Edge Clustering in Human Brain Graphs

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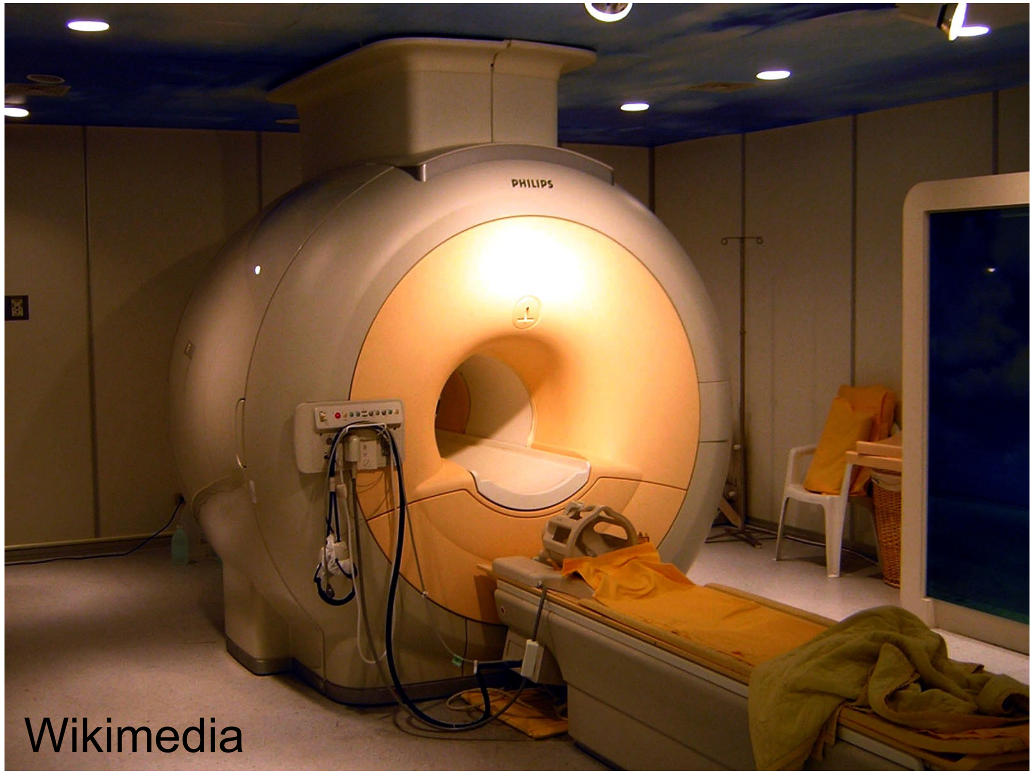
Aim

- Investigate the organization of human brains
- Change in:
  - Aging
  - Training
  - Disease

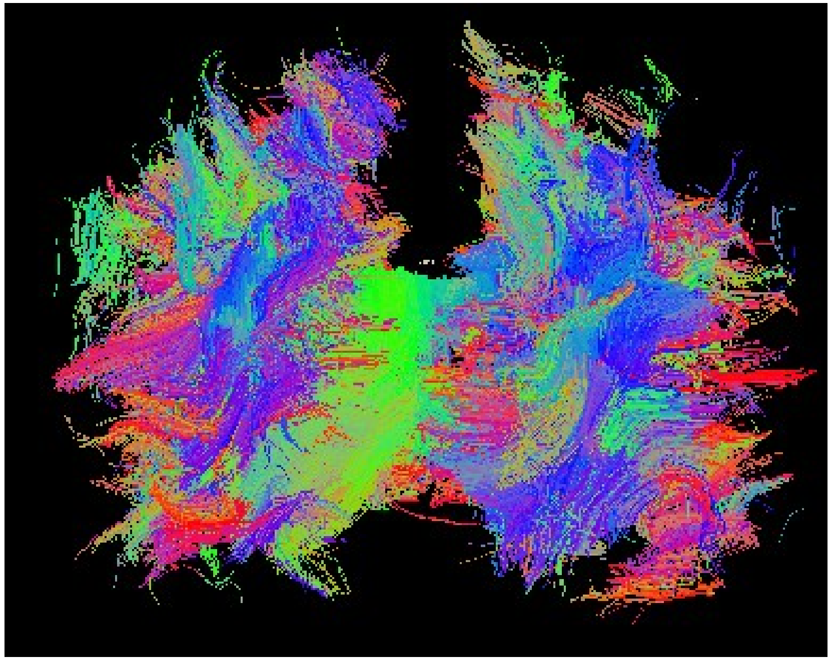
Magnet Resonance Imaging (MRI)

- Strong magnetic field
- Distinct magnetic properties of different tissue
- → image



