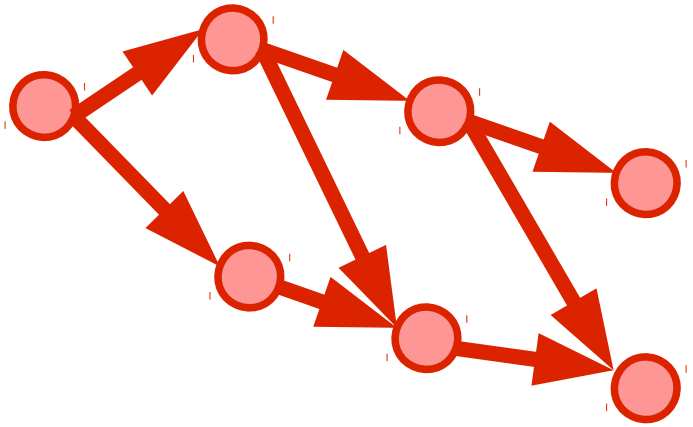

A critical study of network models for neural networks

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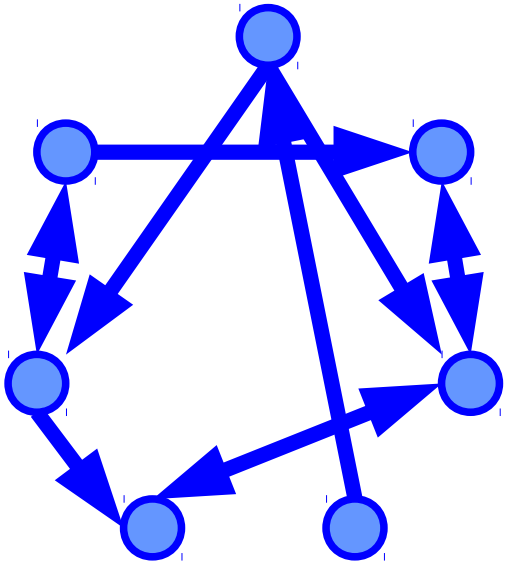
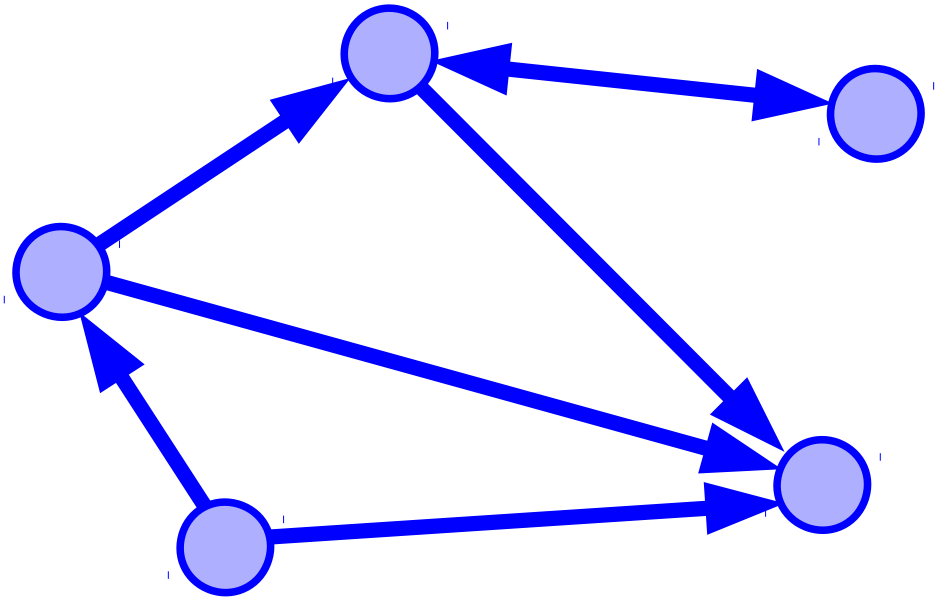


