AWARENESS PARADOX INDUCED BY NETWORK DENSITY, DEGREE HETEROGENEITY, AND DISASSORTATIVITY

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The project's repository is here!

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INTRODUCTION

During an epidemic, individuals are likely to adopt behavioral changes aimed at avoiding the infection if they learn that the prevalence of the disease increases among their contacts. This process, called **local awareness**, has already been incorporated into previously published epidemic models [1, 2, 3]. Based on recent survey results [4] on the nature of local awareness during the COVID-19 epidemic, we aim to study more realistic awareness models and observe new phenomena to improve our understanding on the interplay between epidemic propagation and human behavior.

EPIDEMIC MODEL

We used the Susceptible-Infected-Susceptible (SIS) epidemic model.

$$S \xrightarrow{\beta} I \xrightarrow{\mu} S$$

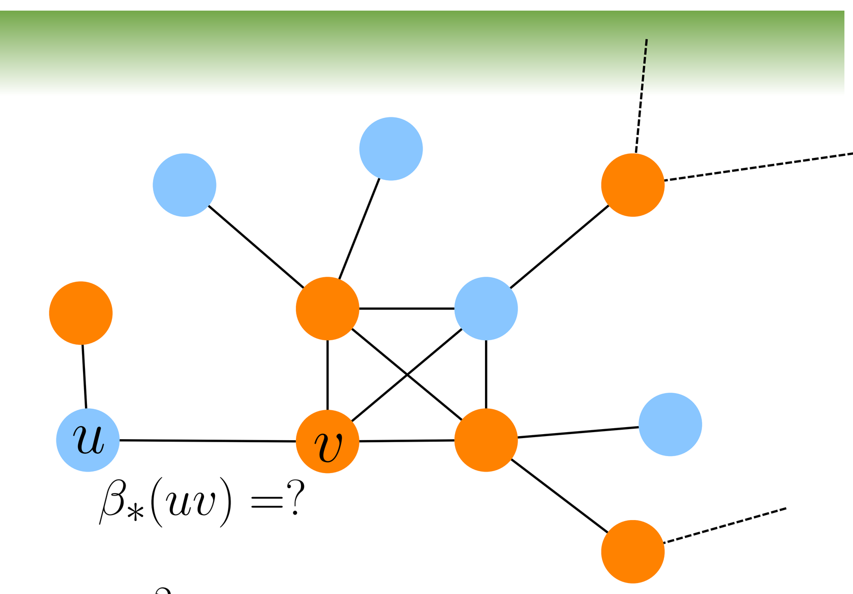
$\beta = 0.6$ infection rate; $\mu = 0.2$ recovery rate

LOCAL AWARENESS MODEL

If a node v is aware then the probability of infection on its neighboring edges drops by a factor of:

$$a(v,t) = e^{-N_I(v,t)},$$

where $N_I(v,t)$ denotes the number of infected neighbors of node v at time t.



Who should be aware?

(i) **Susceptible-only model**: where only the S nodes are aware; $\beta_S(uv) = 0.6e^{-2} \approx 0.08$

(ii) **Infectious-only model**: where the I nodes are aware; $\beta_I(uv) = 0.6e^{-2} \approx 0.08$

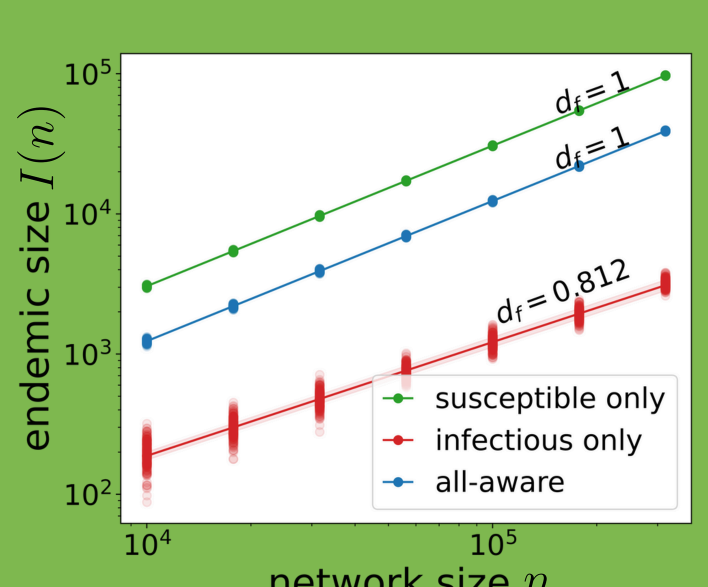
(iii) **All-aware model**: where all nodes are aware. $\beta_{SI}(uv) = 0.6e^{-4} \approx 0.01$

FRACTAL DIMENSION

Let $I(n)$ denote the size of the meta-stable epidemic in SIS models on networks of size n. Then,

$$I(n) \sim n^{d_f}, d_f = \text{fractal dimension}$$

by fitting.