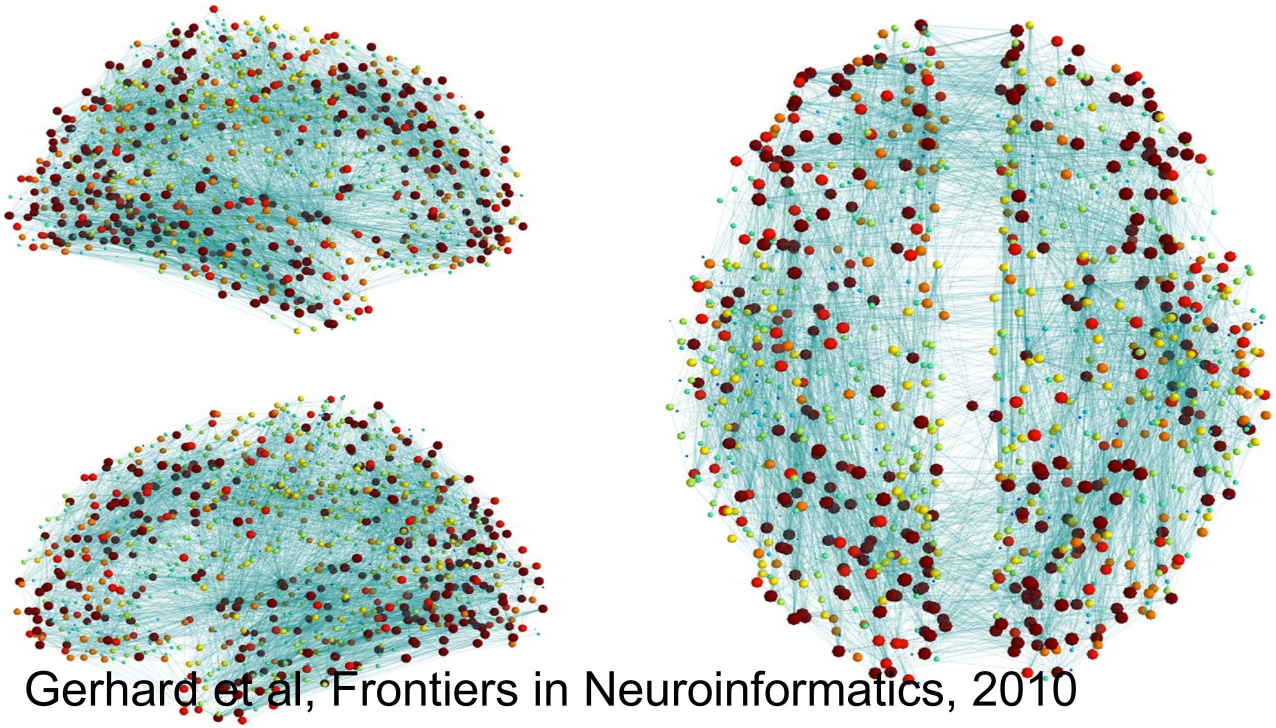
Diffusion MRI

- diffusion process of molecules
- more rapidly in direction of internal fiber structure



Graph Definition

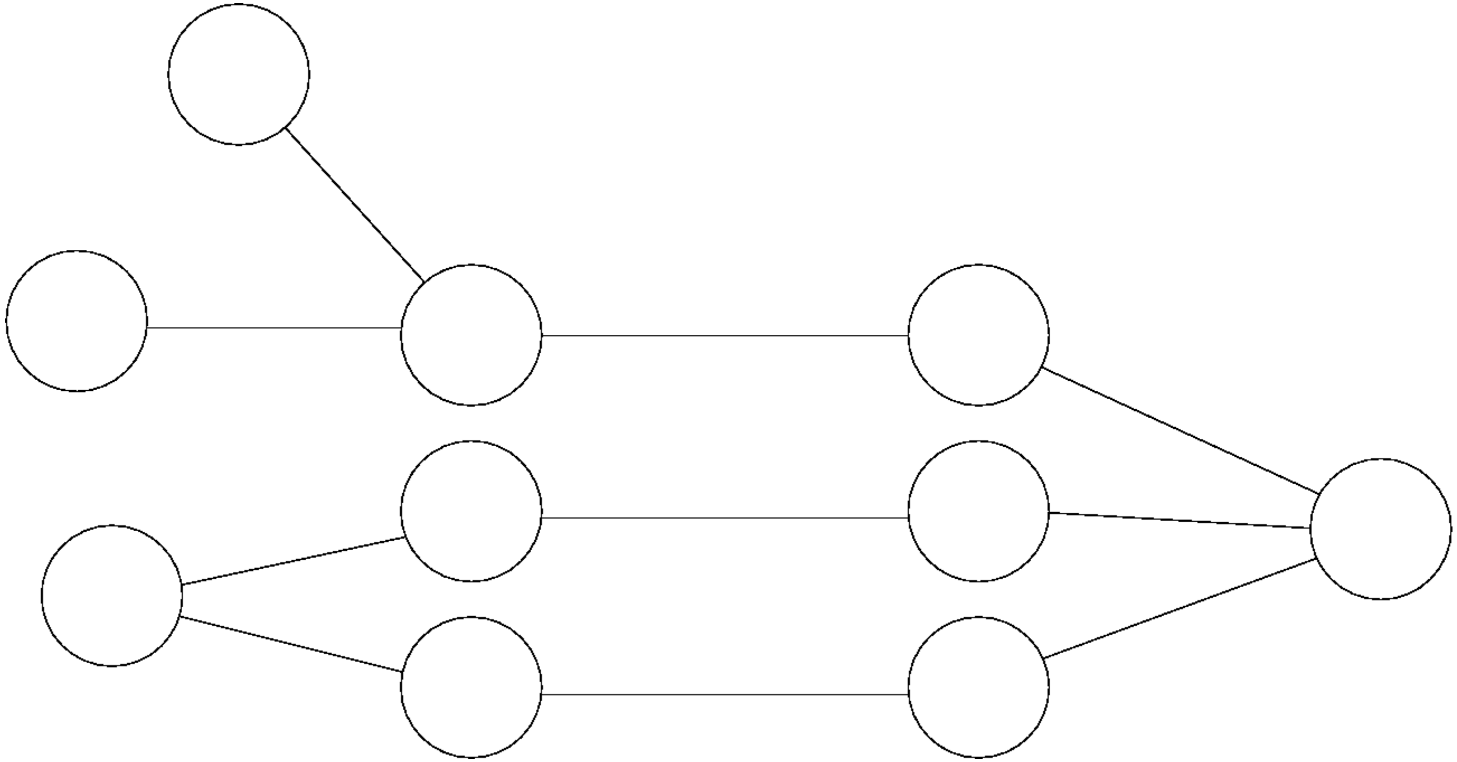
- 3D pixel -> vertices
- fiber - tracts -> edges



