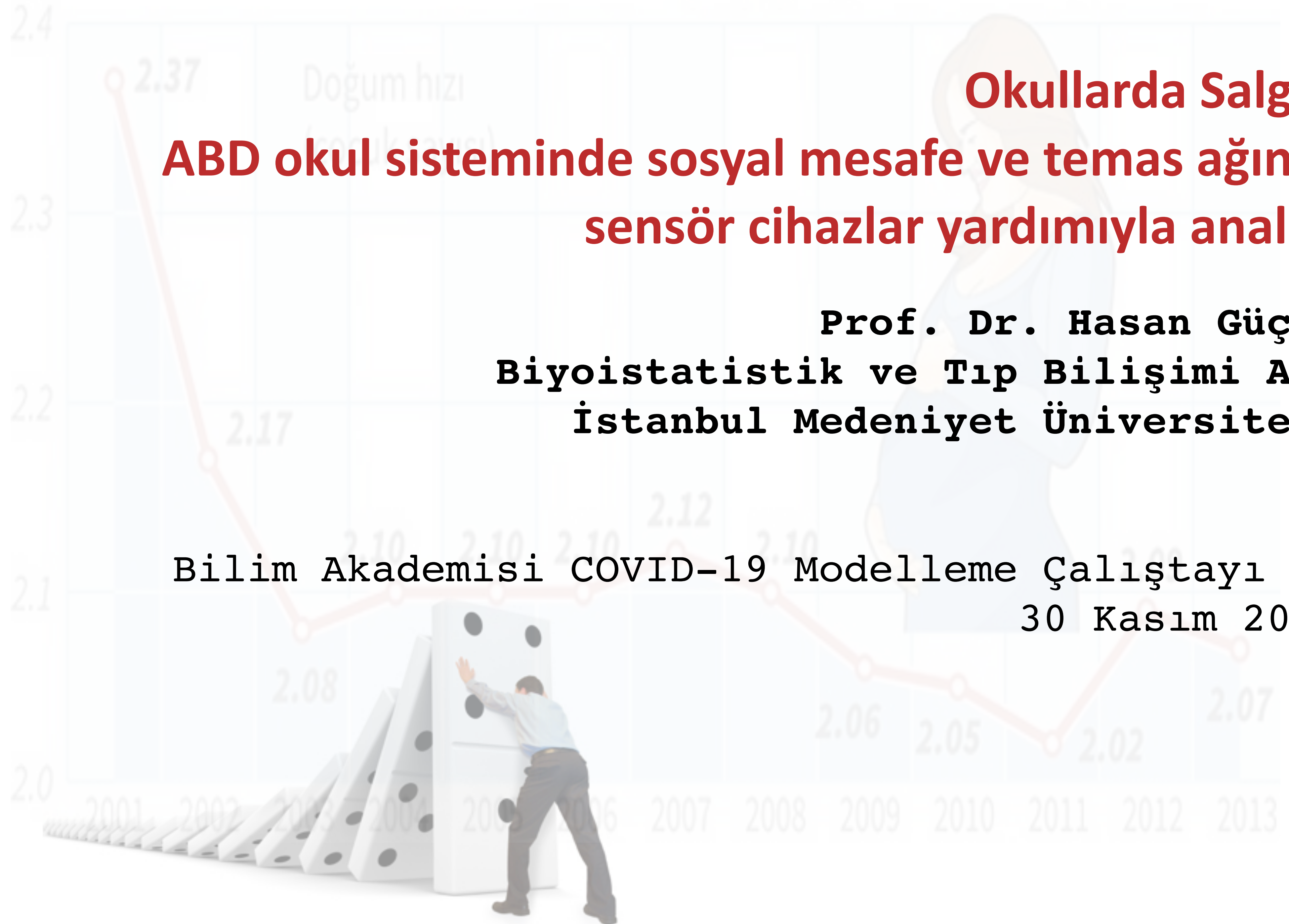


Okullarda Salgın ABD okul sisteminde sosyal mesafe ve temas ağının sensör cihazlar yardımıyla analizi

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İstanbul Medeniyet Üniversitesi

Bilim Akademisi COVID-19 Modelleme Çalıştayı II
30 Kasım 2020



Social Contact Networks and Mixing among Students in K-12 Schools in Pittsburgh, PA

Hasan Guclu^{1,2,3*}, Jonathan Read^{4,5}, Charles J. Vukotich, Jr⁶, David D. Galloway², Hongjiang Gao⁷, Jeanette J. Rainey⁷, Amra Uzicanin⁷, Shanta M. Zimmer⁶, Derek A. T. Cummings⁸

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<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0151139>

Age-specific social mixing of school-aged children in a US setting using proximity detecting sensors and contact surveys

Kyra H. Grantz^{1,2,3}, Derek A.T. Cummings^{1,2,3}, Shanta Zimmer^{4,5}, Charles Vukotich Jr.⁴, David Galloway⁶, Mary Lou Schweizer⁴, Hasan Guclu^{6†}, Jennifer Cousins^{6†}, Carrie Lingle^{6†}, Gabby M.H. Yearwood⁷, Kan Li^{6†}, Patti Calderone⁴, Eva Noble³, Hongjiang Gao⁸, Jeanette Rainey^{8†}, Amra Uzicanin⁸, Jonathan M. Read^{9, 10*}

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² Emerging Pathogens Institute, University of Florida, Gainesville FL USA 32611

³ Department of Epidemiology, Johns Hopkins Bloomberg School of Public Health, Baltimore MD USA 21205

⁴ Division of General Internal Medicine, University of Pittsburgh School of Medicine, Pittsburgh PA USA 15213

⁵ Department of Medicine, University of Colorado School of Medicine, Denver CO USA 80045

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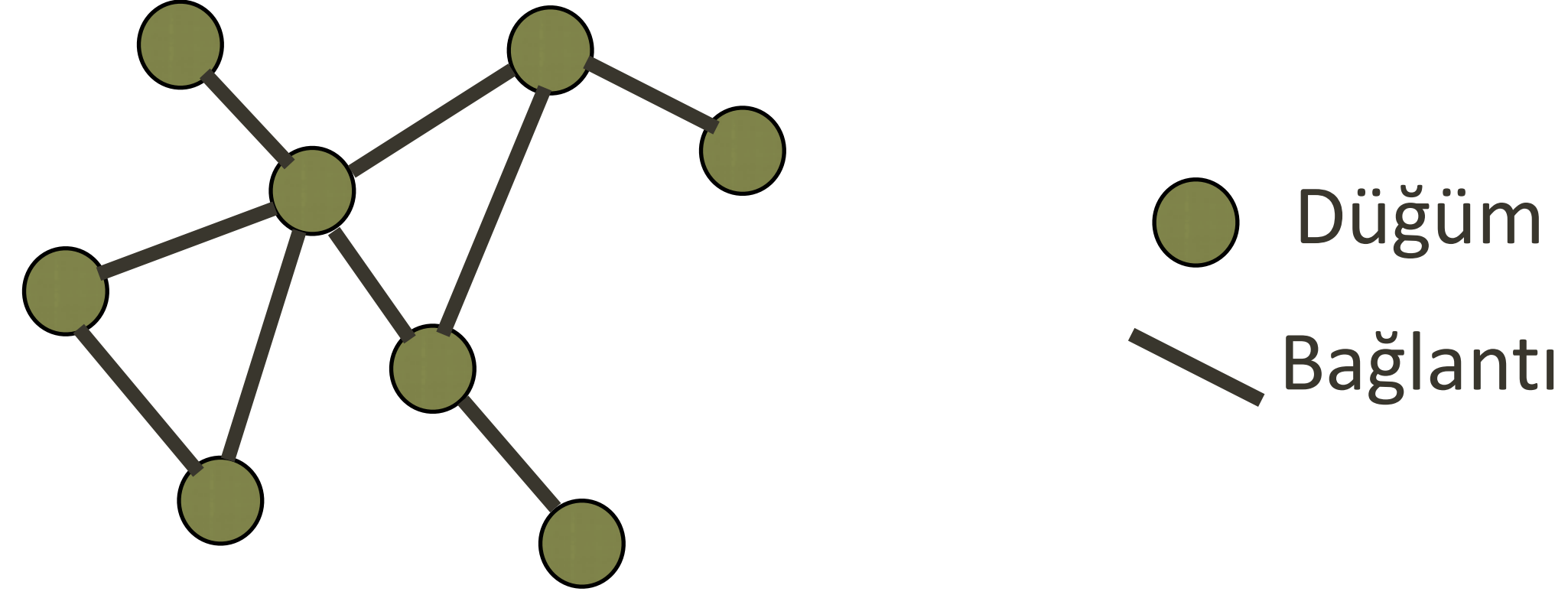
Keywords: social mixing, proximity sensors, contact survey, respiratory virus transmission, school

<https://www.medrxiv.org/content/10.1101/2020.07.12.20151696v1.full.pdf>

Ağ modellemesi

Ağ nedir?

Ağ, ikili bağlantılarla birleştirilmiş düğüm topluluğudur.



Ağ	Düğüm	Bağlantı
Sosyal temas ağı	kişiler	temaslar
doktorların ağı	doktorlar	hasta paylaşımı
enfeksiyon ağı	kişiler	kim kime bulaştırmış
arkadaşlık ağı	kişiler	arkadaşlık
sini ağı	sinir hücreleri	sinaps

