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Can a not-the-most-connected scientist still be important?

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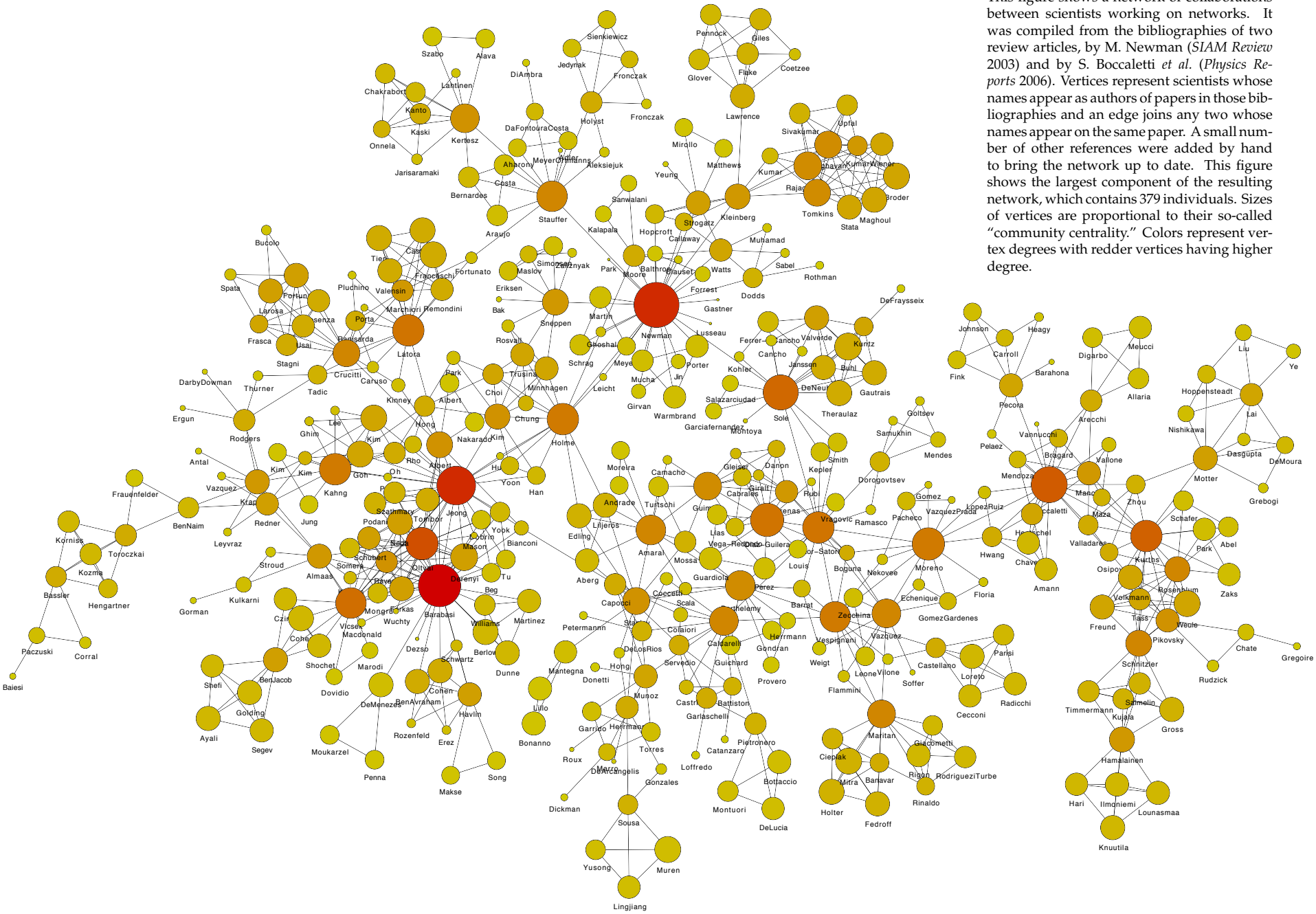
Collaborations Between Network Scientists

This figure shows a network of collaborations between scientists working on networks. It was compiled from the bibliographies of two review articles, by M. Newman (*SIAM Review* 2003) and by S. Boccaletti *et al.* (*Physics Reports* 2006). Vertices represent scientists whose names appear as authors of papers in those bibliographies and an edge joins any two whose names appear on the same paper. A small number of other references were added by hand to bring the network up to date. This figure shows the largest component of the resulting network, which contains 379 individuals. Sizes of vertices are proportional to their so-called "community centrality." Colors represent vertex degrees with redder vertices having higher degree.



http://www-personal.umich.edu/~mejn/centrality/poster.pdf

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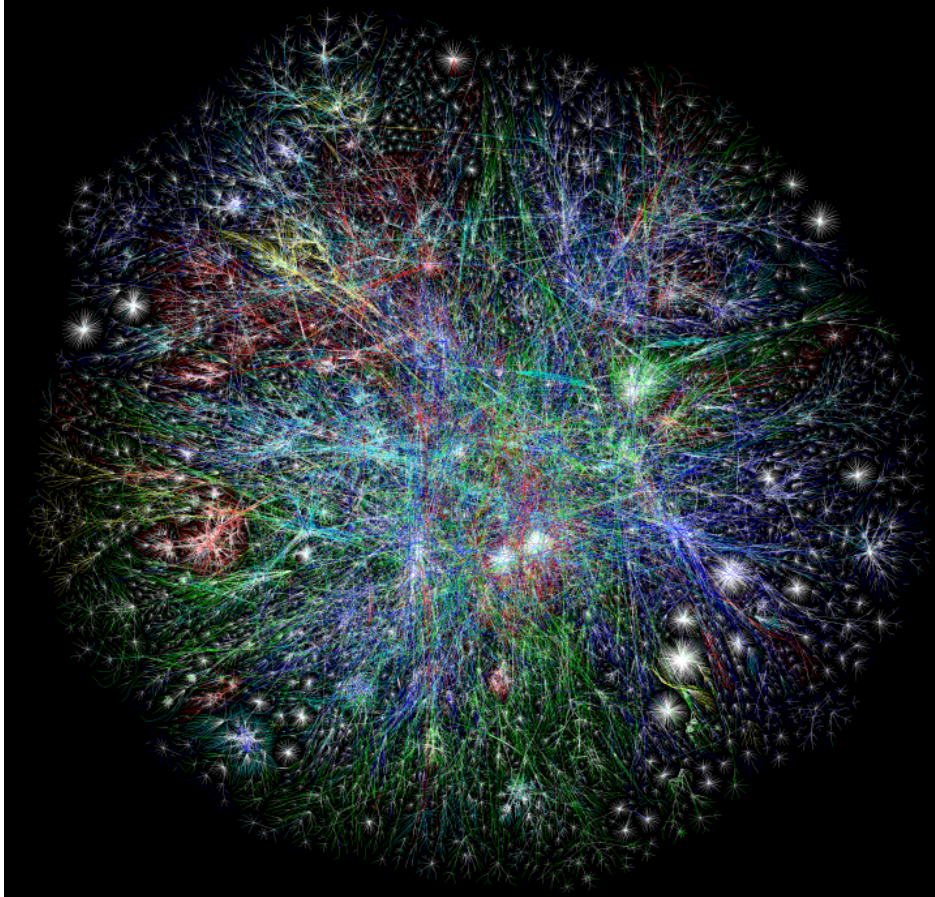
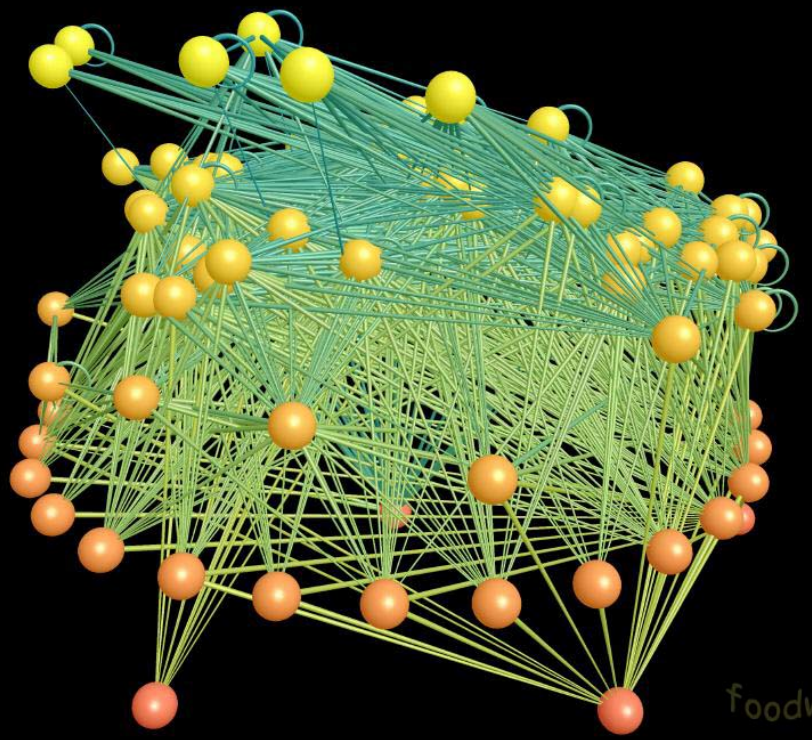
Finding important nodes in networks

