Supplement

Lei Meng

June 6, 2013

Holidays	Duration	Δt=1 week	Δt=1 month	Δt=3 months	Δt=6 months
Fall break(2012)	1 Week	6-7	1	0	0
Thanksgiving(2012)	5 Days	11-12	2	0	0
Winter break(2012)	1 Week	14-19	3-4	1	0
Spring break(2013)	1 Week	27-28	6	2	1
Easter(2013)	4 Days	31	7	2	1
Summer break(2013)	3 Months	36-50	8-11	2-3	1
Fall break(2013)	1 Week	58	13	4	2
Thanksgiving(2013)	5 Days	63-64	14	4	2

Table 1: The time each holiday happened for different time interval Δt

(a) Δt=1 week, w=1 (b) Δt=1 month, w=1 (c) Δt=1 month, w=2 (d) Δt=1 month, w=3 (e) Δt=1 month, w=4

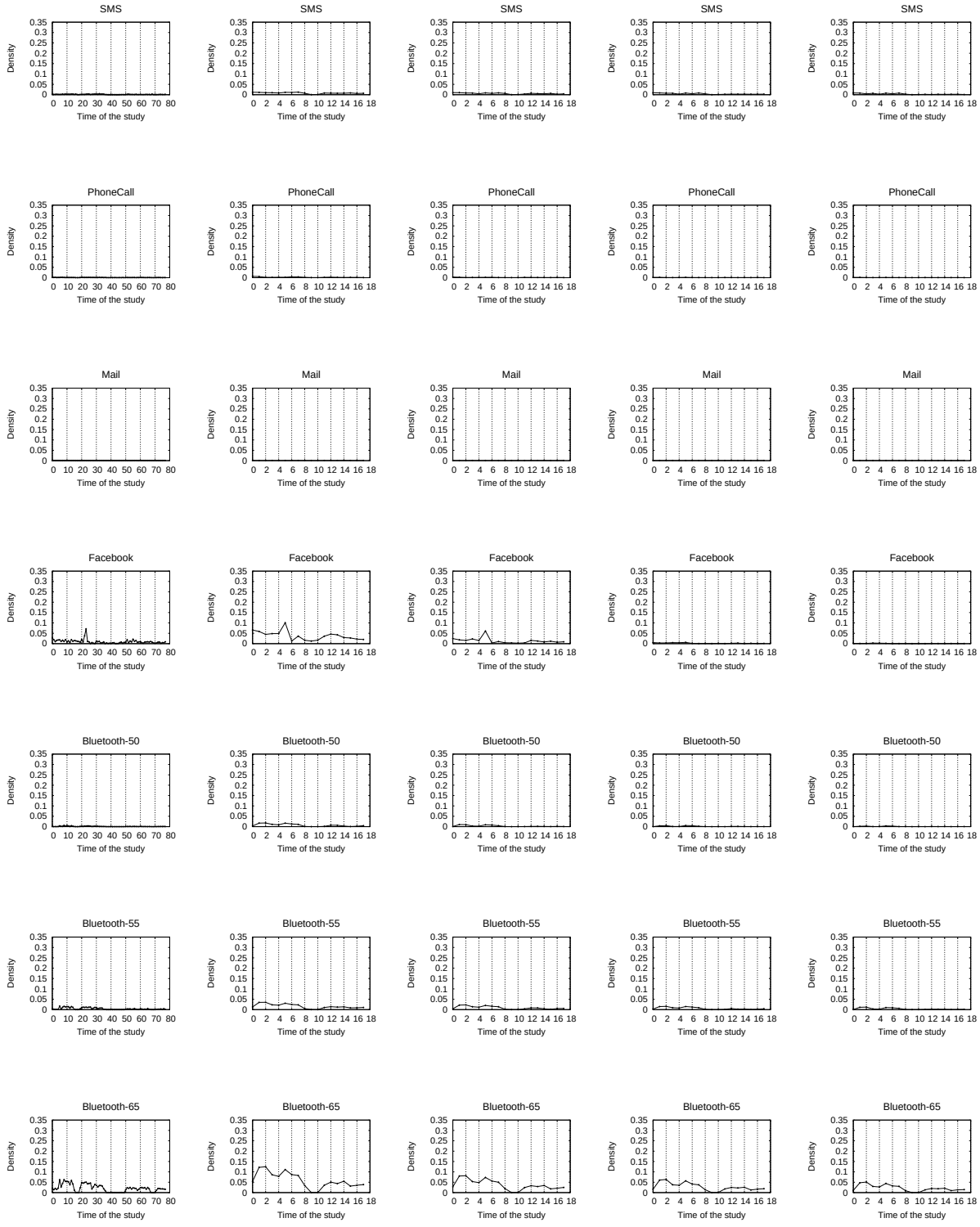


Figure 1: Network density. Each row contains networks of different types and each column contains networks with different parameters. ($\Delta t = 1$ week or Δt =1 month)

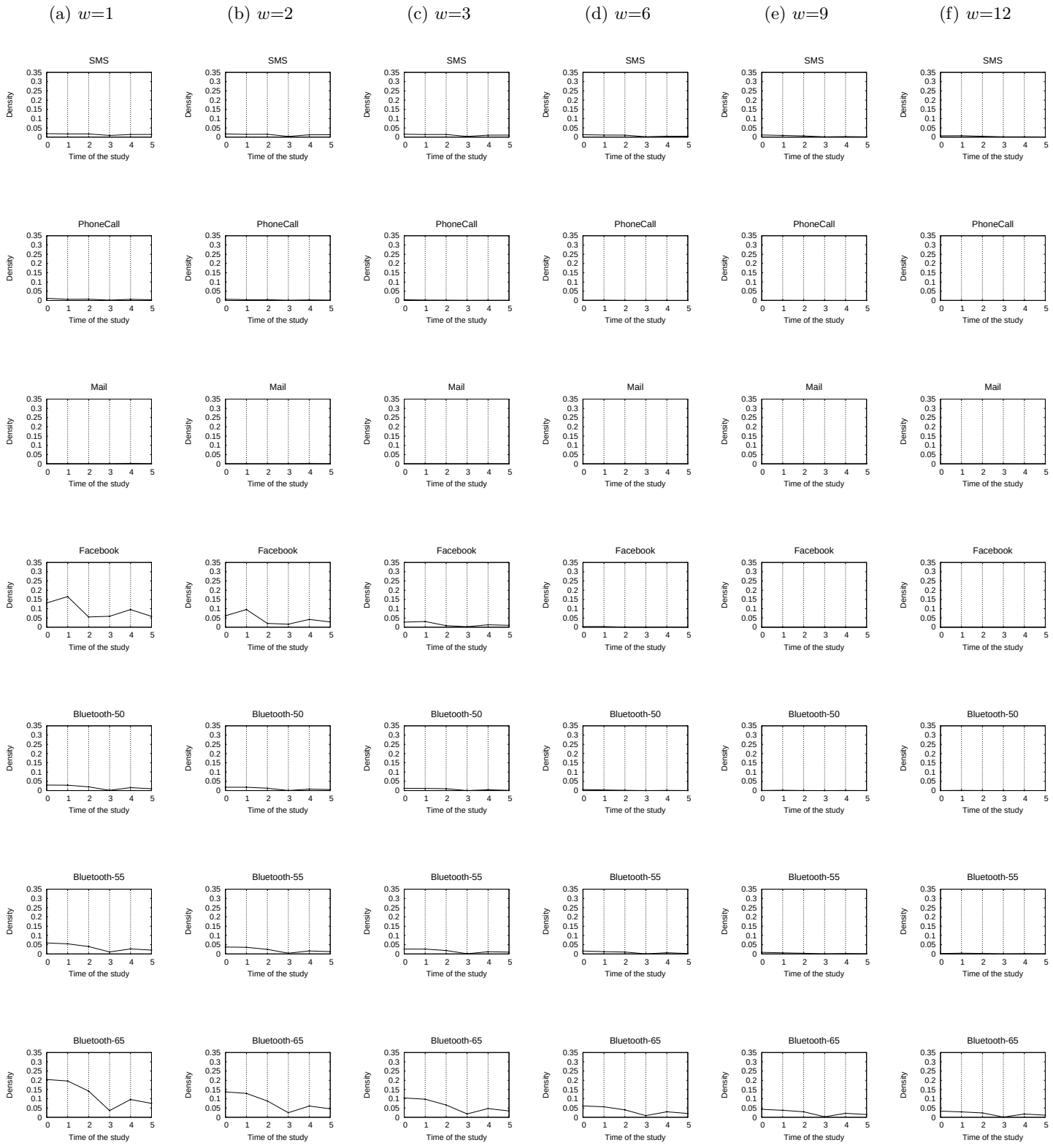


Figure 2: Network density. Each row contains networks of different types and each column contains networks with different parameters. (Δt =3 months)

