Some insights about the Uncapacitated Examination Timetabling Problem

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Christos Gogos[1], Angelos Dimitsas[1], Vasileios Nastos[1], & Christos Valouxis[2]

[1] Dept. of Informatics and Telecommunications, University of Ioannina
[2] Dept. of Electrical and Computer Engineering, University of Patras

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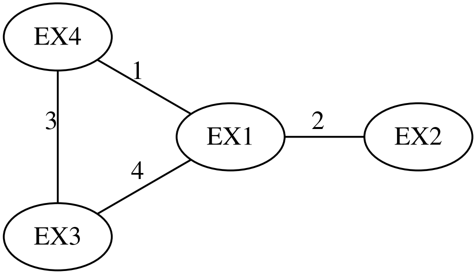
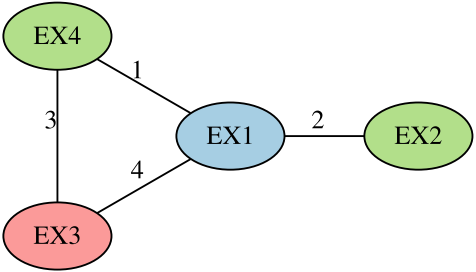
The Uncapacitated Examination Timetabling Problem

Student	Exams
1	EX1, EX2
2	EX1, EX3, EX4
3	EX1, EX3
4	EX1, EX3
5	EX1, EX2
6	EX1, EX3
7	EX3, EX4
8	EX3, EX4



GOAL: Create an examination timetable in three periods. No student is allowed to have more than one exam in each period.

Objective function



Distance	1	2	3	4	5	> 5
Factor	16	8	4	2	1	0

Edge	**Distance**	**Penalty**
EX1-EX2	1	$2 * 16 = 32$
EX1-EX3	2	$4 * 8 = 32$
EX1-EX4	1	$1 * 16 = 16$
EX3-EX4	1	$3 * 16 = 48$
		128

P1	P2	P3
EX1	EX2	EX3
	EX4	

Motivation

- Great problem for introduction to Timetabling, Combinatorial Optimization and Operational Research.

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- Well studied benchmark datasets exist since 1996.
- No dataset has ever been solved optimally.
- The problem is usually considered out of reach for exact approaches, metaheuristics and local search methods dominate the research field.

Reverse Timetable Symmetry

A reversed timetable has the same cost as the original.

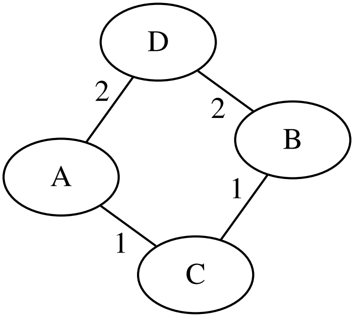
1	2	3	4	5
A	D	B	E	C
J	I	F	H	G

1	2	3	4	5
C	E	B	D	A
G	H	F	I	J

Reverse Timetable Symmetry elimination: Choose two exams with common students, force the second exam to be scheduled after the first.

Interchangeable exams 1/2

A and B have the same neighbors with the same weights and no edge connects them.



P1	P2	P3
A	C	B
	D	

obj= 80

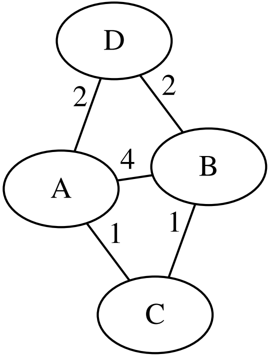
P1	P2	P3
B	C	A
	D	

obj= 80

Symmetry elimination: Force A to be scheduled simultaneously or before B.

Interchangeable exams 2/2

A and B have the same neighbors with the same weights and an edge connects them.



P1	P2	P3
A	C	B
	D	

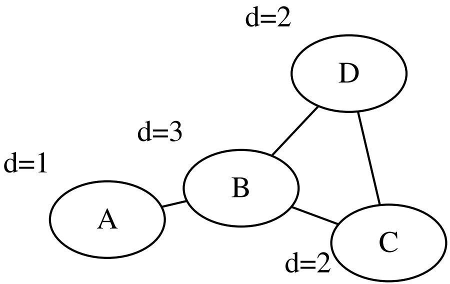
obj= 112

P1	P2	P3
B	C	A
	D	

obj= 112

Symmetry elimination: Force A to be scheduled before B.

Noise exams by degree 1/2



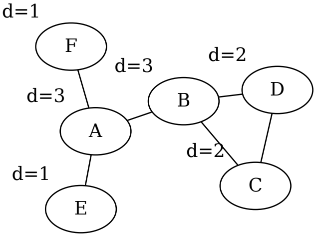
An exam can affect at most 11 periods.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
	x	x	x	x	x	**X**	x	x	x	x	x		

Noise elimination: With P as the number of available periods, remove exams with degree under the threshold $\frac{P}{11}$. For 14 periods exam A with degree of 1 is considered noise.