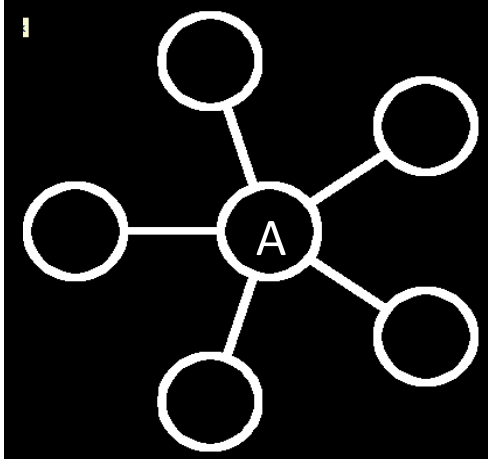


Source - http://myfoodprint.wordpress.com/2008/08/21/the-internet-is-not-all-bad/



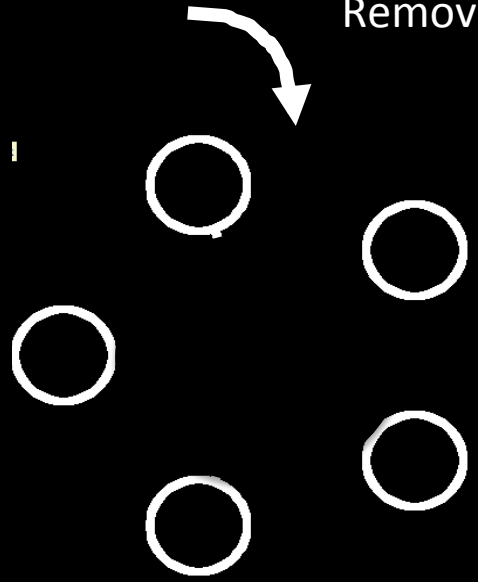
Caribbean Reef Trophic Web (foodwebs.org)
Optiz, S. Trophic interactions in Caribbean coral reefs. ICLARM Tech Rep 43, Manila, Philippines (1996)

Centrality



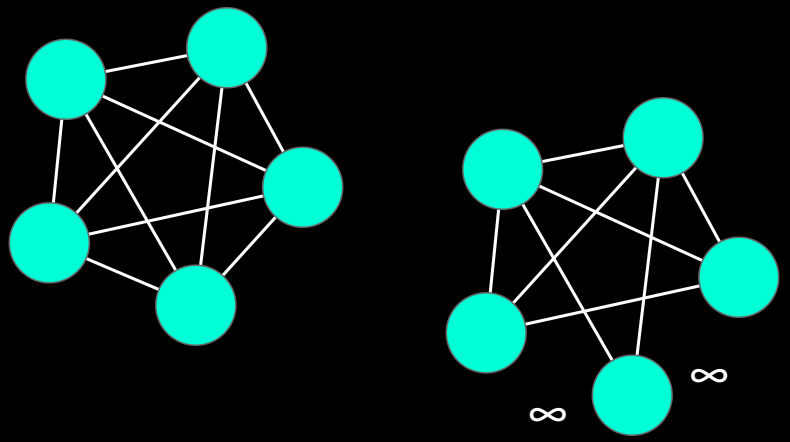
Node A – Highest degree and betweeness

Removing node A



Efficiency

A graph G(V,E) consists of
A set of nodes N and edges E



$$E_{global}(G) = \frac{\sum_{i \neq j \in G} E_{ij}}{N(N-1)} = \frac{1}{N(N-1)} \sum_{i \neq j \in G} \frac{1}{d_{ij}}$$

Latora et al Phys Rev Letts 87 (2001)

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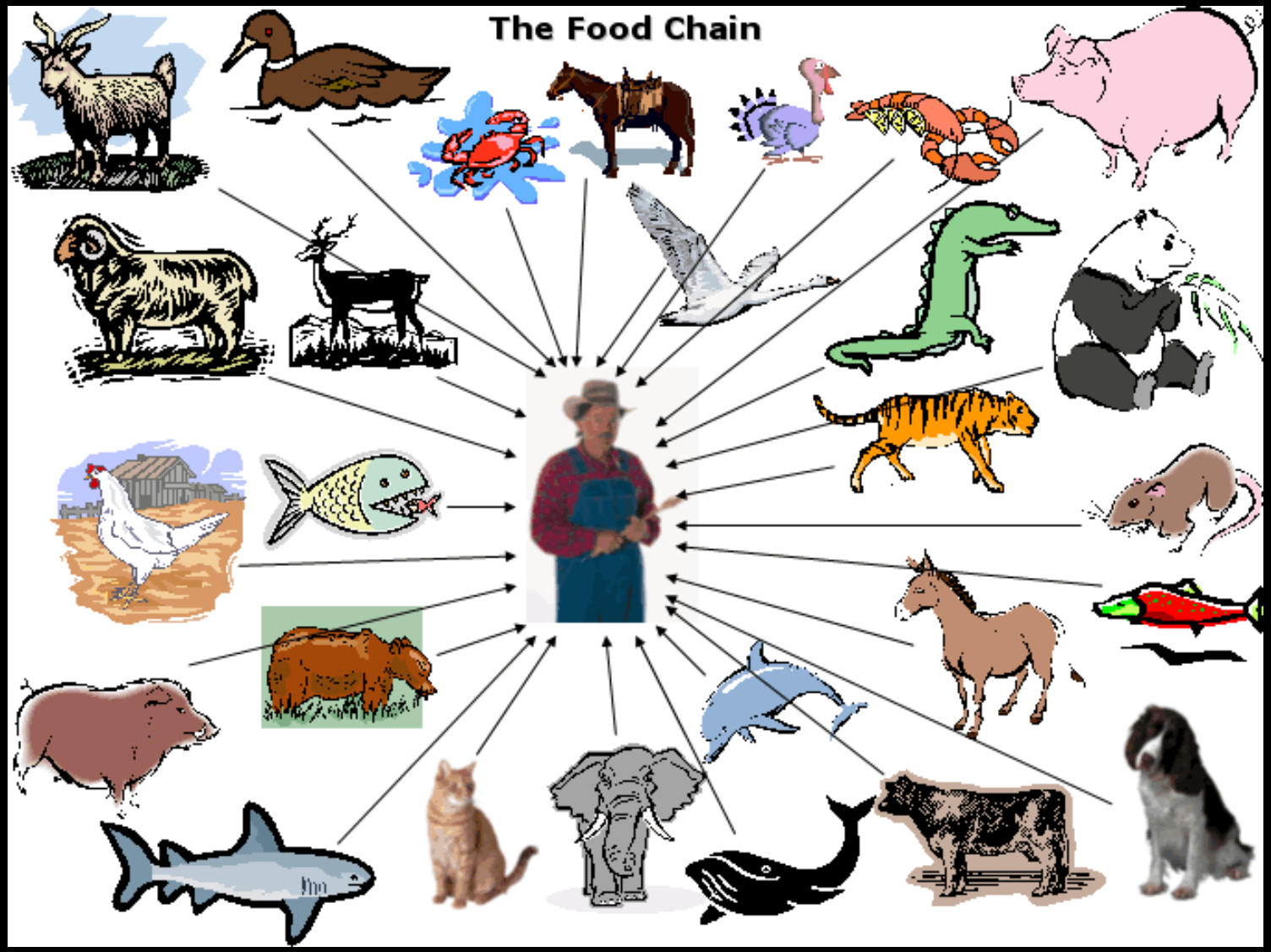
More complex than anticipated….