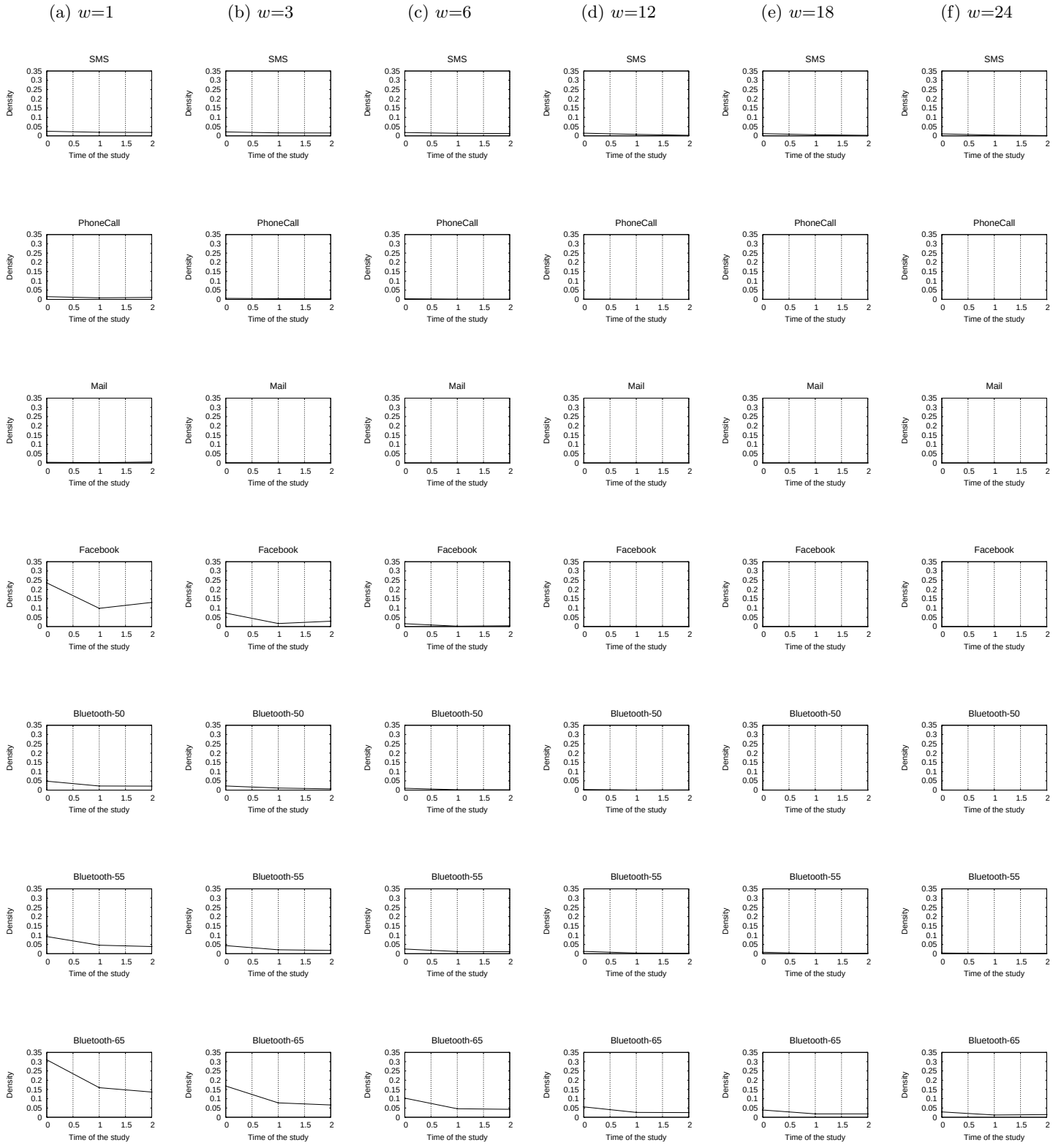


Figure 3: Network density. Each row contains networks of different types and each column contains networks with different parameters. (Δt =6 months)

(a) Δt=1 week, w=1 (b) Δt=1 month, w=1 (c) Δt=1 month, w=2 (d) Δt=1 month, w=3 (e) Δt=1 month, w=4

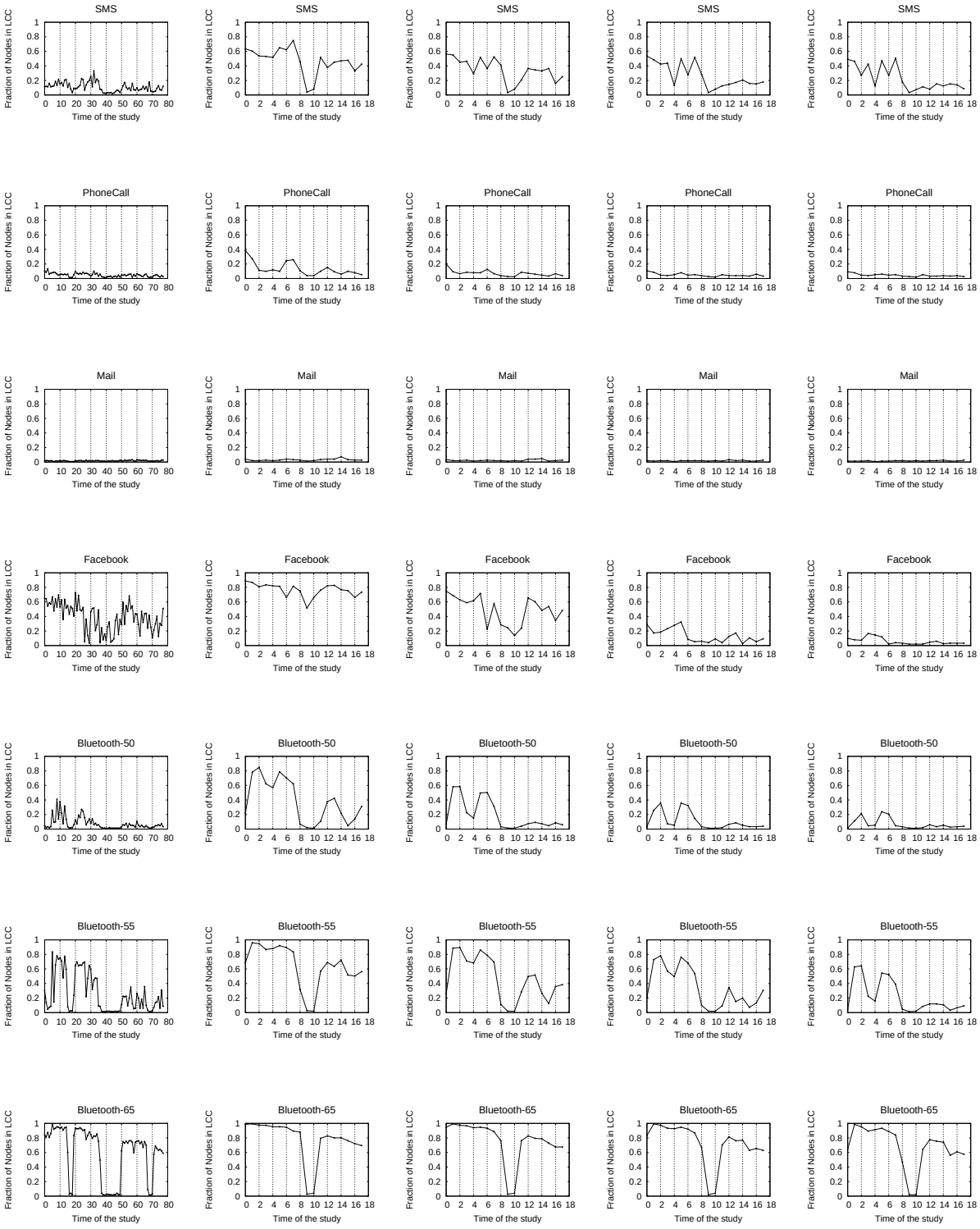


Figure 4: Percentage of nodes from the network in the largest connected component. Each row contains networks of different types and each column contains networks with different parameters. ($\Delta t = 1$ week and Δt =1 month)