SICSA SEABIS and ModAbs meeting 21/05/2012

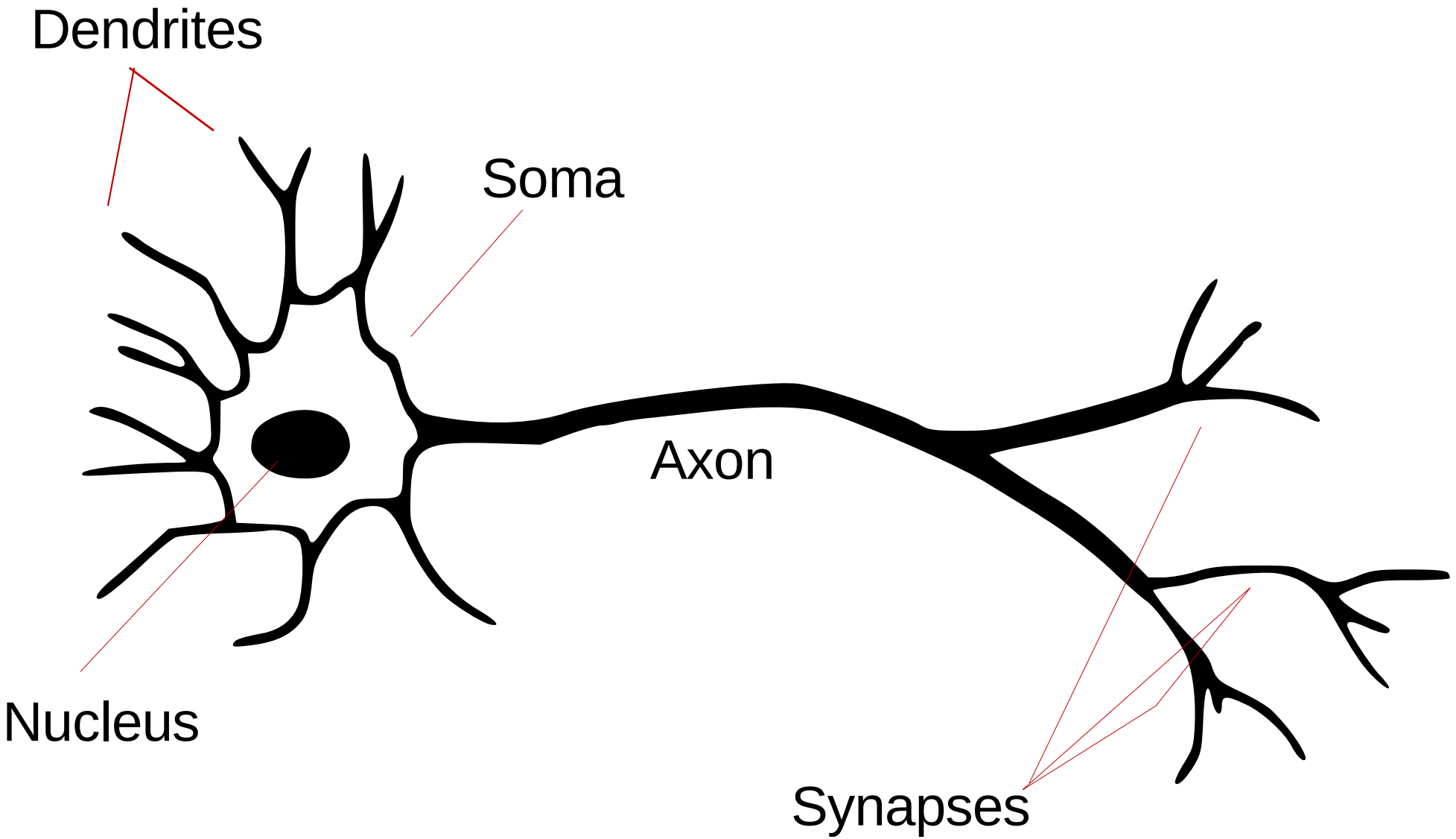
Introduction

many biological concepts can be though of as **networks**



network models have been developed to aid understanding of how these networks

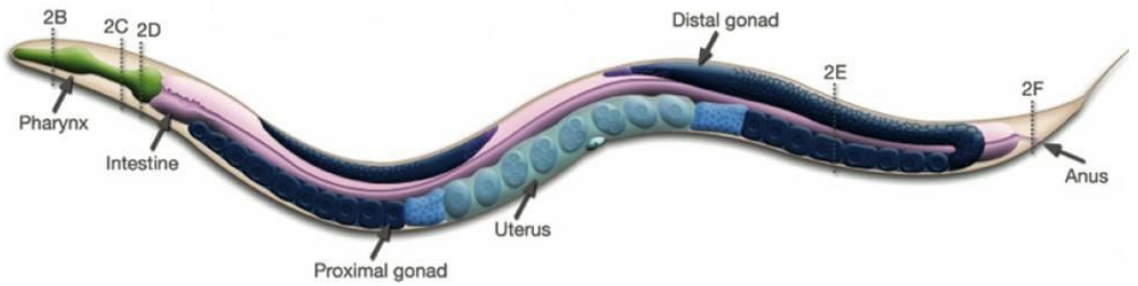
Neurons



http://upload.wikimedia.org/wikipedia/commons/5/52/Neuron_-_annotated.svg

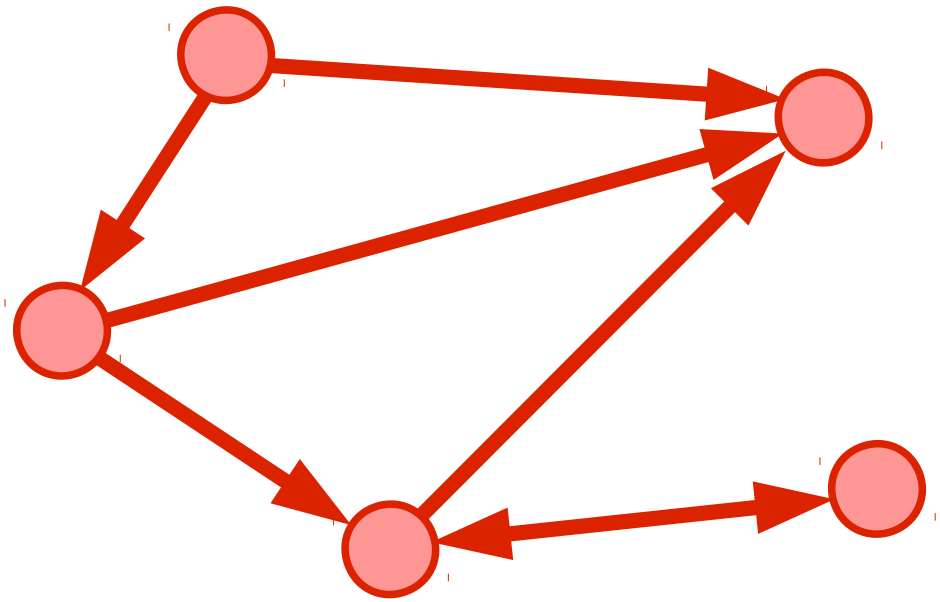
What we did

Used different network models to attempt to create networks with similar measurements to the *C. elegans* neural network.