Source - http://blog.chrisworfolk.com/2006/10/31/the-food-chain/

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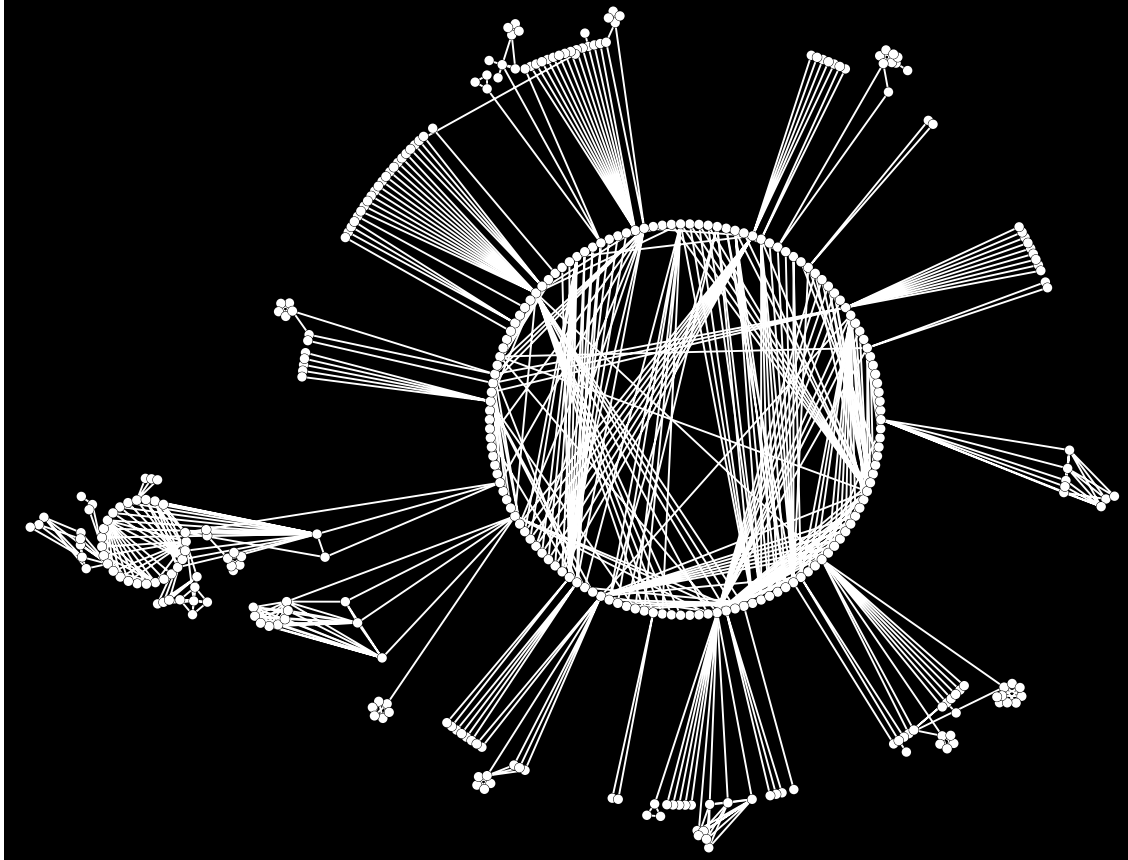
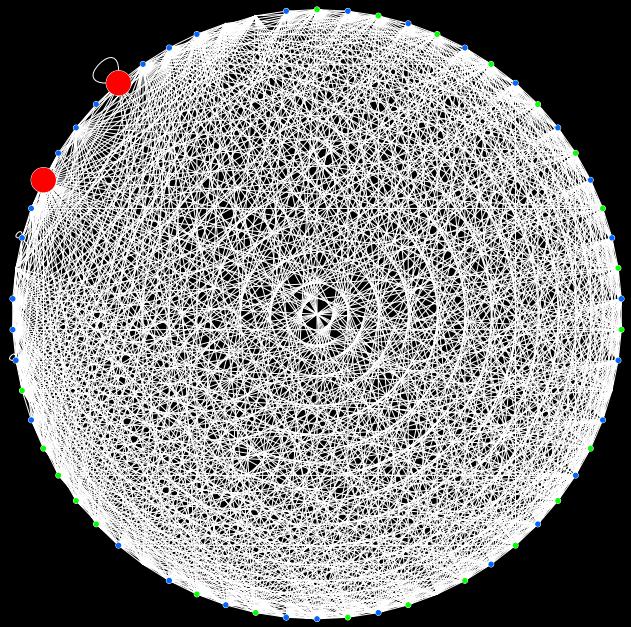
Different network configurations



Largest component of the network scientists
M. E. J. Newman, Phys. Rev. E 74, 036104 (2006)



A freshwater Food web in a stream in England - Data provided by Dr Guy Woodward, Imperial

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Network configurations

- Ghedini and Ribeiro discovered that some networks collapsed prior to removal of all high degree nodes (Physica A, 2011).
  - Suggested that such collapsed must have caused by other configurations in networks.

- Finding nodes that are strategically located in networks.

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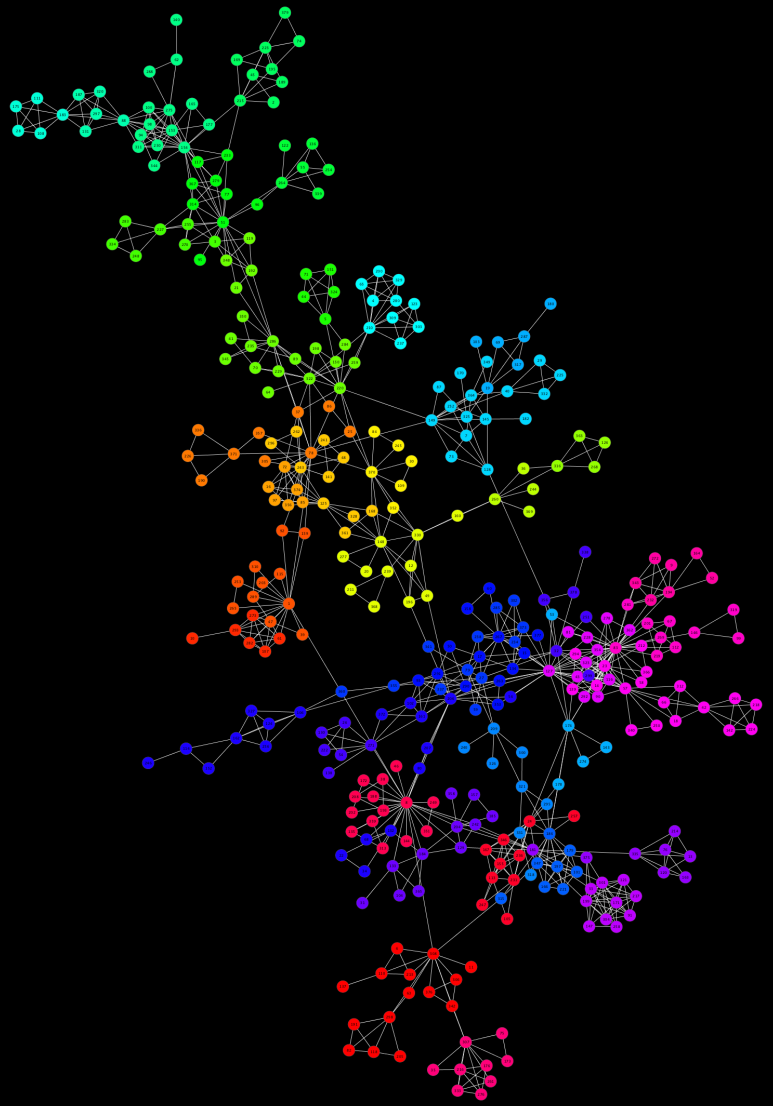
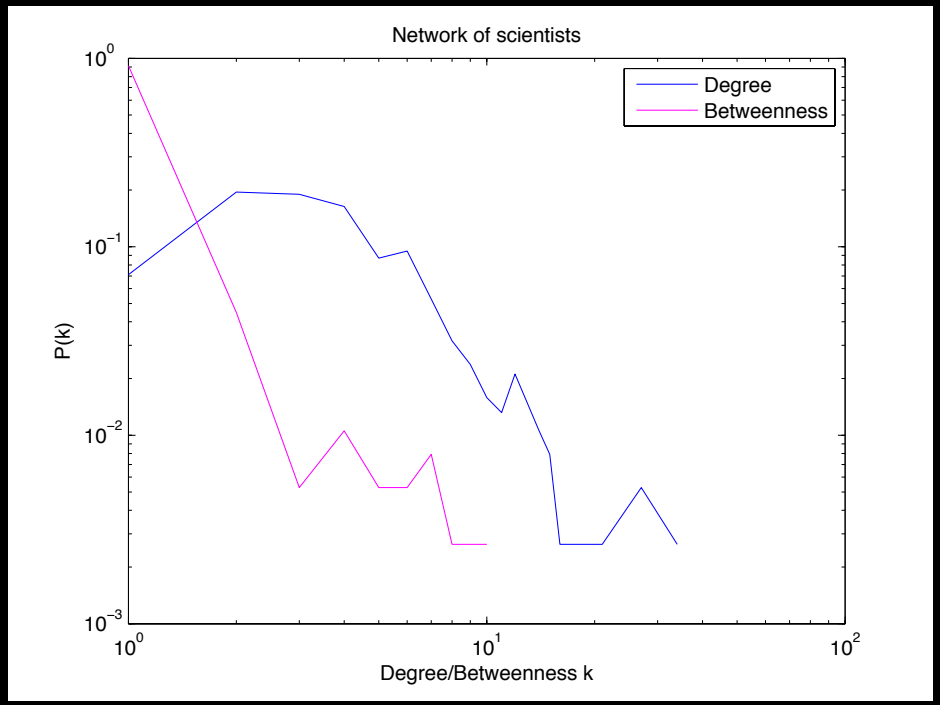
A network of scientists