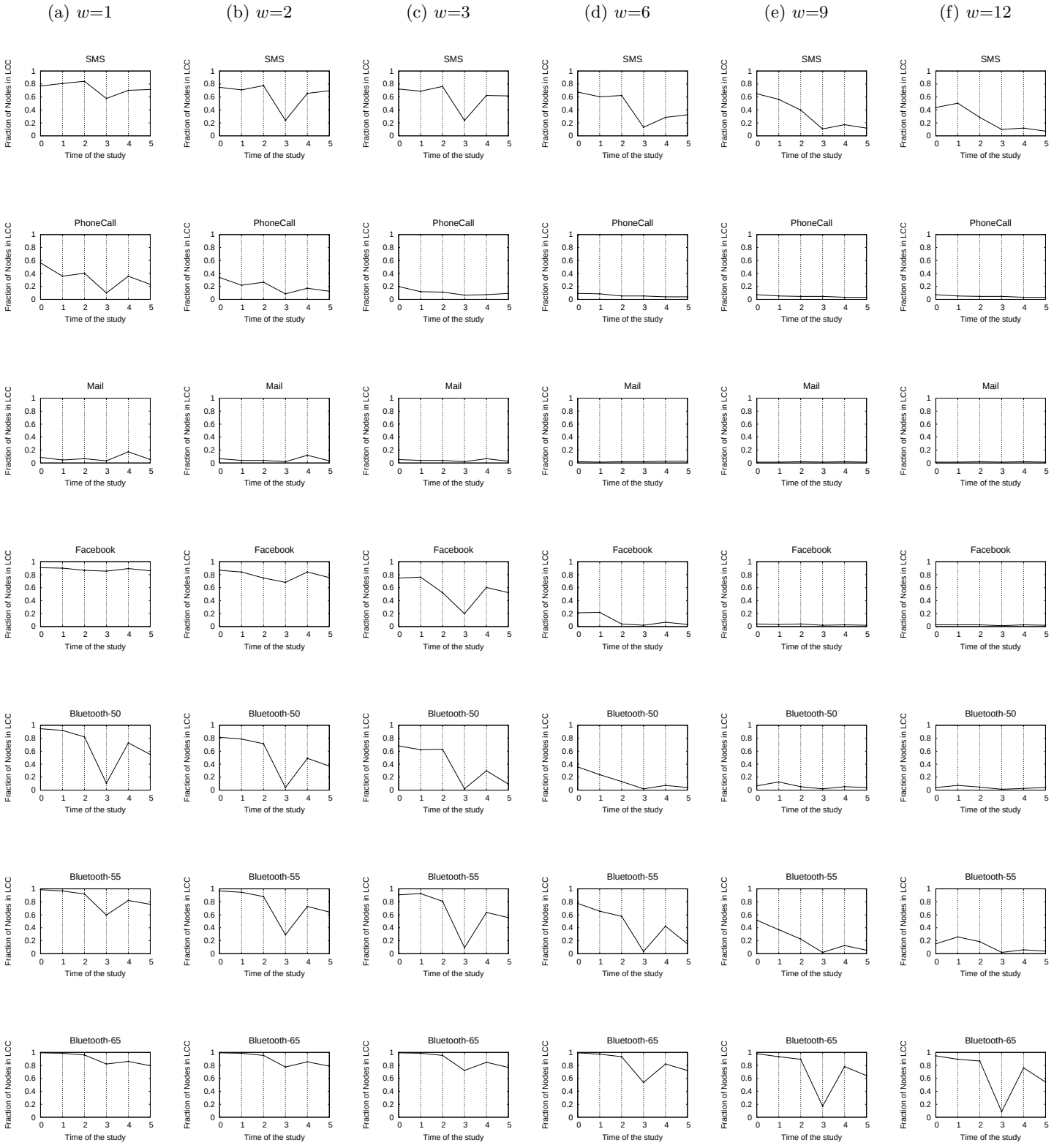


Figure 5: Percentage of nodes from the network in the largest connected component. Each row contains networks of different types and each column contains networks with different parameters. (Δt =3 months)

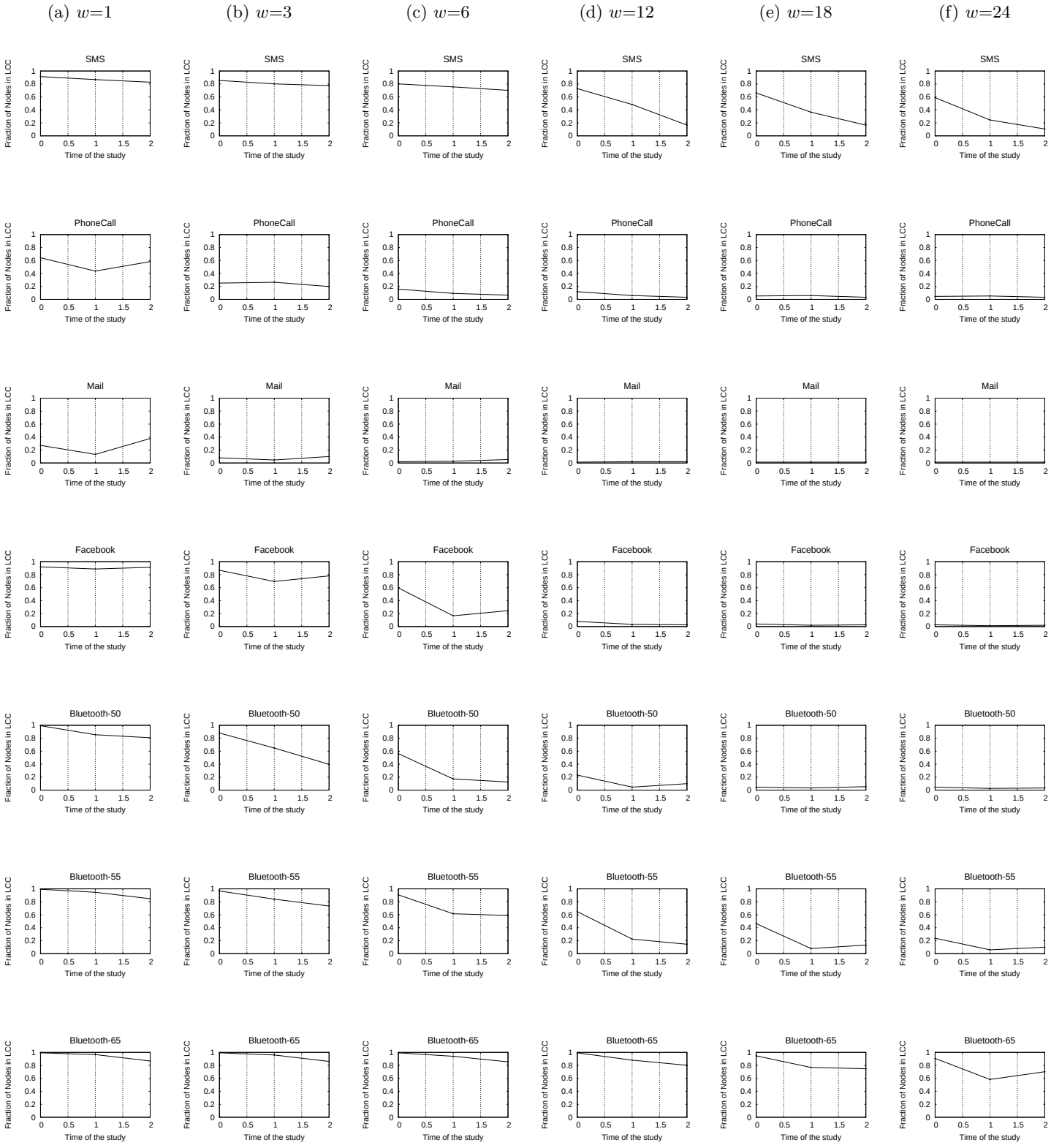


Figure 6: Percentage of nodes from the network in the largest connected component. Each row contains networks of different types and each column contains networks with different parameters. ($\Delta t = 6$ months)