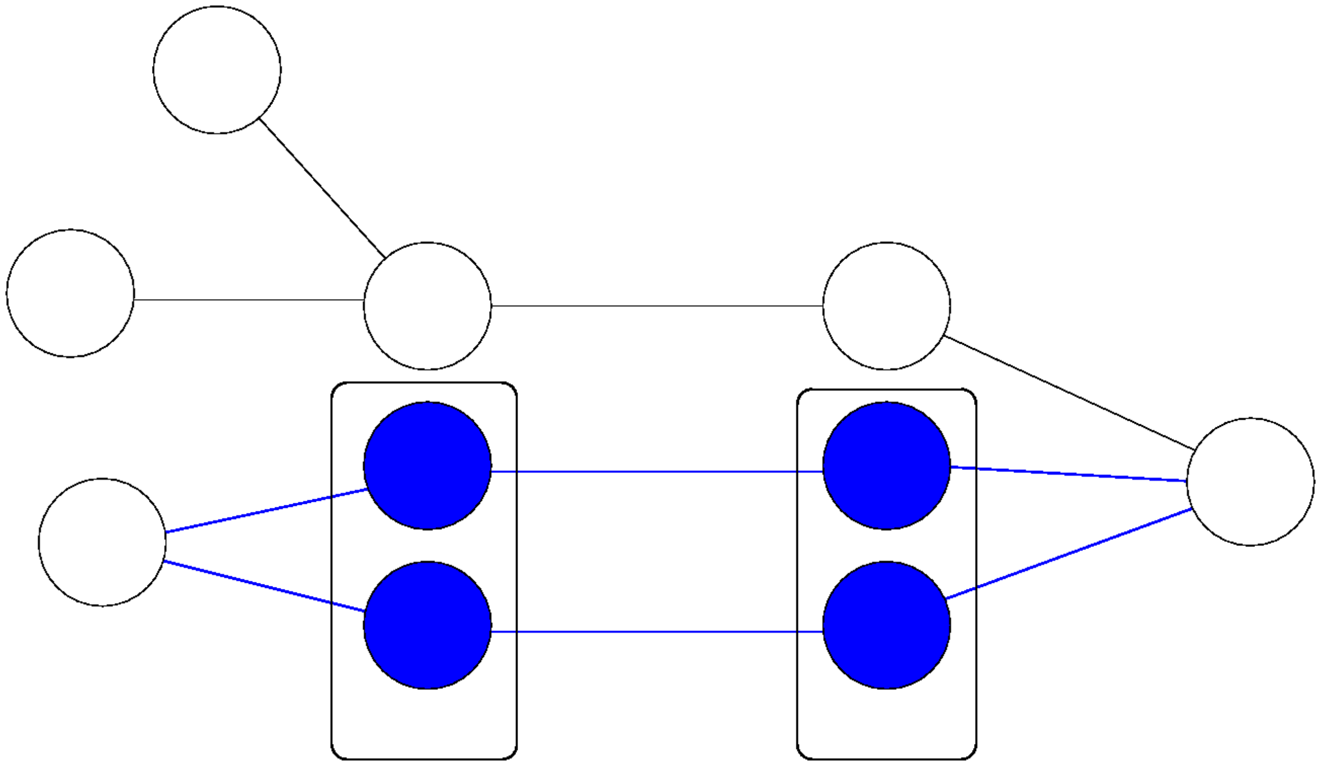
Gerhard et al, Frontiers in Neuroinformatics, 2010

