time, on the same item or document within the software project.

- We support our visualization through the use several information visualization techniques:
  - grid-based structure,
  - selection, navigation, filtering and zoom interaction mechanisms
  - polyfocal display,
  - tree hierarchy (a directed graph),
  - time line.

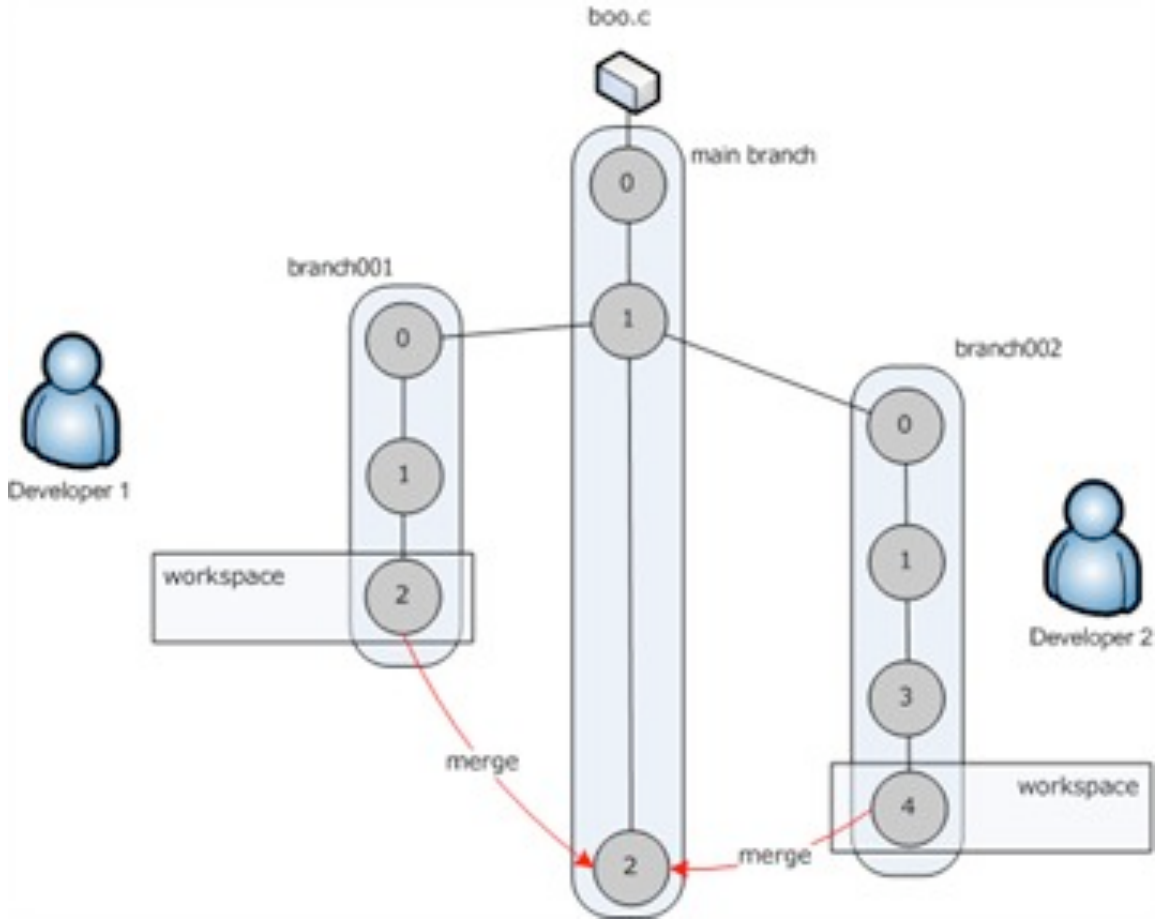
Background

- Software Configuration Management (SCM) controls the evolution of complex systems taking into consideration
  - communication at every level of the organization
  - changes of code and documentation.
- SCM tools must provide
  - management of the component database,
  - concurrency
  - collaboration,
  - recording changes
    - time, date, modules affected, modification duration, who did the change.
- However, in spite of the richness of this data source
  - *there is an important lack of mechanisms to convey, how the contribution and collaboration among team members occurs in a particular project*.

Background

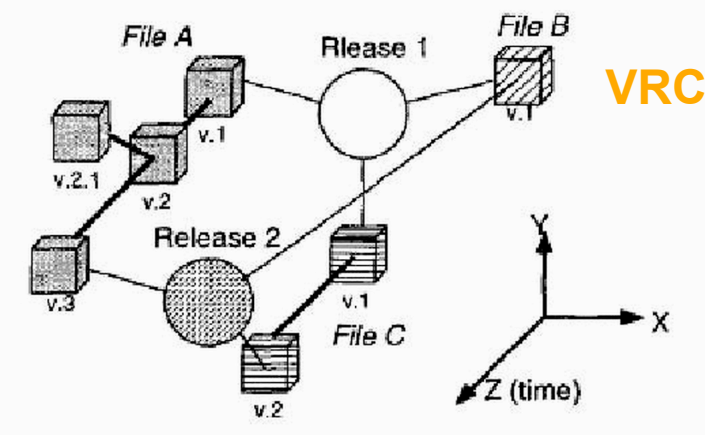
- Plastic SCM supports parallel development so different developers are able to include changes at the same time on the same code base.
- Plastic SCM is able to manage thousands of branches on a single repository with no restriction, providing easy and effective management of files through the development cycle.
  - Understanding of what is really happening inside the team?

Background


boo.c
main branch
0
1
2
branch001
0
1
2
workspace
branch002
0
1
3
4
workspace
Developer 1
Developer 2
merge
merge

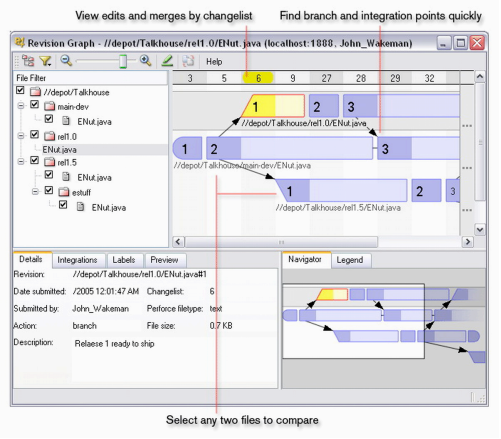
Background

- **VRCS**:
  - evolution of items from the repository of the software management configuration tool.
    - each software item is represented by using two dimensions and the overall visualization with three dimensions



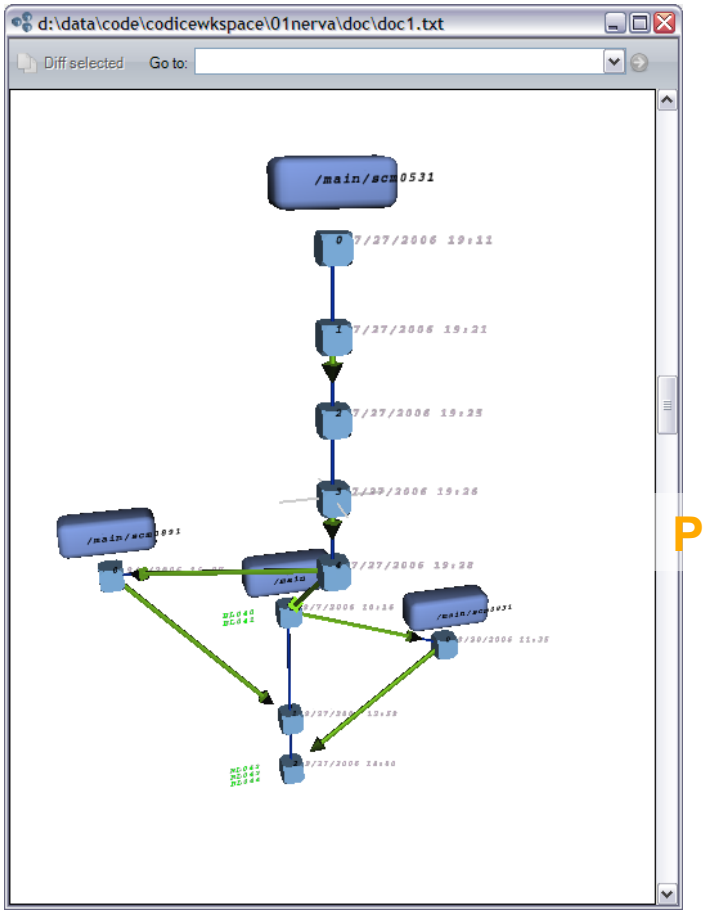
VRCS

- **Perforce:**
  - **a two dimensional visualization and uses a graph to show the relationships between baselines, branches and revisions. It features an overview + detail approach rather than a more convenient focus + context approach**

