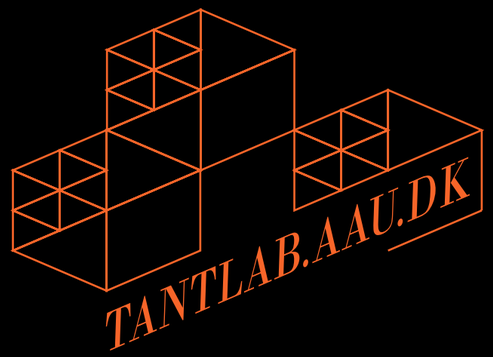


Force-driven layout algorithms

How they work & what to look for in a network map

Mathieu Jacomy
Aalborg University TANTLab

Reading a network
Two modes

As diagrams

Tasks :
- Identify each element
- Retrace paths
- Local patterns (loops...)

What does “readable” mean?
- Few overlaps
- Edges do not cross

Cases:
- Small networks
- Local exploration (ego-networks)

As maps

Tasks:
- Identify clusters
- Identify special nodes and edges
- General patterns (density gradient...)

What does “readable” mean?
- Topology accurately translated
- Articulated with statistical metrics

Cases:
- Medium / large networks
- Multivaried sets (T-SNE, UMAP)

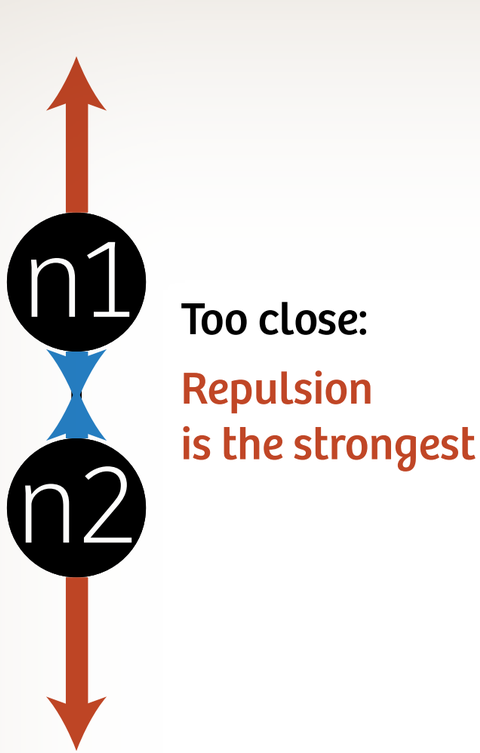
Force-driven layout algorithms

Networks have no proper shape.
We have to give them one.

But our networks are sewn onto themselves.
Like this robe that we cannot “iron”.

We just cannot avoid link crossings.
(this math property is called non-planar)

Force-driven layout algorithms



Too close:

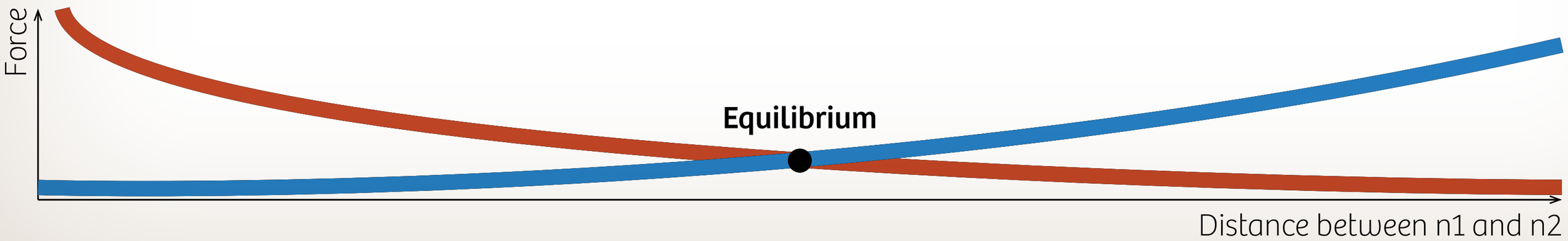
Repulsion
is the strongest

At equilibrium:

Attraction
=
Repulsion

Too far:

Attraction
is the strongest



Papers on layout algorithms
1988

Automatic Graph Drawing and Readability of Diagrams

ROBERTO TAMASSIA, GIUSEPPE DI BATTISTA, AND CARLO BATINI

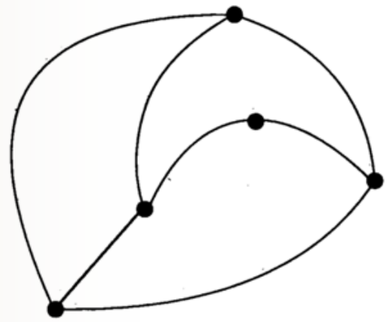
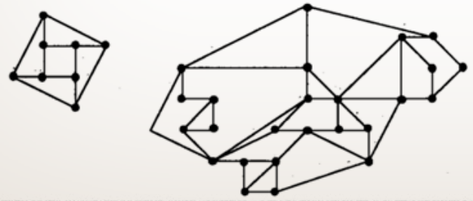


Fig. 8. Visibility representation.