Reasonable Units and Hypergraphs

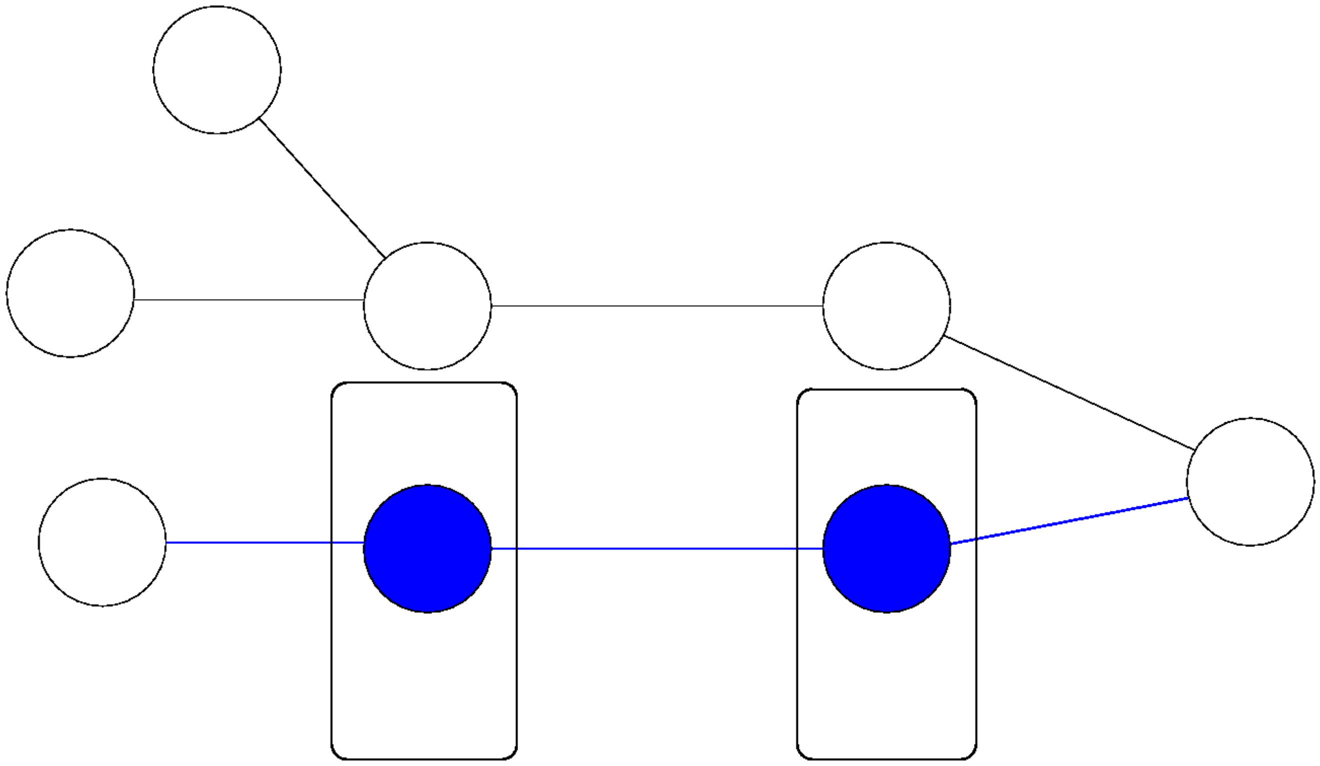
- 3mm isotropic cube a reasonable brain unit?
- Hypergraphs