Ağ verisi

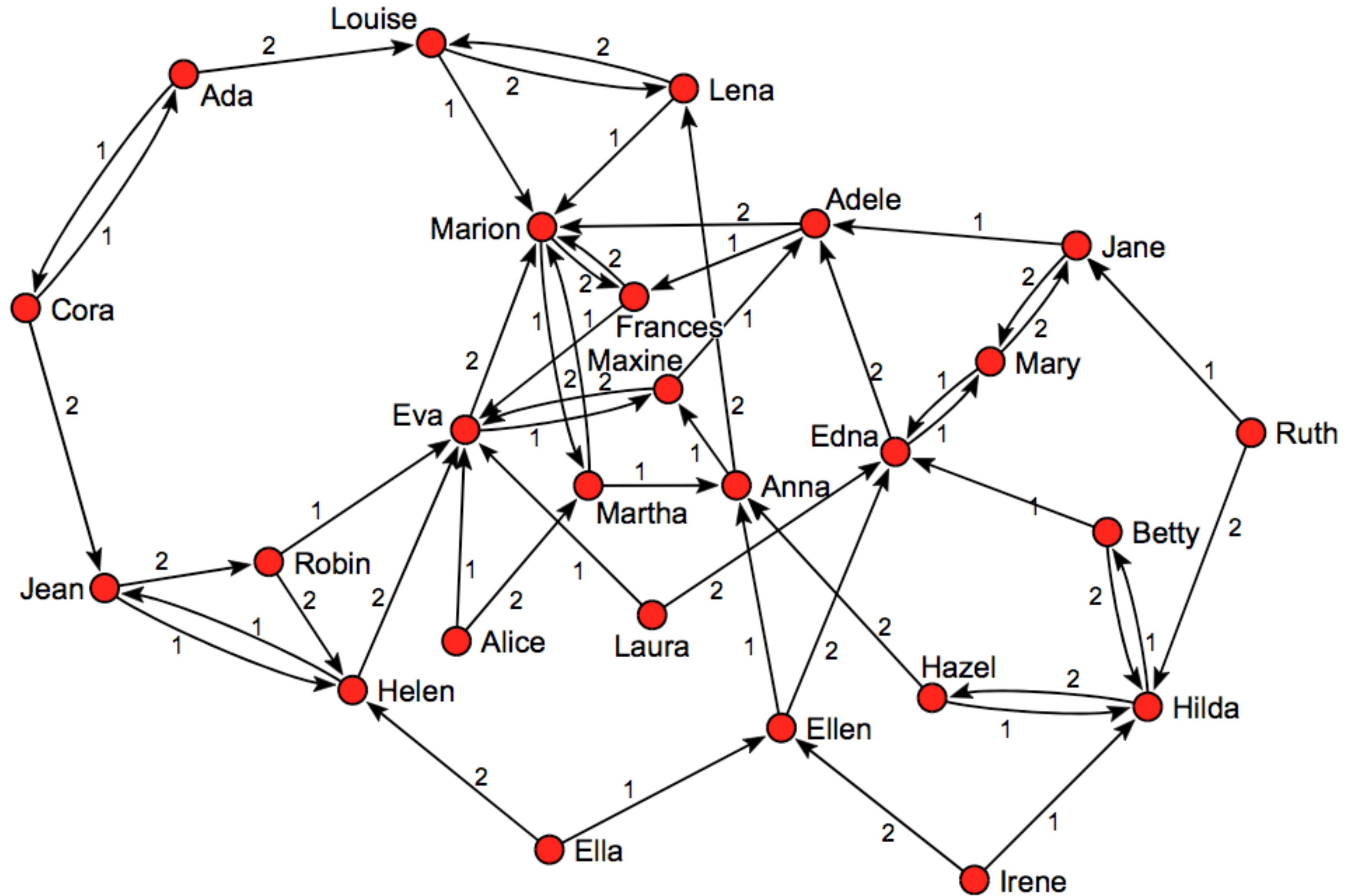
Attribute veri

Kişi	Yaş	VKi	Gelir
Lena	19	23.1	
Adele	20	-	...
Jane	19		...
Robin		19.7	...
Jean		20.3	...
H	22	18.5	...
	21	19.1	...
...	...	...	...

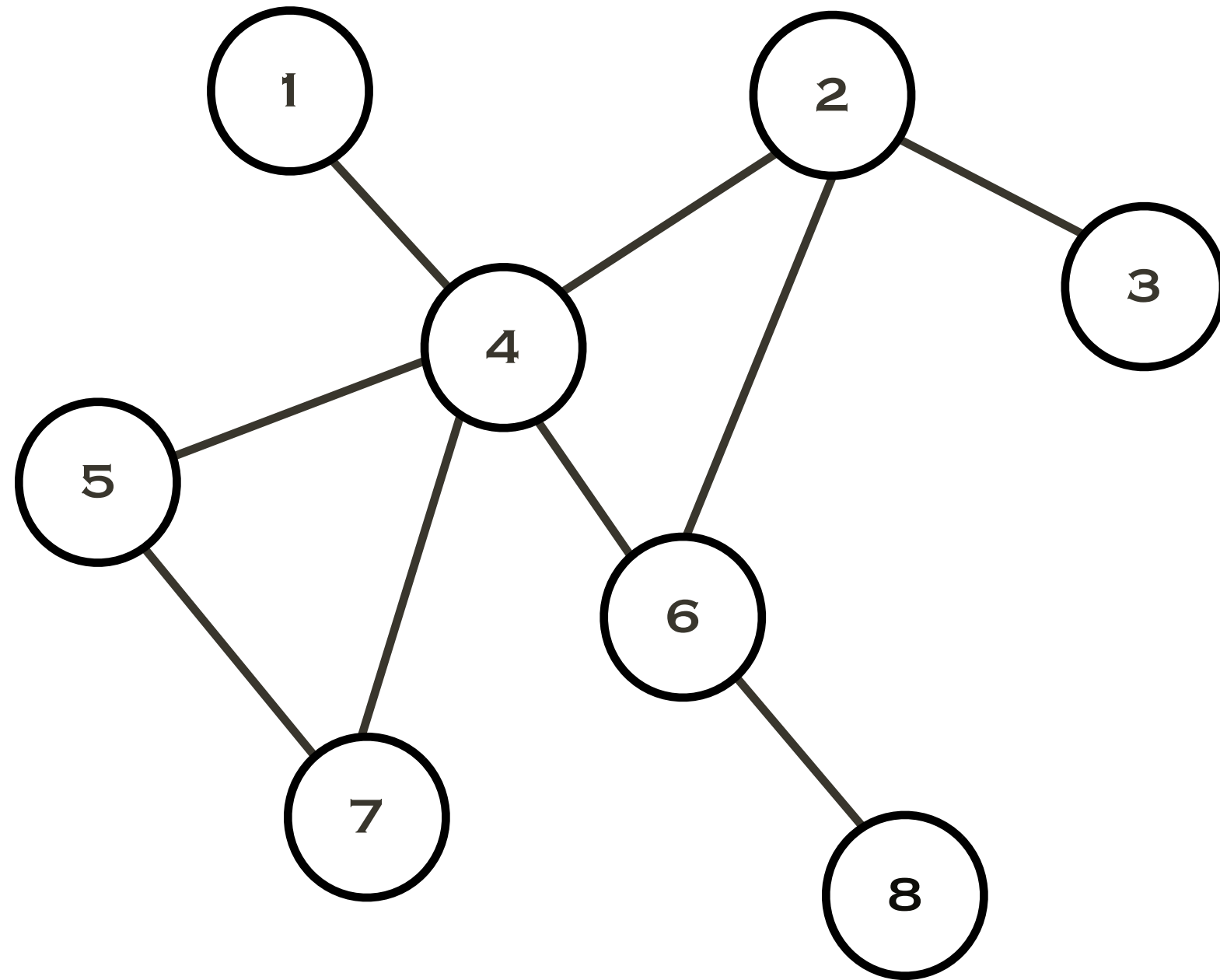
İlişkisel veri

	Lena	Adele	Jane	Robin	Jean	Helen	Martha	...
Lena	0	0	1	0	2	0	0	
Adele	0	0	2	0	0	1	0	
Jane	2	0	0	0			0	
Robin	0	0	1			2	0	
Jean	2	0			0	0	1	
Helen	0			0	2	0	0	
Martha	1	0	0	2	0	0	0	
...	...	...						...

Yemek arkadaşları



Çizge teorisi



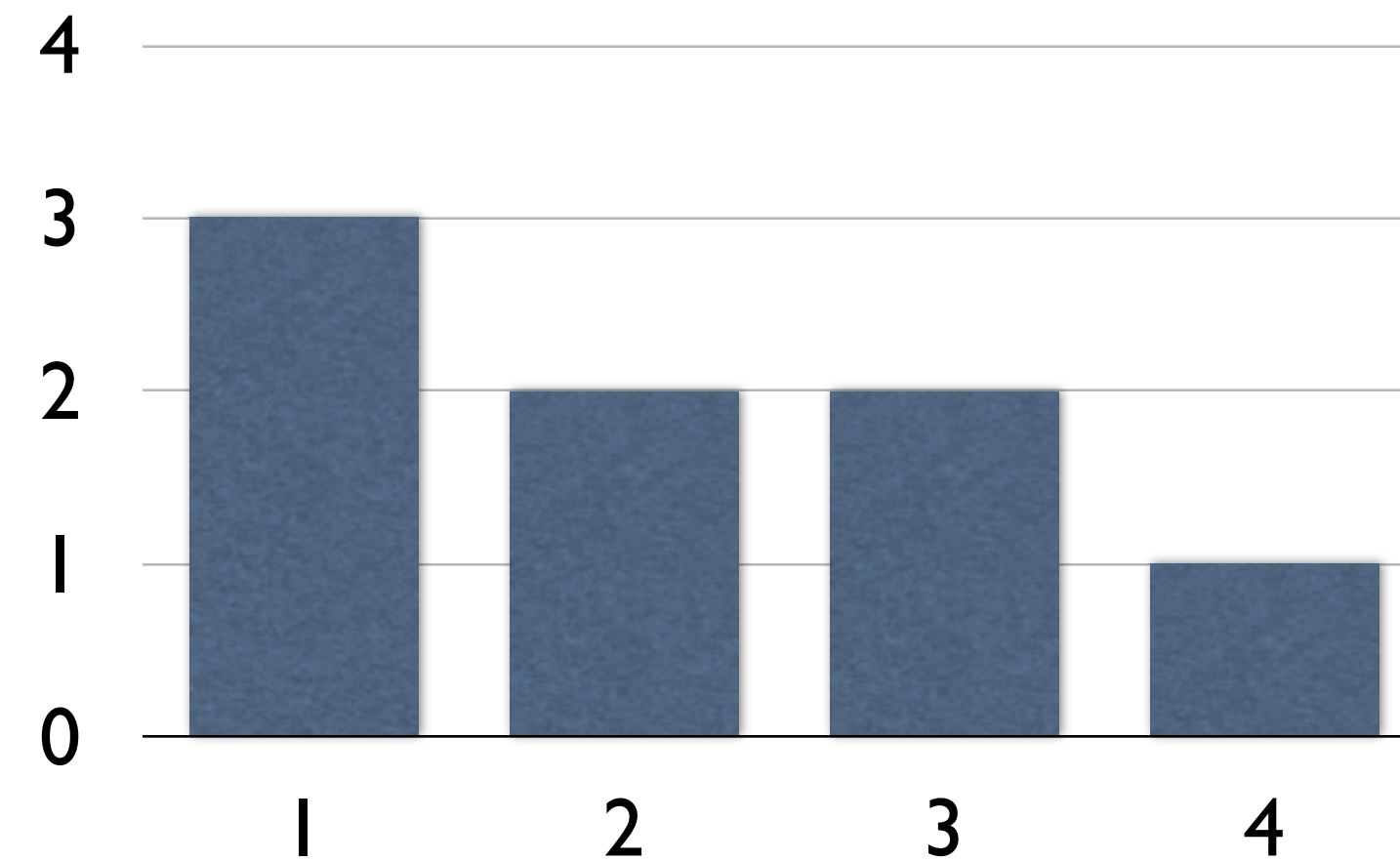
Ekli liste

1 : 4
2 : 3 4 6
4 : 5 6 7
5 : 7

Komşuluk matrisi

$$A = \begin{matrix} & \begin{matrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \end{matrix} \\ \begin{matrix} 1 \\ 2 \\ 3 \\ 4 \\ 5 \\ 6 \\ 7 \\ 8 \end{matrix} & \begin{pmatrix} 0 & 0 & 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 0 & 0 \\ 1 & 1 & 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 0 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 & 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 1 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 & 0 & 0 \end{pmatrix} \end{matrix}$$