M. E. J. Newman, Phys. Rev. E 74, 036104 (2006)

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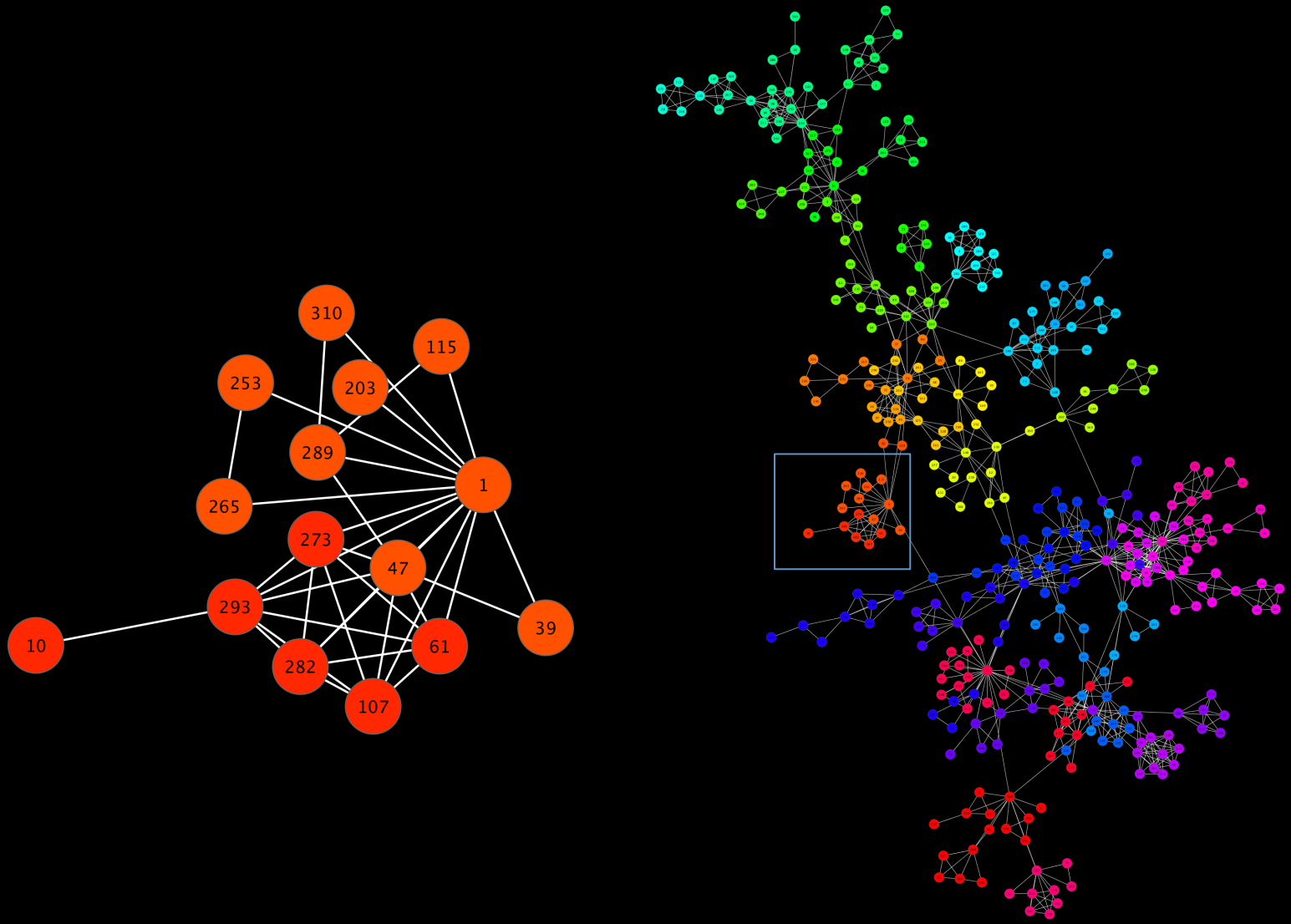
A network of scientists



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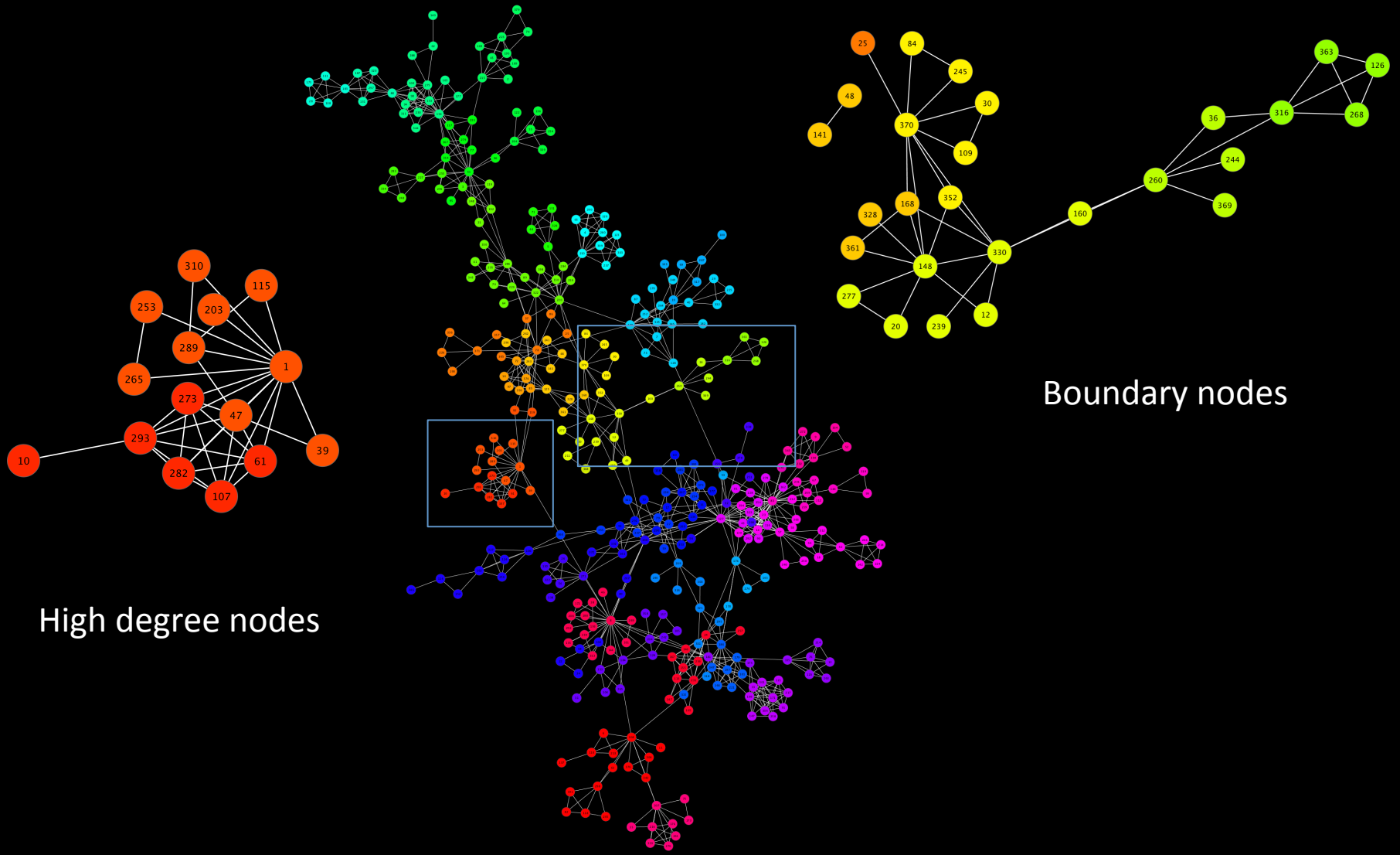
A network of scientists

