SCIENCE CHINA
Information Sciences

• **Supplementary File** •

Cost effective approach to identify multiple influential spreaders based on the cycle structure in networks

Wenfeng SHI[1], Shuqi XU[2,1*], Tianlong FAN[3,4] & Linyuan LÜ[1*]

[1]*Institute of Fundamental and Frontier Sciences, University of Electronic Science and Technology of China, Chengdu* 611731*, China;*
[2]*Institute of Dataspace, Hefei Comprehensive National Science Center, Hefei* 230088*, China;*
[3]*Department of Physics, University of Fribourg, Fribourg* 1700*, Switzerland;*
[4]*Alibaba Research Center for Complexity Sciences, Hangzhou Normal University, Hangzhou* 311121*, China*

Appendix A The pseudocode of NC method.

Algorithm A1 NC method based on basic cycles

Input: Graph $G(V, E)$;
Output: NC_i for node i;
initialization: $T \leftarrow \varnothing$, $U \leftarrow V$, $NC_i \leftarrow 0$, randomly select a node from U, and add it to T
if $T \cap U \neq \varnothing$ **then**
    for z in $T \cap U$ **do**
        for n in $neighbor(z)$ **do**
            if n not in T **then**
                add n to T
            else
                find a basic cycle c
            end if
        end for
        remove z from U
    end for
else
    get cycle basis B
end if
for c in B **do**
    for i in c **do**
        $NC_i \leftarrow NC_i + 1$
    end for
end for

* Corresponding author (email: xushuqi@idata.ah.cn, linyuan.lv@uestc.edu.cn)

Appendix B The degree distribution of three model networks and six empirical networks.

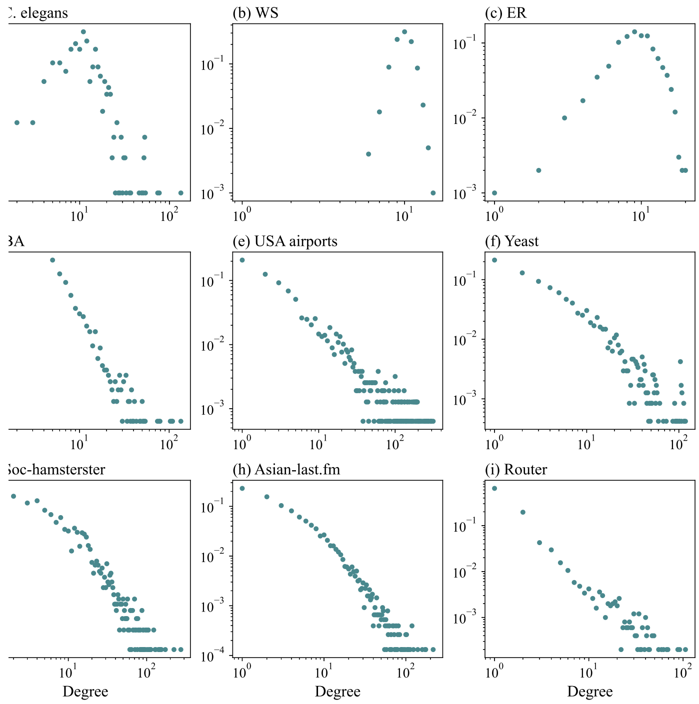

Figure B1 The degree distribution of three model networks and six empirical networks.

Appendix C The Kendall correlation among eight indicators on six empirical networks.