Bağlantı dağılımı



Okullarda temas ağı analizi

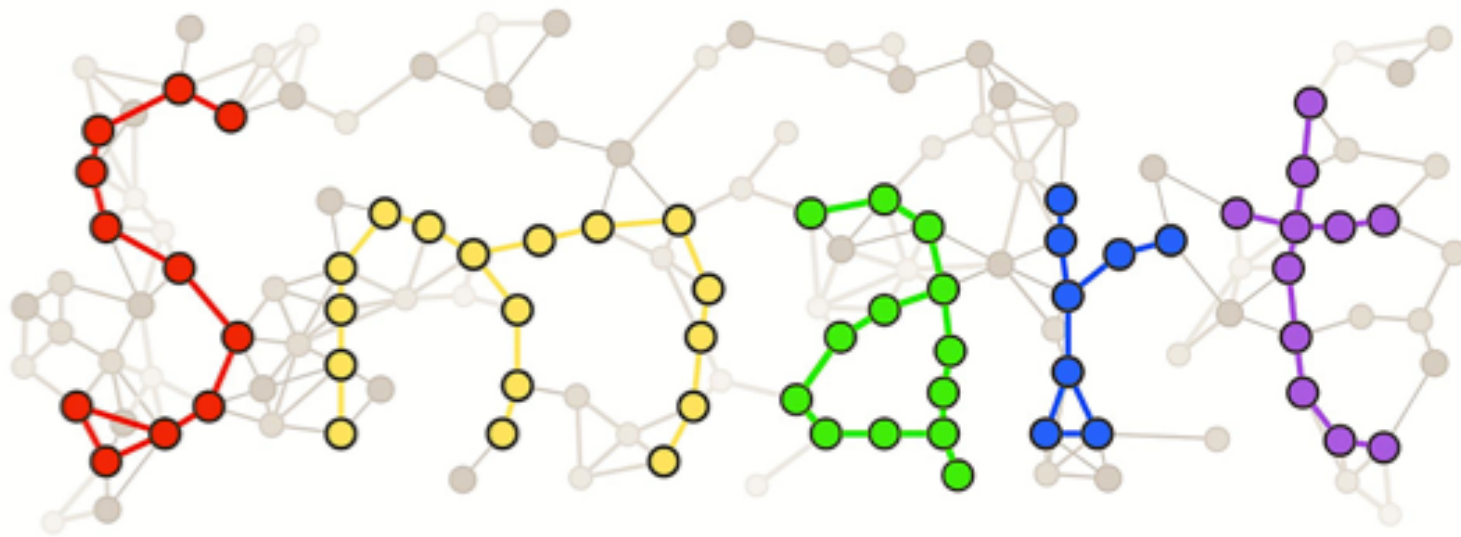


Temas ağı neden önemli?

- Solunum yolu bulaşıcı hastalıkları genelde fiziksel olarak yakın mesafedeki kişiler arasında damlacık (ya da aerosol) yoluyla yayılır
- Amaç: Normal bir okul gününde ABD’de bir okul ortamında öğrenciler arası temasları bulaşıcı hastalıkların yayılımı açısından incelemek
- Yöntem: Kablosuz sensör cihazlarını kullanarak temaslar incelendi. Cihazlar senkronize bir şekilde her 20 saniyede bir uyanarak çevredeki diğer cihazları kaydettiler

Okul temas ağıları

- Temasları ölçmek için öğrenci ve öğretmenlerin takabileceikleri kablosuz sensör cihazlarını (mot) kullandık
- Pittsburgh şehri sınırlarında 10 okulda yaklaşık 1800 öğrenci üzerinde çalıştık
- Projemizin adı SMART (Surveillance, Monitoring Absenteeism and Respiratory Transmission in Schools)



SMART Projesi - okullar

Table 1. List of schools along with the numbers of notes used for students, staff members, and rooms.

School	Day	Total	Stat.	Staff	Students	K	1	2	3	4	5	6	7	8	9	10	11	12
P-ES	Mon	184	29	14	141	27	31	21	32	30	-	-	-	-	-	-	-	-
C-ES	Mon	209	21	17	171	30	30	24	14	34	39	-	-	-	-	-	-	-
C-EM1	Mon	296	32	13	251	31	33	16	34	29	35	17	20	36	-	-	-	-
C-EM2	Wed	389	38	24	327	34	35	37	36	40	33	43	37	32	-	-	-	-
P-MS1	Wed	335	22	11	302	-	-	-	-	-	152	150	-	-	-	-	-	-
P-MS2	Wed	211	38	4	169	-	-	-	-	-	-	-	101	68	-	-	-	-
C-HS	Mon	190	18	18	154	-	-	-	-	-	-	-	-	-	74	67	13	-
P-HS	Tue	362	34	15	313	-	-	-	-	-	-	-	-	-	52	87	88	86