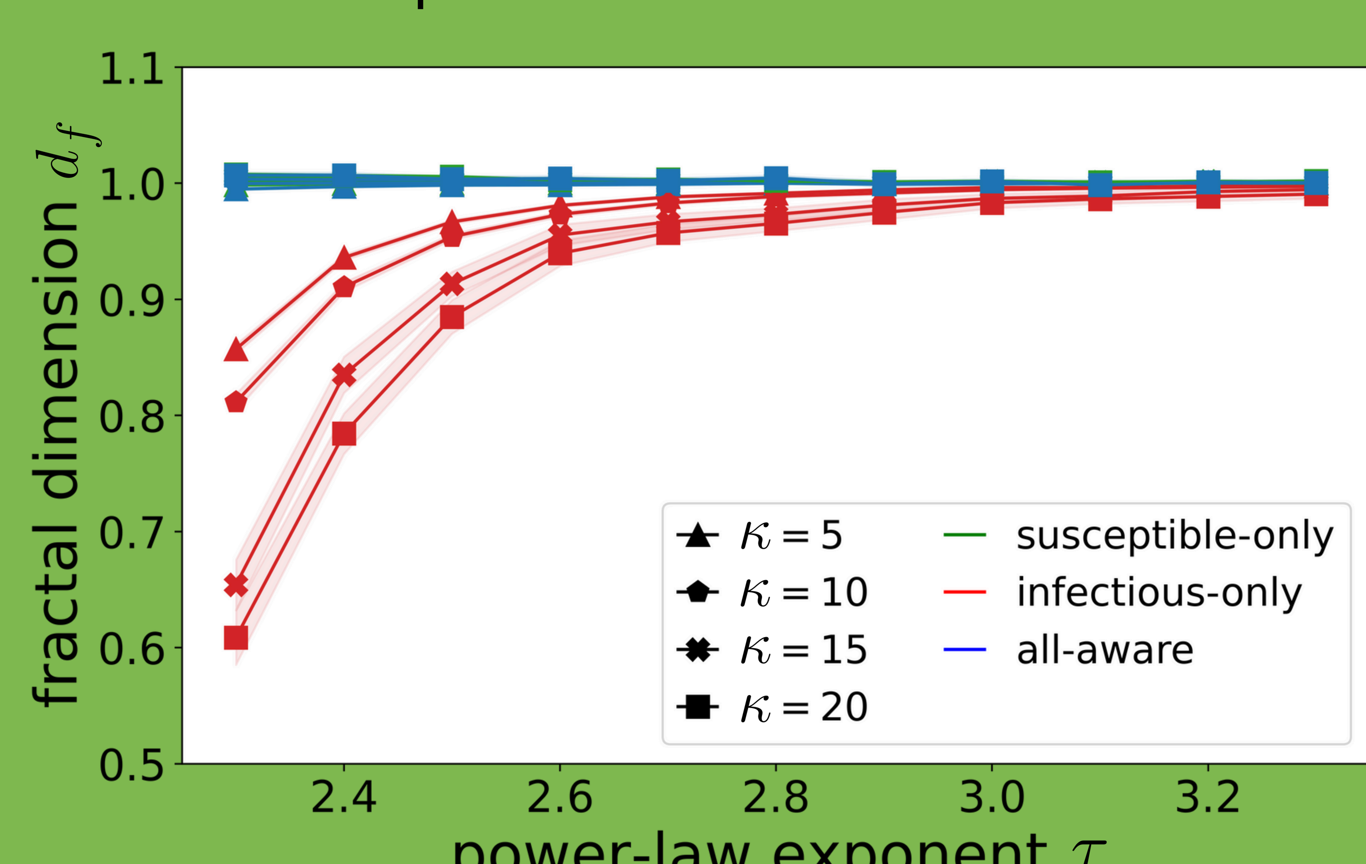


Our Chung-Lu network model is:

- scale-free with power-law exponent τ
- κ scales the mean degree: $\bar{d} = \kappa \dfrac{\tau - 1}{\tau - 2}$

AWARENESS PARADOX

Even though **less nodes are aware** in the infectious-only case, the **epidemic** becomes **smaller** compared to the all-aware case.