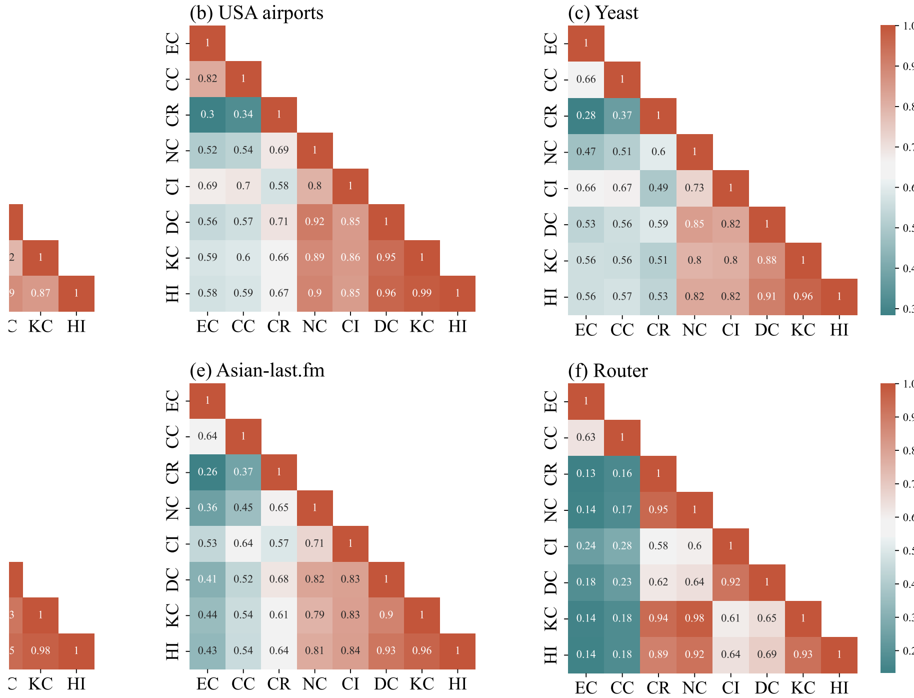

Figure C1 The Kendall correlation coefficients among the eight indicators on the six empirical networks. All the correlation results are statistically significant (p-value <0.001).

Appendix D Supplementary spreading experiments.

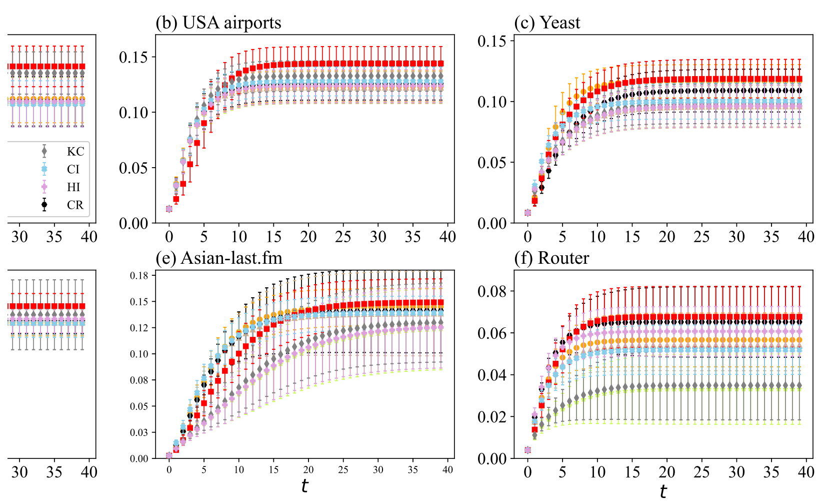

Figure D1 Comparison of the spreading ability R_t of the top-20 nodes ranked by NC and seven benchmark indicators in the six empirical networks. We set the recovery rate $\mu = 0.5$, and the spreading rate $\beta = \beta_c$. Error bars denote the standard deviation among 1000 realizations.

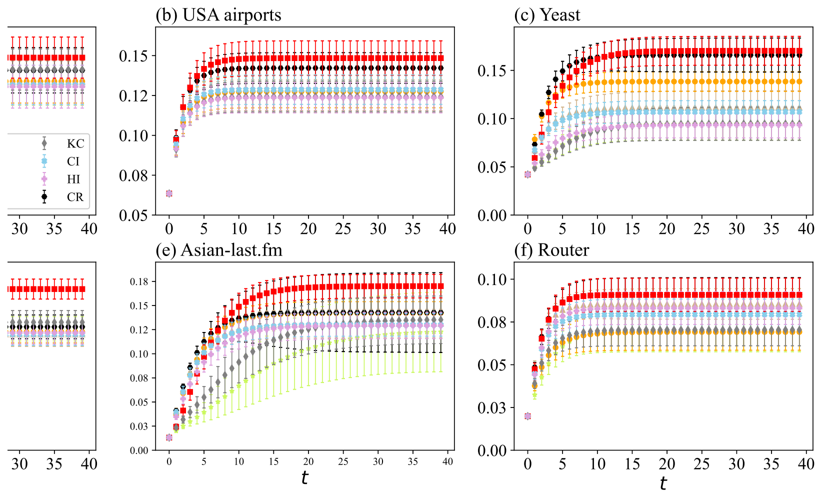

Figure D2 Comparison of the spreading ability R_t of the top-100 nodes ranked by NC and seven benchmark indicators in the six empirical networks. We set the recovery rate $\mu = 0.5$, and the spreading rate $\beta = \beta_c$. Error bars denote the standard deviation among 1000 realizations.