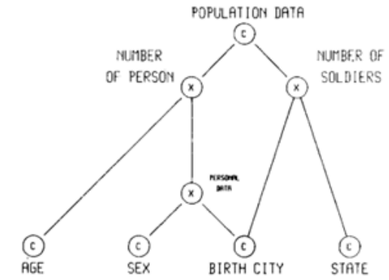


Fig. 10. Hierarchic graph used for statistical databases.

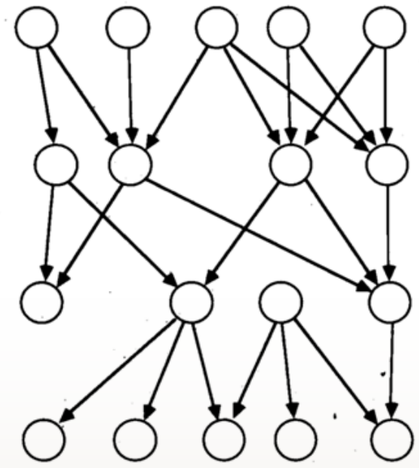


Fig. 11. Proper k-layer graph.

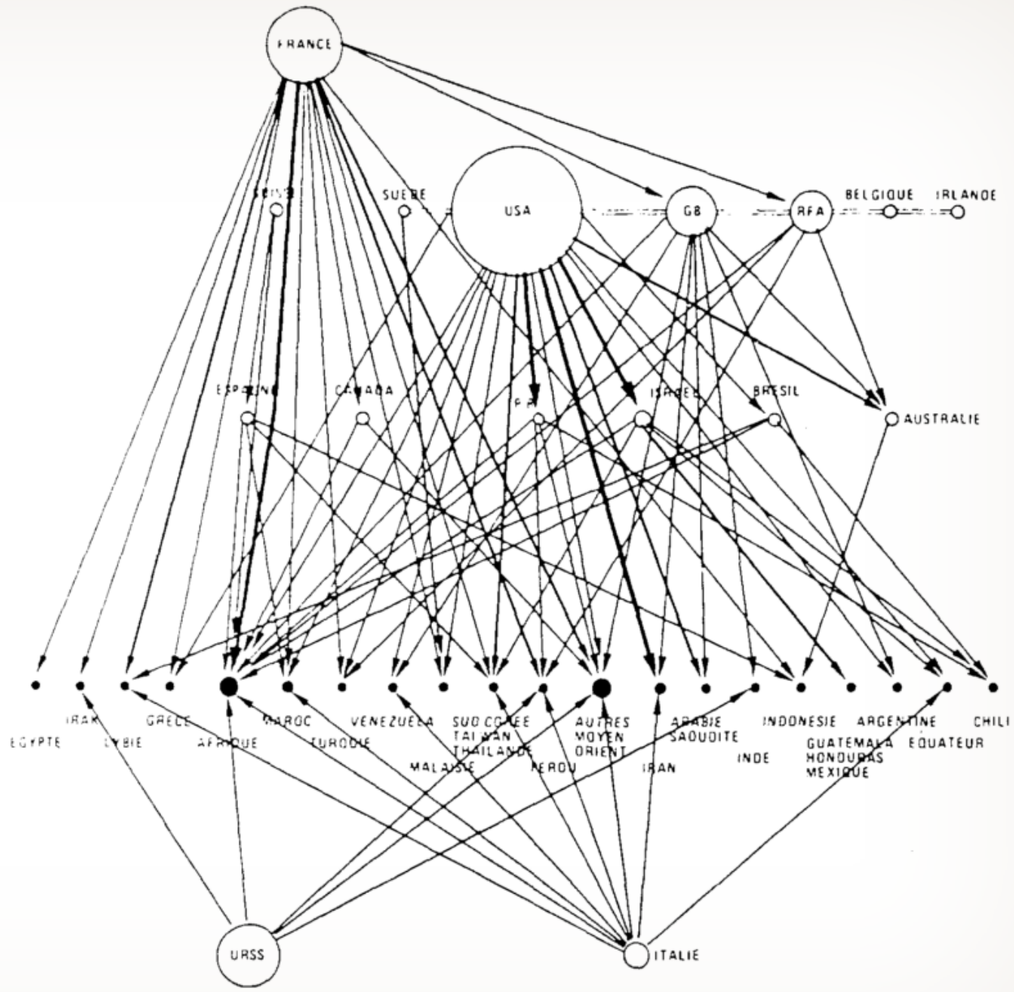


Fig. 12. Hierarchic graph drawn with Carpano algorithm (from [7]).

Papers on layout algorithms
1991 Früchterman-Reingold

Graph Drawing by Force-directed Placement

THOMAS M. J. FRUCHTERMAN* AND EDWARD M. REINGOLD
Department of Computer Science, University of Illinois at Urbana-Champaign, 1304 W. Springfield Avenue, Urbana, IL 61801-2987, U.S.A.