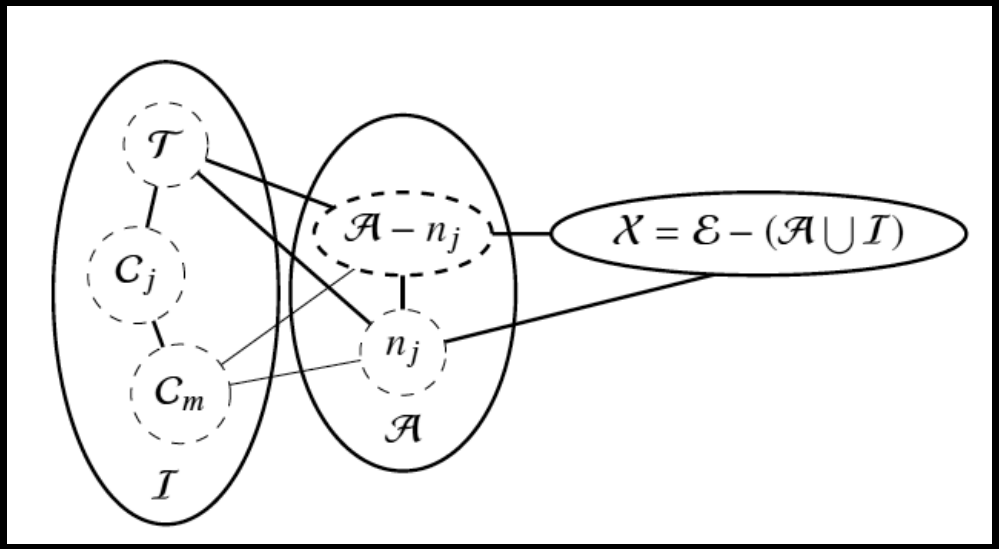


Boundary nodes

High degree nodes

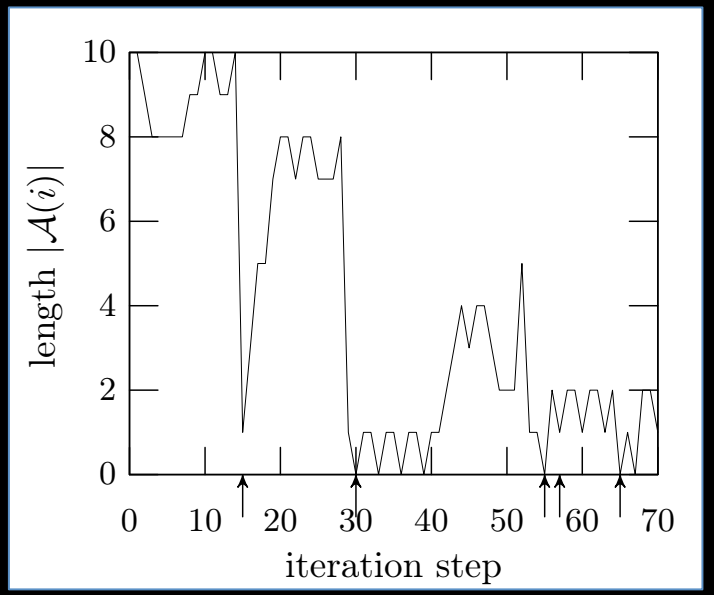
Node tearing

The rest of the nodes

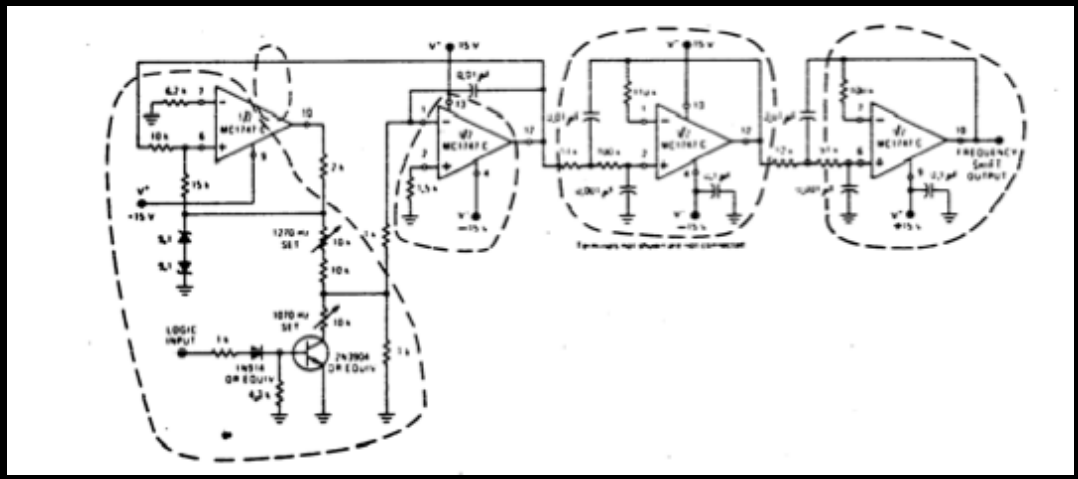


Iterating set

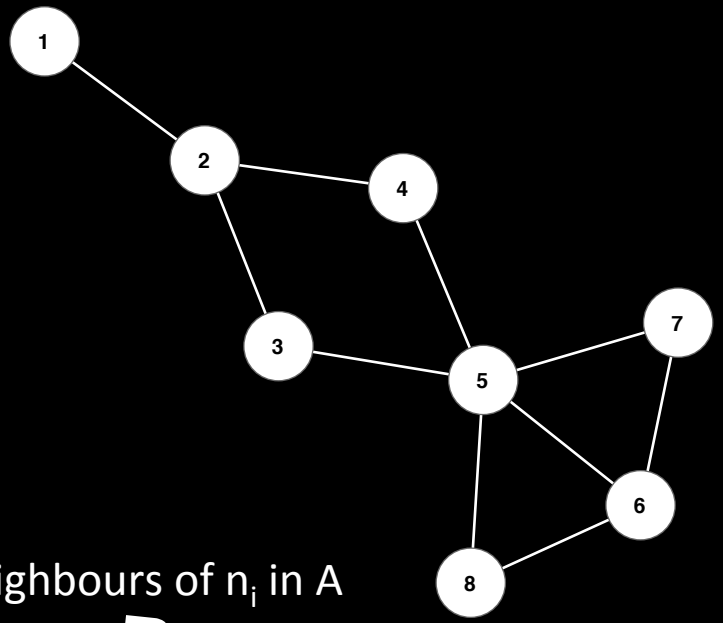
Adjacent set



A. Sangiovanni-Vincentelli et al, IEEE Trans on Circuits and Systems CAS–24 (1977) 709–717.



Node tearing

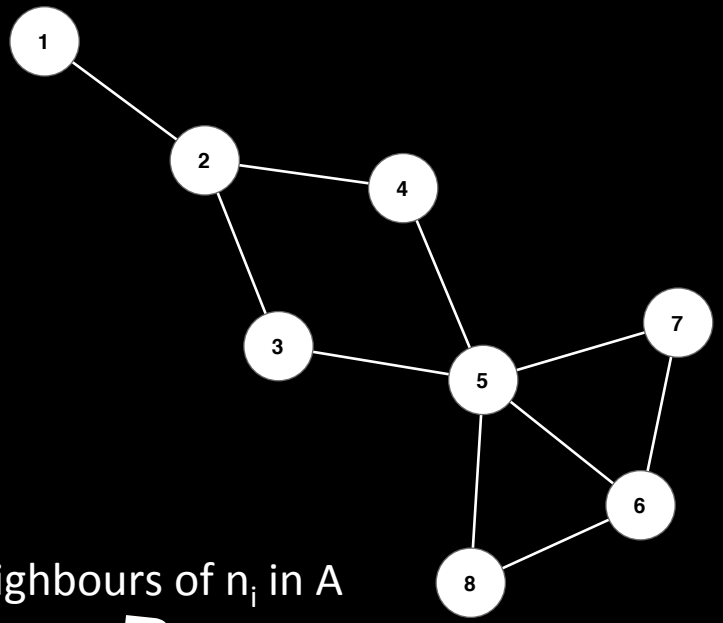


Put neighbours of n_i in A

Start with the node n_i with the min. degree, and put into I

Iterating set I	Adjacent set A	X – the rest
1	2	3,4,5,6,7,8

Node tearing



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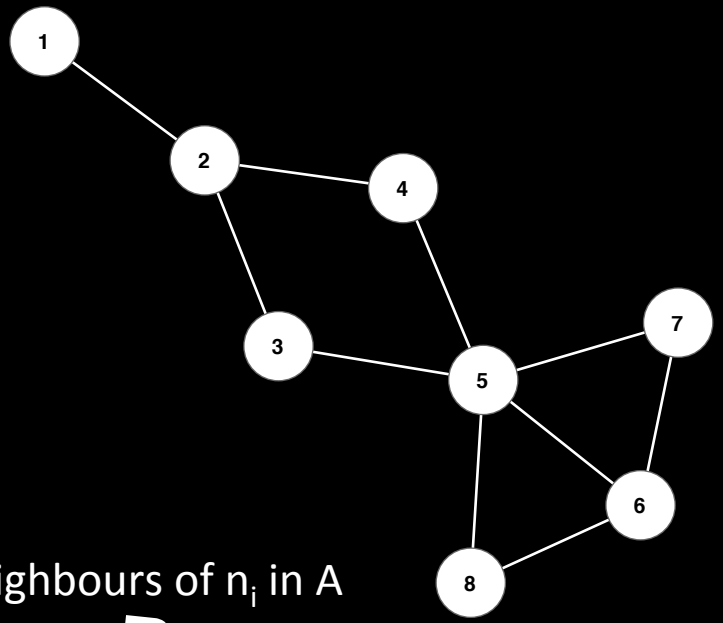