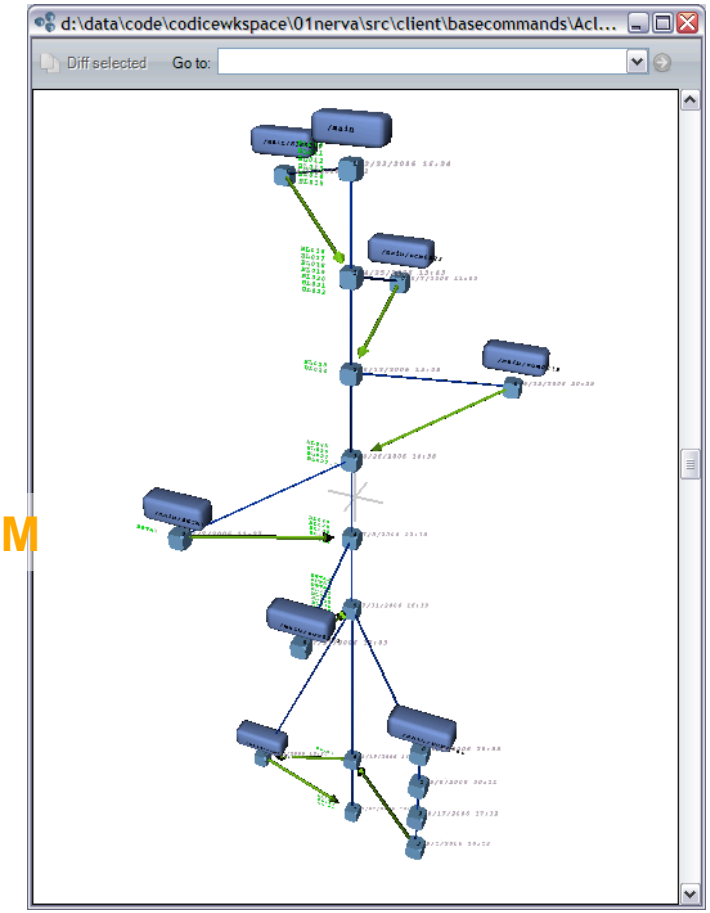


Perforce

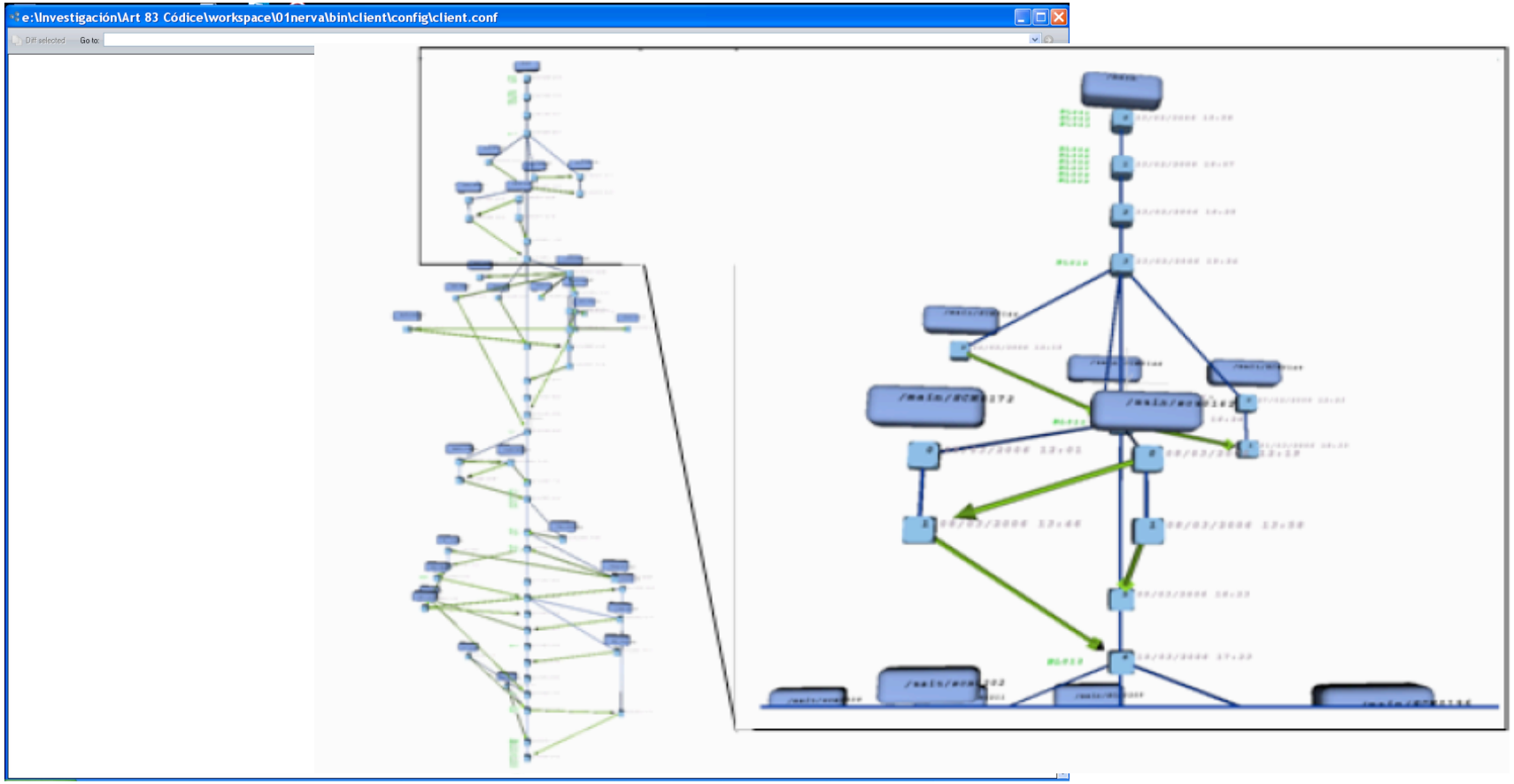
Background



PlasticSCM



Background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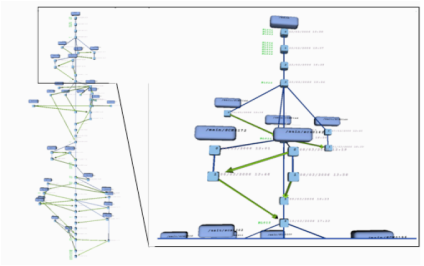
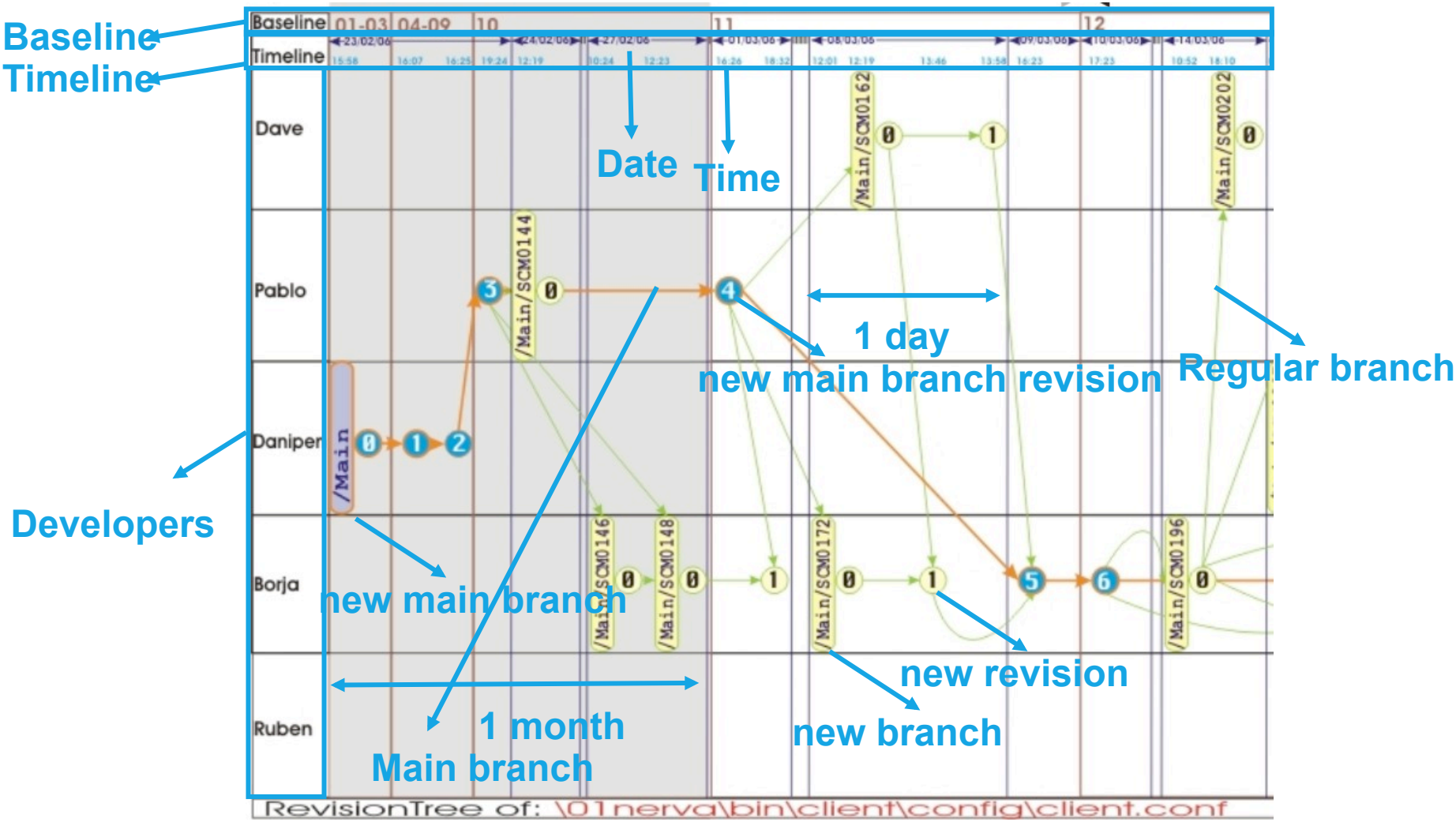
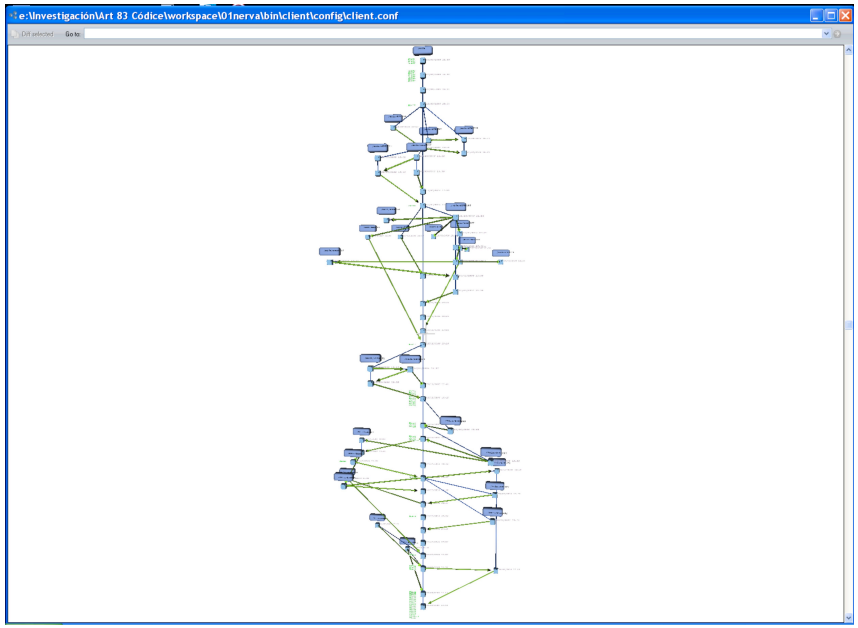


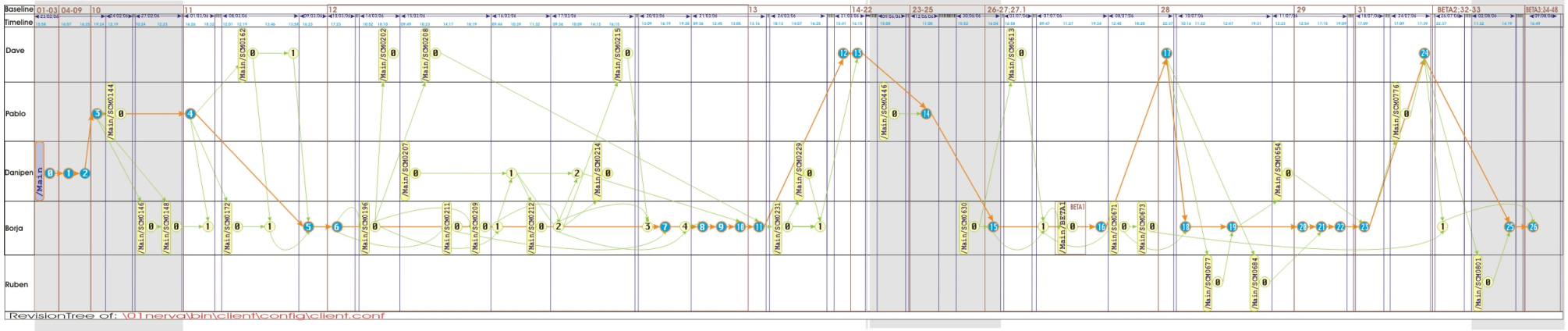
RevisionTree



RevisionTree--design

- grid-based structure
  - it provides an intuitive mechanism to visualize the working relationship between authors and baselines by using the rows to represent the authors and the columns for the baselines
  - Default view:
    - Uses of variable width columns to accommodate the revisions in each baseline, the distribution of the rows is uniform,
- Graph layout
- Focus+context interaction
- *This sketch allows us to appreciate all the baselines and revisions of the item at a glance, as well as the relationships among baselines and the hierarchical association between baselines and revisions.*