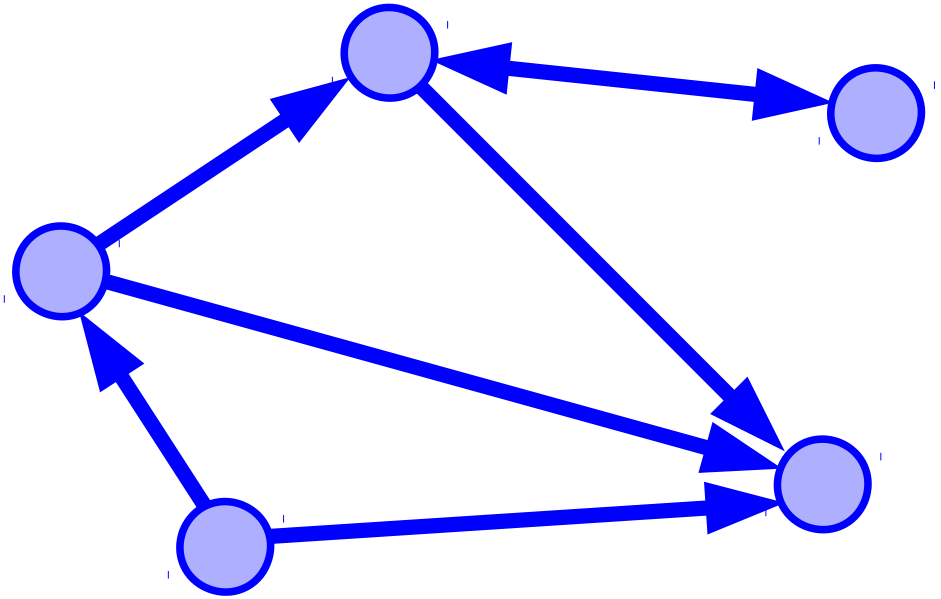
http://publications.csail.mit.edu/abstracts/abstracts07/patrycja/patrycja.html

Average Degree



the average number of edges that a node in the network has
or
the total number of edges, divided by the number of nodes

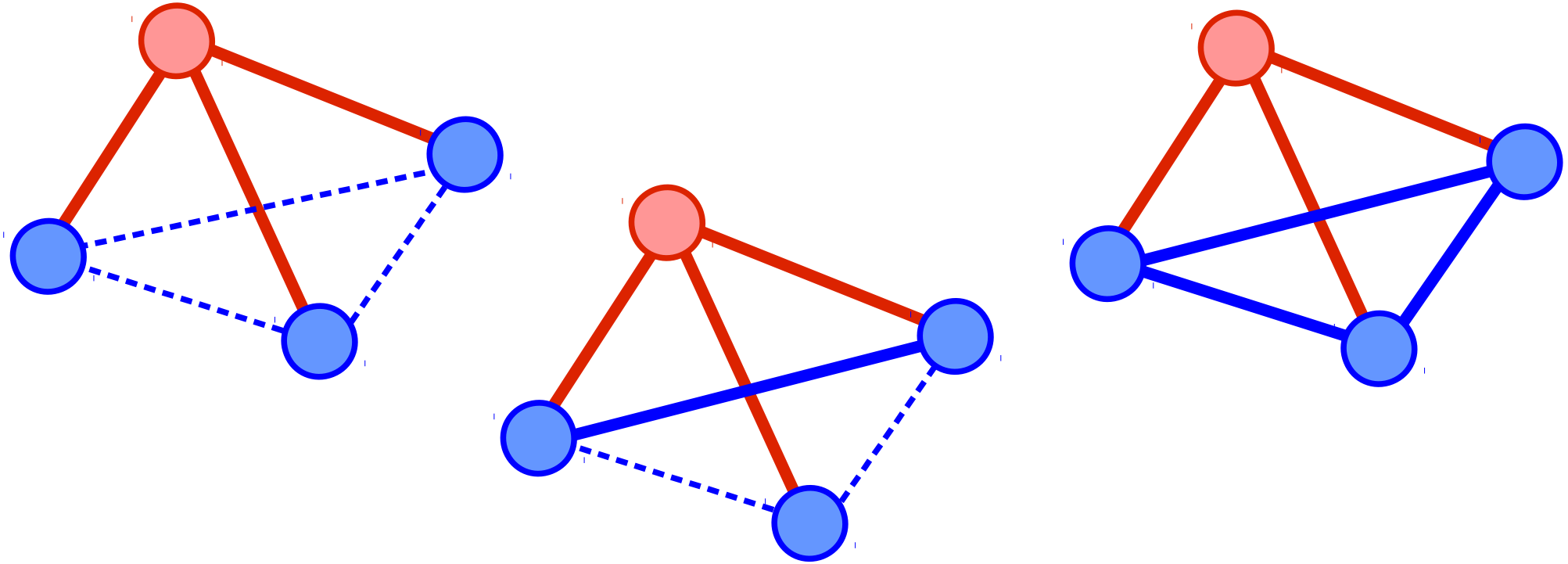
Average Path Length



the average shortest path length between two nodes

calculate the total length of all the shortest paths in the network, and then divide it by the number of paths