Stat.: Number of stationary notes

K: Kindergarten

1–12: Grades 1 through 12

C: Charter school

P: Public school

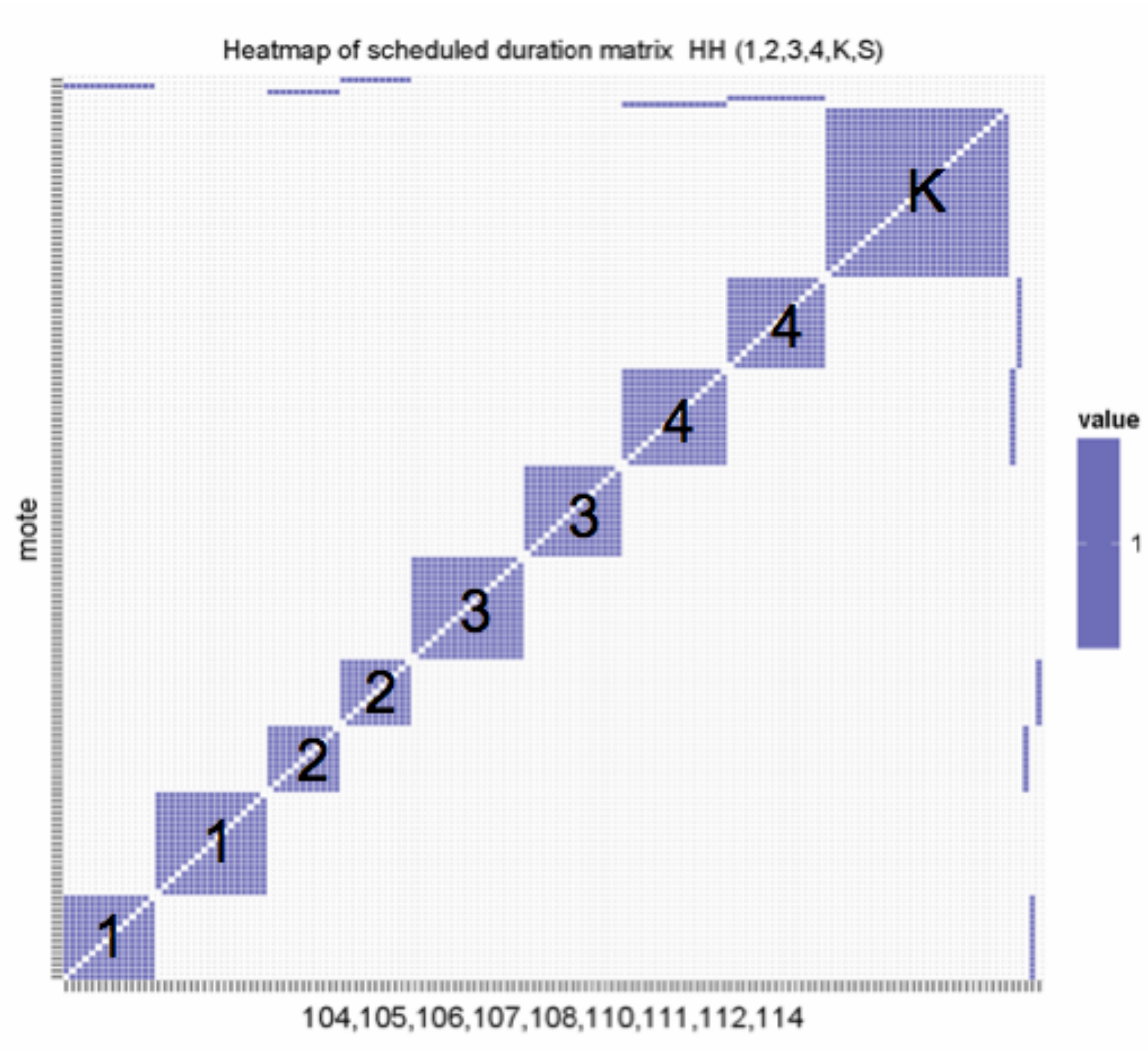
ES: Elementary school

EM: Elementary-middle school

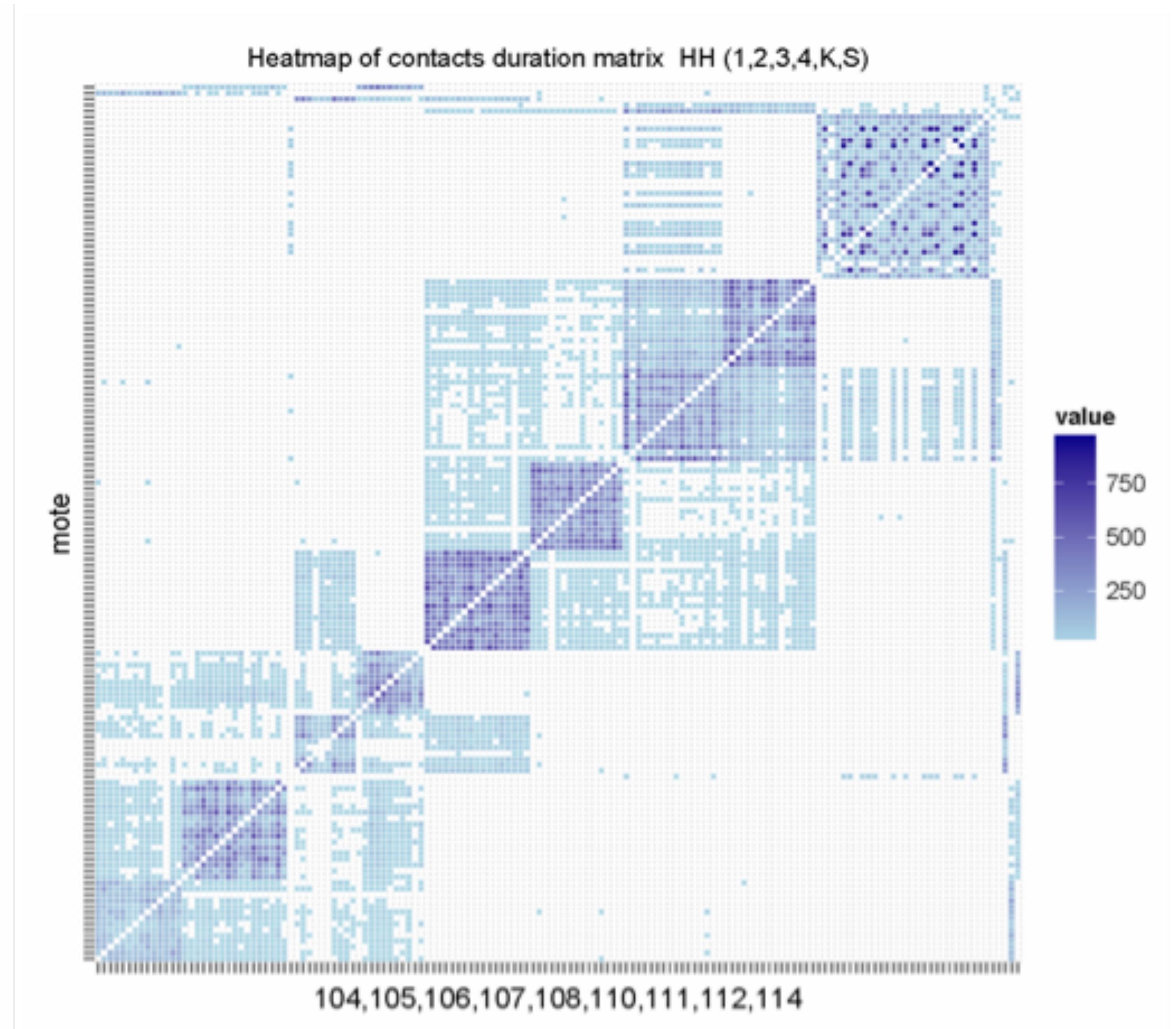
MS: Middle school

HS: High school

Okullarda salgınlar

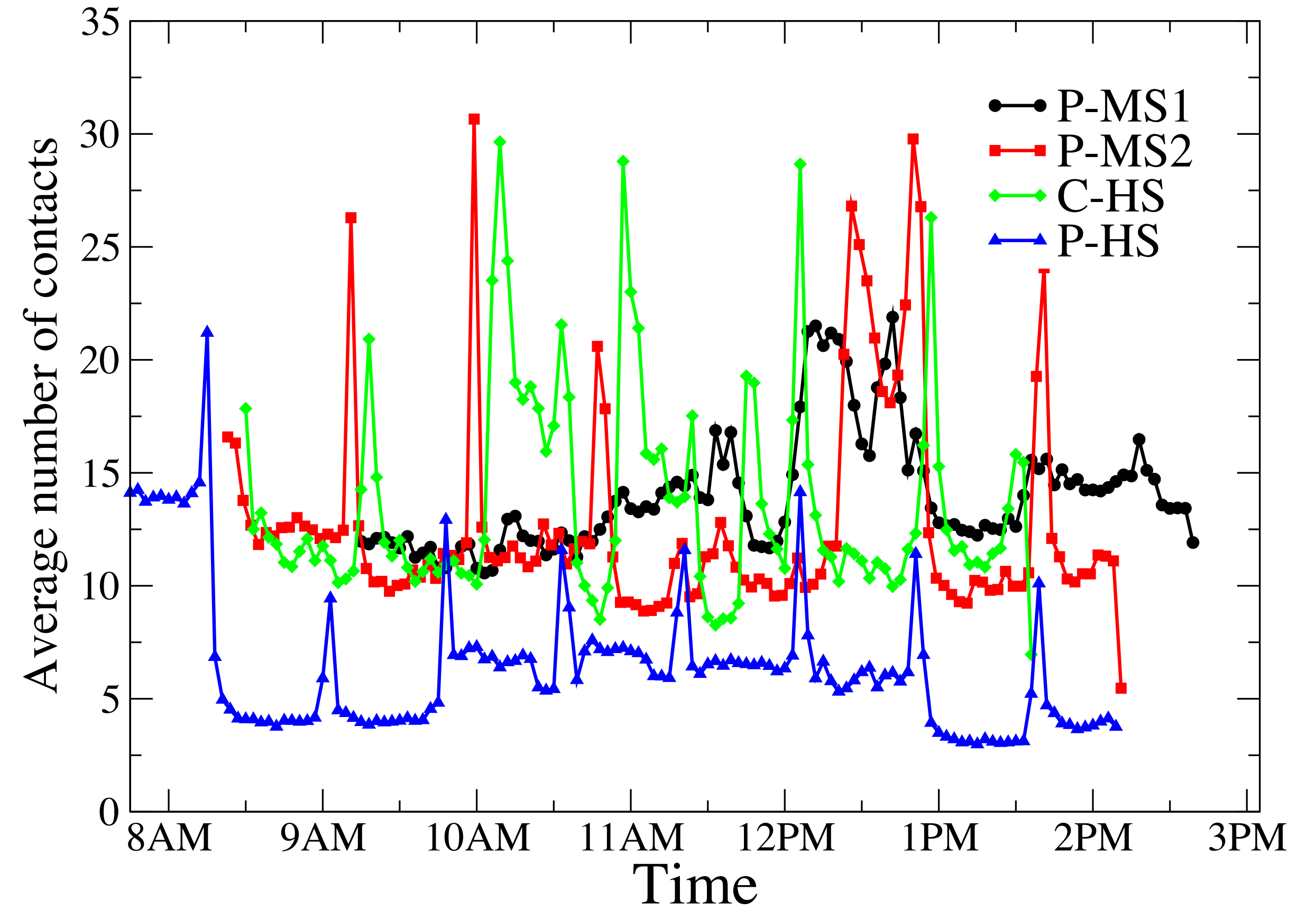
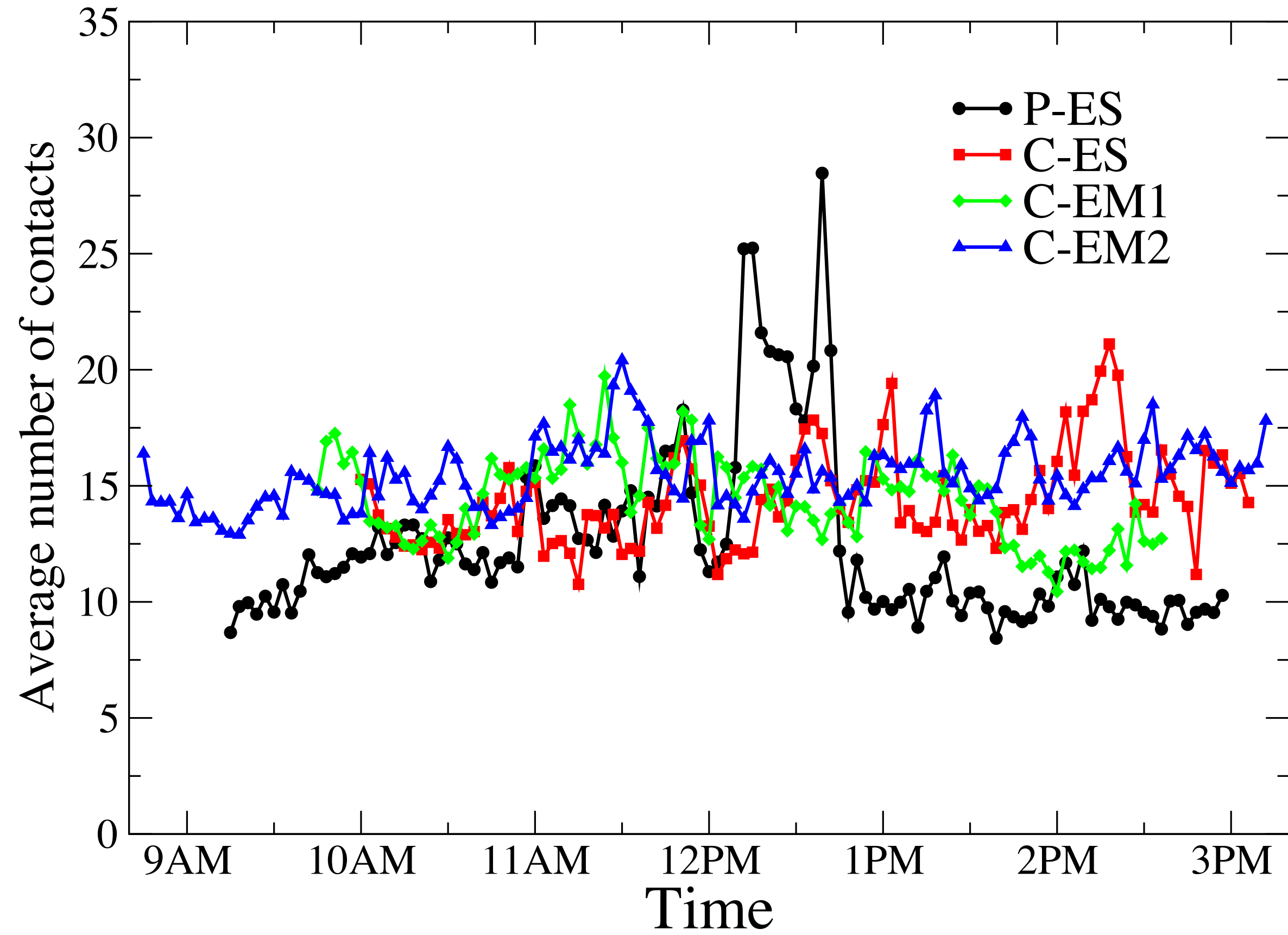