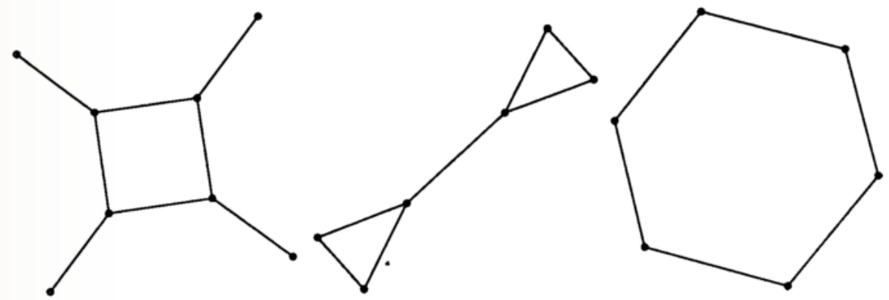


Figure 16. Graphs in Figures 6(a), 4, and 3, respectively, from Kamada and Kawai[8]

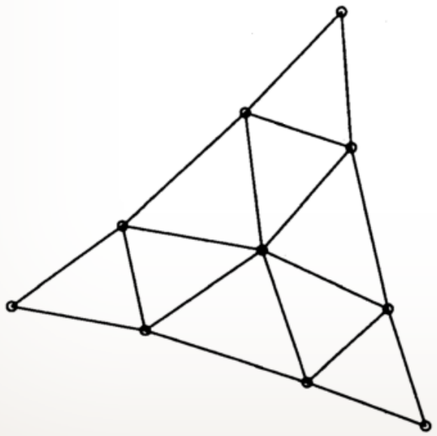


Figure 17. Triangulated triangle (graph in Figure 6(c) from Kamada and Kawai [8])

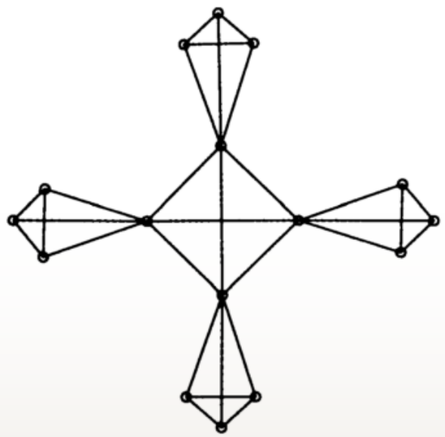


Figure 18. Graph in Figure 16 from Davidson and Harel [16]

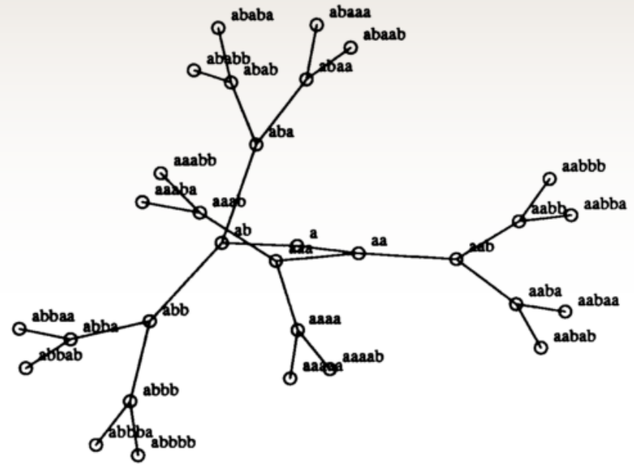


Figure 42. Example of a potential barrier

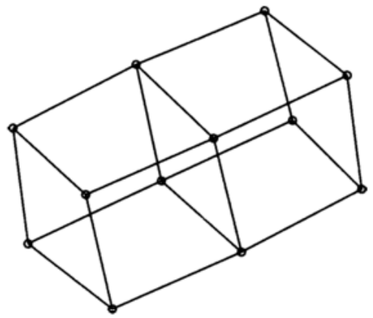


Figure 50. Twin cubes (graph in Figure 11 from Davidson and Harel [19])

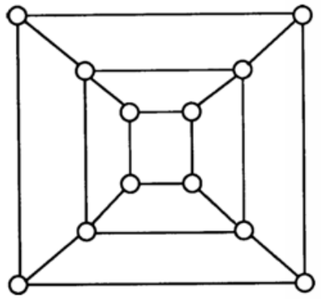


Figure 51. Figure 11(a) from Davidson and Harel as proposed by Davidson and Harel

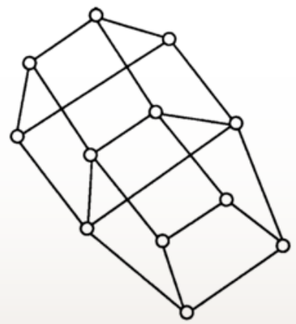


Figure 52. Figure 11(b) from Davidson and Harel [19] as drawn by Davidson and Harel

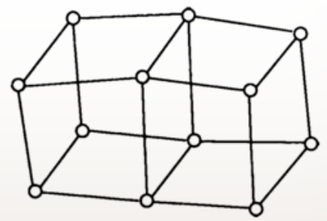


Figure 53. Figure 11(c) from Davidson and Harel [16] as drawn by Davidson and Harel

