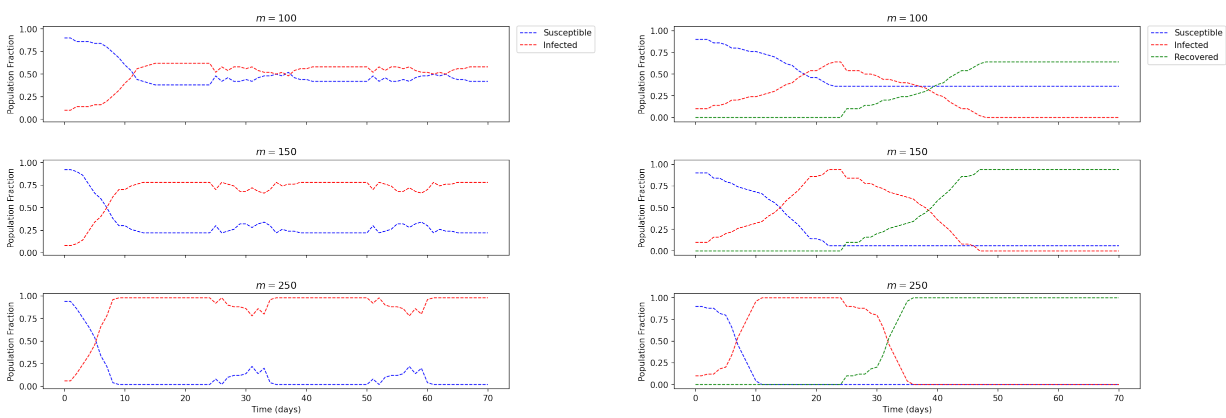
A supplement to the paper "Modeling the Spread of Infectious Diseases through Influence Maximization"

1.1 Comparison of Different Edge Densities

In this subsection, we use three connected Watts-Strogatz small-world graphs of different edge densities for comparison. Each node joins with $5, 7$ and 10 nearest neighbors in an initial ring topology, which generates three graphs of size $m = 100, 150, 250$. Other parameters: the number of nodes $n = 50$, the random reconnection probability $p = 1/2$, the ratio $|V_1|/n = 1/2$, the period $T = 70$, the budget $B = 5$.

It can be seen in Fig. 1 (a) that, at a given time period ($t > 10$), the difference between the number of susceptible and infected individuals becomes larger as the edge density increases. The similar phenomenon also happens between the number of infected and recovered individuals in the end stage of SIR-LT model, as shown in Fig. 1 (b). Moreover, from Fig. 1, we can also find out the time when the number of infections peaked for the first time becomes shorter as the edge density increases.

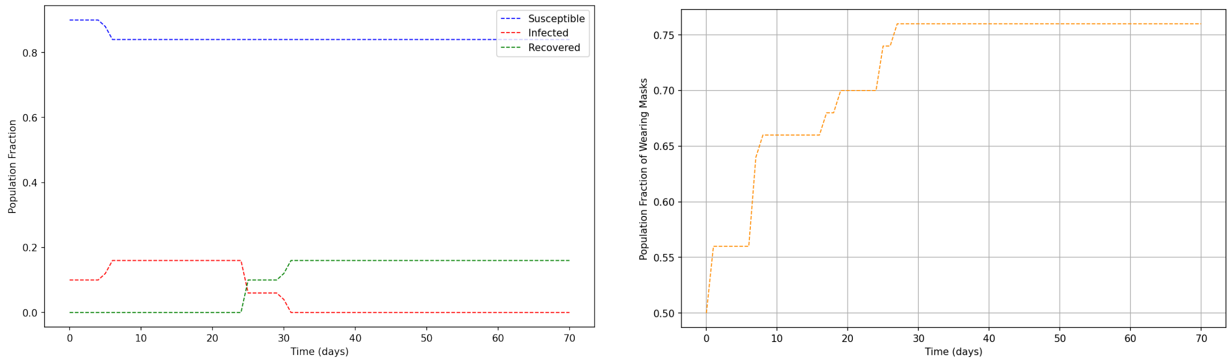


(a) SIS-LT model (b) SIR-LT model

Figure 1: Comparison of different edge densities in LT optimization model with initial values $|V| = 50, T = 70, t_0 = 5, B = 5$.

1.2 Experimental Results for Behavior Changes

Regarding the change of behavior on the transmission process, we compute the infection curves for the dynamic network model as well. Fig. 2 shows how this strategy of wearing masks affects the transmission process in SIR model. Compared with SIR-LT model, the total number of infected individuals within 70 days in this dynamic SIR-LT model is much less than that of SIR-LT model, and three curves in Fig. 2 (a) become stable quickly. To some extent, Fig. 2 illustrates that if people can take precautions quickly to protect themselves, it will be very effective to prevent epidemic spread.