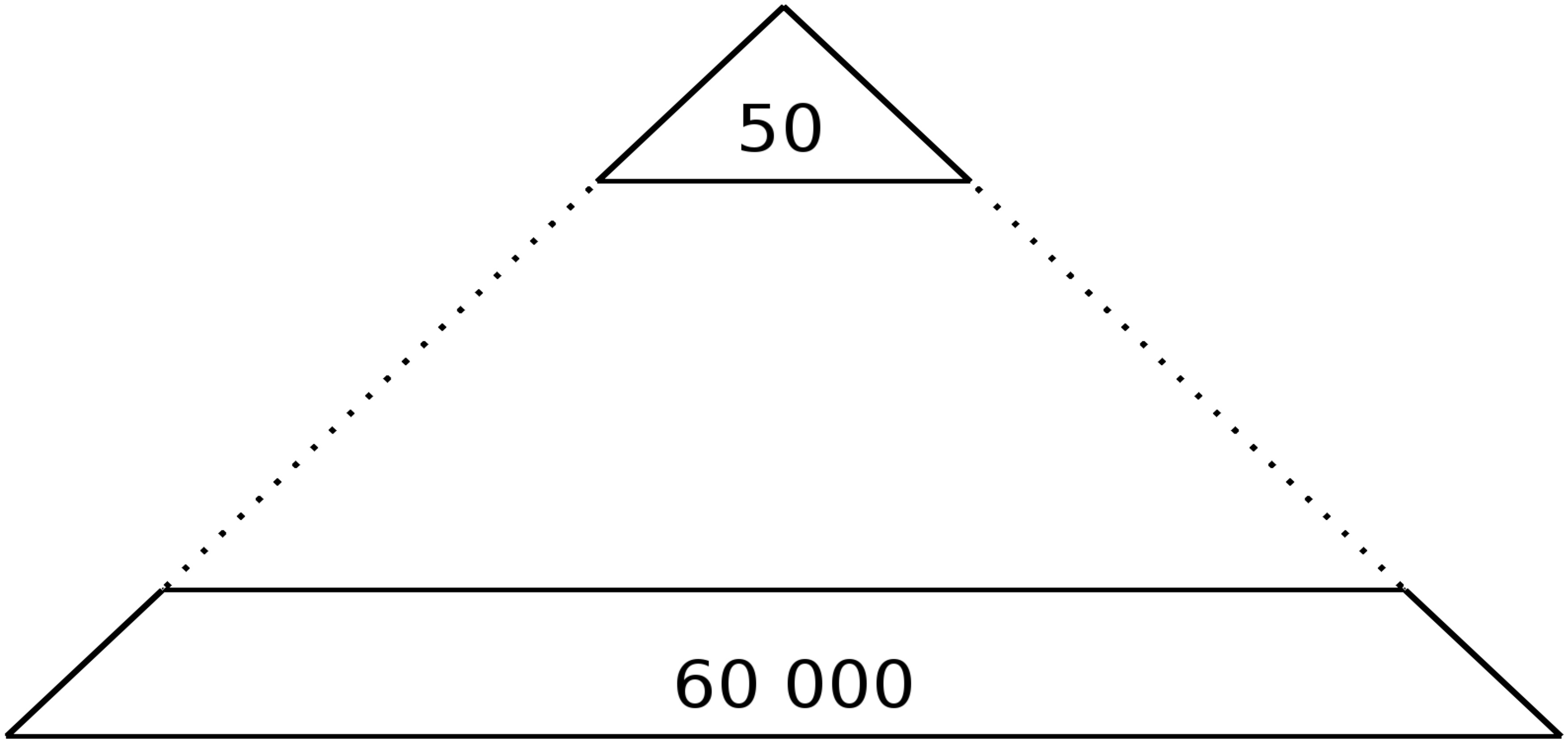
Reasonable Units and Hypergraphs



Reasonable Units and Hypergraphs



Reasonable Units and Hypergraphs



Link Communities

Vol 466 | 5 August 2010 | **doi:10.1038/nature09182**

nature

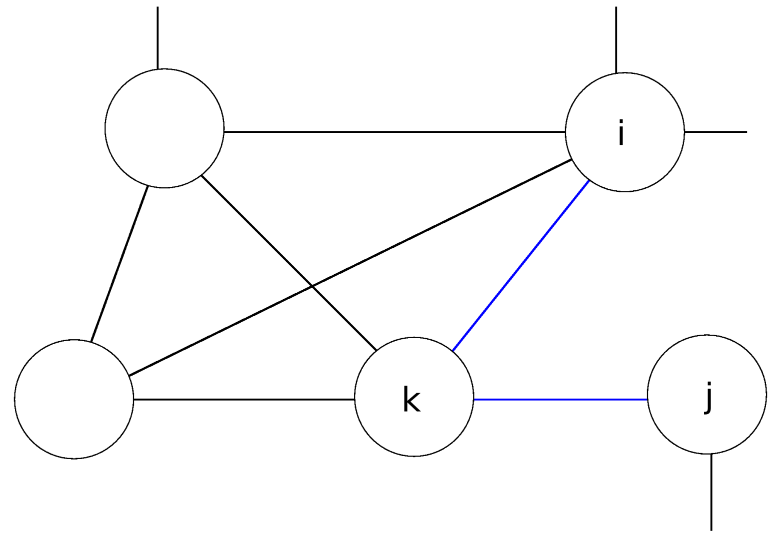
LETTERS

Link communities reveal multiscale complexity in networks