e:\Investigación\Art 83 Códice\workspace\01nerva\bin\client\config\client.conf


Baseline
Timeline
Dave
Pablo
Danipen
Borja
Ruben
RevisionTree of: \01nerva\bin\client\config\client.conf

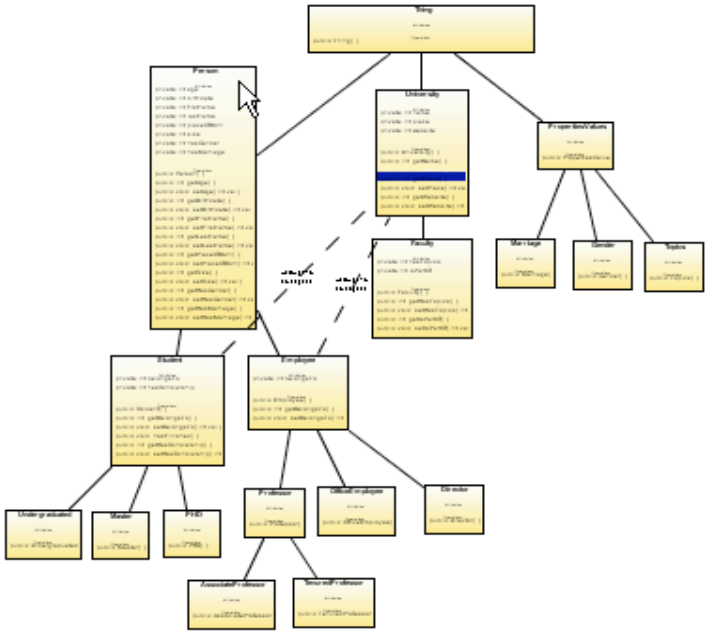
Validation

- In-house validation (CódiceSoftware)
  - it is evident that it is possible to obtain a great amount of information at a glance
    - detailed explanation is not required;
    - it is easy to follow up on contributions to the development of a software item and understand how it has evolved throughout.
  - It provides useful information for project managers
    - who has been working most in the development of the item,
    - Has someone quit or been fired ?
    - Anomaly discovery:
      - Were the last revisions, made by a given programmer, merged?
      - is there a merge that has never been done?