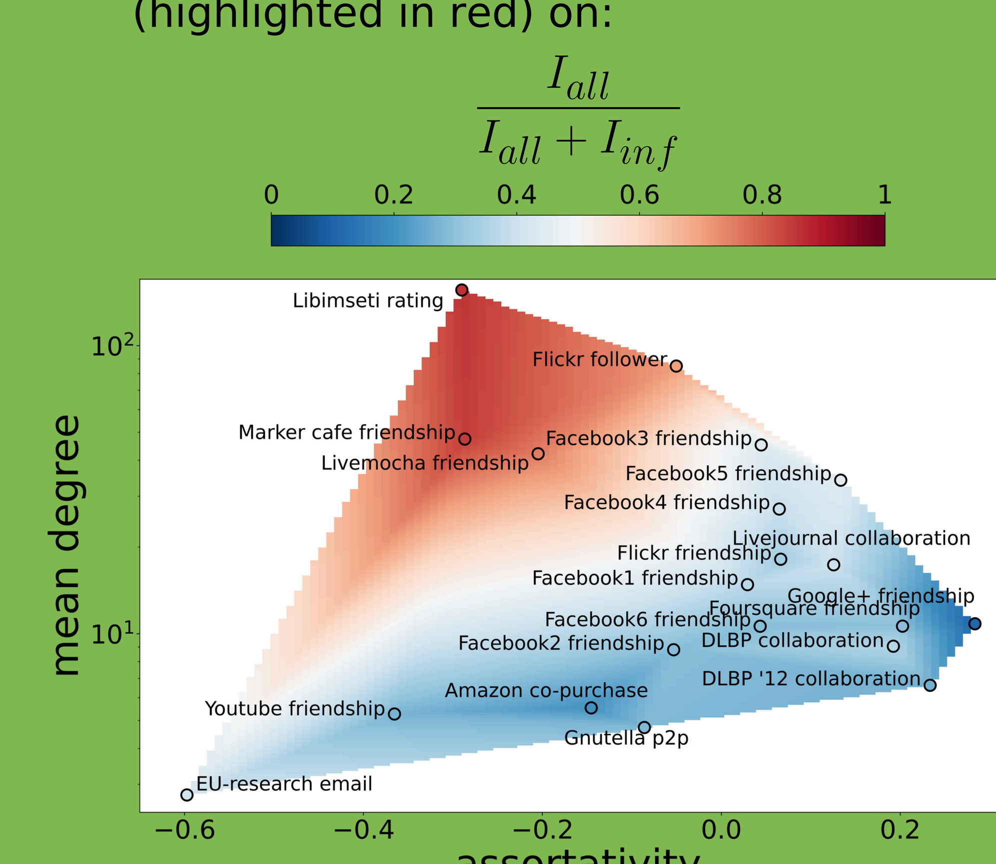


In the infectious-only case with $\tau <$ 3, the endemic epidemic size is sublinear in the size of the population.

ON REAL NETWORKS

The infectious-only model indicates smaller meta-stable epidemic size (highlighted in red) on:

$$\frac{I_{all}}{I_{all} + I_{inf}}$$



- dense,
- dissasortative,
- heterogen,

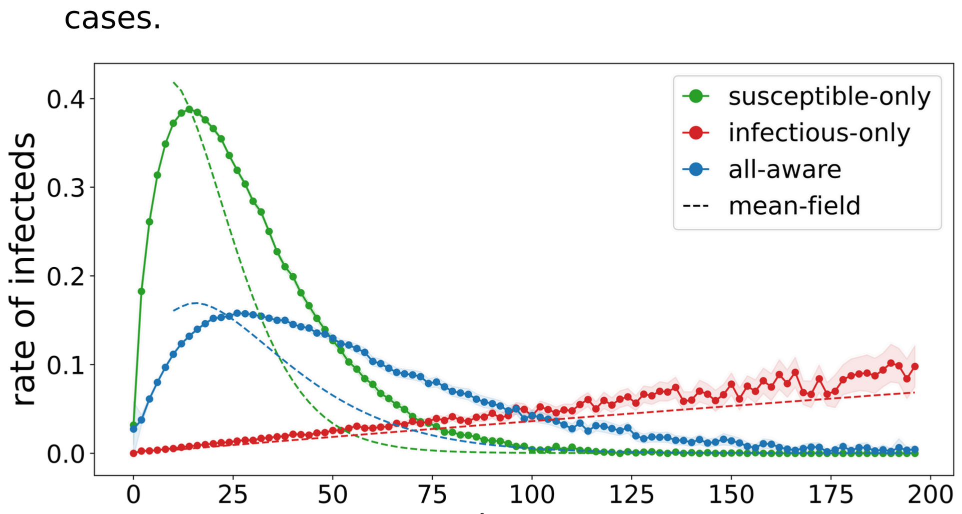
real networks.