Ders programı

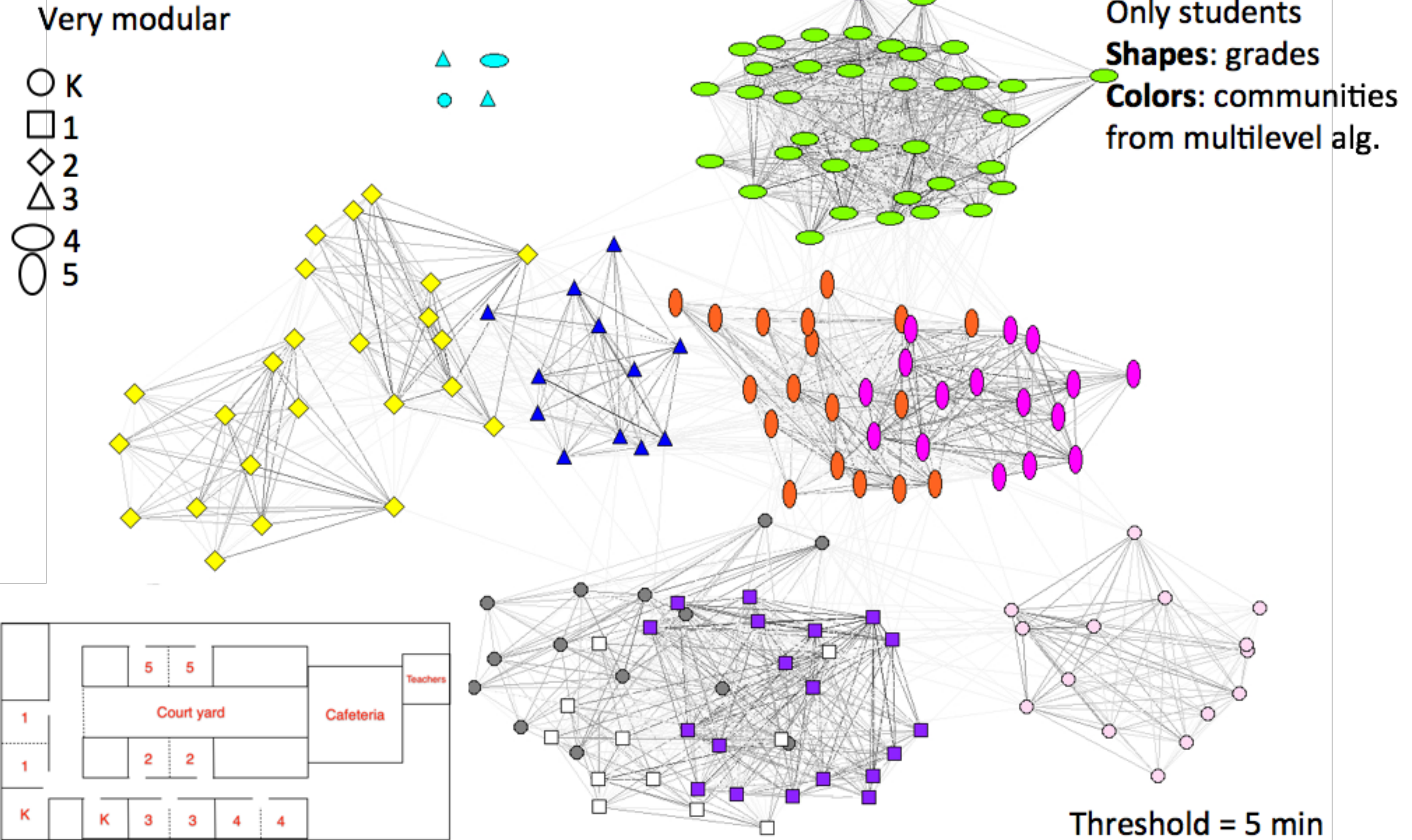


Motlar kullanarak

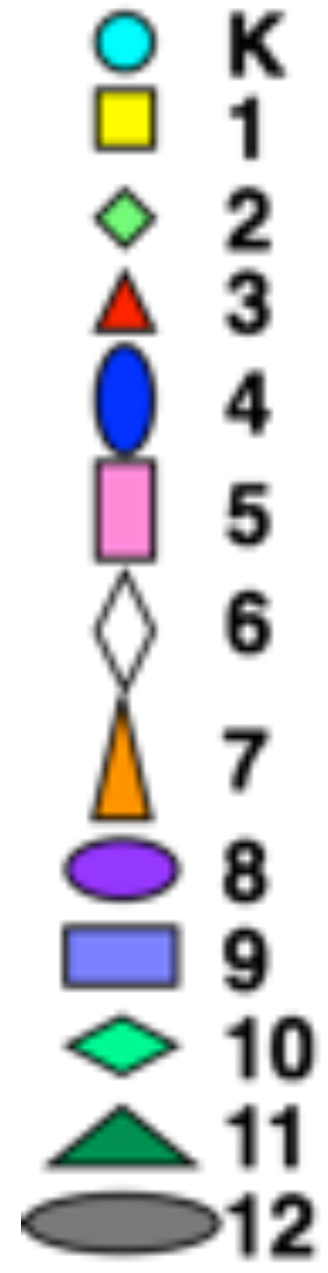
Zamana bağı bağlantı sayısı



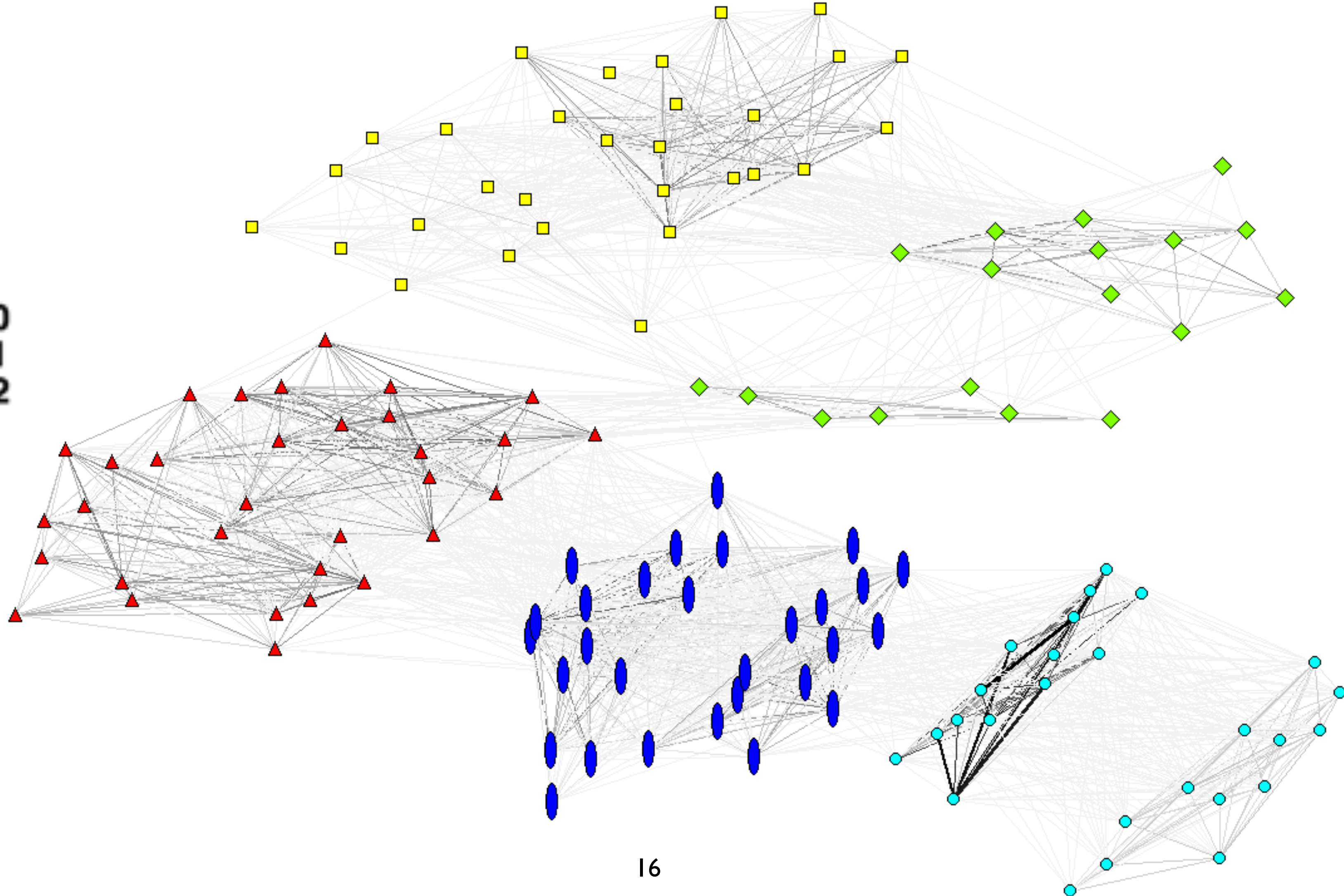
Okul sosyal temas ağı



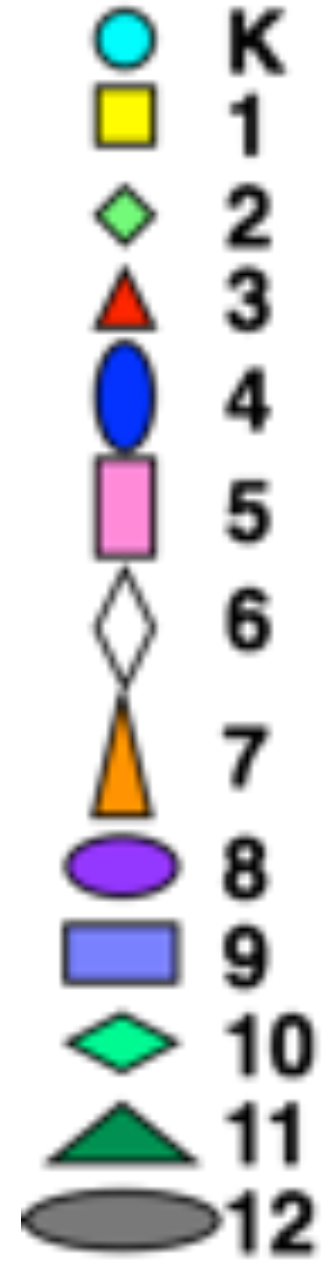
Okul sosyal temas ağı



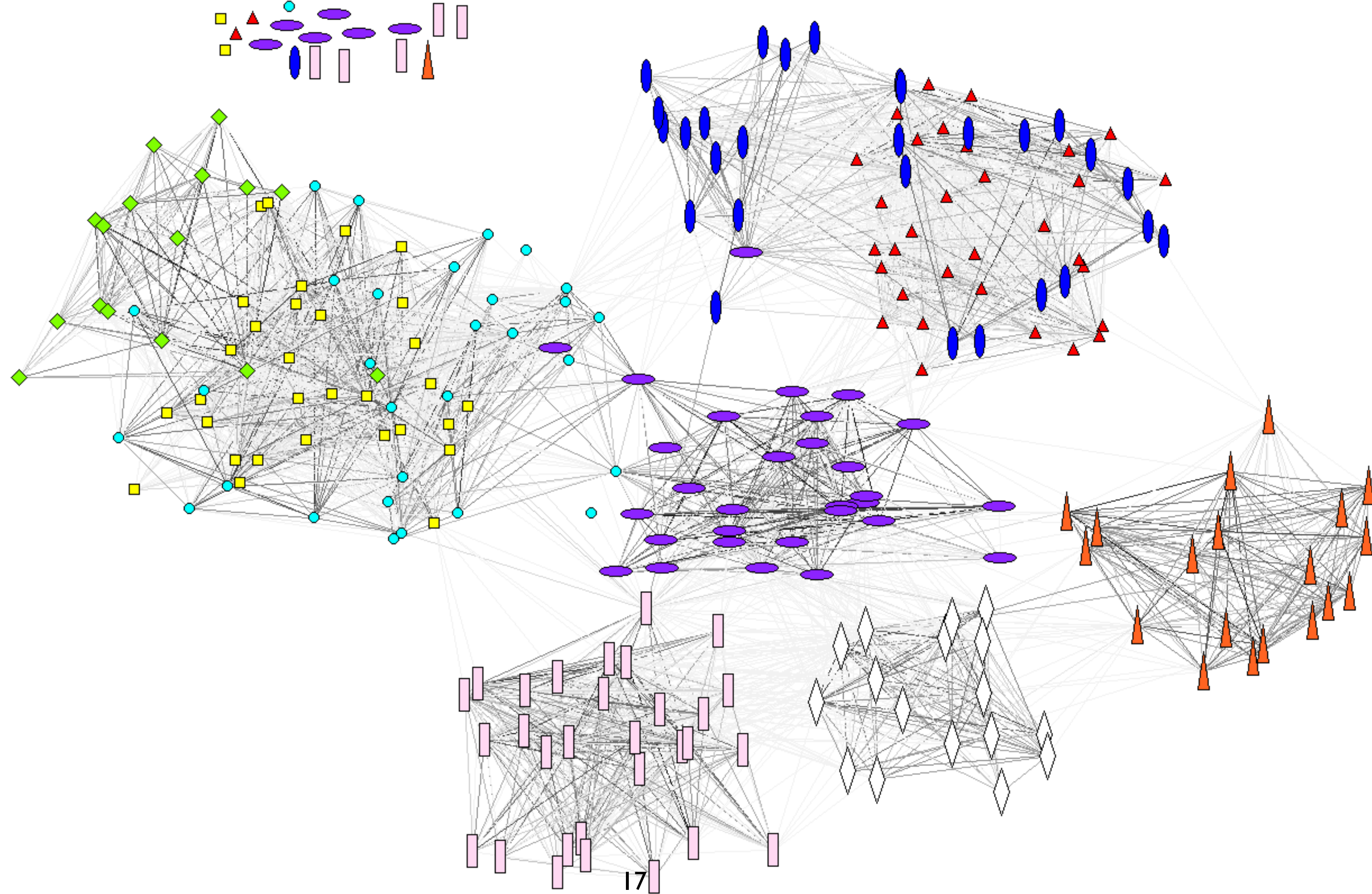
P-ES