Papers on layout algorithms

1995 GEM

A Fast Adaptive Layout Algorithm for Undirected Graphs (Extended Abstract and System Demonstration)

Arne Frick*, Andreas Ludwig, Heiko Mehldau

Universität Karlsruhe, Fakultät für Informatik, D-76128 Karlsruhe, Germany

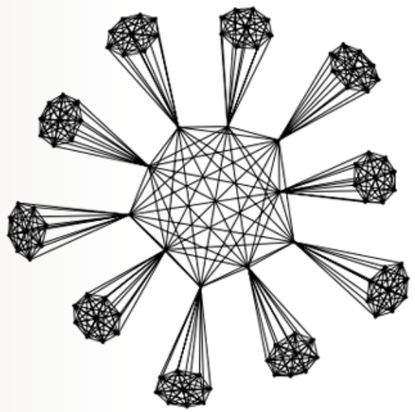


Fig. 5. Iterated K_{10}

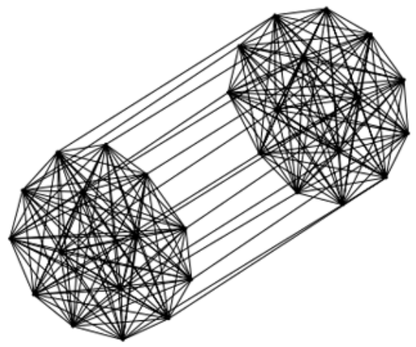


Fig. 6. Duplicated K_{15}; the even vertex distance heuristic forces vertices to be placed inside the hull