Yong-Yeol Ahn[1,2]*, James P. Bagrow[1,2]* & Sune Lehmann[3,4]*

Idea

$$S(e_{ik}, e_{jk}) = \frac{|n_+(i) \cap n_+(j)|}{|n_+(i) \cup n_+(j)|}$$



Idea

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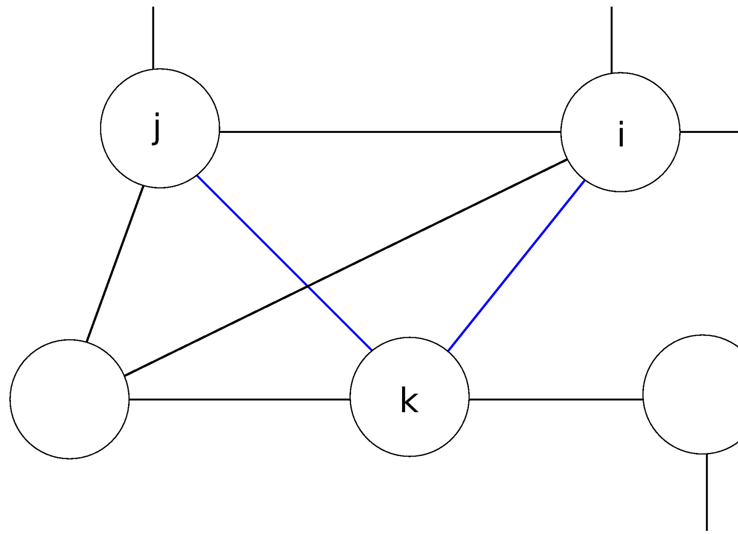
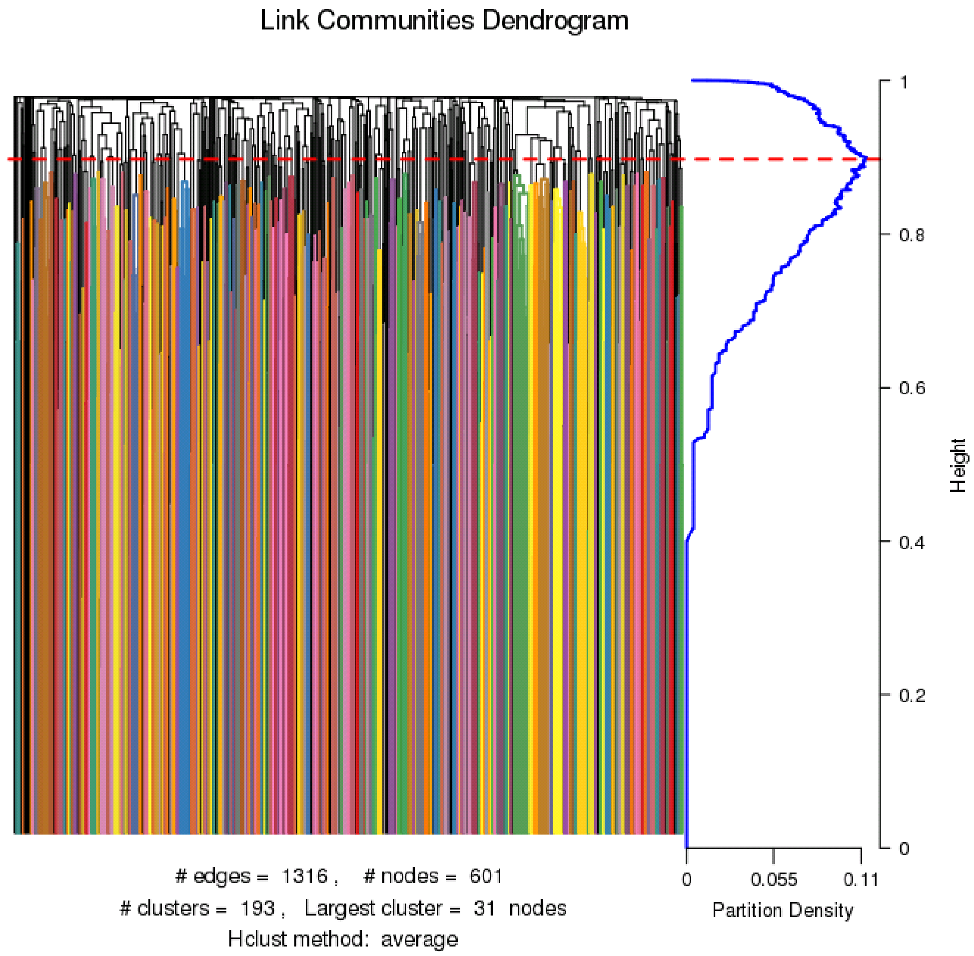
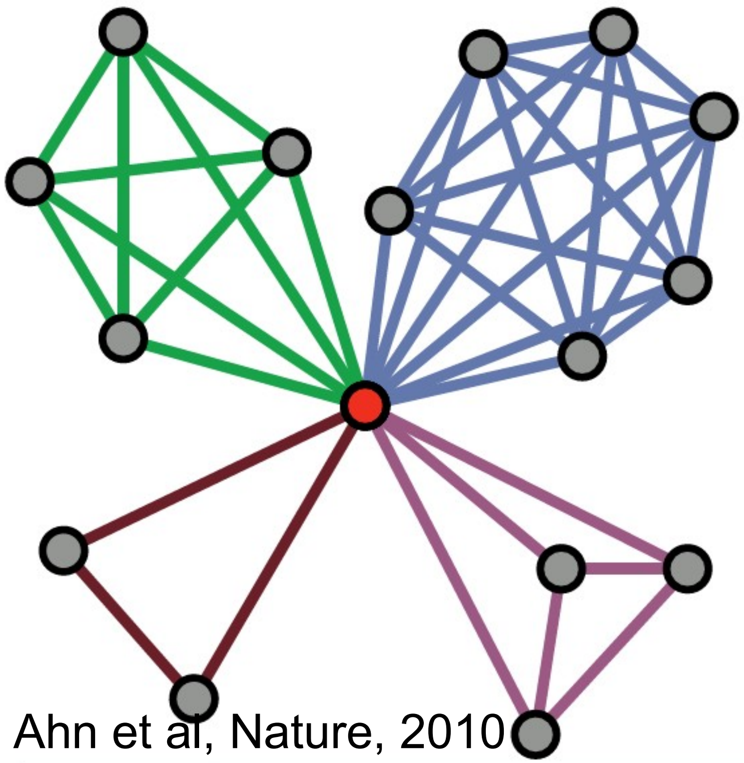