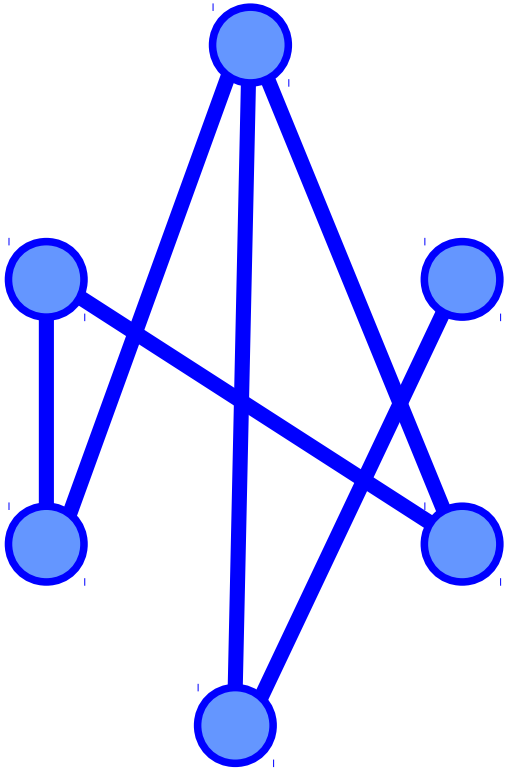
Average Cluster Coefficient



a measure of how many of a node's neighbours are connected together

Erdős-Rényi model

nodes connected together randomly



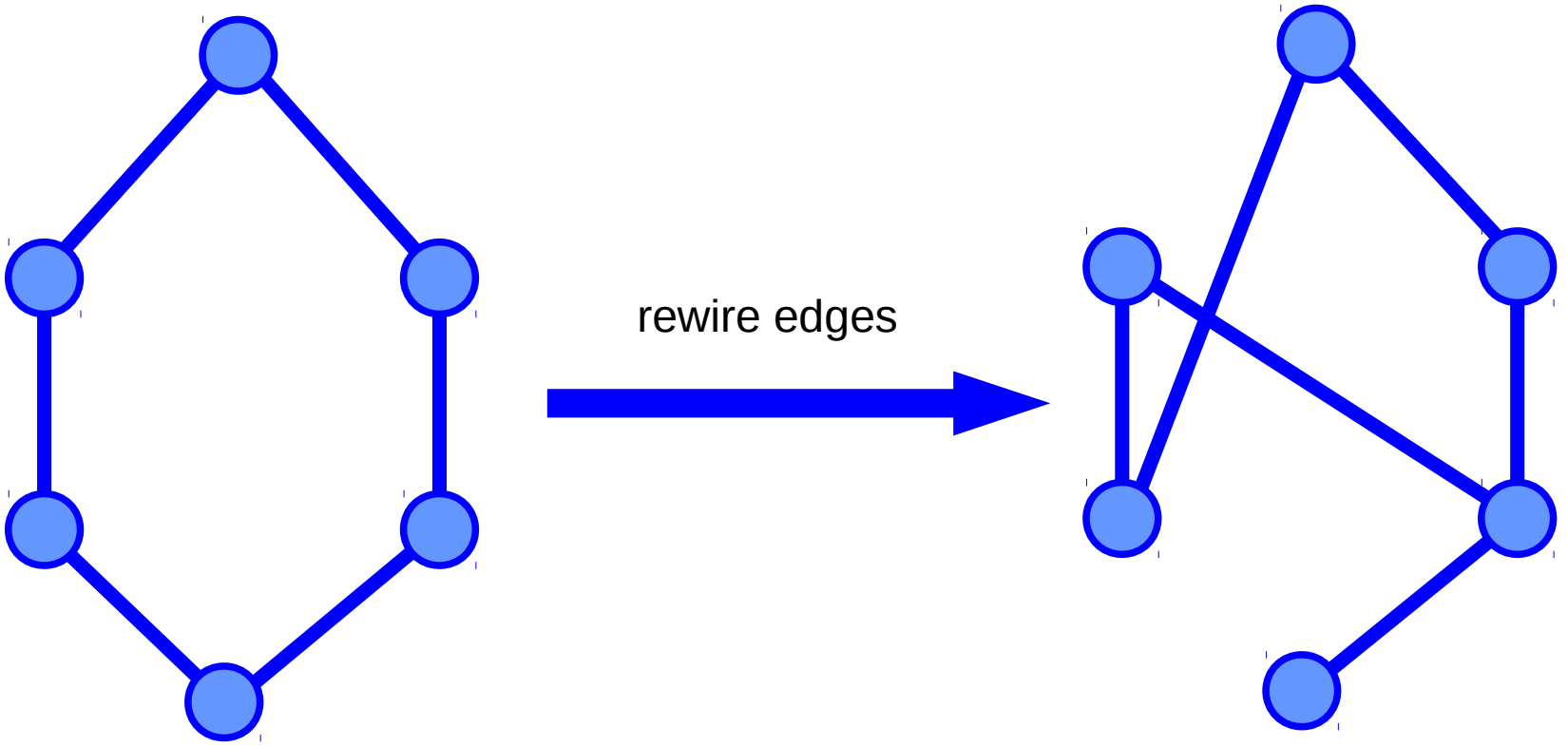
one parameter: probability to have an edge between two nodes

