Introduction	Background	Method	Results

On aggregation of network multiplexity

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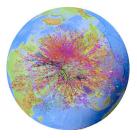
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Network			
Introduction			

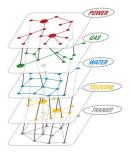


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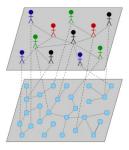
- Many real systems can be modeled as networks.
- Network include nodes and edges.
- There are some dynamics going on.

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Multiplex Network			
Multiplex Net	work		



- Research showed that single layer network may not be sufficient to capture all the feature of the network.
- Different type of edges form different layers of network.
- Multiplex network is a special case of multi-layer network with same node set in all the layers.

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Reduced Multiplex Network			
Reduced Multipl	ex Network		



- Many useful algorithms scale poorly with the number of layers.
- It is possible to aggregate some layers together to get a multiplex network with fewer layers while preserve most information of the original network.

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Case Study			
Airline network			

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- Snapshot of US domestic flight network.
- Weighted by the number of passengers.
- Each carrier forms a layer of network.
- 60 layers in total.

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Case Study			
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Jenson-Shannon distance

$$D_{JS}(\mathcal{N}_{L_1} \parallel \mathcal{N}_{L_2}) = \frac{1}{2} D_{KL}(\mathcal{N}_{L_1} \parallel \mathcal{N}_{L_{12}}) + \frac{1}{2} D_{KL}(\mathcal{N}_{L_2} \parallel \mathcal{N}_{L_{12}})$$

- \mathcal{N}_L is normalized weight distribution over edge set.
- Aggregate two layers with smallest D_{JS} .

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Case Study			
Airline network			

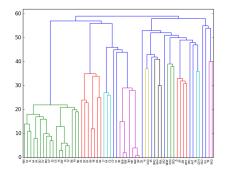


Figure: Dendrogram of Aggregation

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Motivation			
Motivation			

When is it possible to aggregate two layers together?



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Motivation			
Motivation			

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When is it possible to aggregate two layers together?

• When they have similar edge properties.

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Motivation			
Motivation			

When is it possible to aggregate two layers together?

- When they have similar edge properties.
- Or when they have similar structures.

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Network of Chaotic Map			
Network of Cha	aotic Map		

Dynamics

$$x_i(t+1) = (1-\epsilon)f(x_i(t)) + rac{\epsilon}{k_i}\sum_{(i,j)\in G}f(x_j(t))$$

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- The dynamic at each node is a chaotic map f.
- Edges (i, j) represent coupling between nodes.

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Multiplex Setting			
Multiplex Setting			

Dynamics

$$x_i(t+1) = (1 - \epsilon_{L(t)})f(x_i(t)) + \frac{\epsilon_{L(t)}}{k_i} \sum_{(i,j) \in \mathcal{G}_{L(t)}} f(x_j(t))$$

- The edges in different layers take effects alternately.
- *L* is the function to pick a specific layer for time *t*.

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Network Topology			
Two Different Mu	ltiplex Network		

• Independently generated two-layers, with the same coupling parameter.

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• Same network in two-layers, with different coupling parameters.

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Information Measure			
Information N	leasure		

- Convert the time series to discrete alphabet.
- Infer the $\epsilon\text{-machine}$ and calculate information measures.

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Small Network			
Small Network			

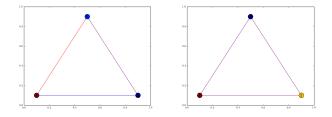


Figure: Small Network with Same Edge Property

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Small Network			
Small Network			

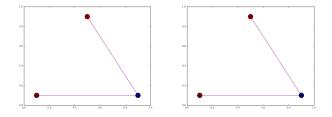


Figure: Small Network with Same Topology

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Random Network			
Random Netw	ork		

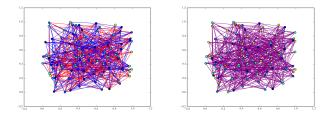


Figure: Random Network with Same Edge Property

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Random Netwo	rk		

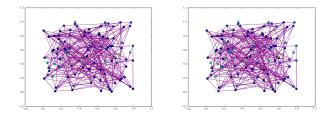


Figure: Random Network with Same Topology

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