Diffusion in Multilayer Networks: An Application to the Transmission of Infectuous Diseases

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Introduction

Nowadays, countries are highly connected, as a result diseases and infections can easily spread having a higher probability of causing pandemics.

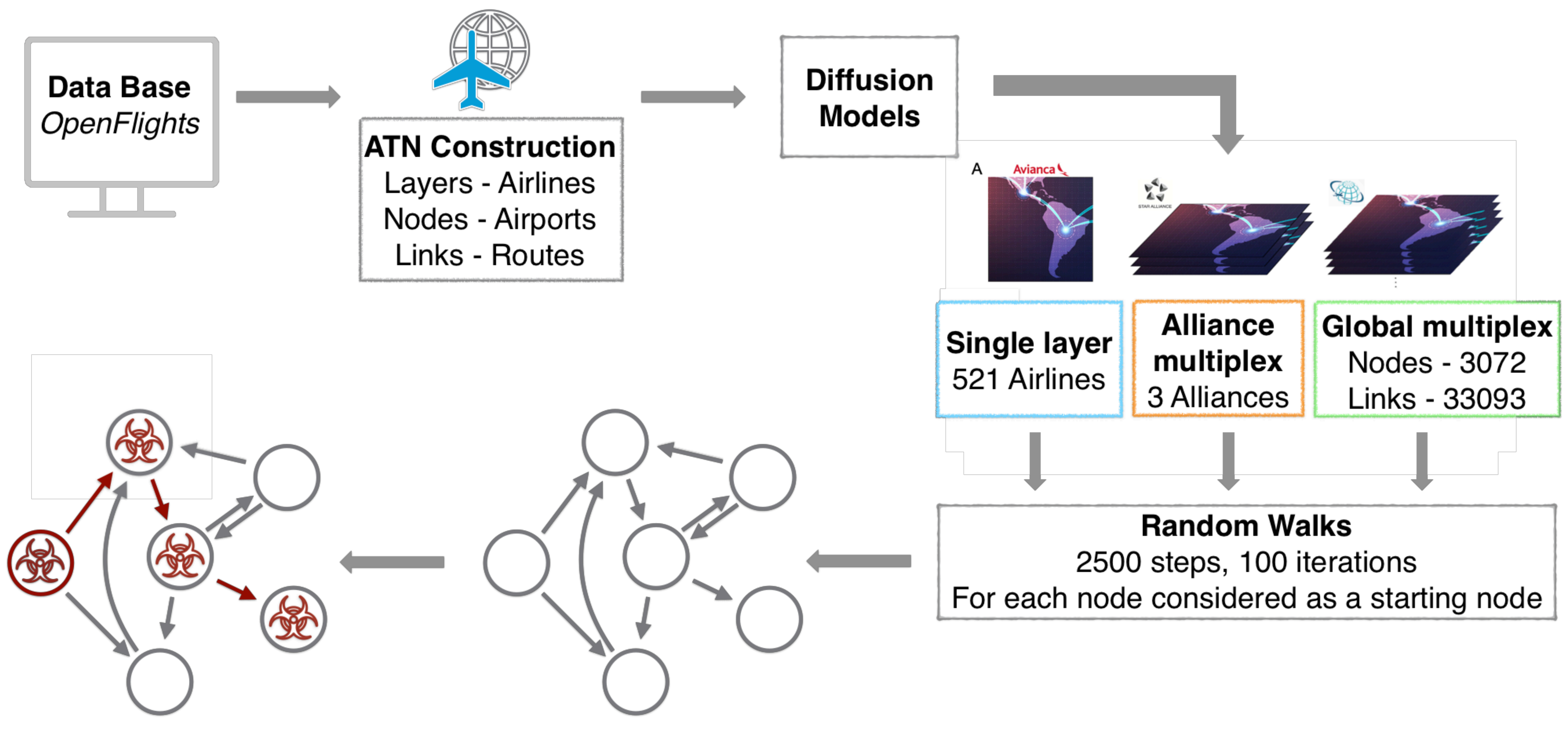
A simple way of disease propagation takes place in the Global Air Transportation Network which can be studied with a multilayer approach.

In real life, it is quite difficult to reach all airports with a single flight. Typically we need to make a connecting flight, from airlines that belong to the same airline alliance or not.

With that in mind, this work considers three different air transportation network structures: global multiplex network [1,2], airline alliance network, and single airline networks.

WILL THE DIFFUSION OF INFECTIOUS DISEASES IN THE AIR TRANSPORTATION NETWORK DEPEND ON CERTAIN TOPOLOGICAL NETWORK PARAMETERS?