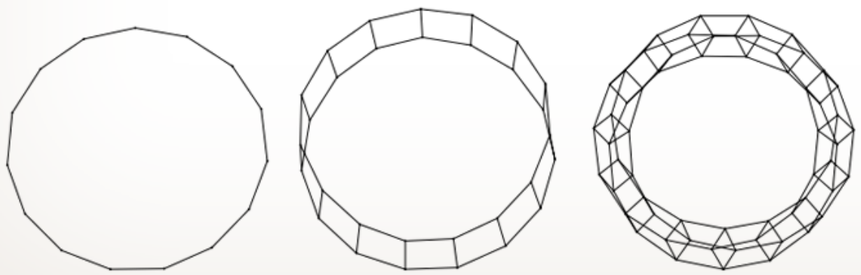


Fig. 7. Torus defined by duplicating a cycle

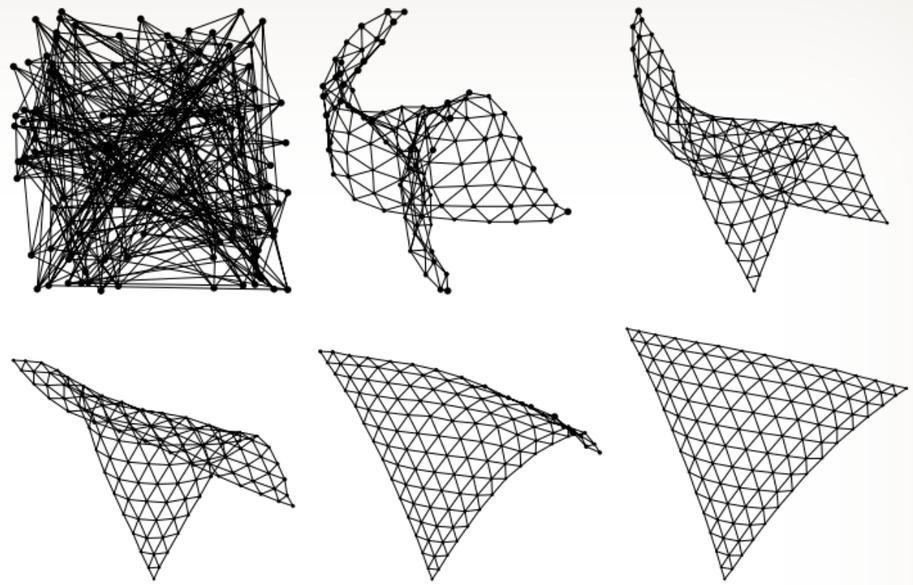


Fig. 11. Intermediate states of a triangular mesh with foldings

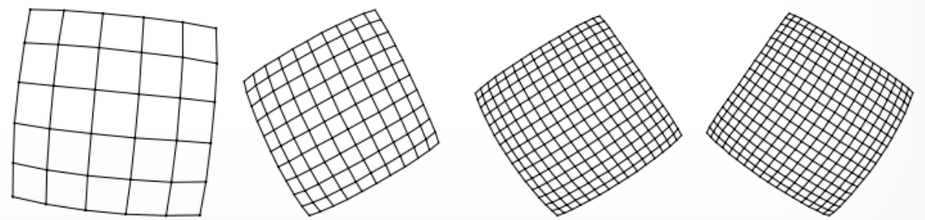
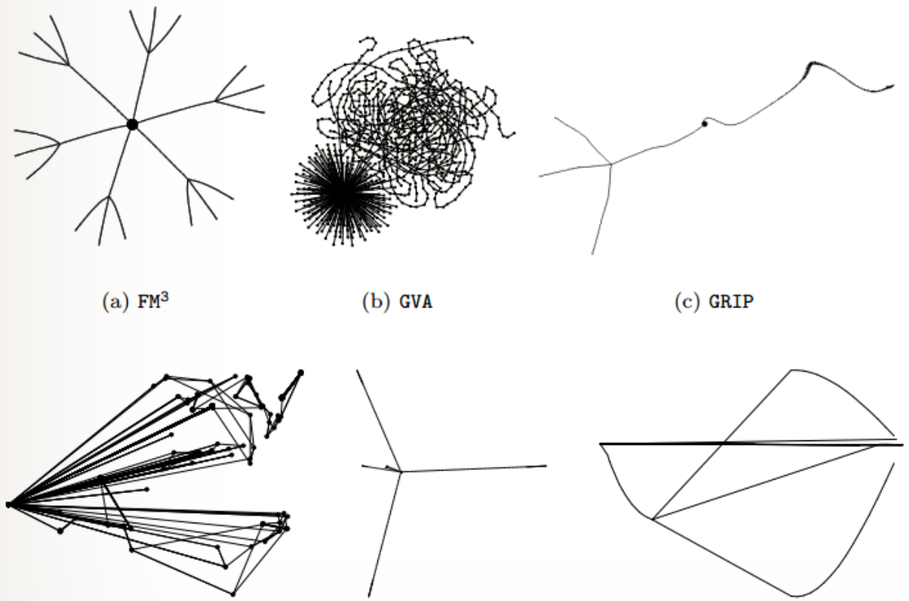


Fig. 12. Square grids of size $|V| = 36, 121, 256, 324$ after $972, 6534, 26880, 42472$ iterations

Papers on layout algorithms
2005 FM3

Large-Graph Layout with the Fast Multipole Multilevel Method

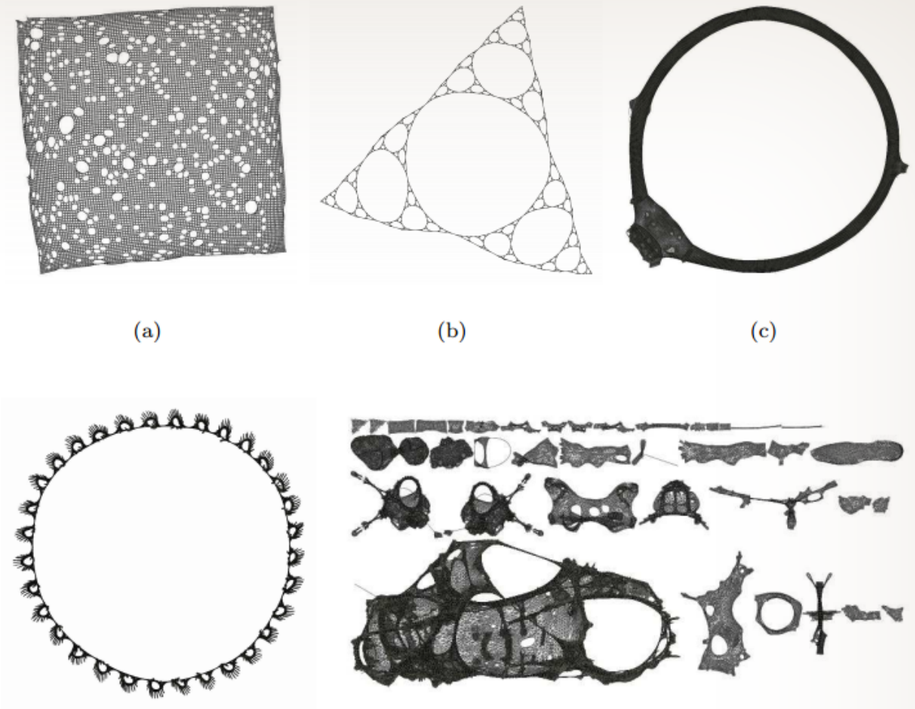
STEFAN HACHUL and MICHAEL JÜNGER
Universität zu Köln, Institut für Informatik



(a) FM^3 (b) GVA (c) GRIP

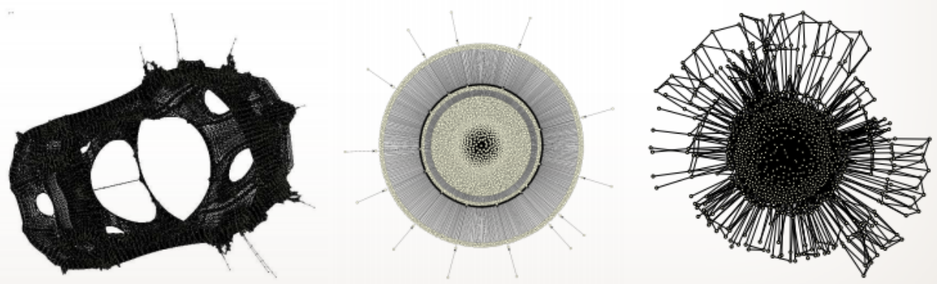
(d) FMS (e) ACE (f) HDE

Fig. 12. (a)-(f) Drawings of snowflake_A generated by different algorithms.