Select a node in A with least no of links with nodes in X

Node tearing



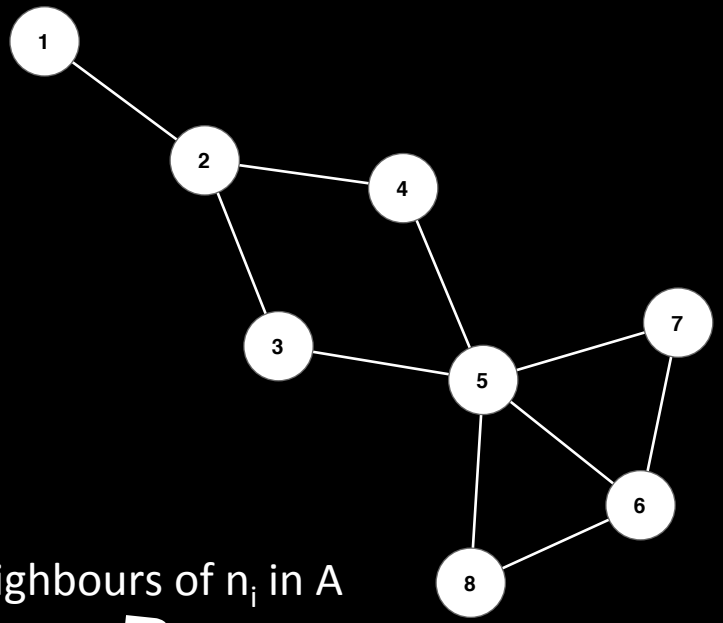
Put neighbours of n_i in A

Start with the node n_i with the min. degree, and put into I

Select a node in A with least no of links with nodes in X

Iterating set I	Adjacent set A	X – the rest
1	2	3,4,5,6,7,8
1,2	3,4	5,6,7,8
1,2,3	4,5	6,7,8
1,2,3,4	5	5,6,7,8
1,2,3,4,5	6,7,8	--

Node tearing



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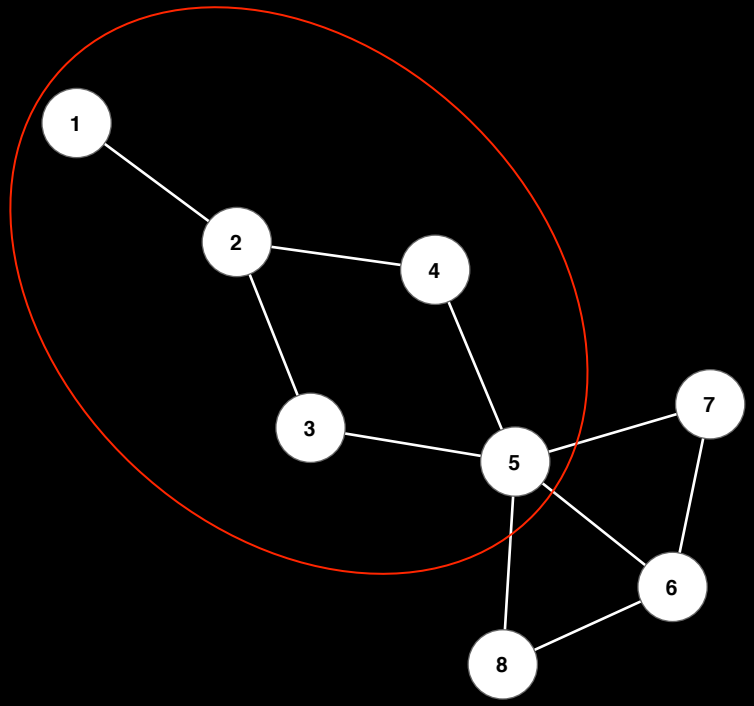
1,2,3	4,5	6,7,8
1,2,3,4	5	5,6,7,8
1,2,3,4,5	6,7,8	--

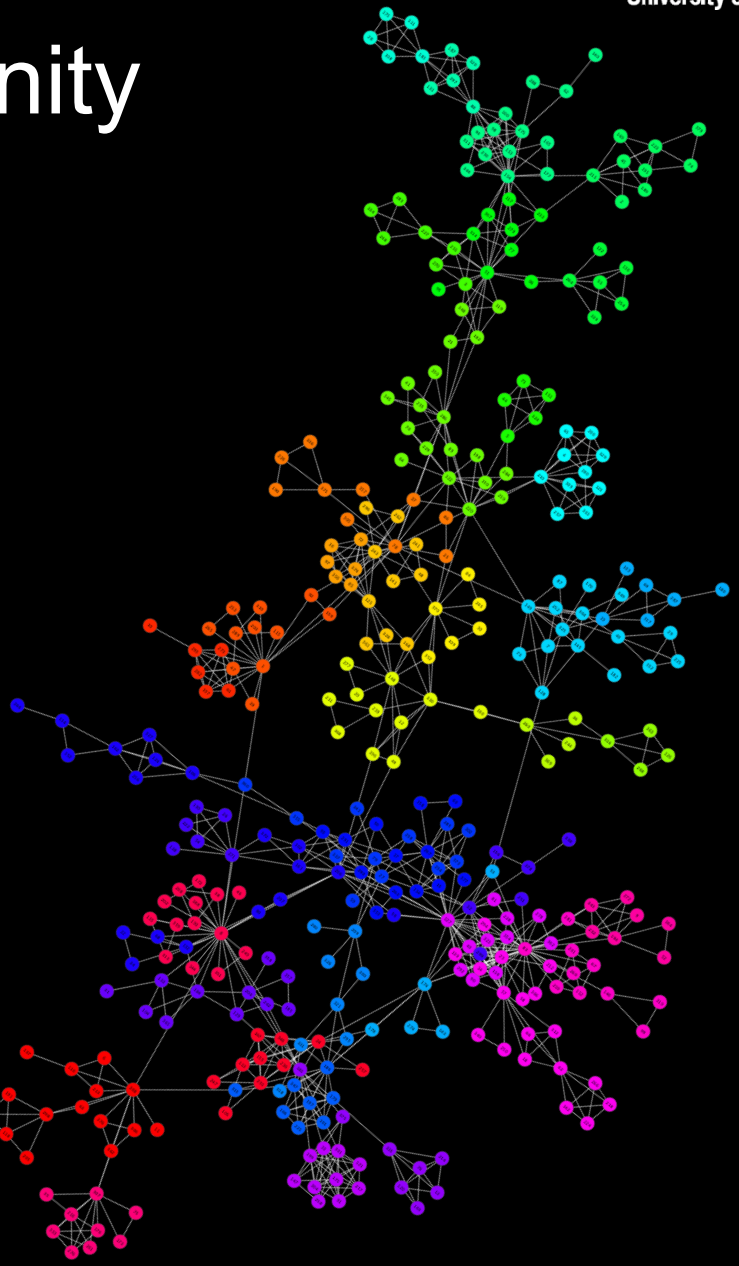
Select a node in A with least no of links with nodes in X

A "cluster" is found when |A| is min.