(a) (b)

Figure 2: Diagram of the SIR-LT dynamic network model with initial values $|V| = 50, |V_1|/|V| = 1/2, T = 70, t_0 = 5, B = 5, n_0 = 1$. (a) the susceptible, infected and recovered population fraction curves; (b) fraction of individuals wearing masks versus time in the network G.

1.3 Numerical Results

We compare the running times and solution properties of above-mentioned optimization models and they are displayed in Table 1. The proposed models were implemented in Python 3.6 using the optimization solver CPLEX 12.10 with default settings. All the experiments were performed on a Linux server running CentOS 7 with one AMD EPYC 7642 48-Core processor (2.3GHz) and 512GB memory. Computational time is reported by CPU seconds.

From Table 1, we can observe that the computation time of these models is closely related to the number of edges in a graph and the budget we provided. And the optimization solver was not efficient in solving these models in large networks. Computational experiments also illustrate that solving SIR-LT-dynamic model is more challenging than solving the other models, as some instances are practically unsolvable within 24 hours in this dynamic model.

Table 1: Comparisons of models on connected Watts-Strogatz small-world graphs

Graphs and Parameters					Model	Time (sec.)	Optimal value	Degree sequence of D in G	Avg. degree of D	Avg. degree of G
n	m	T	t_0	B						
50	100	25	t	3	SI-LT	12.66	49	[2, 4, 6]	4.00	4.00
50	100	25	t	5		28.15	50	[2, 3, 5, 6, 7]	4.60	4.00
50	100	25	t	9		15.87	50	[2, 3, 4, 4, 4, 4, 6, 7, 7]	4.56	4.00
100	200	25	t	5		628.34	94	[3, 4, 4, 5, 5]	4.20	4.00
100	200	25	t	10		676.27	99	[2, 2, 2, 3, 3, 3, 3, 3, 4, 4]	2.90	4.00
100	200	25	t	15		28.56	100	[2, 2, 2, 3, 3, 3, 4, 4, 4, 4, 5, 5, 6, 6, 7]	4.00	4.00
50	100	70	5	3	SIS-LT	14.14	29	[4, 6, 6]	5.33	4.00
50	100	70	5	5		11.42	29	[2, 2, 3, 6, 6]	3.80	4.00
50	100	70	5	9		15.94	29	[2, 4, 4, 4, 5, 5, 5, 6]	4.38	4.00
50	150	70	5	5		50.09	39	[5, 5, 6, 6, 6]	5.60	6.00
50	250	70	5	5		260.55	49	[9, 9, 10, 10, 10]	9.60	10.00
100	200	70	5	5		112.35	58	[2, 3, 4, 4, 4]	3.40	4.00
100	200	70	5	10		232.87	58	[2, 3, 3, 3, 3, 4, 4, 5, 5, 6]	3.80	4.00
100	200	70	5	15		281.78	58	[3, 3, 3, 4, 4, 4, 4, 5, 7, 7]	4.40	4.00
50	100	70	5	3	SIR-LT	65.04	30	[2, 2, 4]	2.67	4.00
50	100	70	5	5		152.34	32	[2, 2, 3, 4, 7]	3.60	4.00
50	100	70	5	9		84.1	36	[2, 2, 4, 4, 4, 4, 5, 5, 7]	4.11	4.00
50	150	70	5	5		252.85	47	[3, 4, 5, 6, 7]	5.00	6.00
50	250	70	5	5		43.61	50	[7, 10, 10, 11, 11]	9.80	10.00
100	200	70	5	5		>24h	-	-	-	-
100	200	70	5	10		2774.7	66	[2, 3, 3, 3, 3, 4, 4, 4, 4, 5]	3.50	4.00
100	200	70	5	15		18155.88	71	[2, 2, 2, 3, 3, 3, 3, 3, 3, 4, 4, 4, 4, 4, 5]	3.27	4.00
50	100	70	5	5	SIR-LT-dynamic	4421.56	8	[3, 3, 4, 5, 5]	4.00	4.00
50	100	70	5	10		1833.23	17	[2, 3, 3, 4, 4, 4, 5, 5, 5, 6]	4.10	4.00
50	100	70	5	15		640.4	24	[2, 2, 2, 3, 3, 3, 3, 4, 4, 4, 4, 4, 5, 5, 5]	3.53	4.00
100	200	70	5	5		>24h	-	-	-	-
100	200	70	5	10		>24h	-	-	-	-
100	200	70	5	15		>24h	-	-	-	-