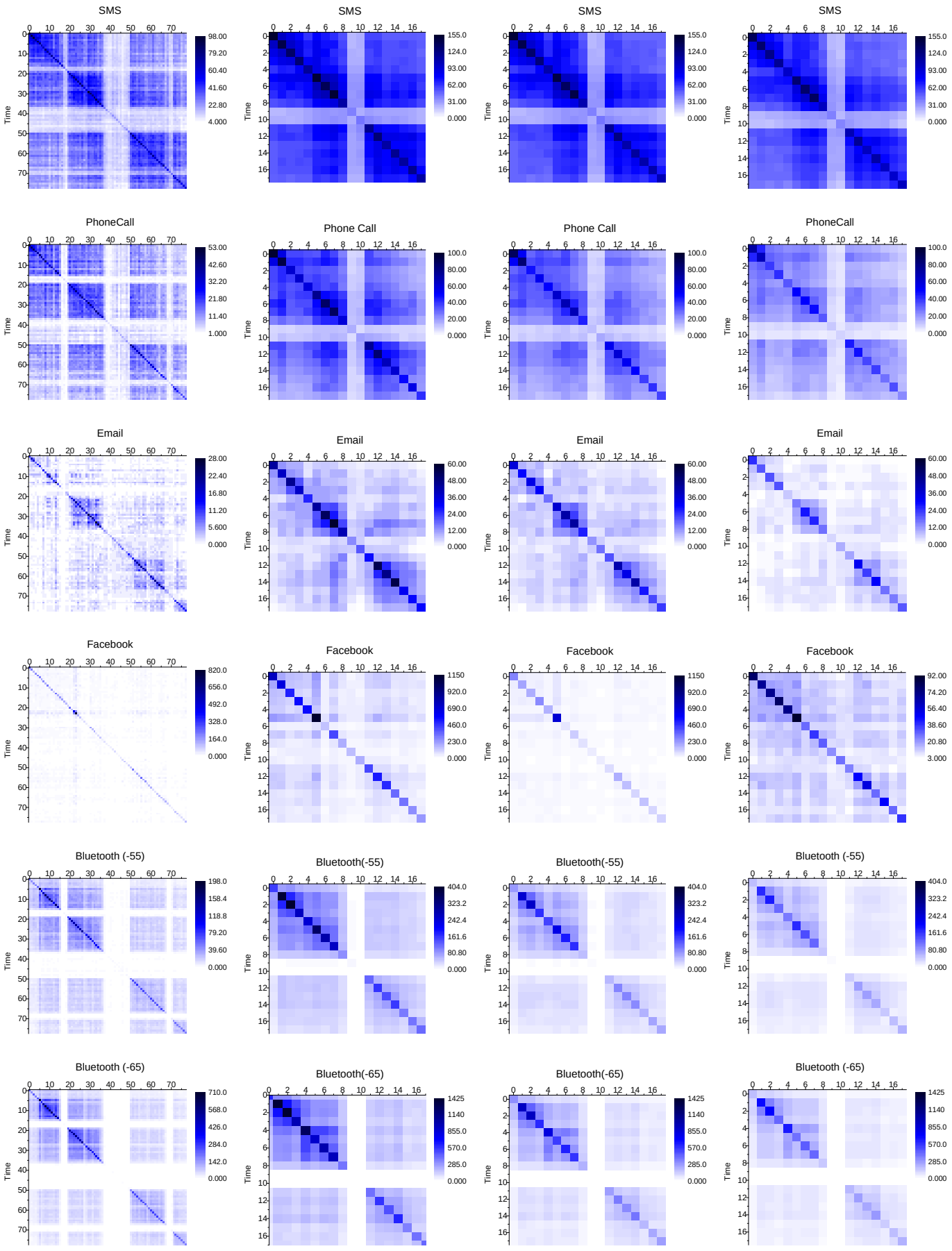


Figure 7: Edge intersection matrix of the same type of networks from different time.

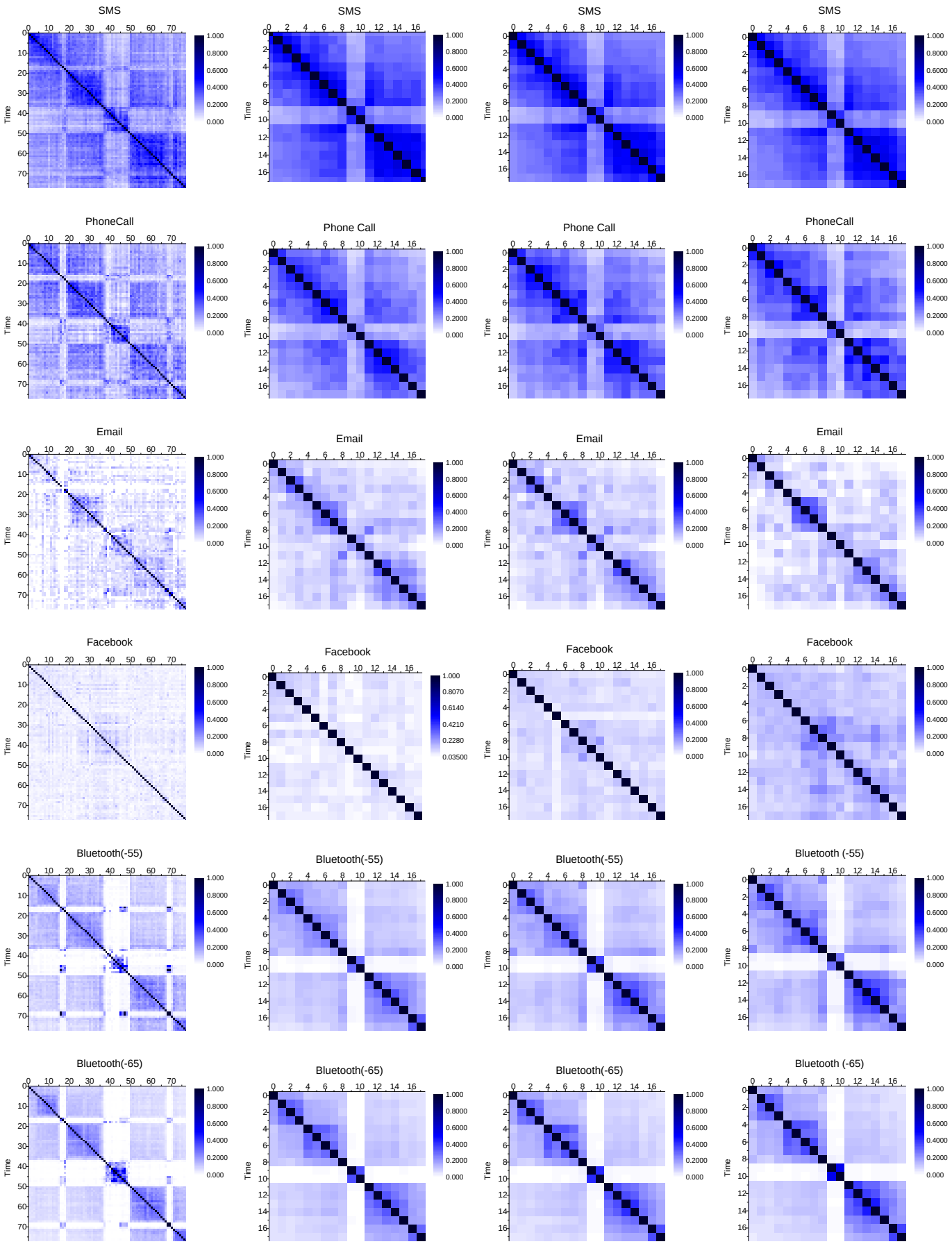


Figure 8: Relative edge intersection matrix of the same type of networks from different time.

(a) $\Delta t = 1$ week, w=1 (b) $\Delta t = 1$ month, w=3

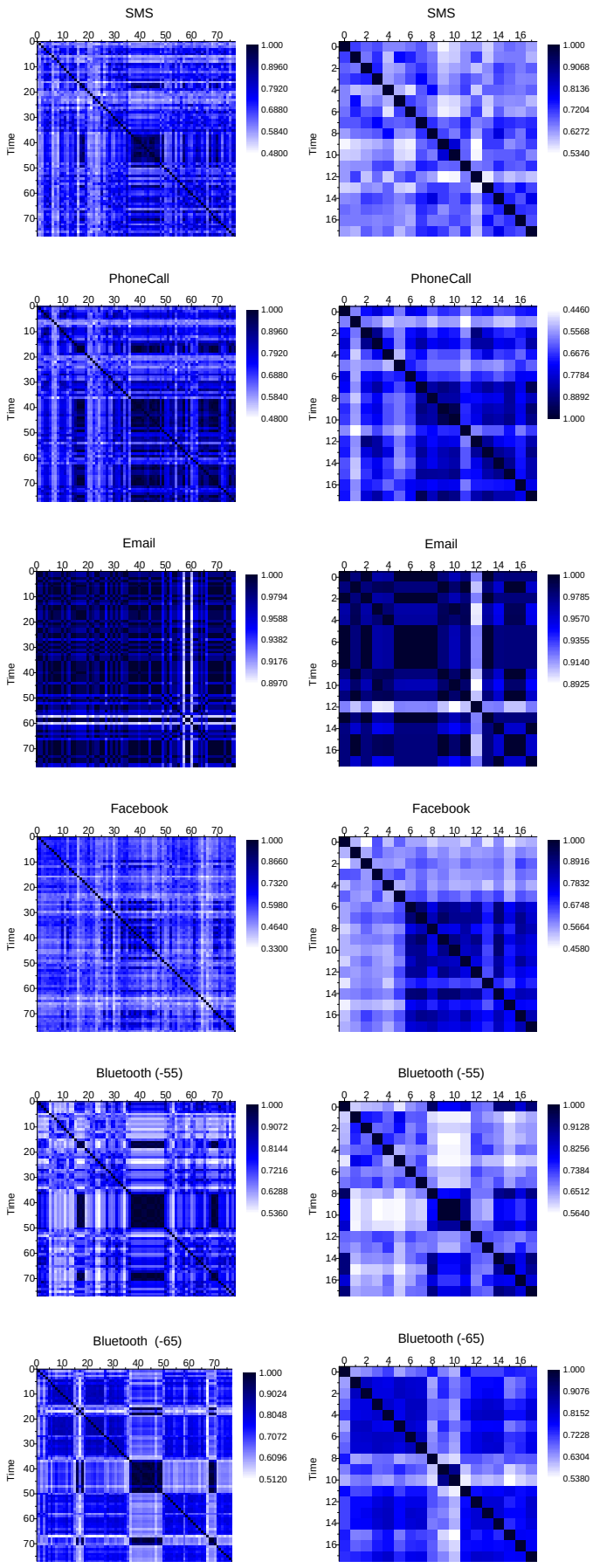


Figure 9: GDD-agreement matrix of the same type of networks from different time.