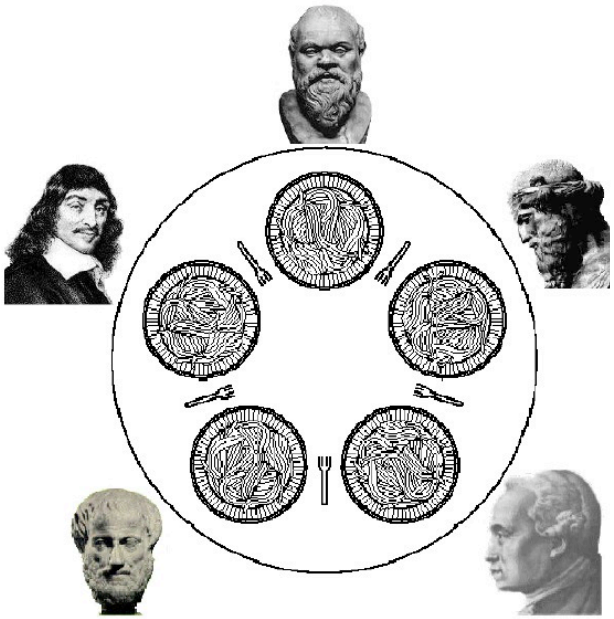
Validation

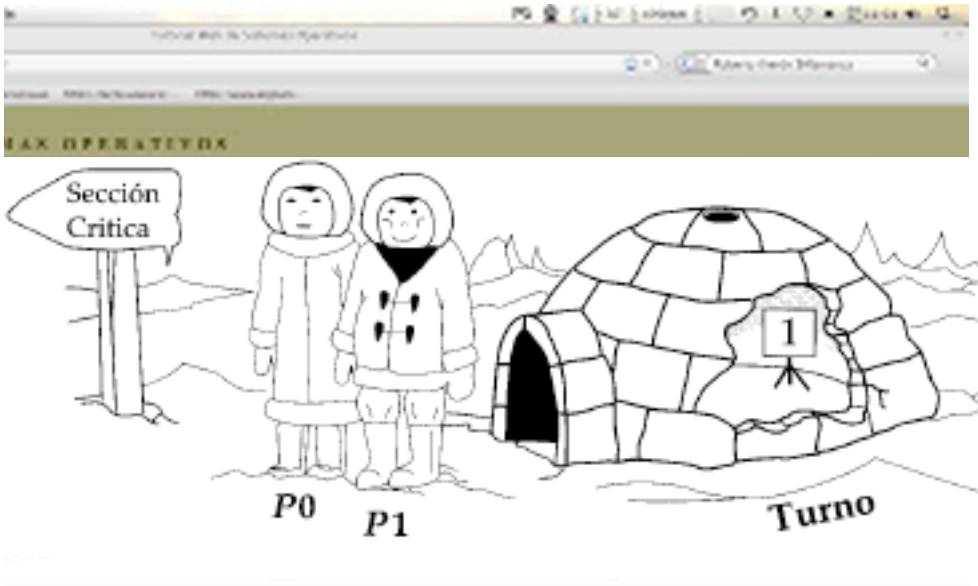
Questions	PlasticSCM	VRCS	Perforce
Does the visualization provide a context view?			✔
How many developers are participating in the development of the software item?			
Who are the developers contributing to the evolution?			
Who is the programmer with more contributions to the evolution of the item?			
How many baselines constitute the whole evolution process?	✔	✔	
Does the tool offer information about dates and times of the creation of baselines and revisions?			✔
Is there a revision without been merged after a long time?			✔
How long has been the development of the item?	✔	✔	✔
Which baseline has more branches and revisions?			
Which branch has more modification activity?			✔
Which is the period of time that does not show any activity?			
Is there a period when the item was stable and then suddenly started having a lot of activity?			
Is it possible to compare baseline activity?			