average degree and path length close to *C. elegans*

clustering coefficient much too low

Watts-Strogatz model

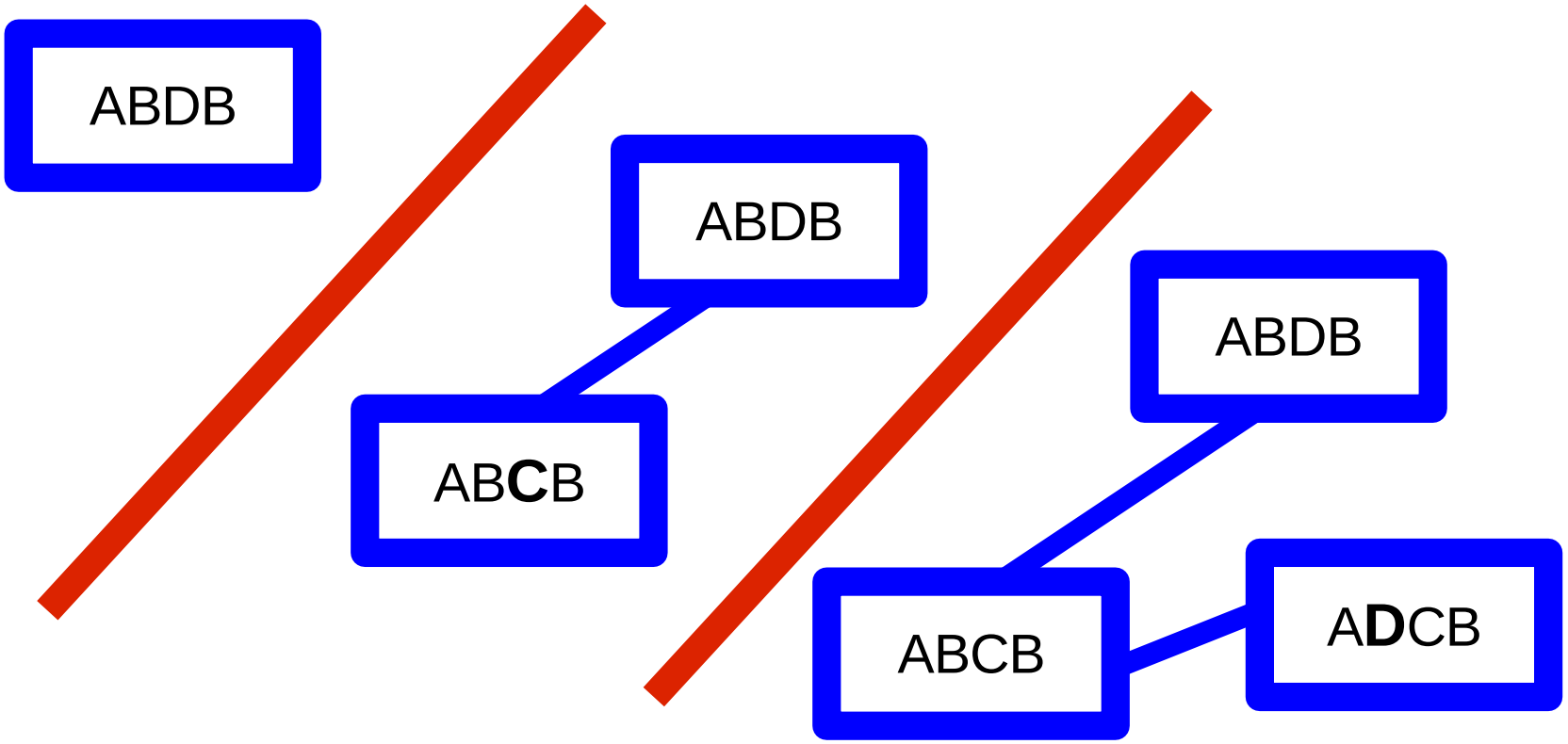
start with a regular network, then add randomness



Ring Lattice

Watt-Strogatz

Structured Node model (SN model)



nodes have a structure

creation of new nodes and edges based on structure

Global topological measurements

Network	Average Degree	Average Path Length	Average Clustering Coefficent
C. Elegans	7.66	2.46	0.284
Erdos-Renyi	7.56±0.15	2.41±0.02	0.05±0.00
Watts-Strogatz	8	2.78±0.01	0.29±0.01
Structured Nodes	6.43±0.41	3.73±0.12	0.36±0.03