(a) $\Delta t = 1$ week, w=1 (b) $\Delta t = 1$ month, w=3

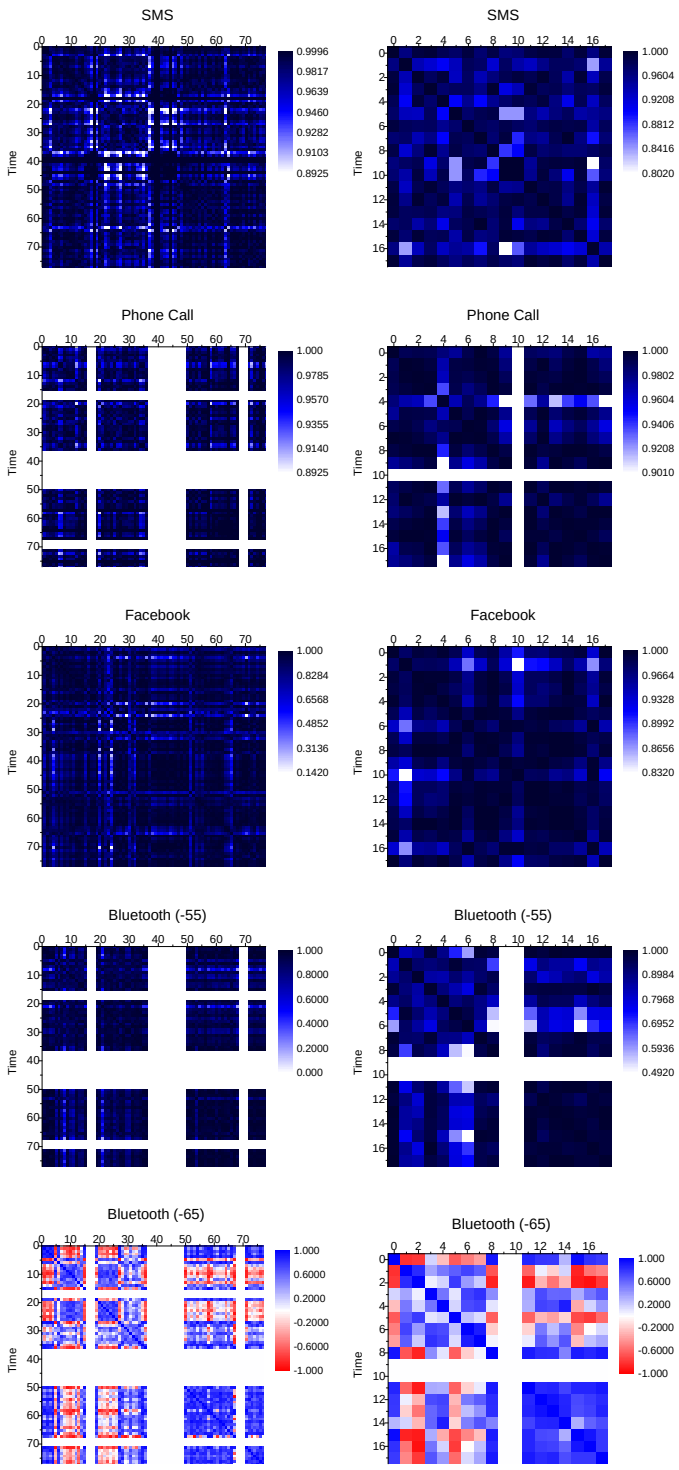
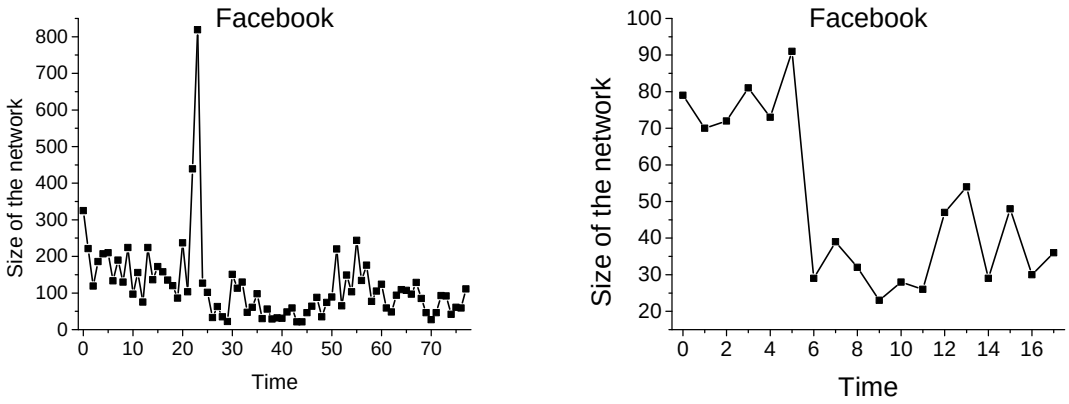


Figure 10: Pearson correlation of degree distribution matrix of the same type of networks from different time.



(a) $\Delta t = 1$ week, $w = 1$

(b) $\Delta t = 1$ month, $w = 3$

Figure 11: Facebook network size (number of edges) over time

	I	RI	GDD
RI	0.905***		
GDD	-0.024	0.039	
PDD	0.052	0.029	0.028

(a) SMS

	I	RI	GDD
RI	0.865***		
GDD	-0.099	0.027	
PDD	0.003	0.056	0.271***

(b) Phone Call

	I	RI	GDD
RI	0.713***		
GDD	-0.018	0.042	
PDD	-0.081	0.026	0.241***

(c) Facebook

	I	RI	GDD
RI	0.791***		
GDD	-0.027*	0.120	
PDD	0.003*	0.117	0.392***

(d) Bluetooth(-55)

	I	RI	GDD
RI	0.804***		
GDD	0.31***	0.183*	
PDD	0.076	0.191*	0.551***

(e) Bluetooth(-65)

Table 2: Pearson correlation of four similarity measures I (Intersection), RI (Relative intersection), PDD (Pearson correlation of degree distribution), GDD (GDD-agreement) in comparing homogeneous networks. The values are computed by computing the Pearson correlation of pairwise vectors taken from the upper triangles of the matrices (excluding the diagonals) generated from the similarity measures as shown in Figure 7-10. For example, the Pearson correlation of RI and I in subtable (a) is computed from two matrices, one is the matrix in Row SMS and Column (a) from Figure 7 and the other matrix is in Row SMS and Column (a) from Figure 8.($\Delta t = 1$ week, $w = 1$, $p < 0.05^{*}, p < 0.01^{**}, p < 0.005^{***}$)

	I	RI	GDD
RI	0.928***		
GDD	0.134	0.110	
PDD	-0.074	-0.042	-0.065

(a) SMS

	I	RI	GDD
RI	0.862***		
GDD	0.160	0.025	
PDD	0.079	0.140	0.052

(b) Phone Call

	I	RI	GDD
RI	0.864***		
GDD	-0.087	0.165*	
PDD	0.057	0.097	0.194*

(c) Facebook

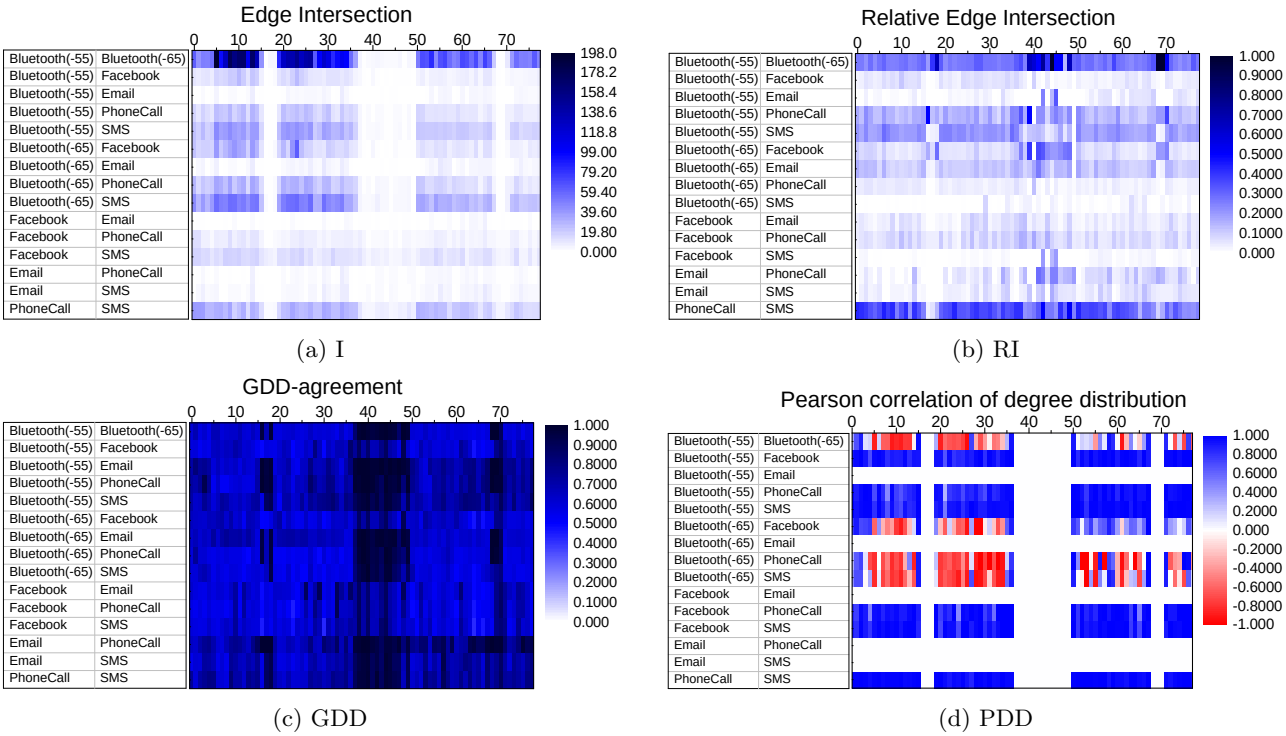
	I	RI	GDD
RI	0.795***		
GDD	0.128	-0.016	
PDD	0.152	-0.016	0.507***