Cluster(s) ⇔ community



$K_{in}(C_j) = 10$
$K_{out}(C_j) = 3$



- Finding "cuts" in the graph to define clusters.
- Satisfying the weak community definition by Radicchi et al.
  $K_{in}(C_j)/K_{out}(C_j) > 1$

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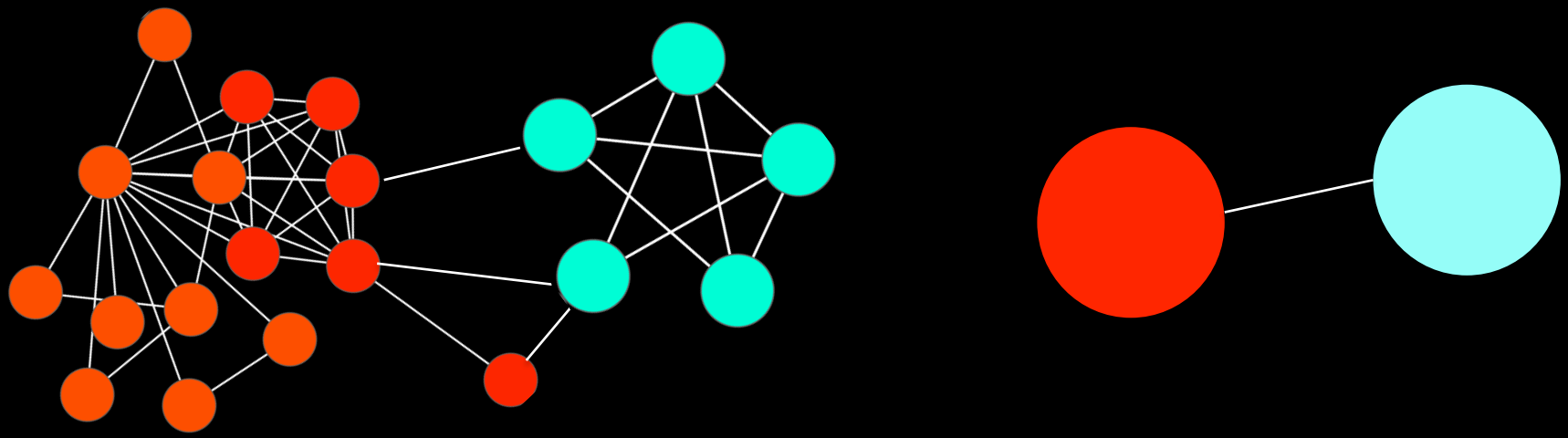
Ranking boundary nodes

- Depends on the hierarchy and connectivity with neighbouring communities.
- Rank from the top level by a node's participation with neighbouring communities.

"Cut nodes"

Bridging communities and hence have strongly influence on the *flow* in a network.

Removal of cut nodes may result in isolated communities or splitting communities



Level 0 → Level 1

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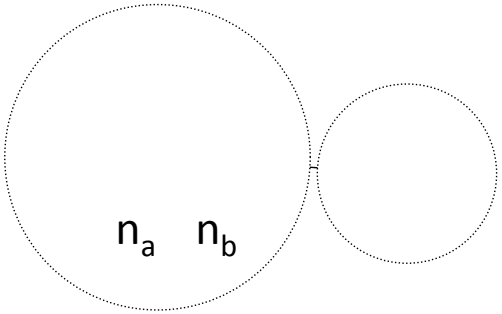
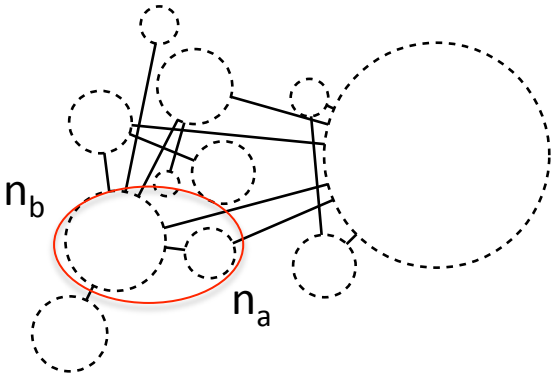
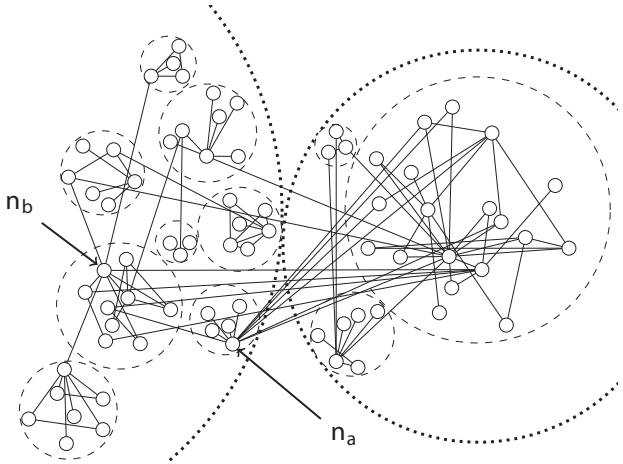
Finding important nodes …

- Degree
- Cut-nodes – ranked by a node's participation with other communities, from the top hierarchy.
- Running-rank – using cut-nodes but re-rank every time a node is removed