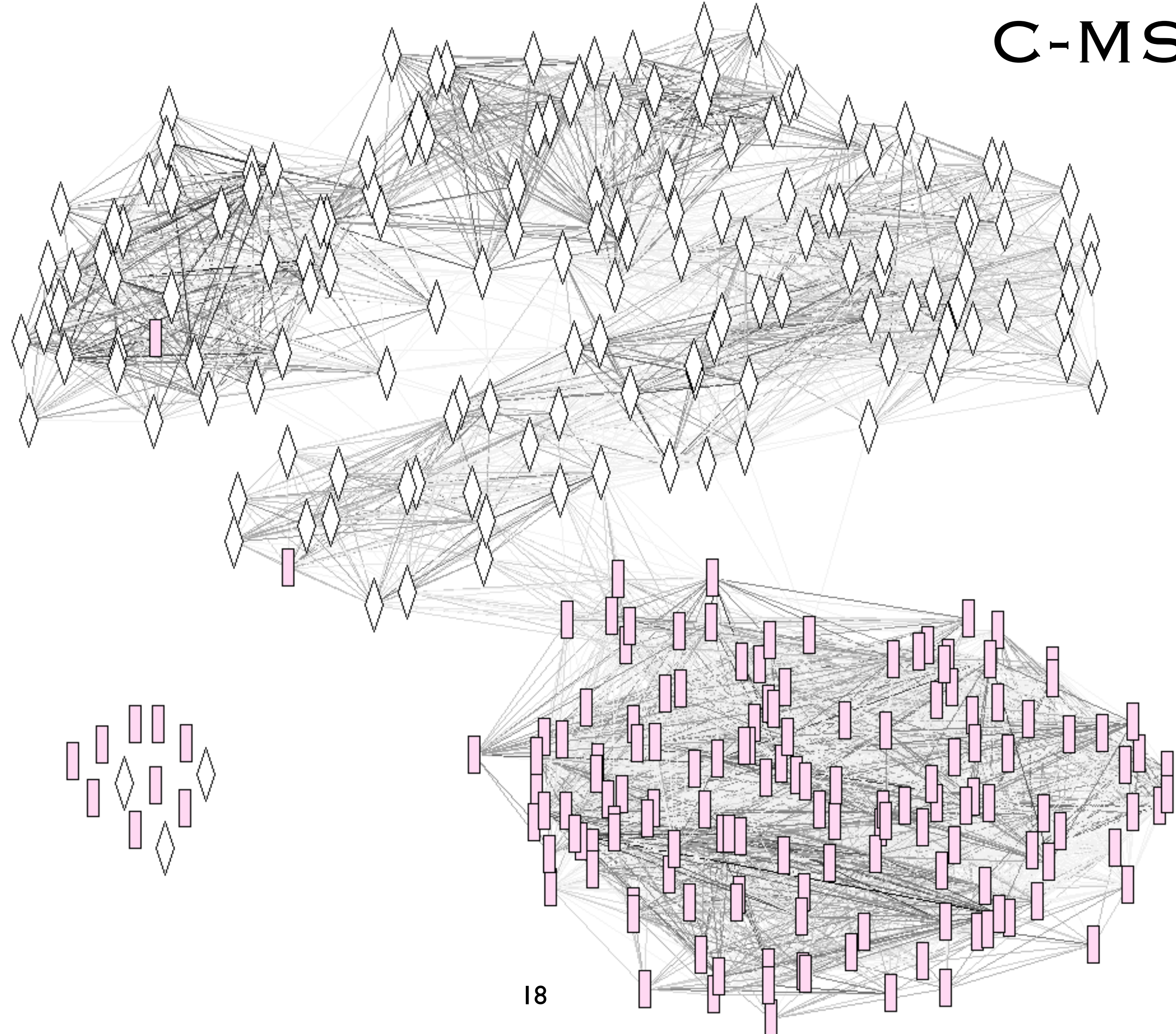
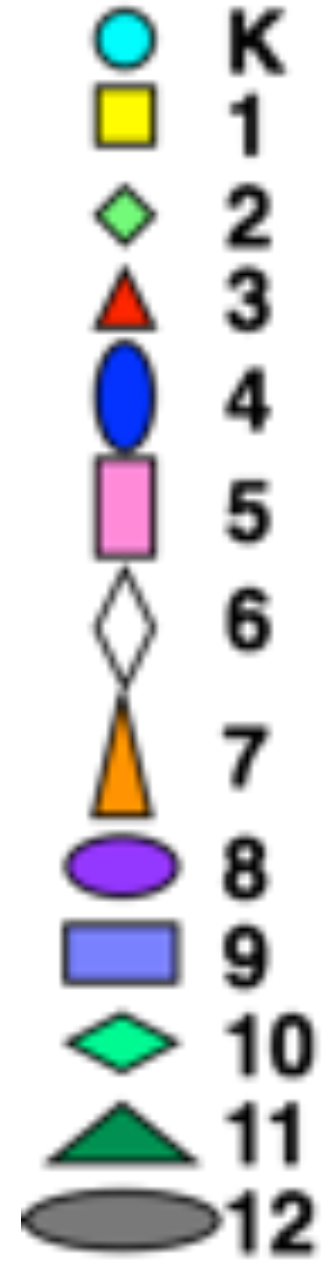
Okul sosyal temas ağı



C-EM 1



Okul sosyal temas ağı



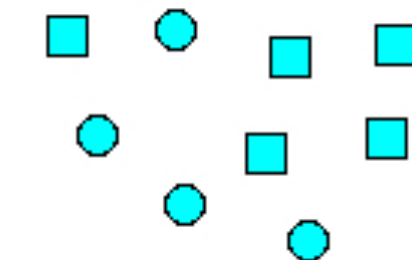
Okul sosyal temas ağı - topluluklar

○ 9

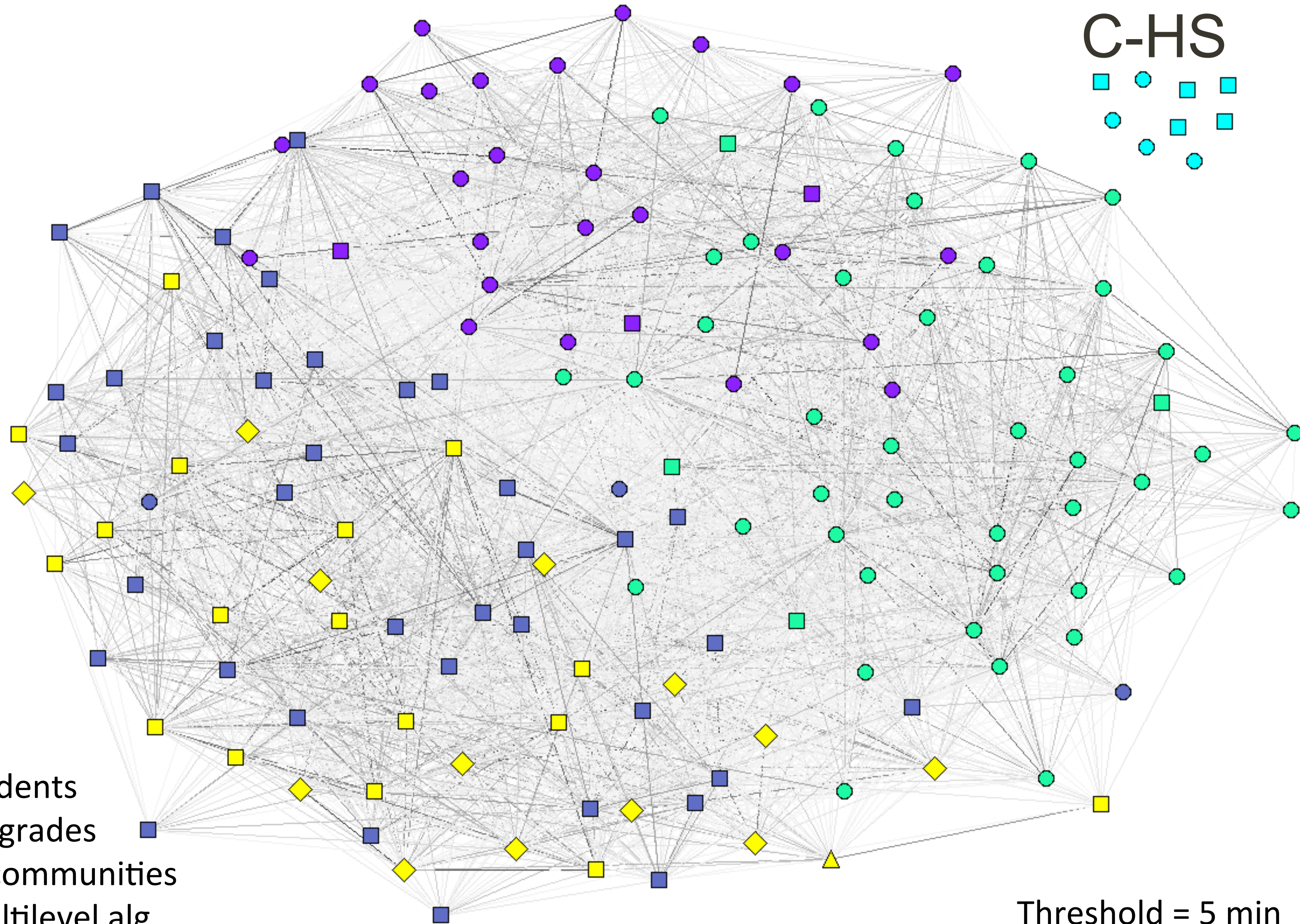
□ 10

◇ 11

C-HS



Only students
Shapes: grades
Colors: communities
from multilevel alg.