(a) (b) (c)

(d) (e)



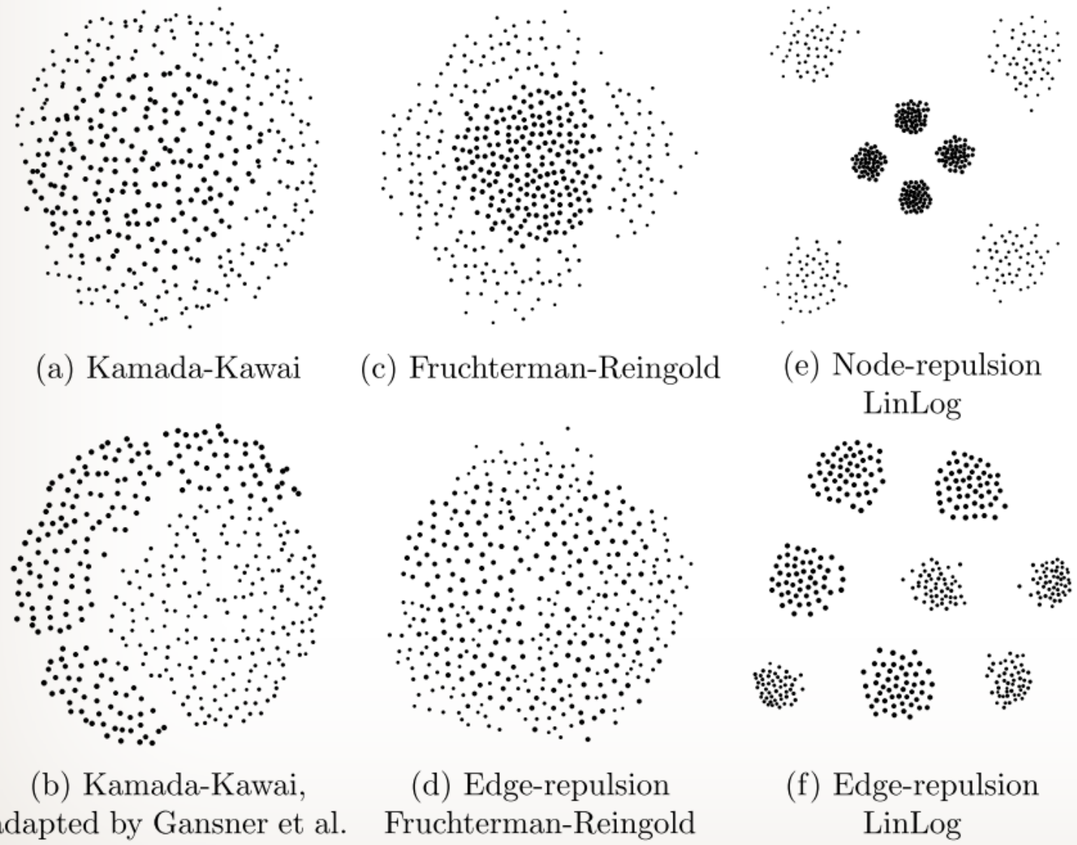
(f) (g) (h)

Papers on layout algorithms
2007 LinLog

Energy Models for Graph Clustering

Andreas Noack

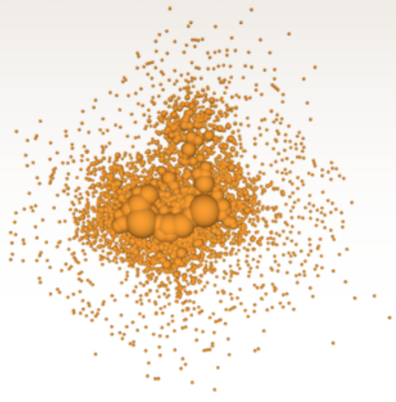
Institute of Computer Science
Brandenburg Technical University, Cottbus, Germany
an@informatik.tu-cottbus.de



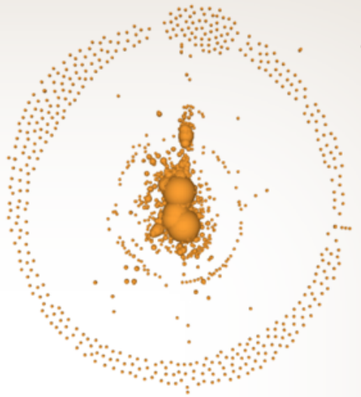
(a) Kamada-Kawai (c) Fruchterman-Reingold (e) Node-repulsion LinLog

(b) Kamada-Kawai, adapted by Gansner et al. (d) Edge-repulsion Fruchterman-Reingold (f) Edge-repulsion LinLog