Example: Structure of Software

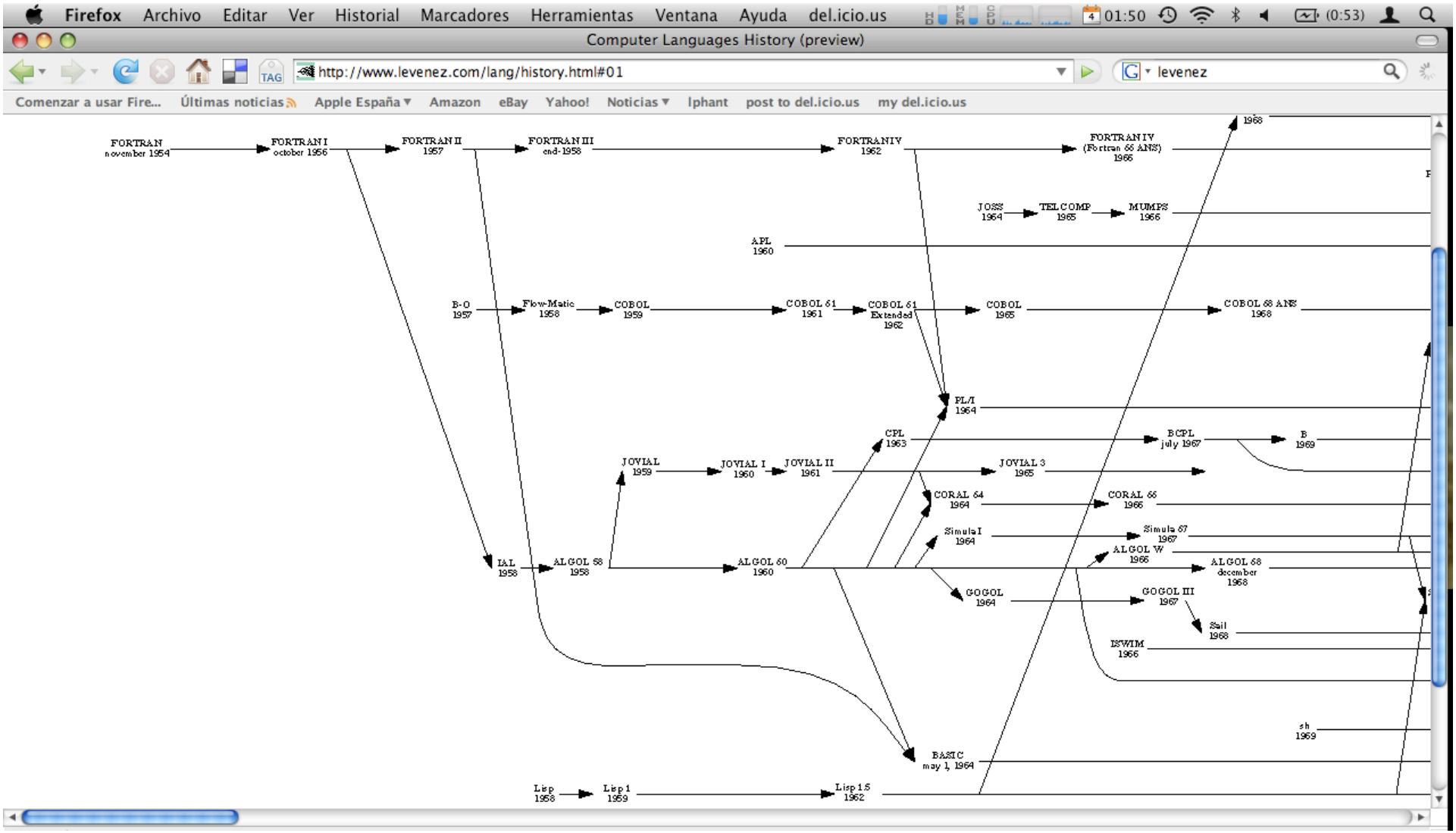


Example: Algorithms

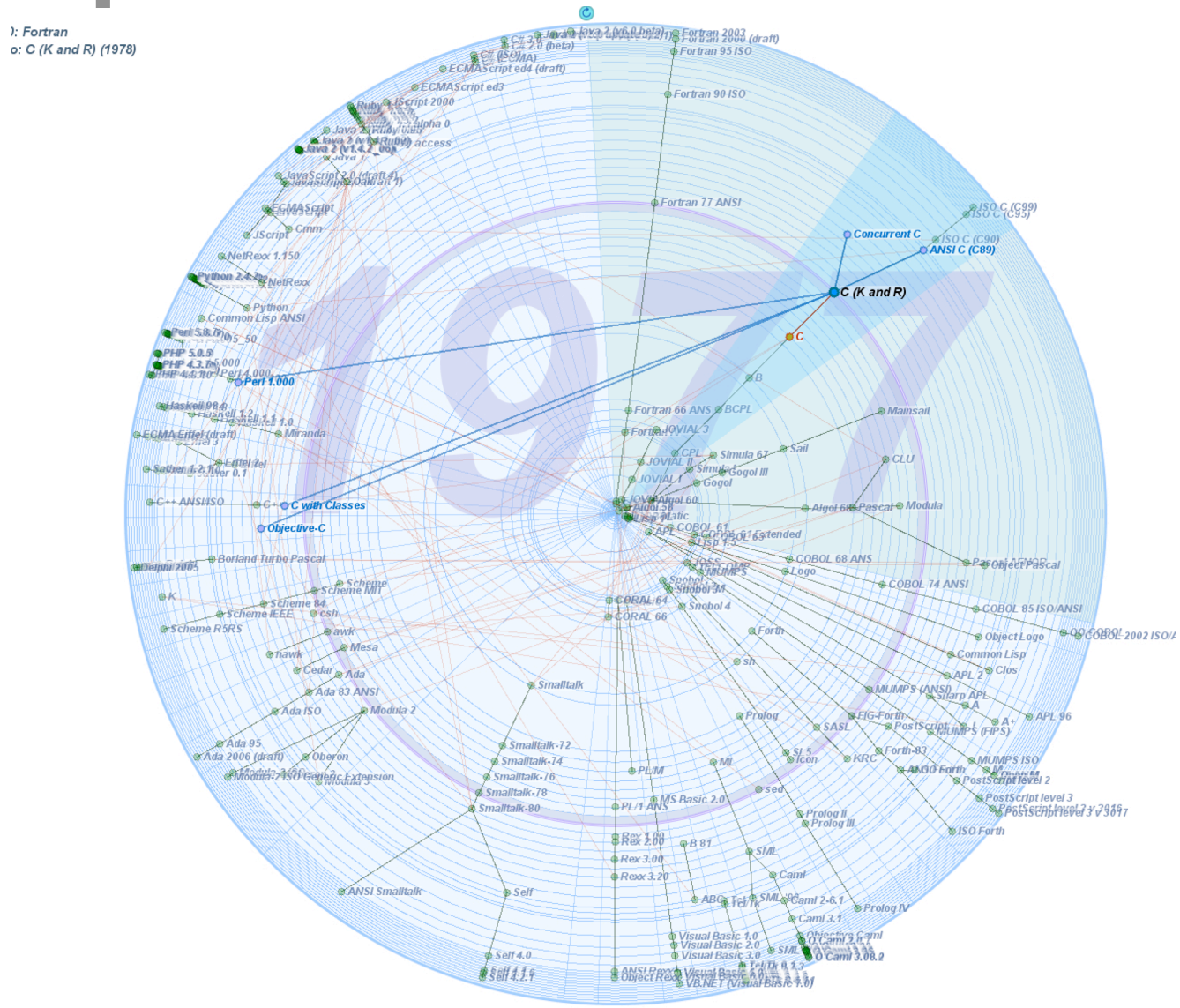




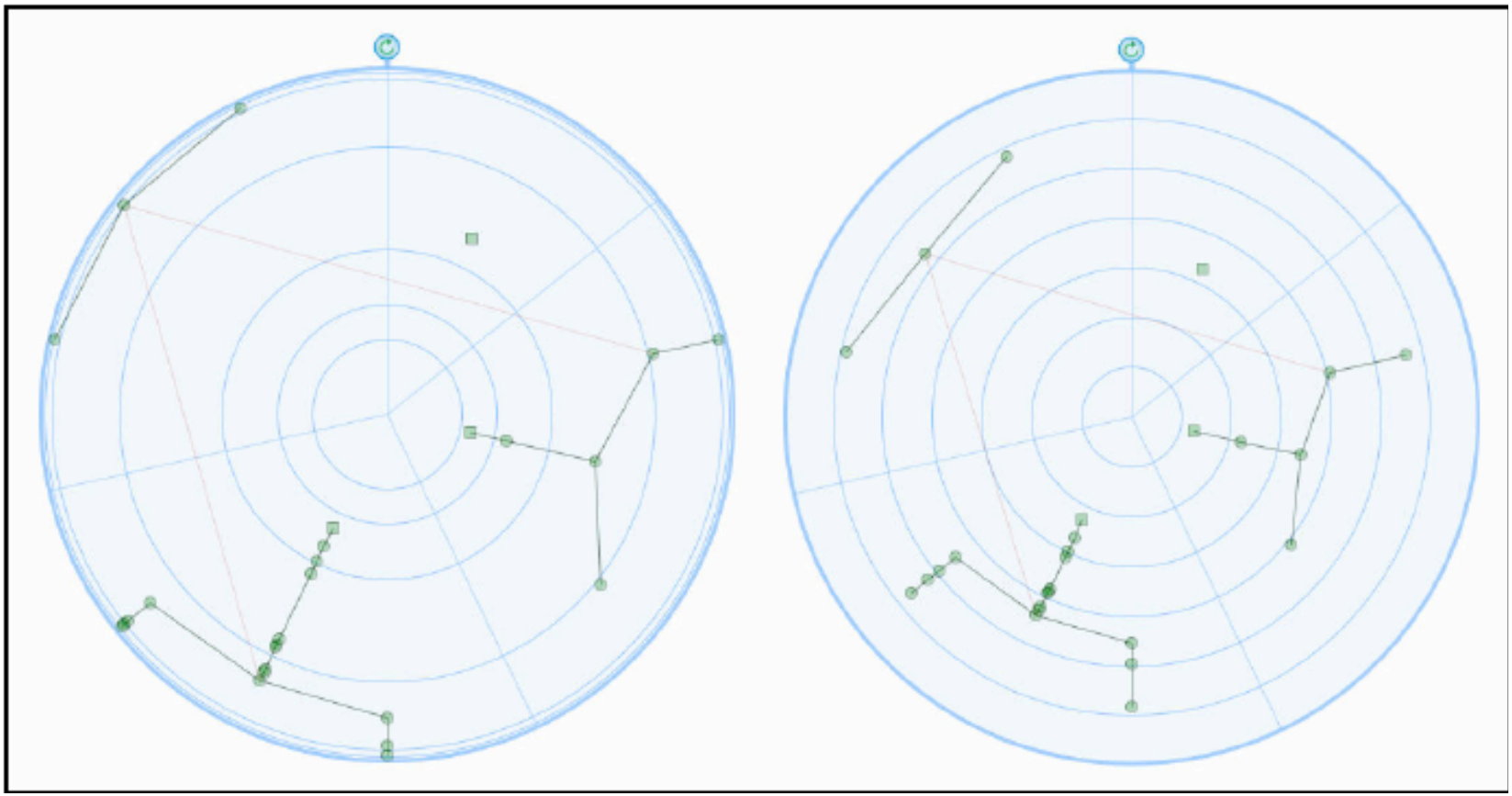
Example: Hierarchies + Time



Example: Hierarchies + Time

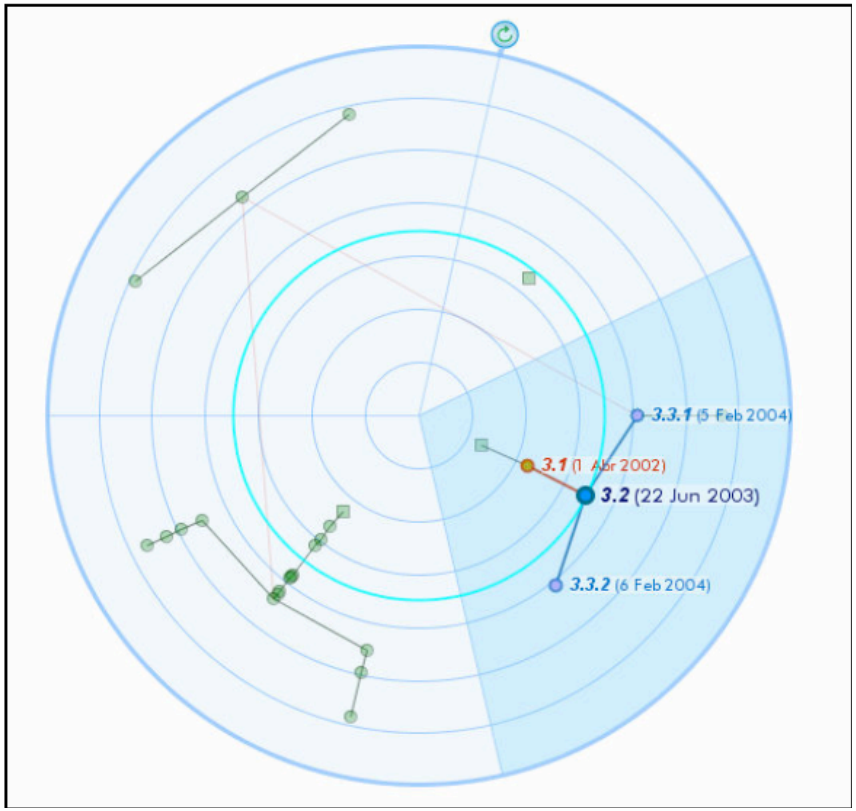


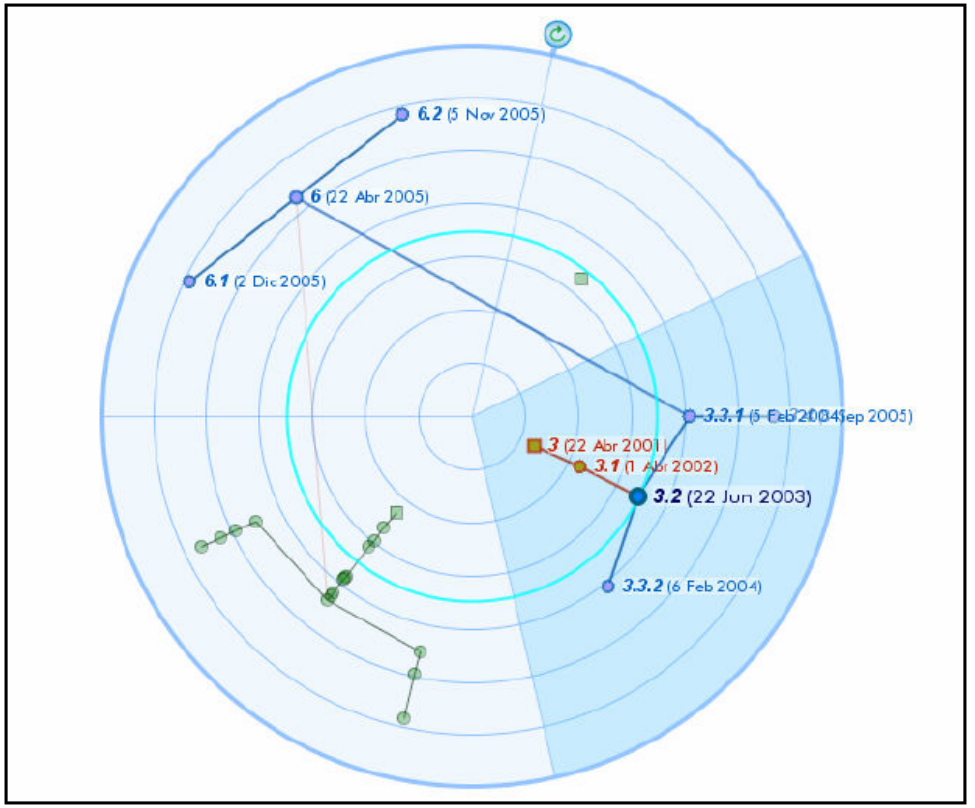