Watts-Strogatz and SN models are good fits

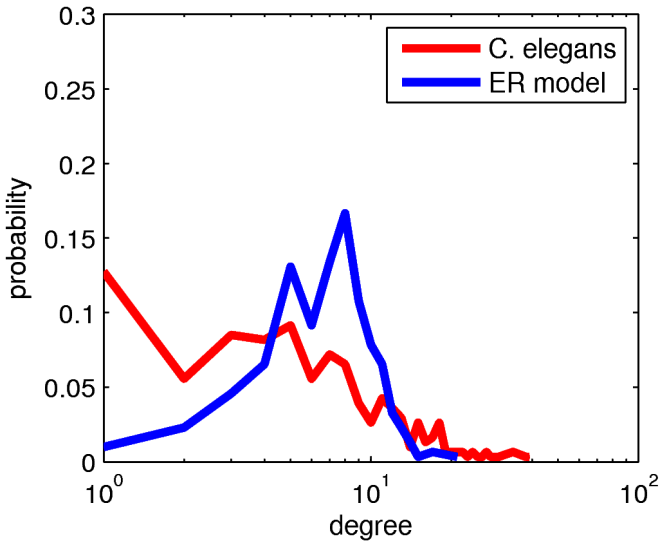
Distributions of measurements

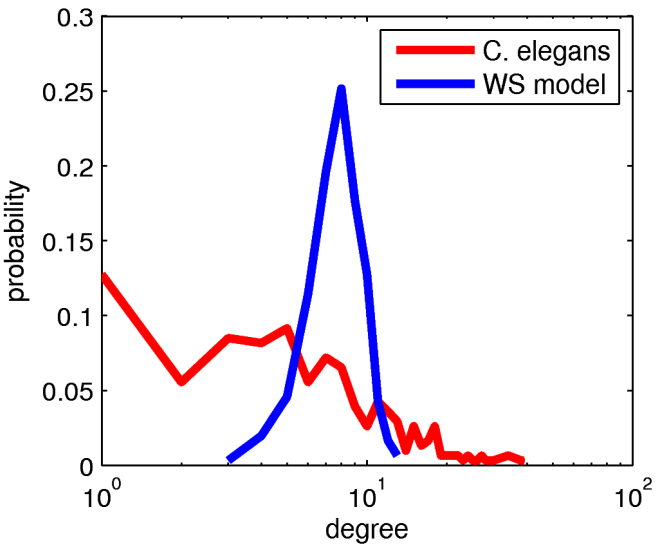
tells us more than just the global averages