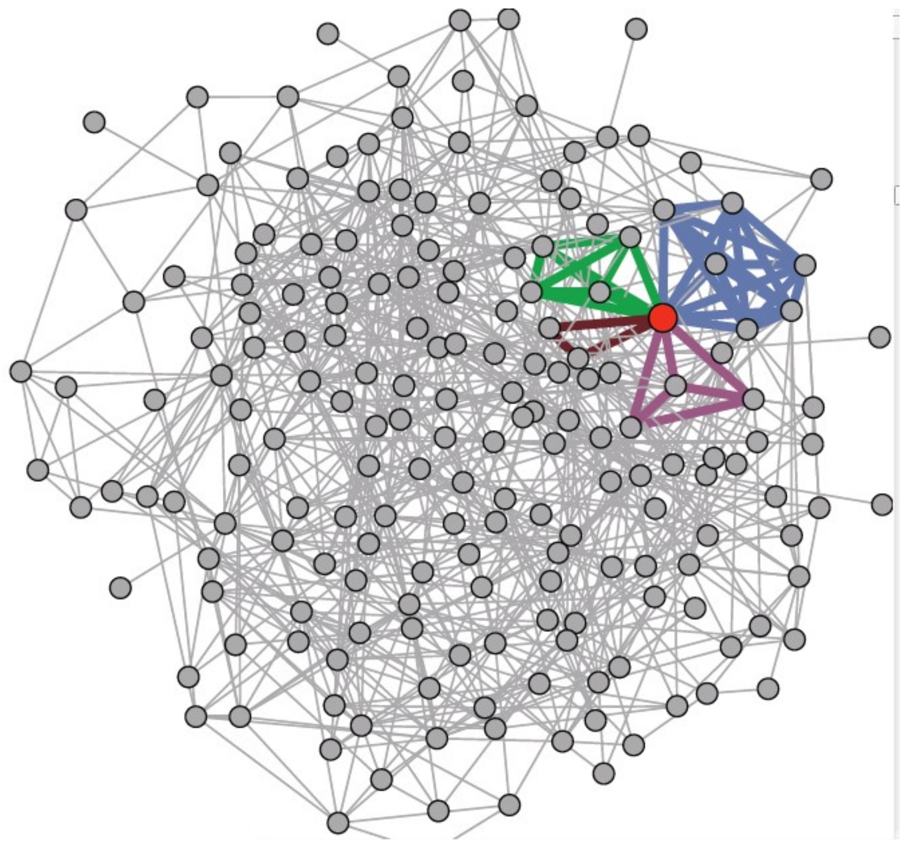
Idea


Link Communities Dendrogram
1
0.8
0.6
0.4
0.2
0
Height
0
0.055
0.11
Partition Density
edges = 1316 , # nodes = 601
clusters = 193 , Largest cluster = 31 nodes
Hclust method: average