Example: Hierarchies + Time



COMPUTER SCIENCE		MATHEMATICS, STATISTICS, AND DATA MINING		GRAPHIC DESIGN		INFOVIS AND HCI
acquire	parse	filter	mine	represent	refine	interact

Example: Hierarchies + Time





COMPUTER SCIENCE

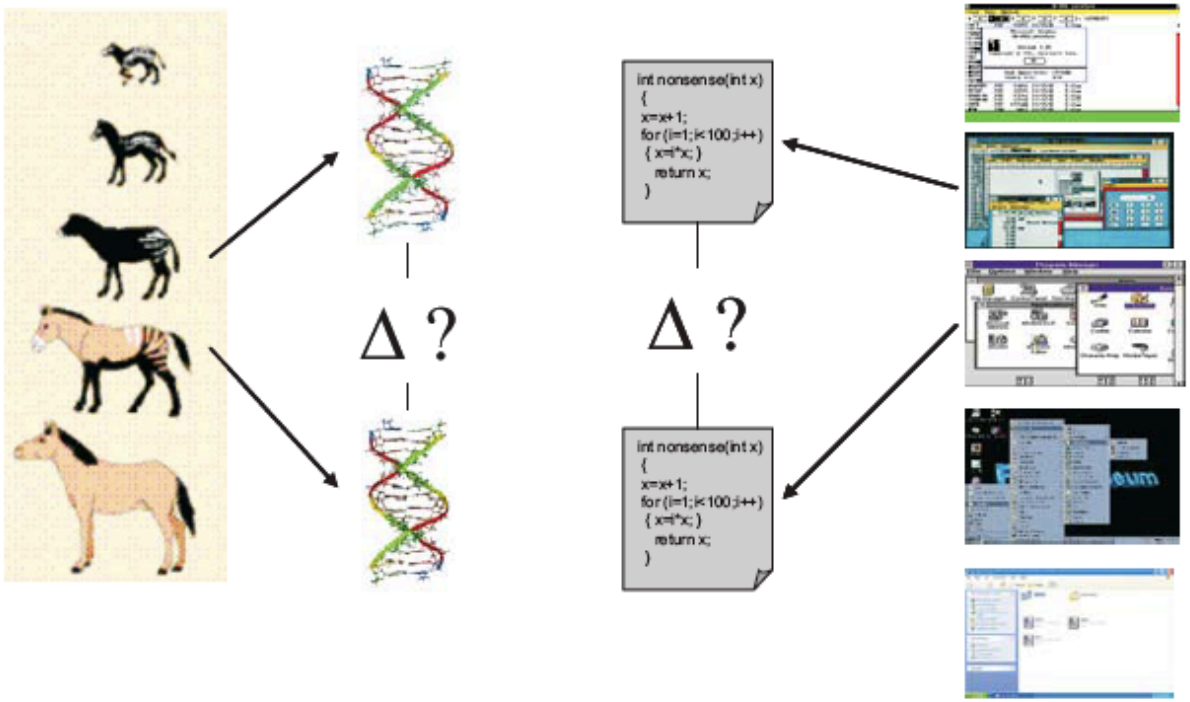
MATHEMATICS, STATISTICS, AND DATA MINING