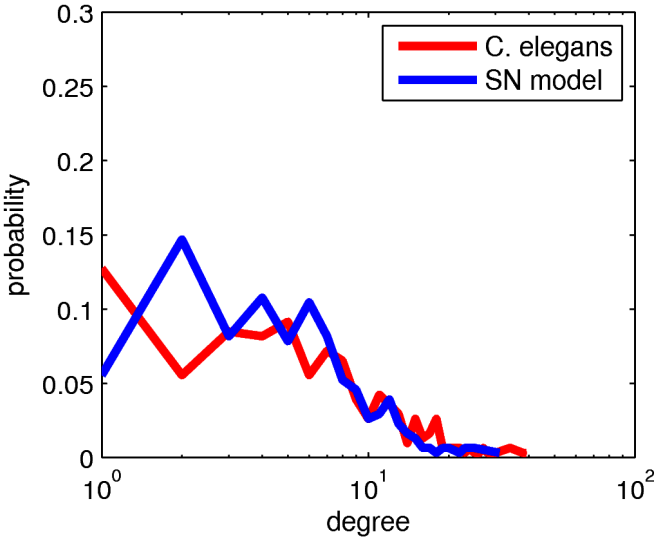
but are harder to analyse

provide multidimensional data

Degree distribution



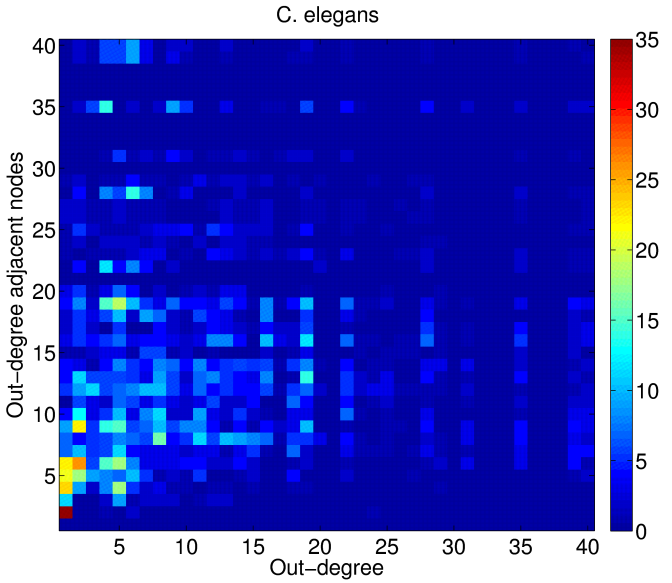


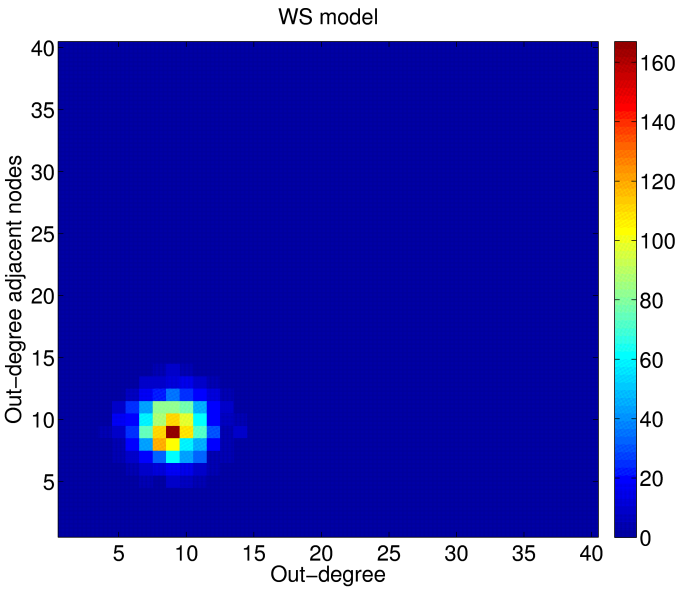


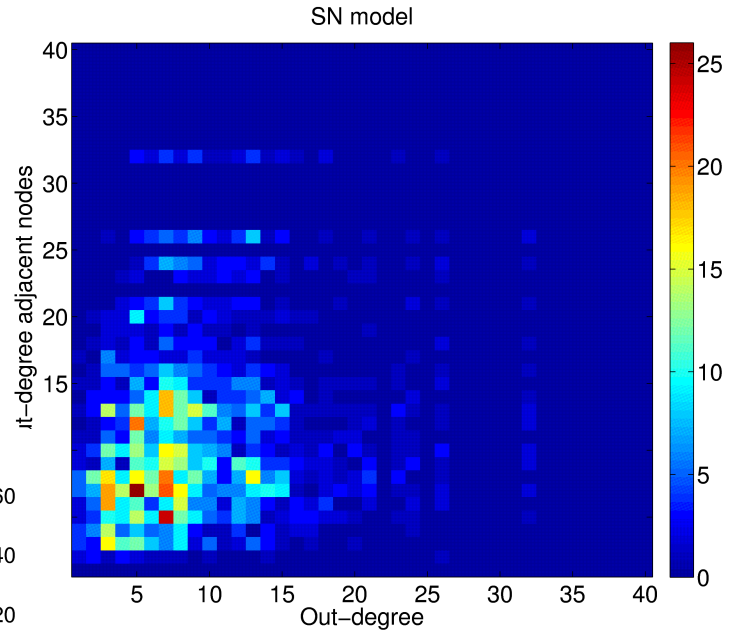
WS model not like *C. elegans*

SN model similar to *C. elegans*

Outgoing edge heatmaps







shows how nodes are connected to other nodes based on their degree

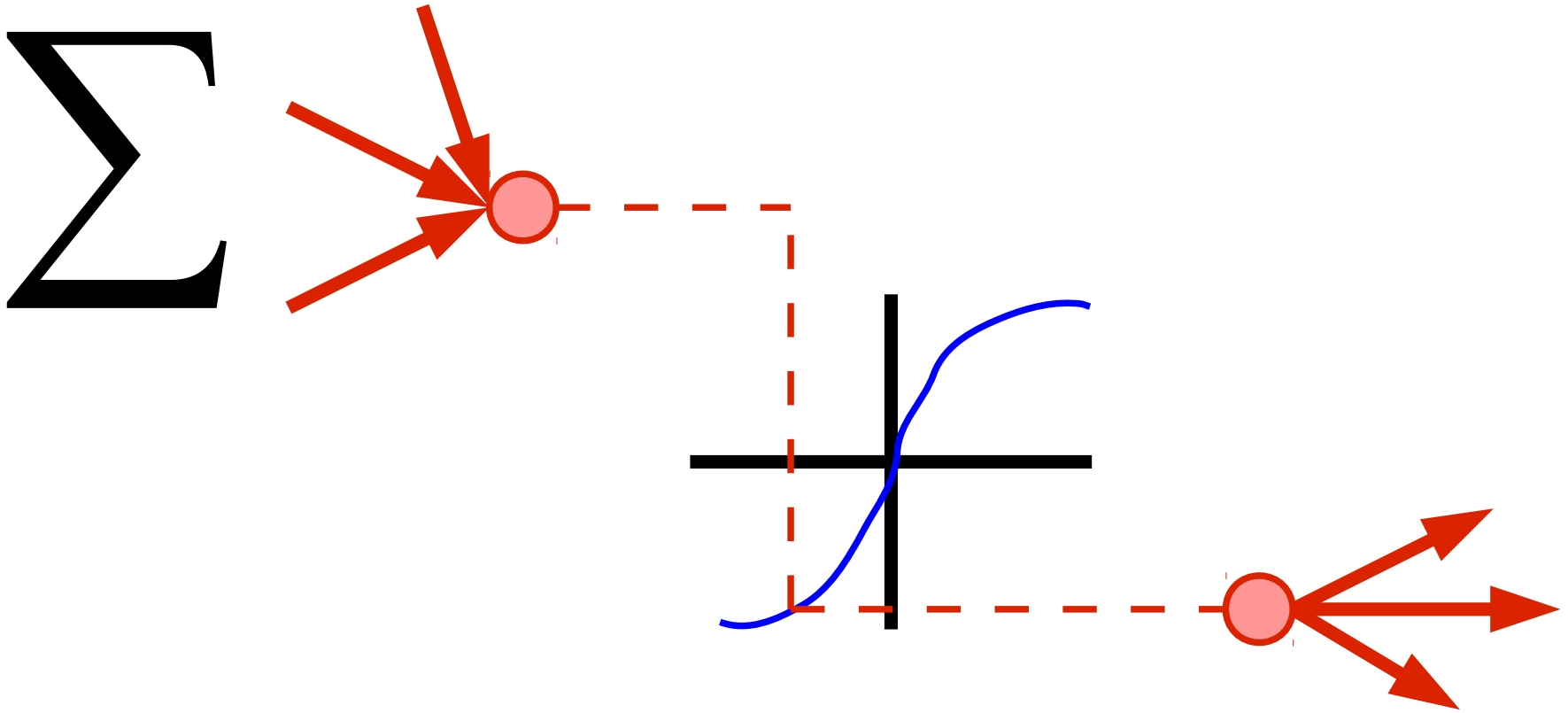
Distributions of measurements

network	avg. degree	avg. path length	avg. clustering coefficent	similar to degree distribution
C. Elegans	7.66	2.46	0.284	--
Erdos-Renyi	7.56±0.15	2.41±0.02	0.05±0.00	No
Watts-Strogatz	8	2.78±0.01	0.29±0.01	No
Structured Nodes	6.43±0.41	3.73±0.12	0.36±0.03	Yes

the SN model is the best fit of the distribution