Noise exams by degree 2/2

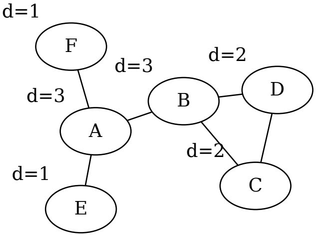
Noise identification sequence for P=12.

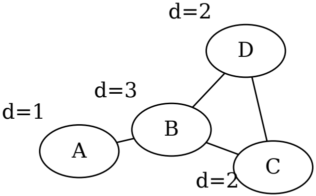


Noise elimination: With P as the number of available periods, remove exams with degree under the threshold $\frac{P}{11}$. Recalculate the degrees and repeat.

Noise exams by degree 2/2

Noise identification sequence for P=12.





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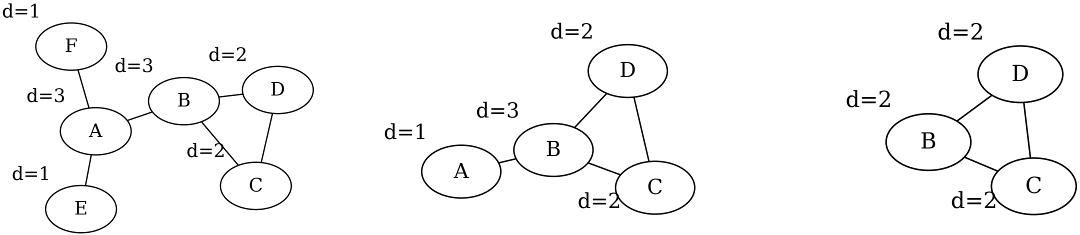
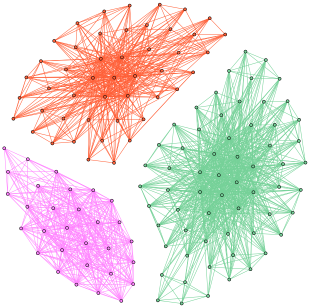


Noise elimination: With P as the number of available periods, remove exams with degree under the threshold $\frac{P}{11}$. Recalculate the degrees and repeat.

Disconnected Components

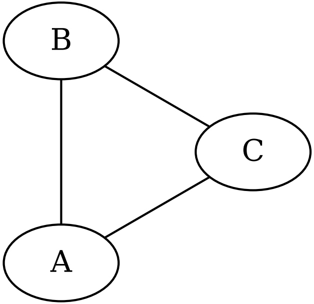
Figure: Disconnected Components of sta83 [1].



Divide and conquer: Each disconnected component can be solved independently.

[1] A dataset in Carter Datasets

Noise Components



1	2	3	4	5	6	7	8	9	10	11	12	13
A	ab	ab	ab	ab	ab	**B**	bc	bc	bc	bc	bc	**C**

Noise elimination: With P as the number of available periods, all exams for a component with size less or equal than $\frac{P-1}{6} + 1$ are noise. For 13 periods any component with size $\leq \frac{13-1}{6} + 1 = 3$ is considered noise.

Lower Bounds

Lower bounds can be estimated by examining each student in isolation and calculating the penalty that is unavoidable due to the actual number of exams that he is enrolled to, given the number of periods. Summing up all those penalties is a lower bound that is further enhanced by considering the maximum number of students a period can accommodate and which can be calculated by solving a problem that combines graph coloring and knapsack.

Dataset	Max students	Lower bound
car-f-92	4571	145
car-s-91	4707	100
ear-f-83	870	20542
hec-s-92	1382	10773
kfu-s-93	3906	30682
lse-f-91	1611	9147
pur-s-93	12126	N/A
rye-s-93	7108	43484
sta-f-83	611	92900
tre-s-92	1461	3750
uta-s-92	4856	46
ute-s-92	2432	59398
yor-f-83	698	18014

Carter Datasets

Dataset	Nr. of noise exams	Nr. of noise students	Nr. of connected components
car92	10	3988	3
car91	12	3434	6
ear83	0	1	1
hec92	0	321	1
kfu93	29	288	21
lse91	3	100	3
pur93	83	2811	9
rye93	1	2025	2
sta83	0	0	3
tre92	2	688	2
uta92	2	6183	1
ute92	0	78	2
yor83	0	1	1

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- Indicate noise exams.
- Decomposed problem in independent sub-problems.
- A novel way to calculate lower bounds.

Thank you. Questions?