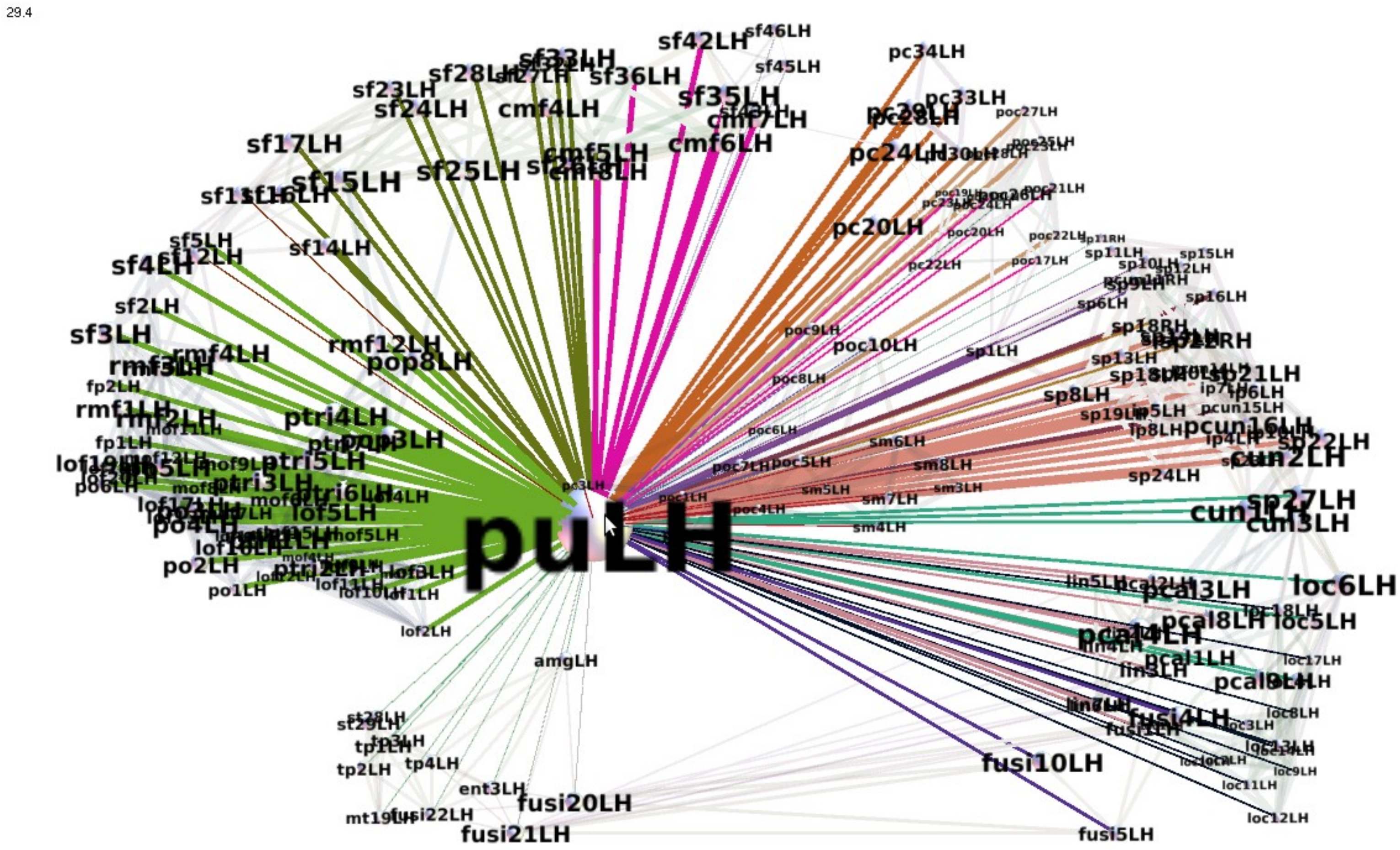
Illustration



Ahn et al, Nature, 2010



Edge Cluster Putamen Left Hemisphere



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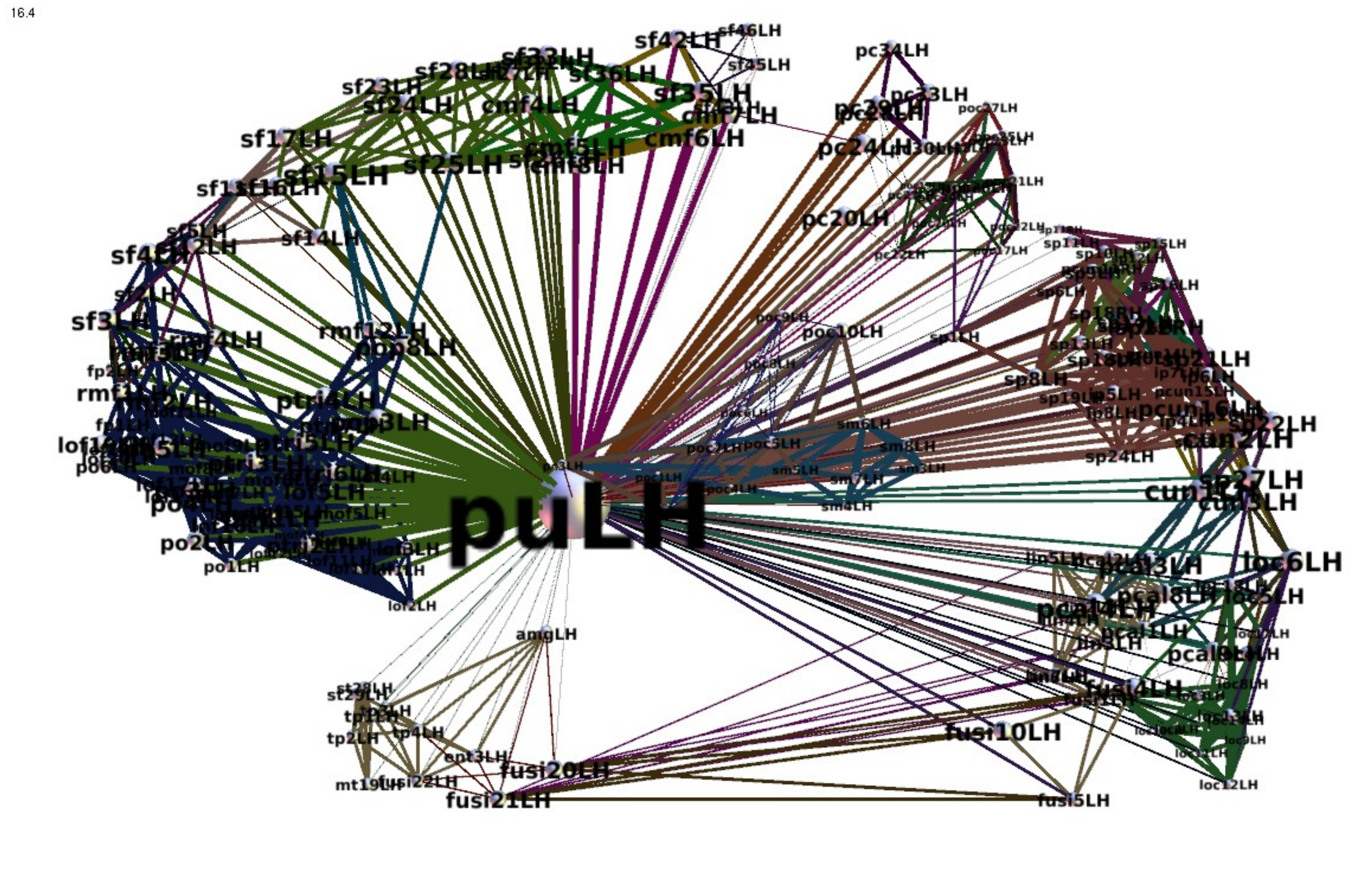
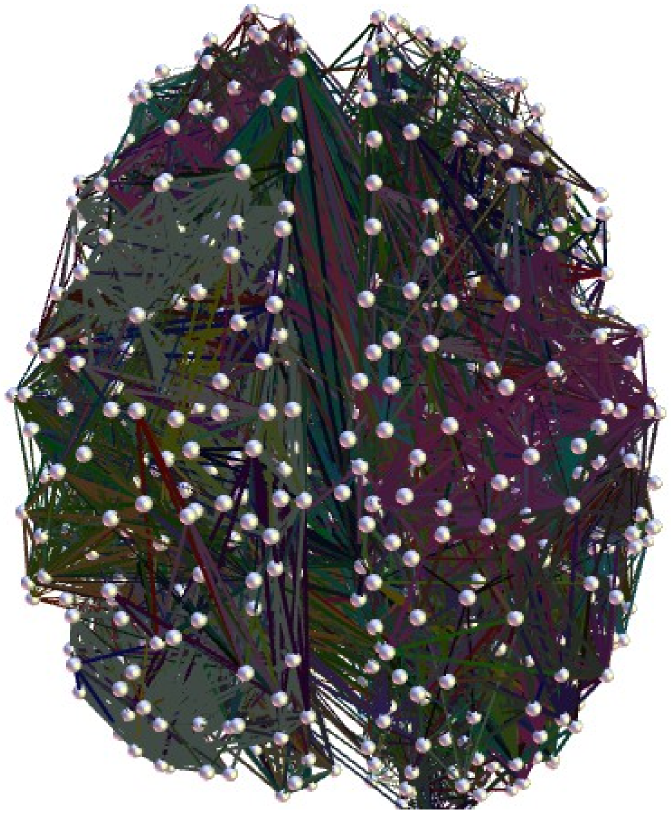


Future Directions

- functional MRI
- multiscale aspect
- change in cluster size



- Acknowledge
  - Daniel Margulies
  - Gaby Lohmann
  - Arno Villringer

- Thank you

Partition Density

Partition density. For a network with M links, $\{P_1, \ldots, P_C\}$ is a partition of the links into C subsets. Subset P_c has $m_c = |P_c|$ links and $n_c = \left|\cup_{e_{ij} \in P_c} \{i,j\}\right|$ nodes. Then we define

$$D_c = \frac{m_c - (n_c - 1)}{n_c(n_c - 1)/2 - (n_c - 1)}$$

This is m_c normalized by the minimum and maximum numbers of links possible between n_c connected nodes. (We assume that $D_c = 0$ if $n_c = 2$.) The partition density, D, is the average of D_c, weighted by the fraction of present links:

$$D = \frac{2}{M} \sum_c m_c \frac{m_c - (n_c - 1)}{(n_c - 2)(n_c - 1)} \quad (1)$$

Equation (1) does not possess a resolution limit[25] because each term is local in c.

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Systems biology

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linkcomm: an R package for the generation, visualization, and analysis of link communities in networks of arbitrary size and type

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