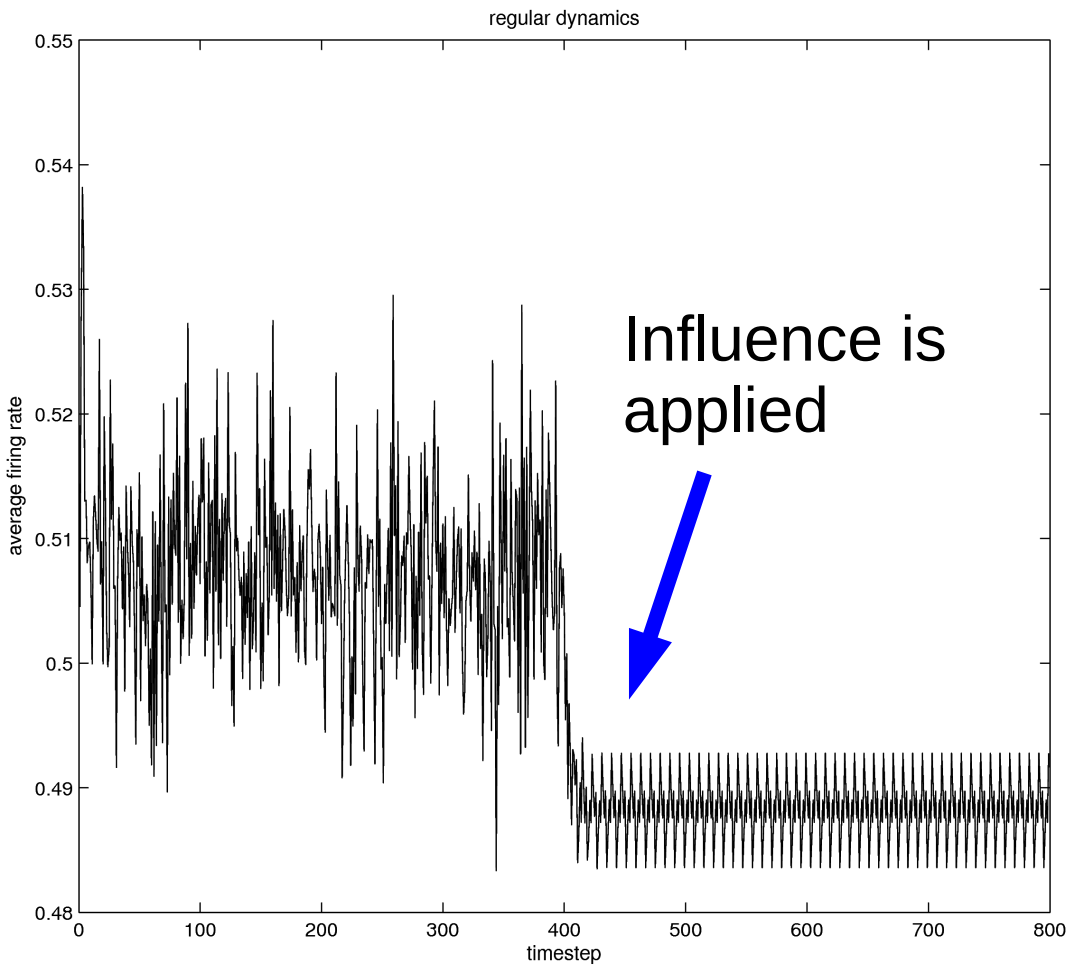
Random Recurrent Neural Networks

simple model of a neural network



Observing the Dynamics

Average firing rate



Time

Average firing rate

Exploring the dynamics

network	% regular all nodes	% regular most connected nodes	% regular least connected nodes
C. Elegans	100	100	90
Erdos-Renyi	94	67	54
Watts-Strogatz	75	27	29
Structured Nodes	82	52	40

C. elegans has by far the most regular dynamics!

Conclusions

The WS model, though widely used, fails to model any distributions of measurements.

None of the examined models come close to matching the regularity of the dynamics shown by the *C. elegans* network.

Future models may need to draw inspiration from neural development.

Thanks for listening,

any questions?

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