GRAPHIC DESIGN

INFOVIS AND HCI

acquire parse filter mine represent refine interact

Example: Hierarchies + Time

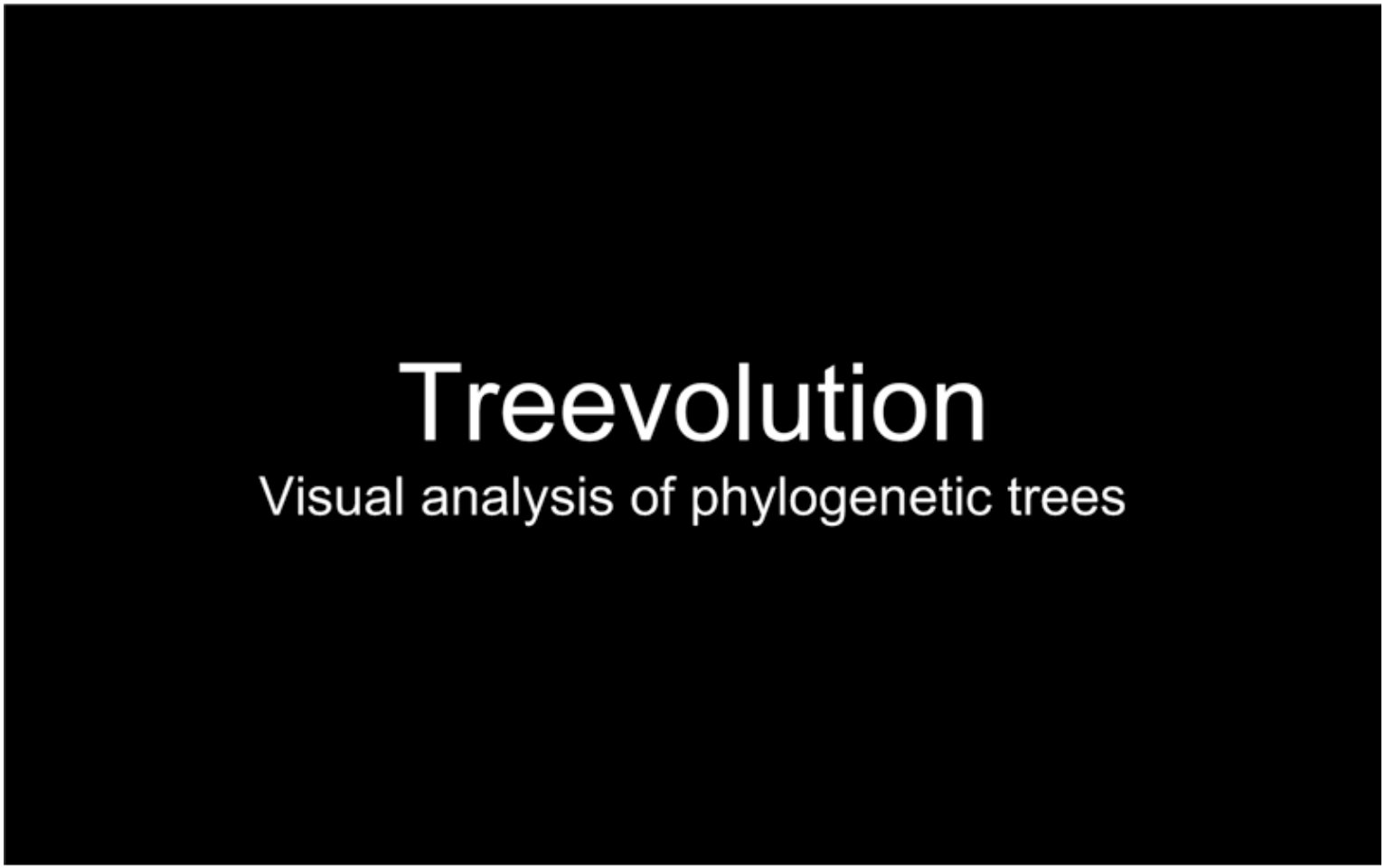


(Diehl, 2007)

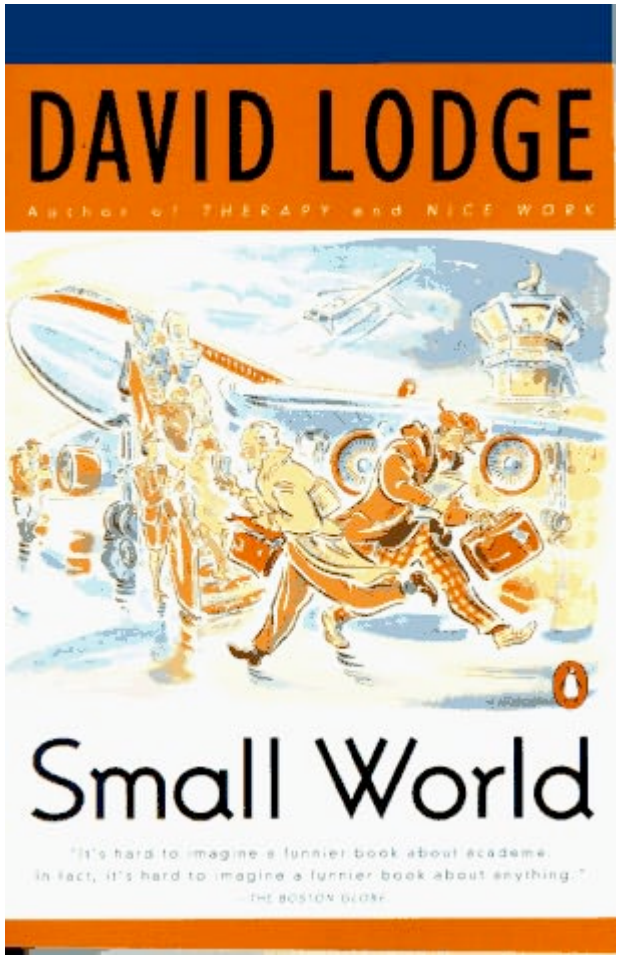
Fig. 5.1. Analogy between biological and software evolution

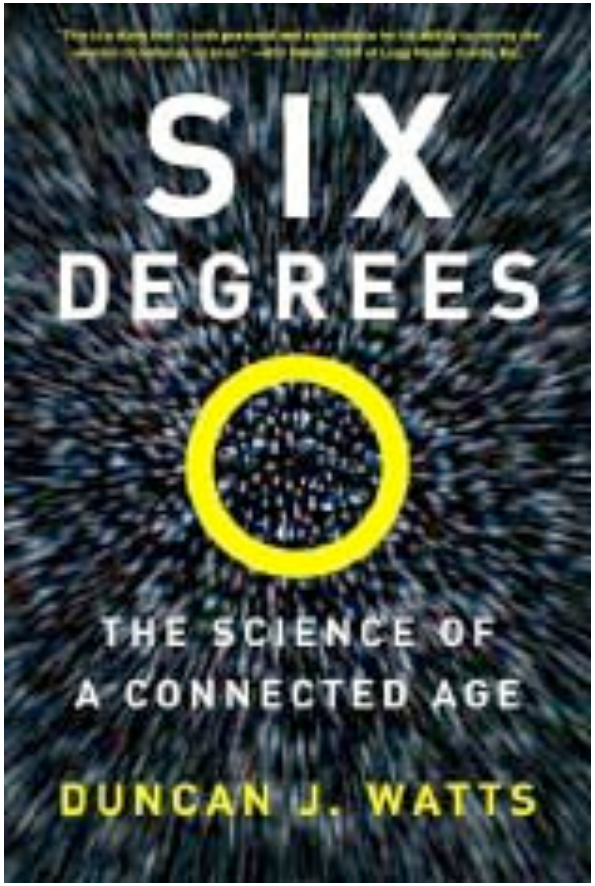
As shown in Fig. 5.1, evolutionary biologists look for differences in genes. Finding common patterns in these differences enables them to formulate rules about how a certain species evolves or even how species in general evolve. Genes are often called the programs of life. By use of this analogy, software evolution researchers can use methods similar to those of evolutionary biologists.