SMART Projesi - sosyal temas ağları

Table 2. Contact network measurements and their standard deviations (and standard errors) for school contact networks*.

School	n	δ	d	s	CC
P-ES	141	0.189	27.6 ± 9.1 (0.9)	38.3 ± 14.8 (1.4)	0.81 ± 0.12 (0.02)
C-ES	171	0.147	25.6 ± 10.3 (0.8)	41.9 ± 10.3 (0.9)	0.82 ± 0.14 (0.01)
C-EM1	251	0.108	29.1 ± 10.1 (0.8)	43.3 ± 15.6 (1.2)	0.76 ± 0.14 (0.02)
C-EM2	327	0.116	38.0 ± 13.3 (0.8)	44.9 ± 18.8 (1.1)	0.76 ± 0.13 (0.01)
P-MS1	302	0.096	30.0 ± 9.5 (0.6)	52.8 ± 20.0 (1.3)	0.72 ± 0.18 (0.01)
P-MS2	169	0.302	52.9 ± 19.3 (1.7)	27.4 ± 6.2 (0.6)	0.71 ± 0.09 (0.01)
C-HS	154	0.345	56.1 ± 15.5 (1.6)	21.7 ± 3.9 (0.5)	0.56 ± 0.06 (0.01)
P-HS	314	0.114	35.9 ± 11.7 (0.6)	17.8 ± 4.4 (0.3)	0.41 ± 0.15 (0.01)

* The contacts with total duration less than 5 minutes are ignored

n: number of students

δ : density of the network

d: average degree (number of contacts)

s: strength (average duration per contact) in minutes

CC: average clustering coefficient

C: Charter school

P: Public school

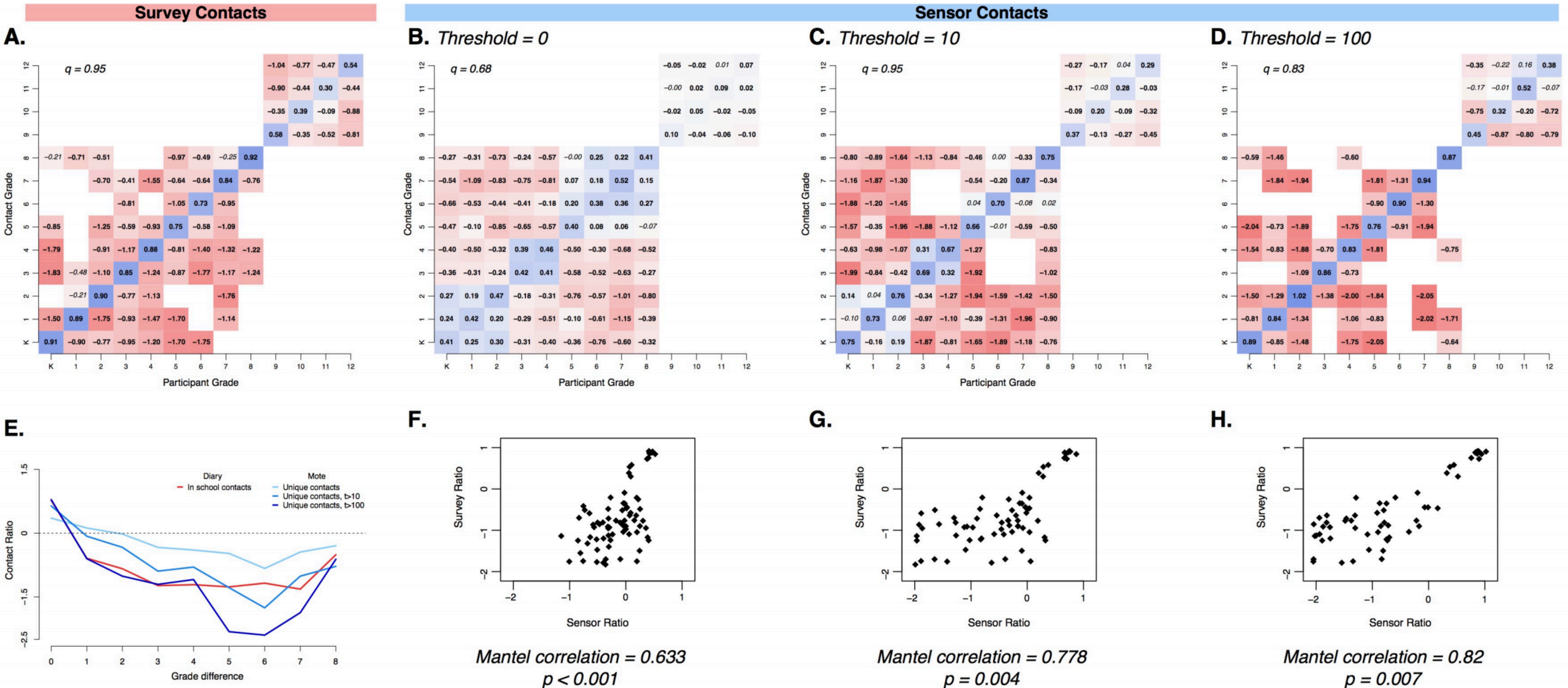
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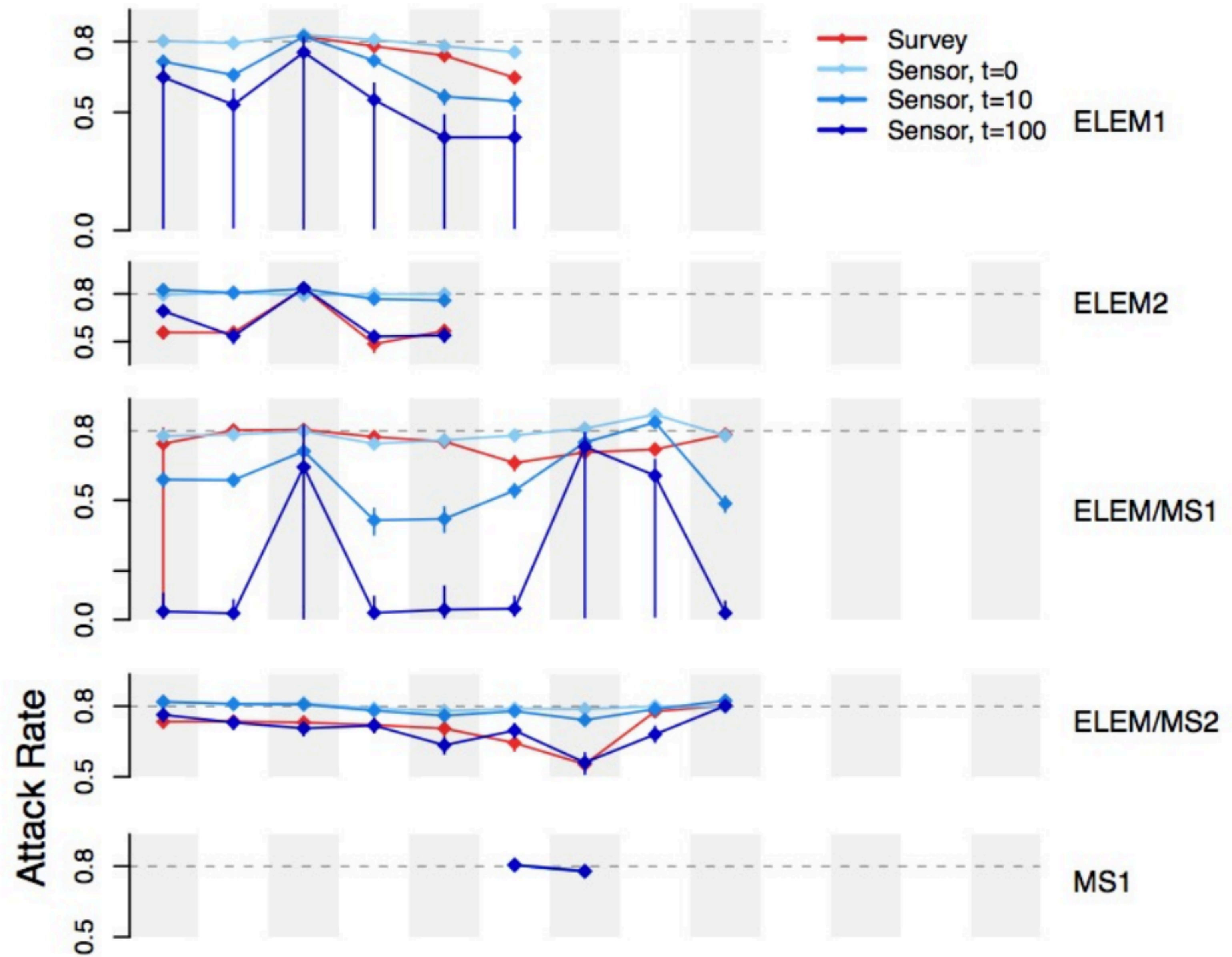
MS: Middle school