(d) Bluetooth(-55)

	I	RI	GDD
RI	0.804***		
GDD	0.170*	0.245**	
PDD	0.213*	0.103	0.565***

(e) Bluetooth(-65)

Table 3: Pearson correlation of four similarity measures I (Intersection), RI (Relative intersection), PDD (Pearson correlation of degree distribution), GDD (GDD-agreement) in comparing homogeneous networks. The values are computed by computing the Pearson correlation of pairwise vectors taken from the upper triangles of the matrices (excluding the diagonals) generated from the similarity measures as shown in Figure 7-10. For example, the Pearson correlation of RI and I in subtable (a) is computed from two matrices, one is the matrix in Row SMS and Column (d) from Figure 7 and the other matrix is in Row SMS and Column (d) from Figure 8.($\Delta t = 1$ month, $w = 3$, $p < 0.05^{*}, p < 0.01^{**}, p < 0.005^{***}$)



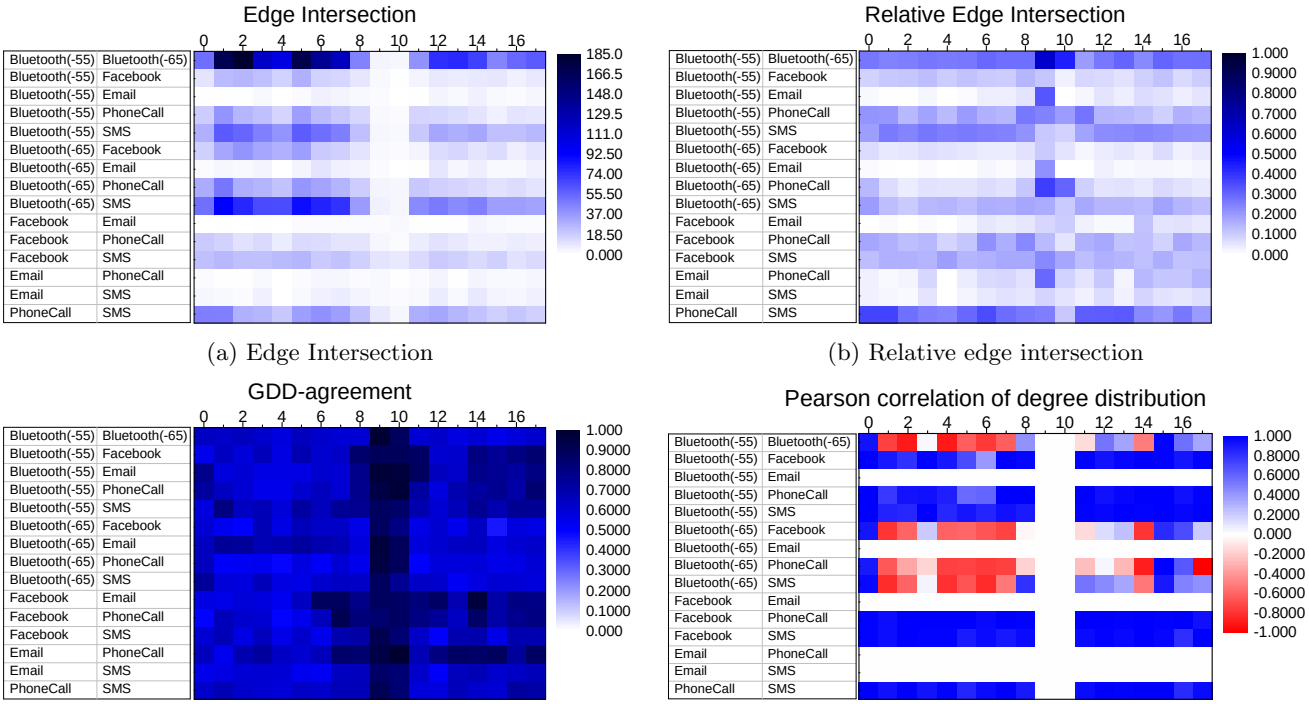
(a) I (b) RI

(c) GDD (d) PDD

Figure 12: Similarity matrices in comparing heterogenous networks. Columns are the time of the networks and rows are pairs of networks to compare. ($\Delta t = 1$ week, $w = 1$)

Network I	Network II	I avg (std)	RI avg (std)	GDD avg (std)	PDD avg (std)
Bluetooth(-55)	Bluetooth(-65)	**67.615**(52.910)	**0.341(0.175)**	-0.086(0.612)	0.687(0.157)
Bluetooth(-55)	Facebook	8.077(6.654)	0.043(0.025)	0.930(0.075)	0.643(0.098)
Bluetooth(-55)	Email	1.756(1.867)	0.030(0.051)		**0.767**(0.141)
Bluetooth(-55)	Phone Call	11.923(8.377)	0.164(0.080)	0.891(0.132)	**0.763**(0.143)
Bluetooth(-55)	SMS	**20.73**(13.559)	**0.176**(0.067)	**0.934**(0.090)	0.754(0.108)
Bluetooth(-65)	Facebook	13.462(12.295)	0.100(0.086)	0.163(0.590)	0.638(0.089)
Bluetooth(-65)	Email	2.5(2.475)	0.112(0.041)		0.723(0.138)
Bluetooth(-65)	Phone Call	15.770(10.770)	0.034(0.018)	-0.245(0.683)	0.662(0.161)
Bluetooth(-65)	SMS	**29.321**(18.684)	0.010(0.016)	-0.162(0.647)	0.644(0.137)
Facebook	Email	0.846(1.129)	0.047(0.027)		0.65(0.112)
Facebook	Phone Call	5.243(2.875)	0.076(0.034)	0.907(0.132)	0.625(0.106)
Facebook	SMS	10.590(4.377)	0.015(0.035)	**0.937**(0.079)	0.629(0.101)
Email	Phone Call	1.667(1.568)	0.069(0.068)		**0.812(0.128)**
Email	SMS	2.705(2.222)	0.046(0.036)		0.727(0.120)
Phone Call	SMS	20.487(10.556)	**0.318**(0.092)	**0.974(0.028)**	0.756(0.110)

Table 4: The average and standard deviation of similarities over time for each pair of networks of different types. The network pairs correspond to the rows in Figure 12, which are the two network types to compare. The average values of network pair p from similarity measure f is computed by averaging the values of Row p in the corresponding matrices in Figure 13. The numbers in bold are the three largest averages in each column. ($\Delta t = 1$ week, $w = 1$).