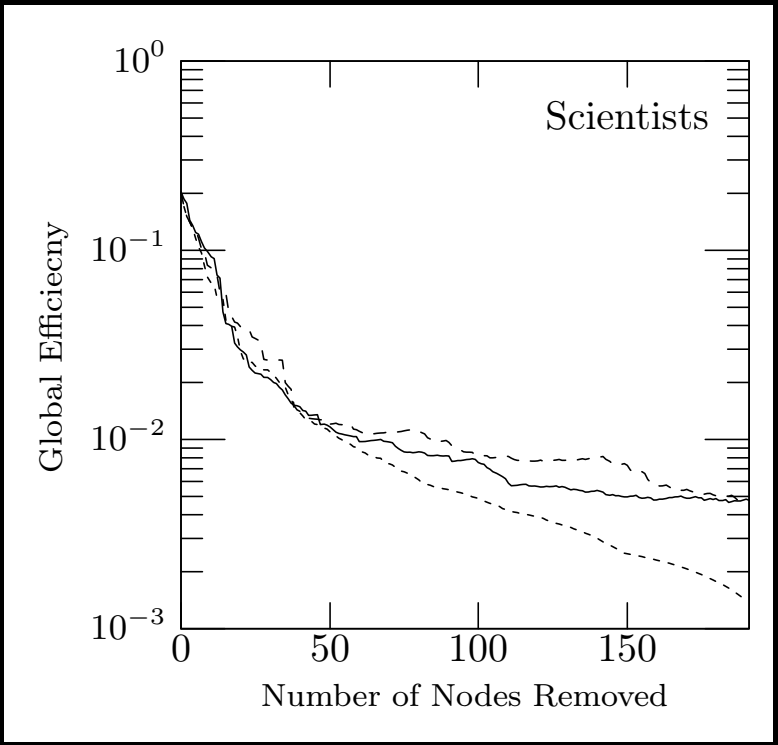


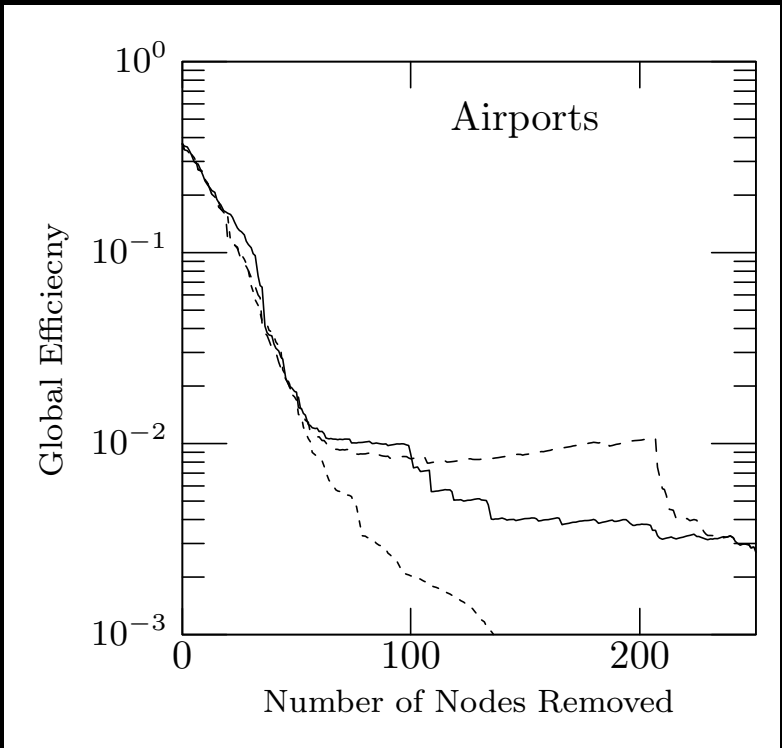
$n_a = 1$
$n_b = 1$

$n_a = 2$
$n_b = 4$

$n_a = 8$
$n_b = 11$

Effect on efficiency

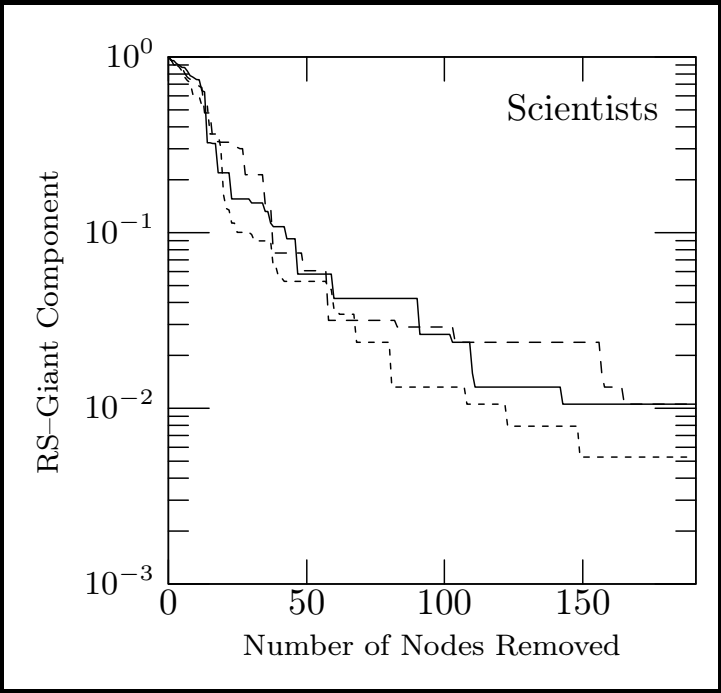


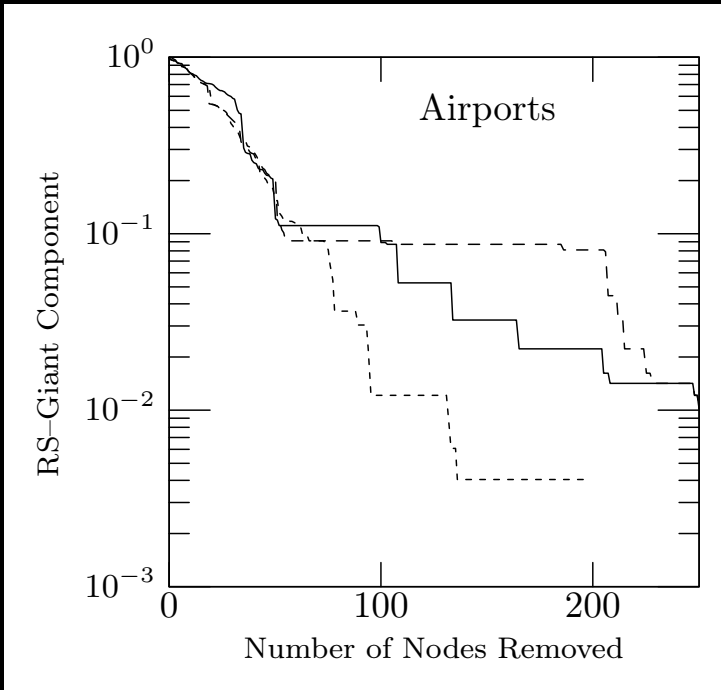


Decrease in efficiency when 50% of the nodes are removed.
Solid - Degree
Dashed – cut-nodes
Dotted – Running rank

A. Ma & R.J. Mondragón, Physica A Vol.391, 24 (2012)

Effect on the size of the giant component

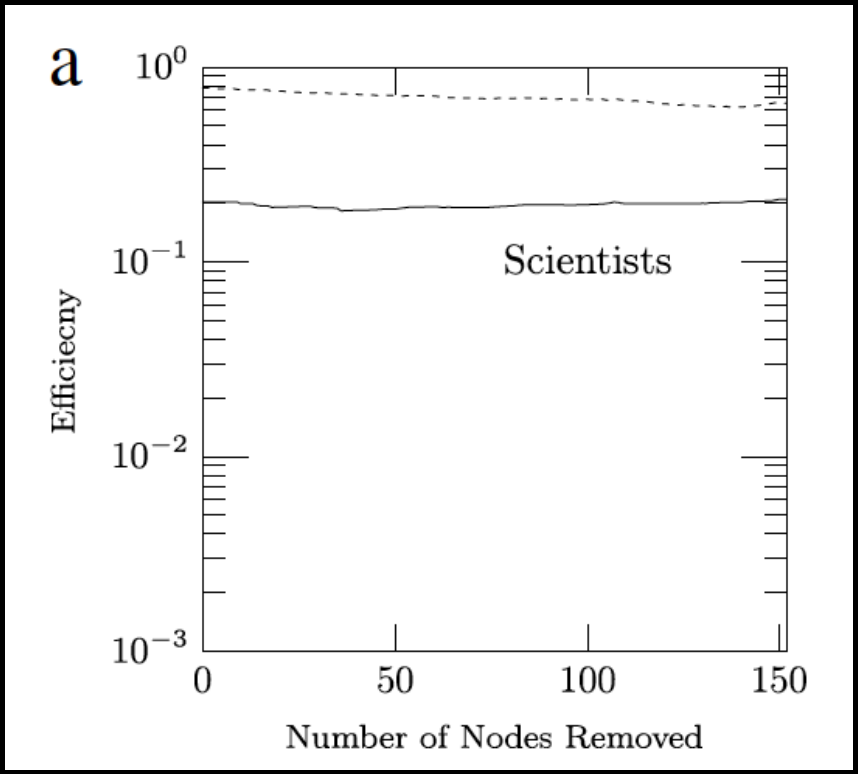


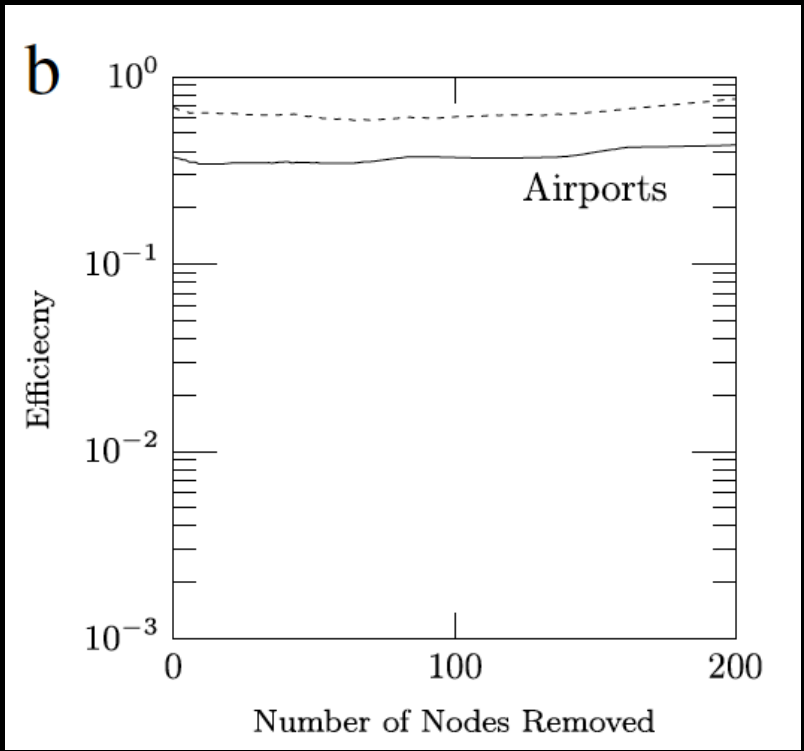


Decrease in efficiency when 50% of the nodes are removed.
Solid - Degree
Dashed – cut-nodes
Dotted – Running rank

A. Ma & R.J. Mondragón, Physica A Vol.391, 24 (2012)

Removing internal nodes….





Decrease in global and local efficiencies when 40% of the nodes are removed.
Solid – Global efficiency
Dashed – Average local efficiency

A. Ma & R.J. Mondragón, Physica A Vol.391, 24 (2012)

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Conclusions

- Take the overall network structure into consideration when examining a node's significance.
- Network hierarchical and modular structure help define nodes in the boundary areas.
- Results have shown that cut-nodes do have substantial impact on network efficiency, sometime regardless of its degree.

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Thank you!

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