EXPLANATION

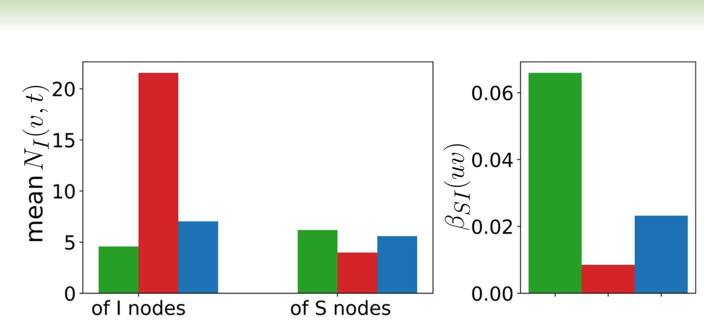
The infected population is distributed differently in the network for the three different awareness definitions. In the infectious-only case the

- high degree nodes are more likely to be infected,
- low degree nodes are less likely to be infected

compared to the susceptible-only and the all-aware cases.



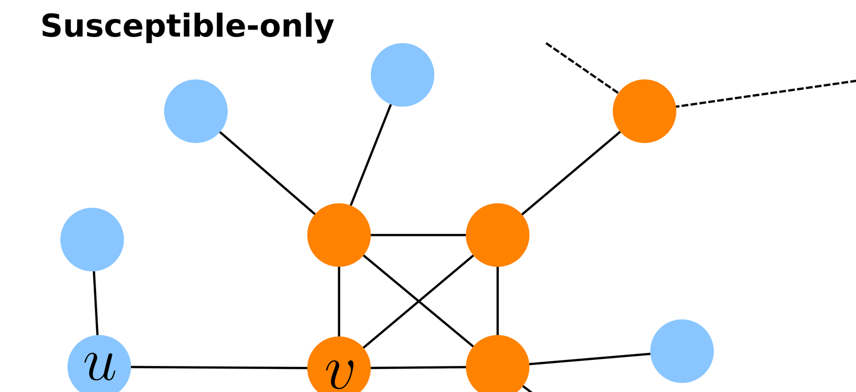
Through mean-field calculations we concluded that the fractal dimensions and the infection distributions by degree show qualitative agreements with the simulation results.



edge uv is an uniformly random chosen SI edge

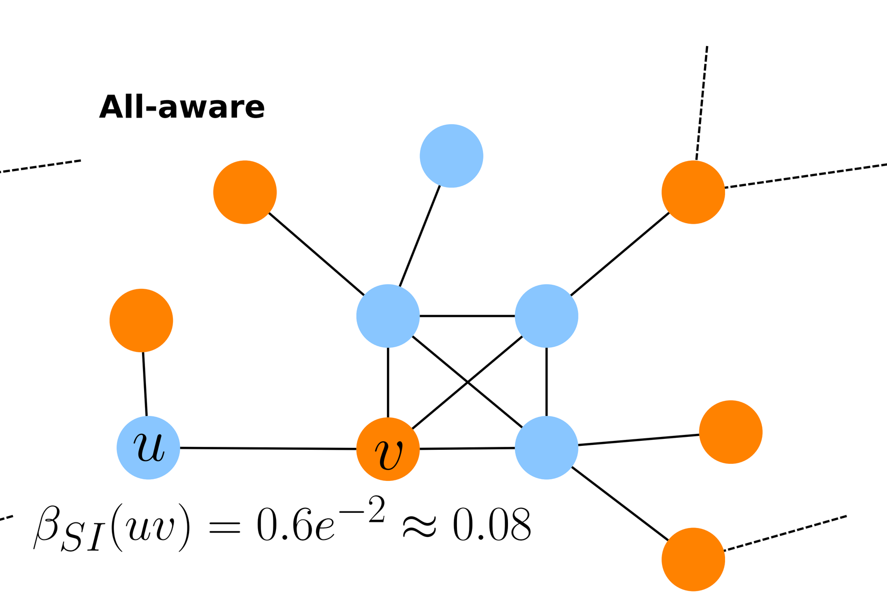
The distribution of the infectious-only model realizes more awareness in the network compared to the all-aware case. Because the infected high degree nodes are radiating the awareness.

Susceptible-only



$\beta_I(uv) = 0.6e^{-3} \approx 0.03$

All-aware



$\beta_{SI}(uv) = 0.6e^{-2} \approx 0.08$

CONCLUSION

- Small changes in local awareness definition leads hugely different distribution in the degree of the infected nodes
- Hubs play an important role in the epidemic dynamics with local awareness
- Under certain conditions, adopting an infectious-only awareness strategy yields smaller epidemics compared to all-aware awareness

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