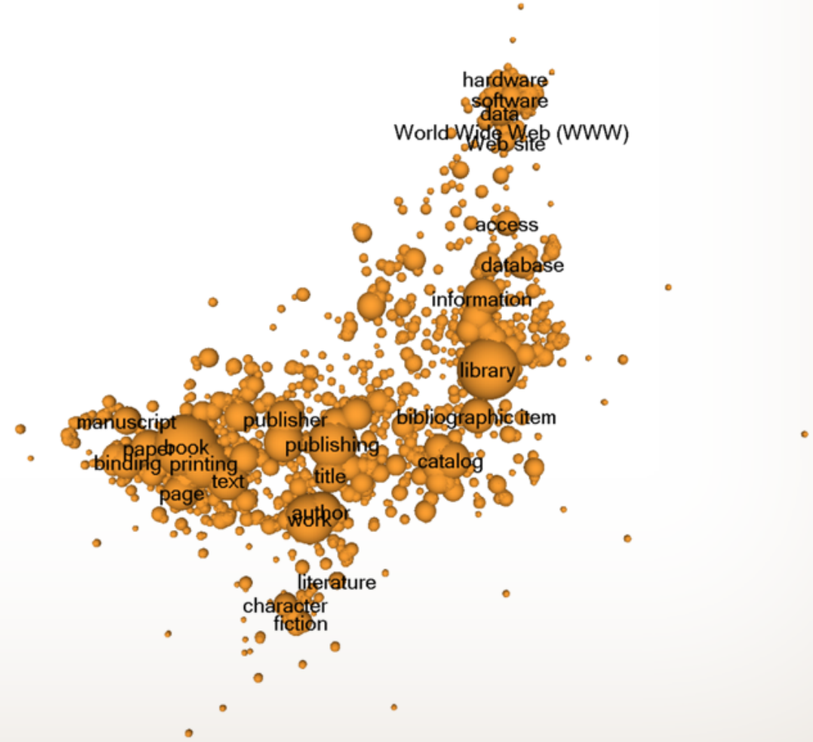
Figure 2: Pseudo-random graph



(a) Fruchterman-Reingold model



(b) Node-repulsion LinLog model

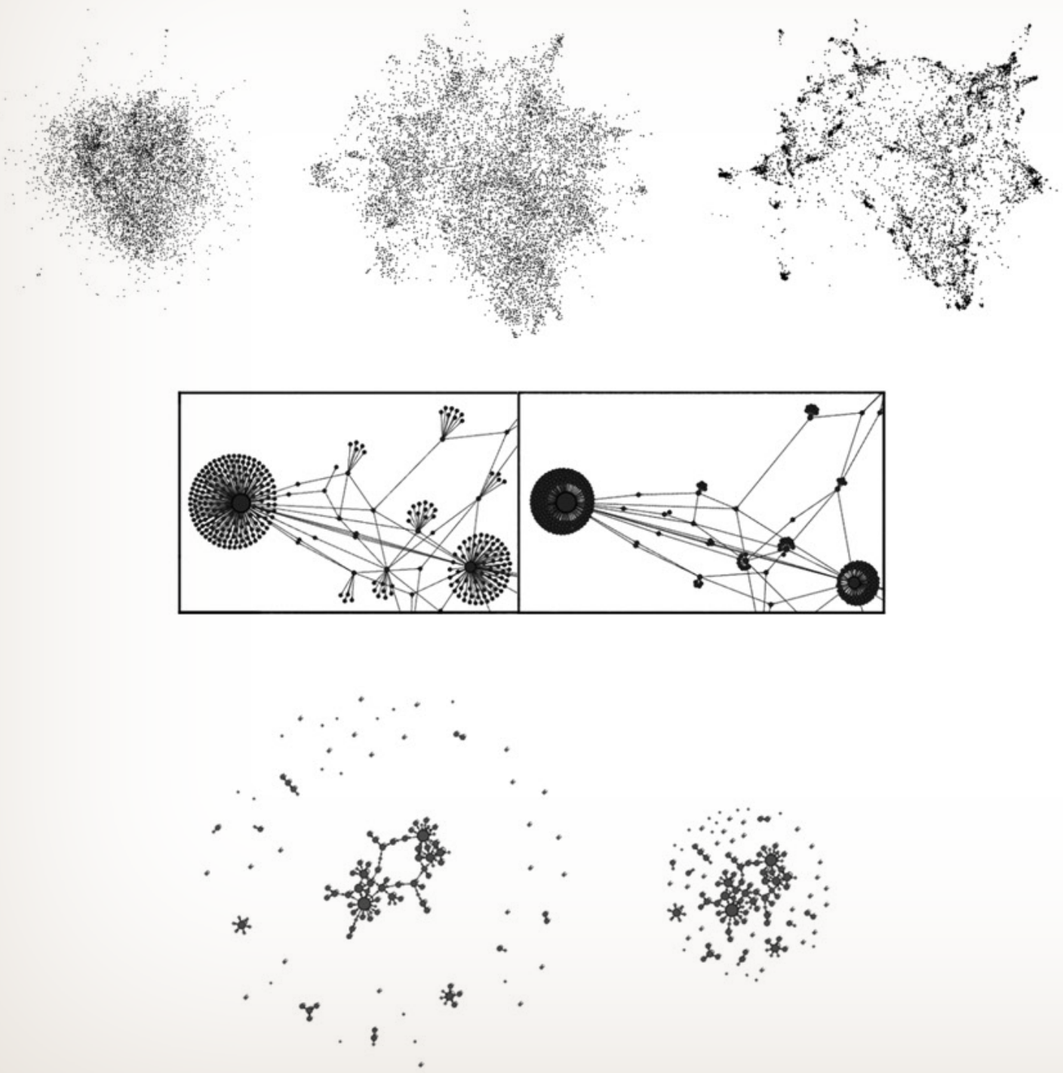


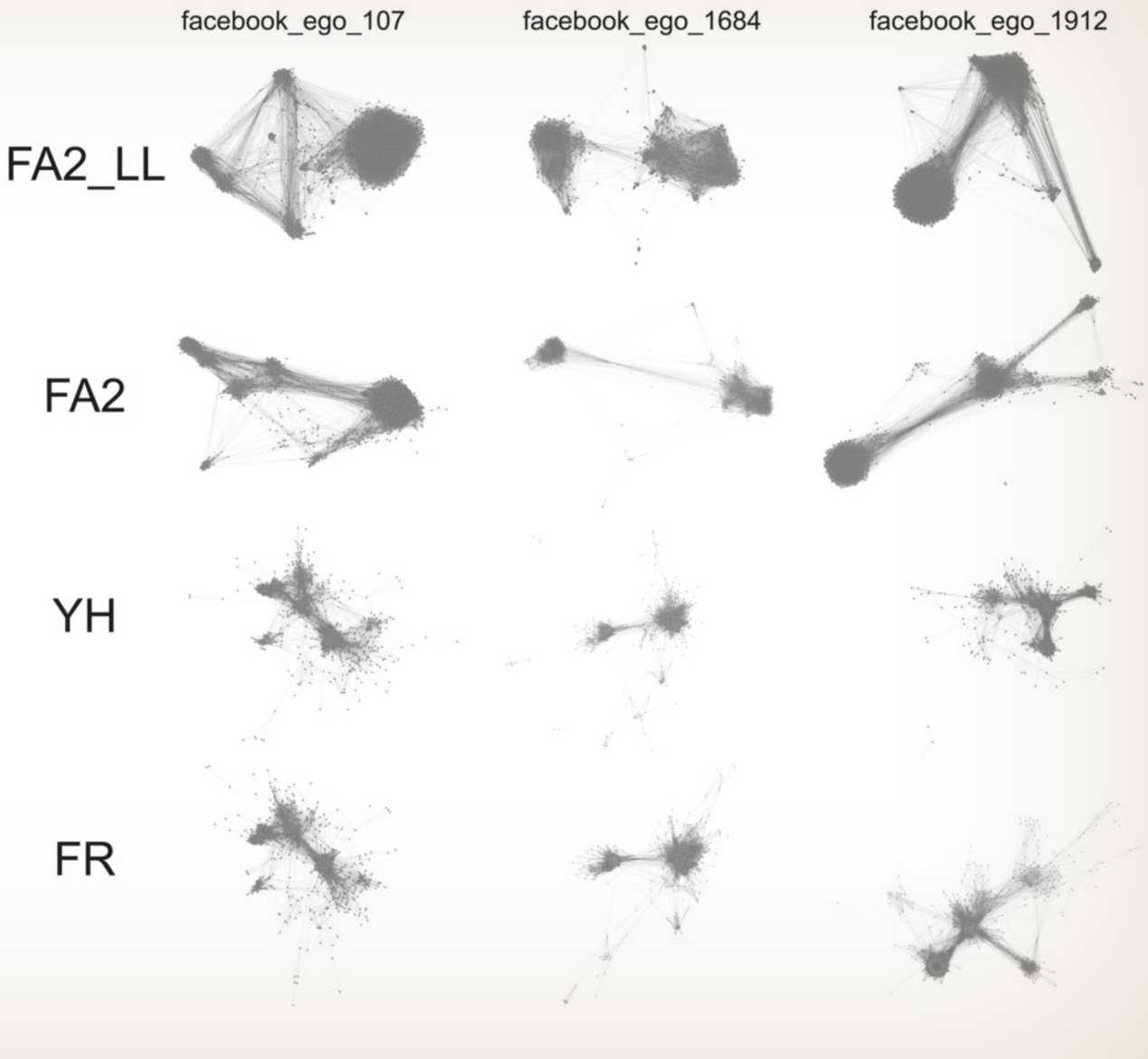
(c) Edge-repulsion LinLog model

Papers on layout algorithms
2014 Force Atlas 2

ForceAtlas2, A Continuous Graph Layout Algorithm for Handy Network Visualization designed for the Gephi software

Mathieu Jacomy*[1,2,3], Tommaso Venturini[1], Sebastien Heymann[3,4] Mathieu Bastian[3]





https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0098679

Thank you for your attention

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Mathieu.Jacomy@gmail.com