HS: High school

Temas ağıları: anketlere karşı motlar

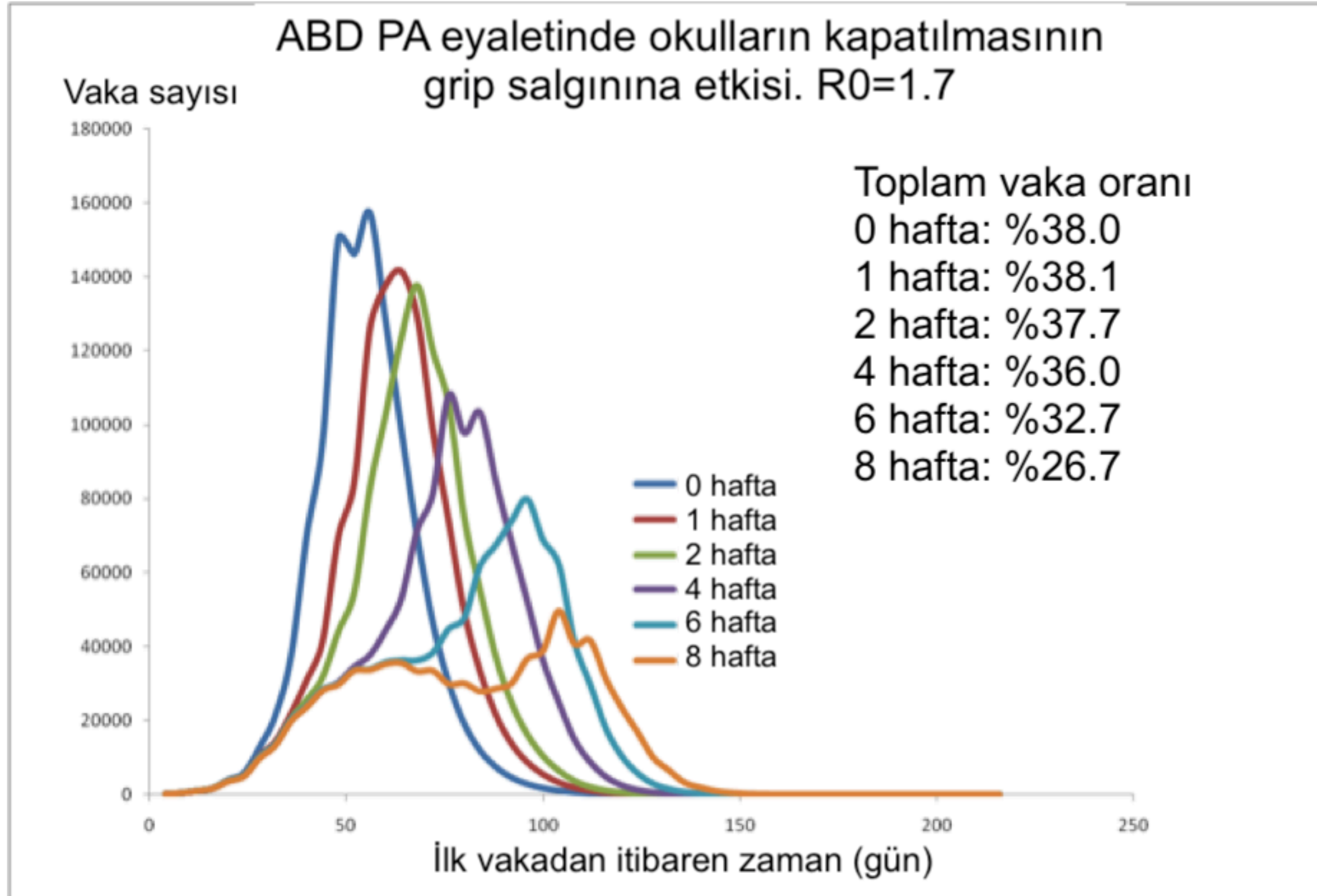


Temas ağıları: anketlere karşı motlar



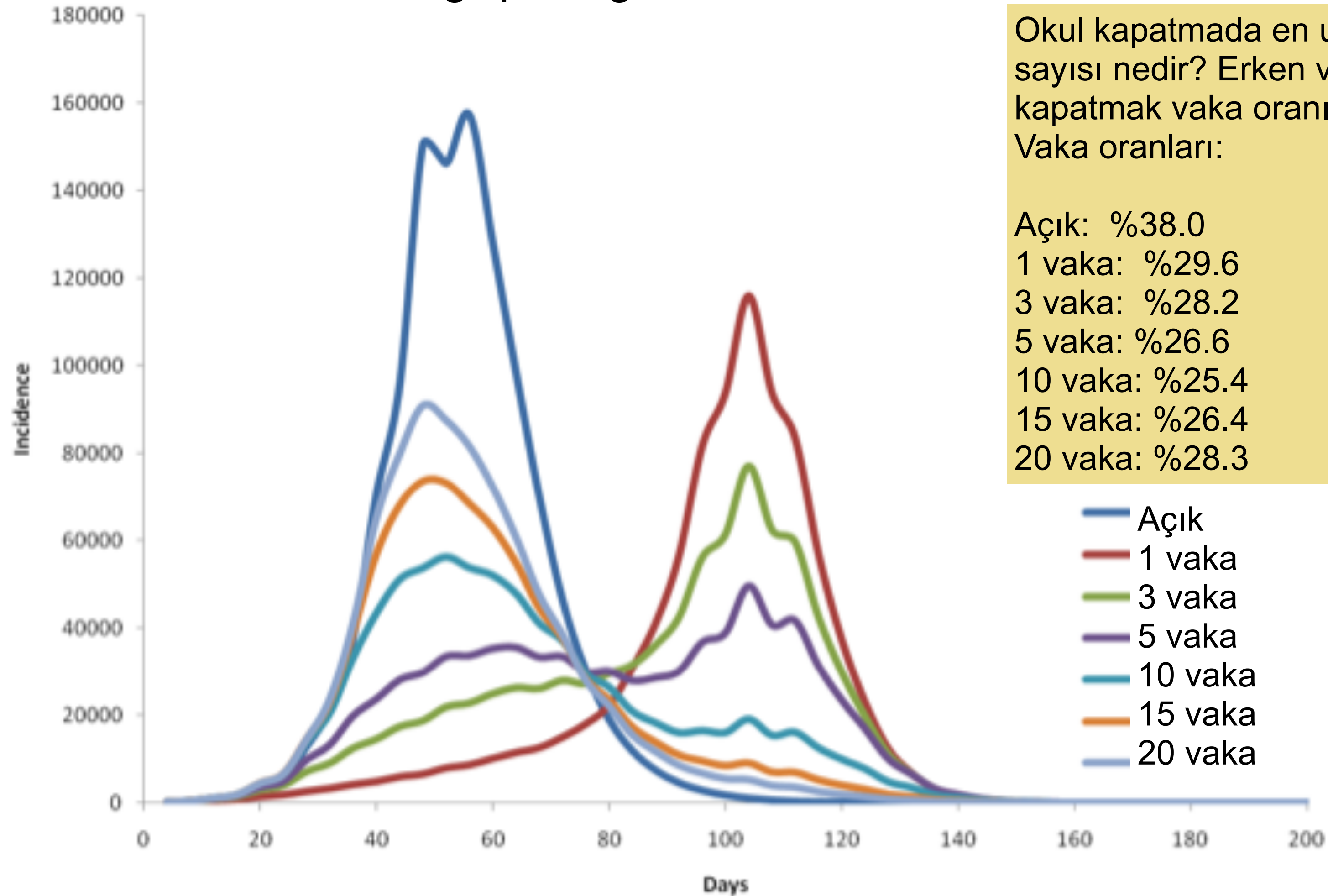
Salgınların modellenmesi ve simülasyonu

Okulları kapatmak



Şartlı okul kapatma

Vaka sayısına göre okulların kapatılmasının
grip salgınına etkisi. $R_0=1,7$



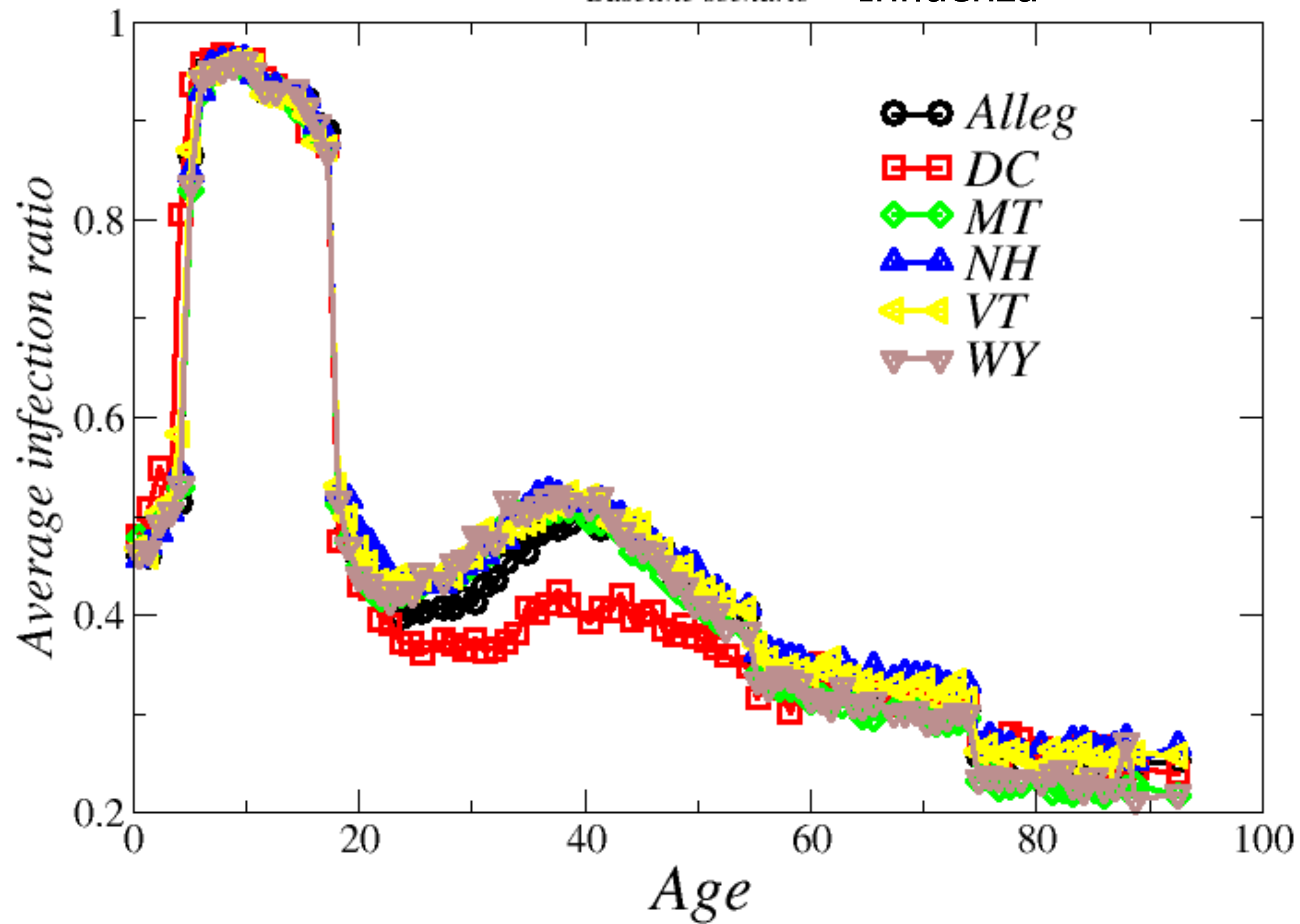
Okul kapatmada en uygun vaka sayısı nedir? Erken veya geç kapatmak vaka oranını artırıyor. Vaka oranları:

Açık: %38.0
1 vaka: %29.6
3 vaka: %28.2
5 vaka: %26.6
10 vaka: %25.4
15 vaka: %26.4
20 vaka: %28.3

Average infection ratio vs age for 1000 independent runs

Baseline scenario

Influenza



Sosyal temas ağı analizi sonuçları

- Sosyal temas ağı sensör motları kullanılarak okul programından daha iyi modellenenebilir
- Sosyal temas ağı göreceli olarak yüksek bir yoğunluğa ve küçük dünya ağları özelliklerine sahiptir
- Temas süresi ve temas sayısı homojen bir dağılım göstermektedir
- Sosyal temas ağının analizi rastgele aşılama yerine hedefli bir aşılamanın çok daha etkili olacağını gösteriyor
- Temas ağı üzerinde yapılan Covid-19 ve influenza simülasyonları öğrencilerin devam verisi ile uyum gösteriyor

Sonraki alıřmalar

- Benzeri bir alıřmayı yksek frekanslı tařınabilir cihazlar kullanarak lkemizde yapmayı planlıyoruz
- Aynı sistem sadece okullarda deęil iřyerlerinde ve alışveriş merkezlerinde de denenecek
- Elde edilen temas aęı verileri ile sosyal karřılařma ve etkileřim profillerini daha iyi anlama řansına sahip olacaęız

