Supplemental Fig. 1. Flow chart of NPR method.

Supplemental Fig. 2. Dynamics of $R_m(N, E)$. $\beta = 0.1$ (A), 0.4 (B), 0.7 (C), 1.0 (D).

Supplemental information

The whole rewiring process as well as the dynamic features are presented in supplemental information. The flow chart of NPR method is shown in Supplemental Fig. 1. Consider the same original non-scale-free networks in Section 4.2 generated by WS model with parameters of N=3000, K=4, $\beta = 0.1$, $\beta = 0.4$, $\beta = 0.7$, and $\beta = 1.0$. The PRI in optimization process is set as α=6. In order to show dynamics of optimization process more clearly, we set the iteration of NPR method as 30. 10 independent topology optimization experiments are implemented for

each kind of original network.

The dynamic changes of $R_m(N, E)$ in 10 independent optimization processes are shown in Supplemental Fig. 2. The standard error of the dynamic changes of $R_m(N, E)$ is very small and ten curves for each original network tend to be overlapped which denote that the performance of NPR method is very stable. In addition, the dynamics of $R_m(N, E)$ exhibit as bell-shaped curves for all original networks. Especially, the optimization process terminates after just 1 iteration when $\beta = 0.1$ if the TCR is set as 0.8 (Supplemental Fig. 2A). However, $R_m(N, E)$ is still on the left of the peak in this scenario which means insufficient optimization rewiring, and this coincide with the observations in Fig. 4A green circle scatters. The optimization process terminate after about 5-6 iterations when $\beta = 0.4, 0.7$, and 1.0 if the TCR is set as 0.8. $R_m(N, E)$ crossed the peaks in these scenarios and it denote that the network topology has been optimized to a certain degree (Supplemental Fig. 2B, C, and D, Fig. 4 B, C, and D). $R_m(N, E)$ decays sharply from 0.8 to about 0.2. In addition, most of the network topology modifications are accomplished when $R_m(N, E)$ reaches 0.5 (Fig. 4 A, B, C, and D). The network topology are fine-tuned when $R_m(N, E)$ decays from 0.5 to 0.2. The decrease velocity of $R_m(N, E)$ become more and more slow when $R_m(N, E)$ cross 0.2 and it bring with few changes of network characteristics.