Example: Hierarchies + Time



Example: Visual analytics




SIX
DEGREES
THE SCIENCE OF
A CONNECTED AGE
DUNCAN J. WATTS

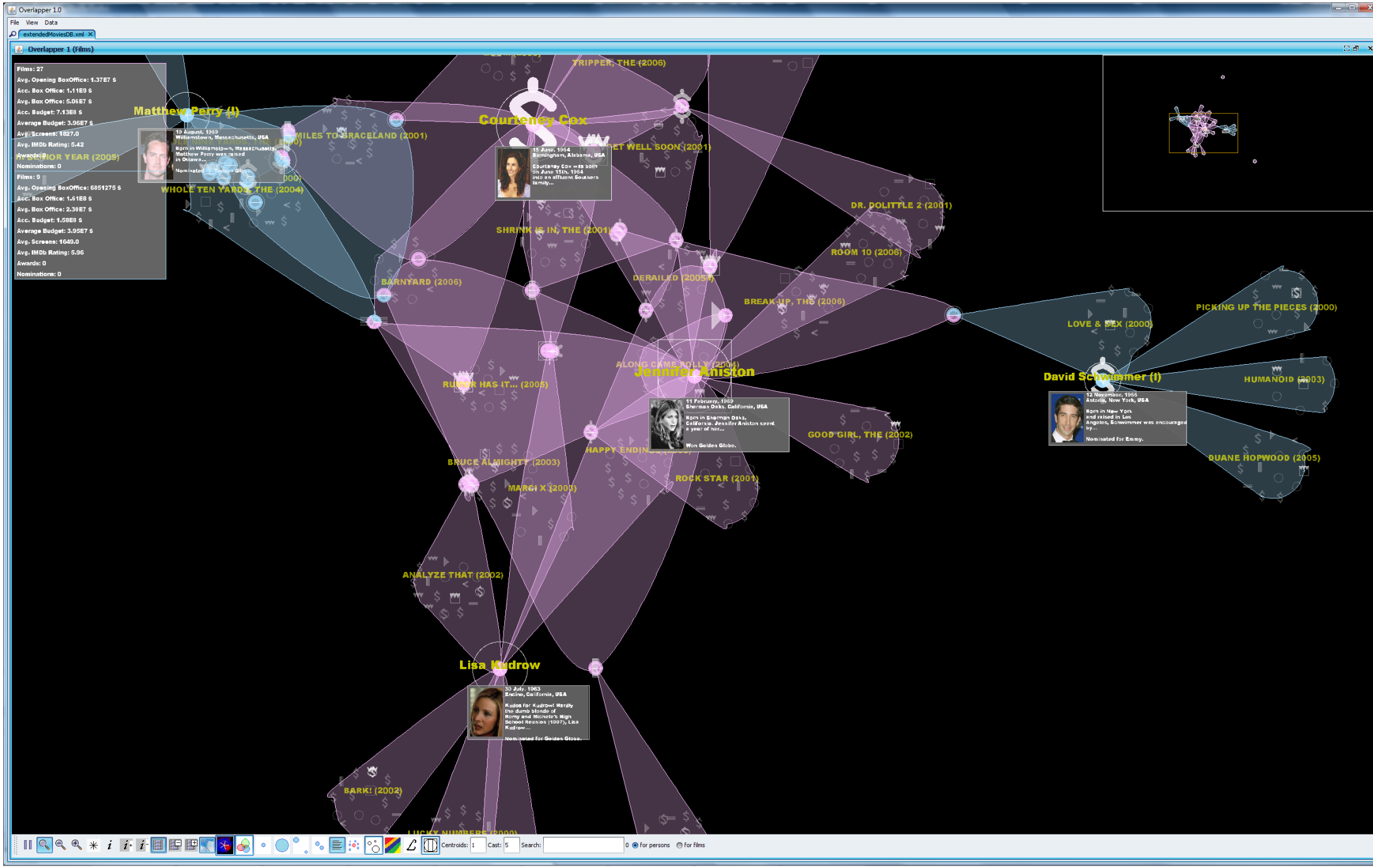
Small World

The small world experiment comprised several experiments examining the average path length for social networks of people in the United States. The research was groundbreaking in that it suggested that human society is a small world type network characterized by short path lengths
(Stanley Milgram)

six degrees of separation

Duncan J. Walls: D. J. Watts and S. H. Strogatz. Collective dynamics of 'small-world' networks, Nature, 393:440-442 (1998)

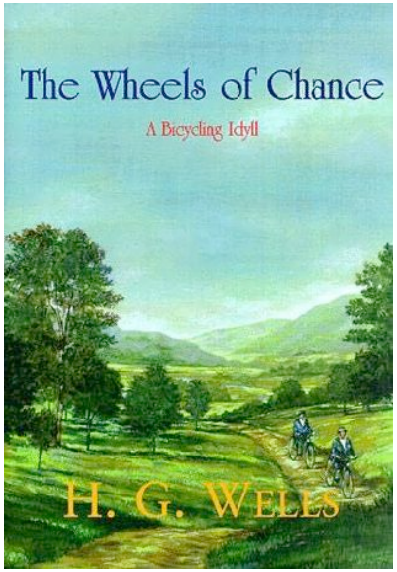
Bacon number
Erdős number


Overlapper 1.0
File View Data
extendedMoviesDB.xml
Overlapper 1 (Films)
Films: 27
Avg. Opening BoxOffice: 1.37E7 $
Acc. Box Office: 1.11E9 $
Avg. Box Office: 5.06E7 $
Acc. Budget: 7.13E8 $
Average Budget: 3.95E7 $
Avg. Screens: 1827.0
Avg. IMDb Rating: 5.42
Awards: 0
Nominations: 0
Films: 9
Avg. Opening BoxOffice: 6851275 $
Acc. Box Office: 1.61E8 $
Avg. Box Office: 2.30E7 $
Acc. Budget: 1.58E8 $
Average Budget: 3.95E7 $
Avg. Screens: 1649.0
Avg. IMDb Rating: 5.96
Awards: 0
Nominations: 0
TRIPPER, THE (2006)
Courteney Cox
15 June, 1964
Birmingham, Alabama, USA
Courteney Cox was born on June 15th, 1964 into an affluent Southern family...
GET WELL SOON (2001)
Matthew Perry (I)
19 August, 1969
Williamstown, Massachusetts, USA
Born in Williamstown, Massachusetts, Matthew Perry was raised in Ottawa...
Nominated for Golden Globe.
MILES TO GRACELAND (2001)
WHOLE TEN YARDS, THE (2004)
DR. DOLITTLE 2 (2001)
SHRINK IS IN, THE (2001)
ROOM 10 (2006)
BARNYARD (2006)
DERAILED (2005)
BREAK-UP, THE (2006)
LOVE & SEX (2000)
PICKING UP THE PIECES (2000)
Jennifer Aniston
11 February, 1969
Sherman Oaks, California, USA
Born in Sherman Oaks, California, Jennifer Aniston spent a year of her...
Won Golden Globe.
David Schwimmer (I)
12 November, 1966
Astoria, New York, USA
Born in New York and raised in Los Angeles, Schwimmer was encouraged by...
Nominated for Emmy.
HUMANOID (2003)
DUANE HOPWOOD (2005)
GOOD GIRL, THE (2002)
RUMOR HAS IT... (2005)
BRUCE ALMIGHTY (2003)
ROCK STAR (2001)
MARCI X (2003)
ANALYZE THAT (2002)
Lisa Kudrow
30 July, 1963
Encino, California, USA
Kudos for Kudrow! Hardly the dumb blonde of Romy and Michele's High School Reunion (1997), Lisa Kudrow...
Nominated for Golden Globe.
BARK! (2002)
Centroids: 1
Cast: 5
Search:
for persons
for films

Example: Visual Analytics

Conclusions

- Give the end users the opprtunity to view what they are looking for
- Developers: focus on genuine user needs
- Provide multiple-linked views
- Make use of the plethora of visualization techniches available
- Do not understimate the importance of aesthetics
- Rethink the problem as a whole (CID)
- And…



'Every time I see an adult on a bicycle, I no longer despair for the future of the human race.'

Unknown source1904

'Cycle tracks will abound in Utopia.'

A modern utopia1905

H. G. Wells

Visualizing working groups in research papers

Roberto Therón
theron@usal.es

http://vis.usal.es/
http://carpe.usal.es/~roberto

Universidad de Salamanca
GIR MIDA information visualization and visual analytics