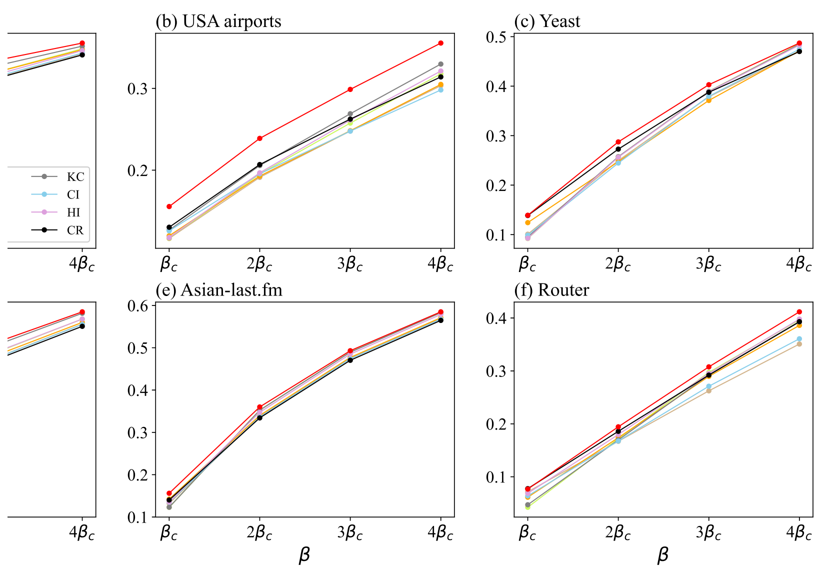

Figure D3 Comparison of the overall spreading ability (R) of the top-50 nodes ranked by NC and seven benchmark indicators with different spreading rates ($\beta = \beta_c$, $2\beta_c$, $3\beta_c$, and $4\beta_c$). The recovery rate $\mu = 0.5$, and the results are obtained by averaging over 1000 independent realizations.

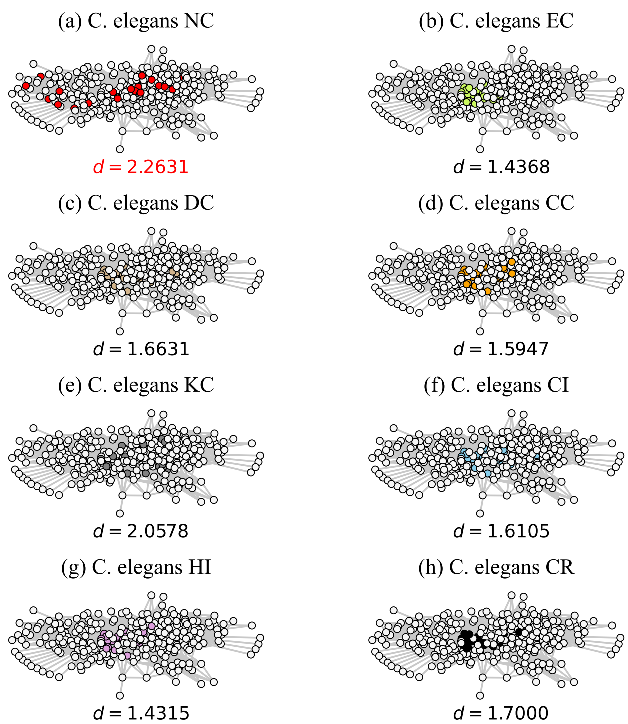

Figure D4 Visualization of the top-20 nodes selected by *NC* and other indicators in *C. elegans* network. d below each panel denotes the average shortest distance among the top-20 nodes selected by the corresponding indicator.