(a) Edge Intersection

(b) Relative edge intersection

(c) GDD-agreement

(d) Pearson correlation of degree distribution

Figure 13: Similarity matrices in comparing heterogenous networks. Columns are the time of the networks and rows are pairs of networks to compare. ($\Delta t = 1$ month, $w = 3$)

Network I	Network II	I avg (std)	RI avg (std)	GDD avg (std)	PDD avg (std)
Bluetooth(-55)	Bluetooth(-65)	**86.056**(55.248)	**0.300**(0.095)	0.651(0.109)	-0.067(0.664)
Bluetooth(-55)	Facebook	13.056(8.419)	0.100(0.027)	**0.719**(0.120)	0.902(0.155)
Bluetooth(-55)	Email	2.667(1.910)	0.049(0.075)	0.716(0.135)	
Bluetooth(-55)	Phone Call	17.167(10.194)	0.178(0.050)	0.708(0.122)	0.908(0.135)
Bluetooth(-55)	SMS	**34.167**(17.281)	**0.221**(0.049)	0.717(0.085)	0.940(0.060)
Bluetooth(-65)	Facebook	17.611(11.668)	0.053(0.019)	0.615(0.101)	-0.110(0.597)
Bluetooth(-65)	Email	4.278(3.025)	0.026(0.050)	0.689(0.103)	
Bluetooth(-65)	Phone Call	21.944(11.988)	0.102(0.093)	0.603(0.124)	-0.259(0.628)
Bluetooth(-65)	SMS	**51.889**(25.481)	0.150(0.024)	0.637(0.086)	0.011(0.675)
Facebook	Email	1.667(1.237)	0.041(0.036)	**0.749**(0.138)	
Facebook	Phone Call	10.111(4.562)	0.146(0.043)	0.718(0.13)	**0.984**(0.018)
Facebook	SMS	18.944(5.599)	0.159(0.027)	0.662(0.102)	**0.956**(0.048)
Email	Phone Call	2.556(1.464)	0.086(0.069)	**0.775**(0.126)	
Email	SMS	4.444(2.382)	0.049(0.024)	0.638(0.092)	
Phone Call	SMS	27.389(11.748)	**0.277**(0.064)	0.668(0.086)	**0.954**(0.051)

Table 5: The average and standard deviation of similarities over time for each pair of networks of different types. The network pairs correspond to the rows in Figure 13, which are the two network types to compare. The average values of network pair p from similarity measure f is computed by averaging the values of Row p in the corresponding matrices in Figure 13. The numbers in bold are the three largest averages in each column. ($\Delta t = 1$ month, $w = 3$).

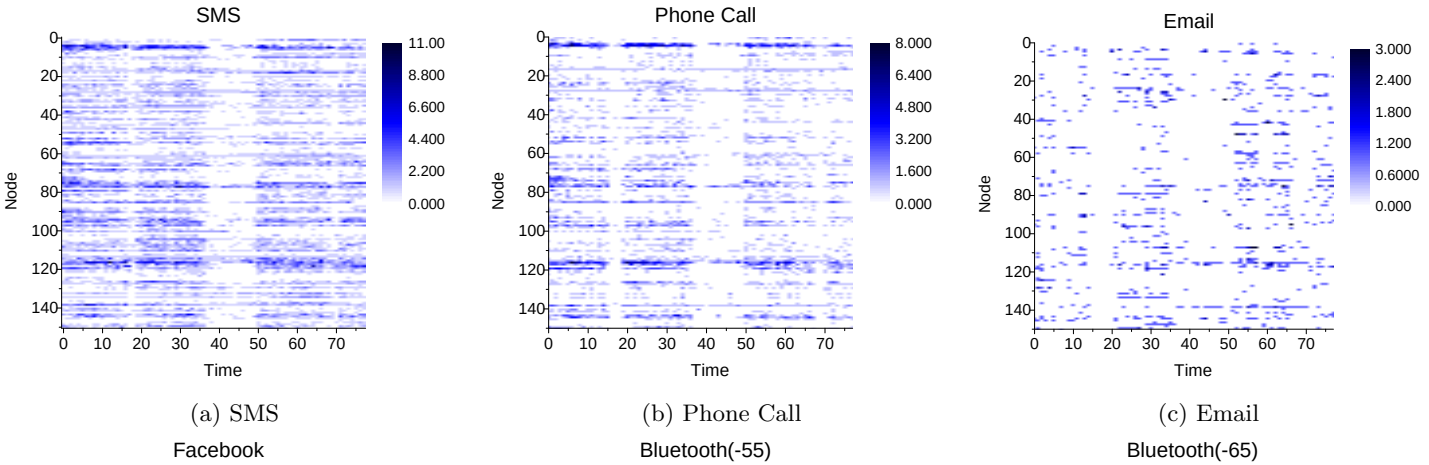
	I	RI	GDD
RI	0.415***		
GDD	-0.087	0.402***	
PDD	-0.517	0.179*	0.378***

(a) $\Delta t = 1$ week, $w = 1$

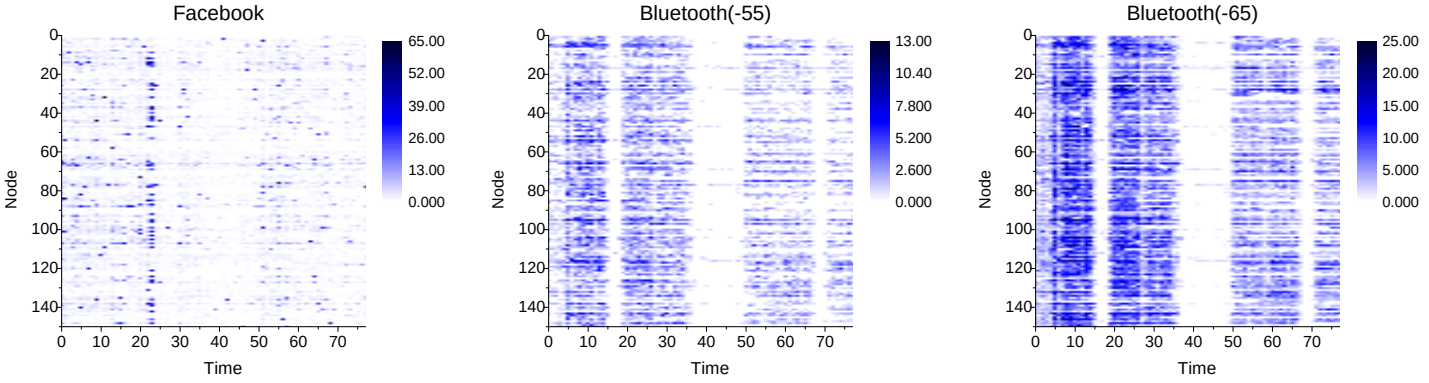
	I	RI	GDD
RI	1***		
GDD	0.195*	0.195*	
PDD	0.311***	0.311***	0.395***

(b) $\Delta t = 1$ month, $w = 3$

Table 6: Pearson correlation of four similarity measures I, RI, PDD, GDD in comparing heterogenous networks. The values are generated by computing the Pearson correlation of pairwise vectors taken from the matrices generated from the similarity measures as shown in Figure 12 and Figure 13 for different parameters respectively. For example, the Pearson correlation of RI and I in subtable (a) is computed from two matrices in Figure 12 (a) and (b). ($p < 0.05^{*}, p < 0.01^{**}, p < 0.005^{***}$)