Methodology



Results

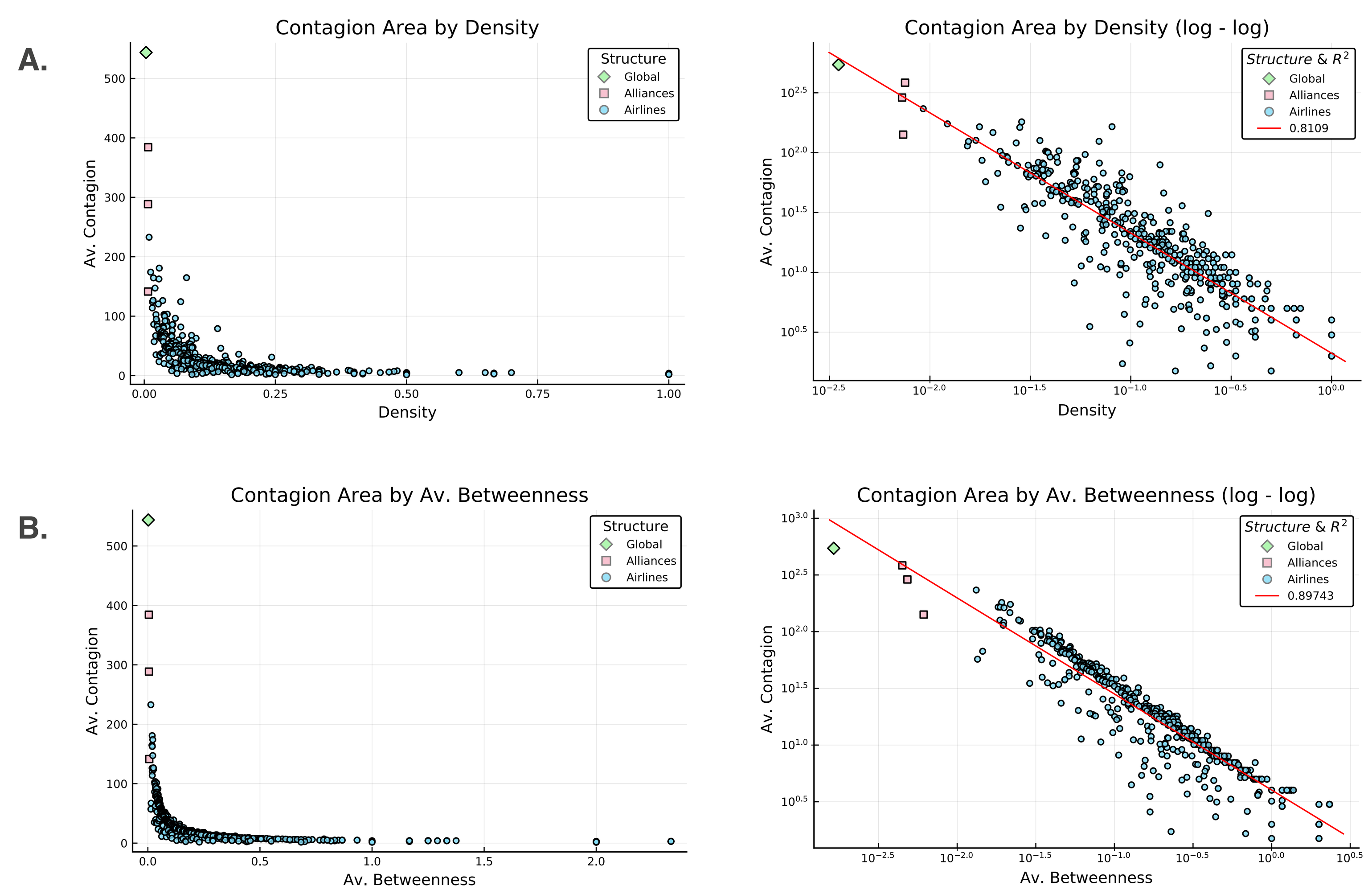


Fig.1. A. Graph of contagion area by density (left). Log-log graph with linear regression (right)
B. Graph of contagion area by average betweenness (left). Log-log graph with linear regression (right).

Table 1. Networks Information

Network	Density	Av. Betweenness	Coverage
global	0.0035	0.0016	543.75
Star_Alliance	0.0075	0.0045	384.35
Sky_Team	0.0073	0.0048	288.58
oneworld	0.0074	0.0061	141.49
AA	0.0189	0.0135	57.16
TK	0.0093	0.0132	232.86
DL	0.0218	0.0145	67.17
MU	0.0286	0.0192	180.86
CZ	0.0353	0.0187	126.27
UA	0.0269	0.0198	120.55
FR	0.0806	0.0182	164.74
BA	0.0122	0.0218	174.09
AF	0.0154	0.0196	113.85
LH	0.0176	0.0188	164.44
...	...	...	...

Results (cont.)

- Properties such as number of links, nodes, density, av. degree, global clustering coefficient, and av. betweenness, were analized to figure out which ones were related to the diffusion of the disease.
- A correlation between the infected area and density as well as av. betweenness was found.
- Both have a logarithmic relation and it was confirmed by transforming the graph to log axis.

Conclusion

- Results indicate the contagion area is larger in the global multiplex.
- The area of disease contagion in the Air Transportation Network is affected by topological properties of the network such as edge density and its average betweenness.

References

[1] Cardillo, A. et al. (2013) *Scientific Reports* 3 : 1344
[2] Verma, T. et al. (2014) *Scientific Reports* 4 : 5638