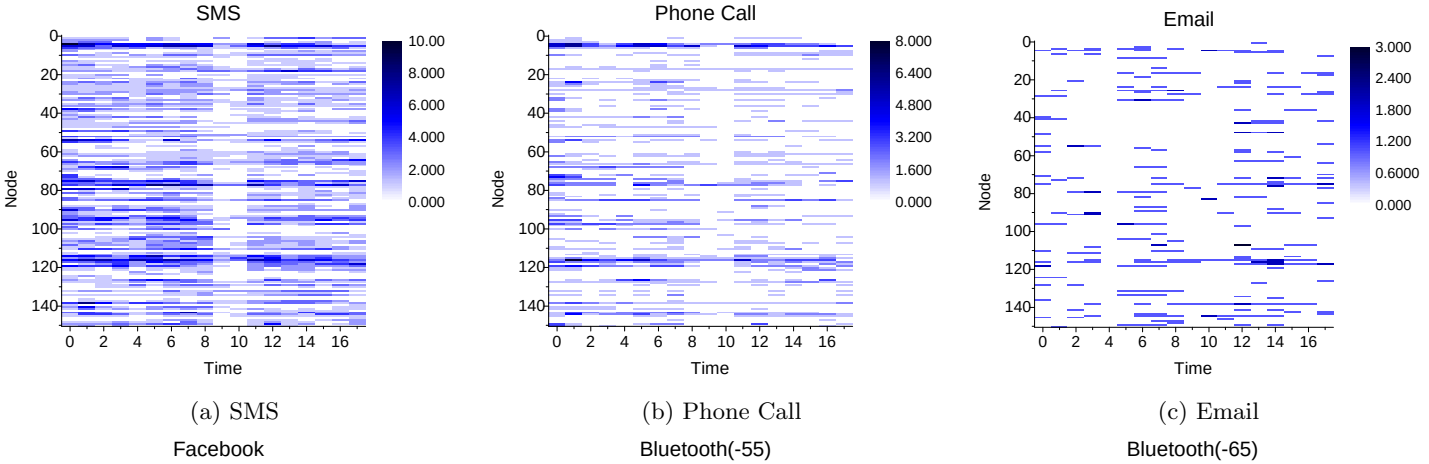


(a) SMS (b) Phone Call (c) Email

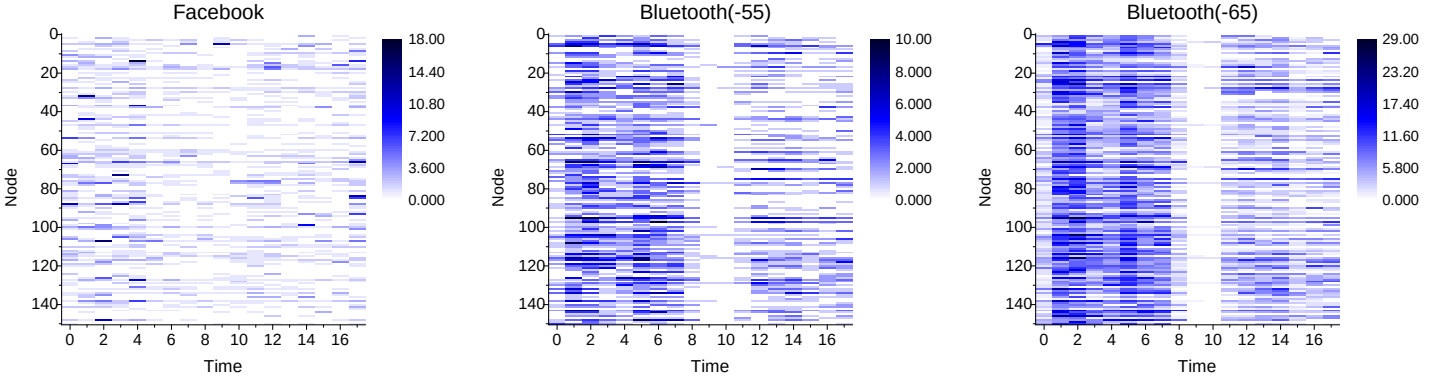


(d) Facebook (e) Bluetooth -55 (f) Bluetooth -65

Figure 14: Node degree over time. The nodes are in the same order in different figures. ($\Delta t = 1$ week, $w = 1$)

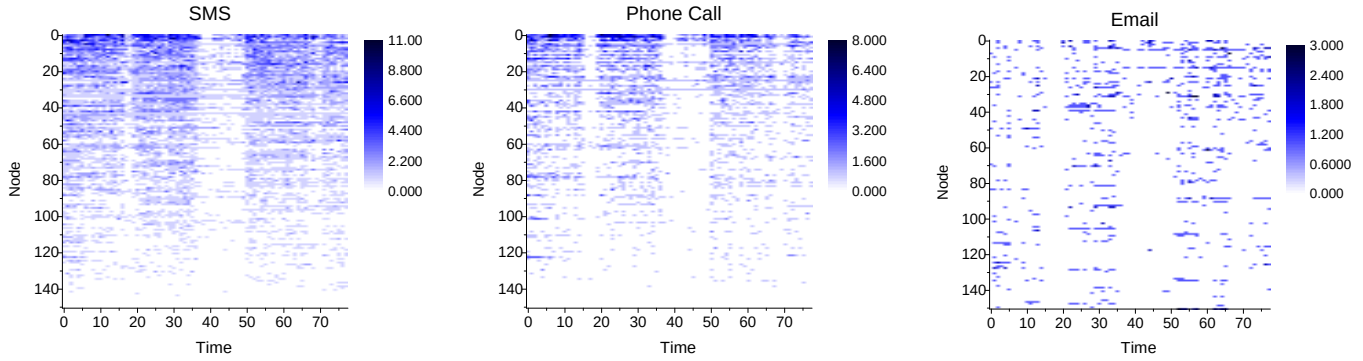


(a) SMS (b) Phone Call (c) Email



(d) Facebook (e) Bluetooth -55 (f) Bluetooth -65

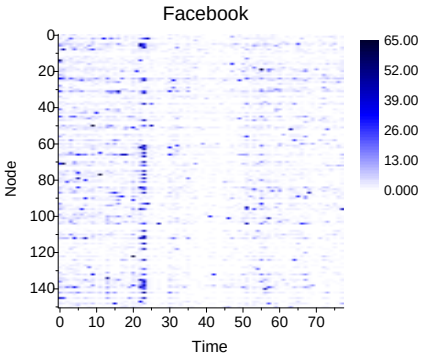
Figure 15: Node degree over time. The nodes are in the same order in different figures. ($\Delta t = 1$ month, $w = 3$)



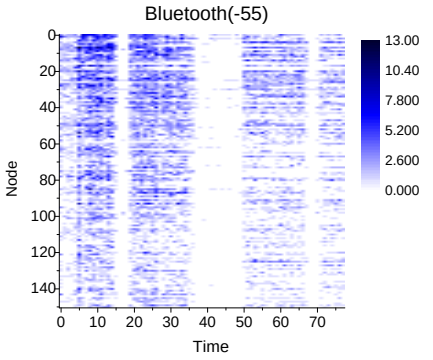
(a) SMS

(b) Phone Call

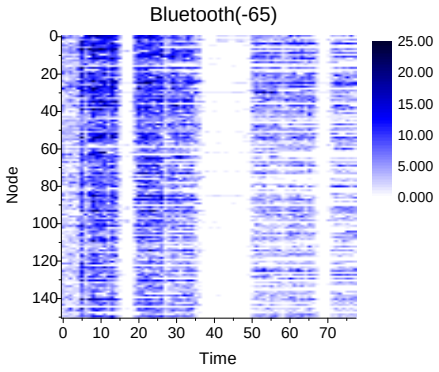
(c) Email



(d) Facebook

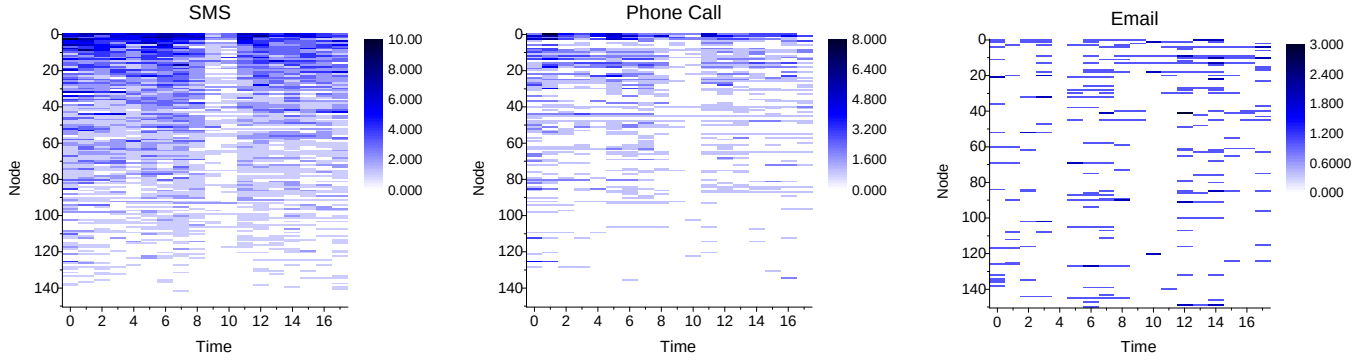


(e) Bluetooth -55



(f) Bluetooth -65

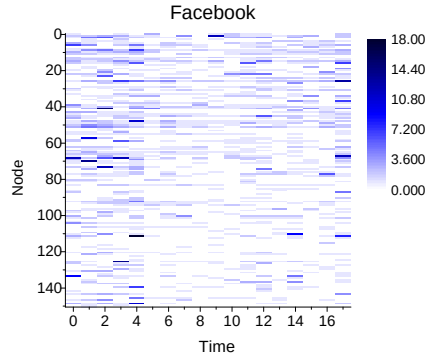
Figure 16: Node degree over time and nodes are ordered by their average degree in the SMS network from large to small. The nodes are in the same order in different figures. ($\Delta t = 1$ week, $w = 1$)



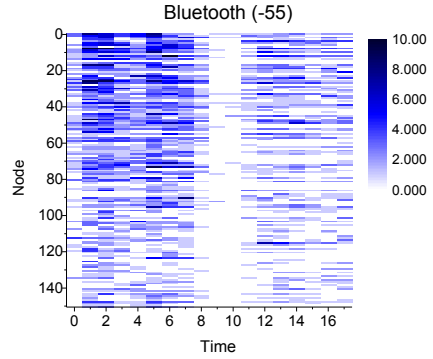
(a) SMS

(b) Phone Call

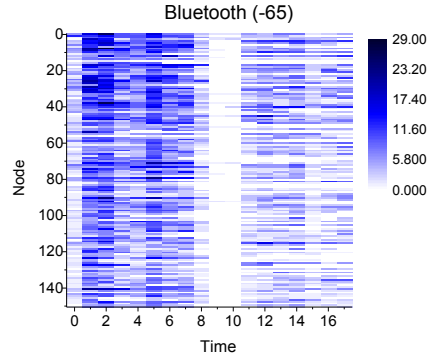
(c) Email



(d) Facebook



(e) Bluetooth -55



(f) Bluetooth -65

Figure 17: Node degree over time and nodes are ordered by their average degree in the SMS network from large to small. The nodes are in the same order in different figures. ($\Delta t = 1$ month, $w = 3$)