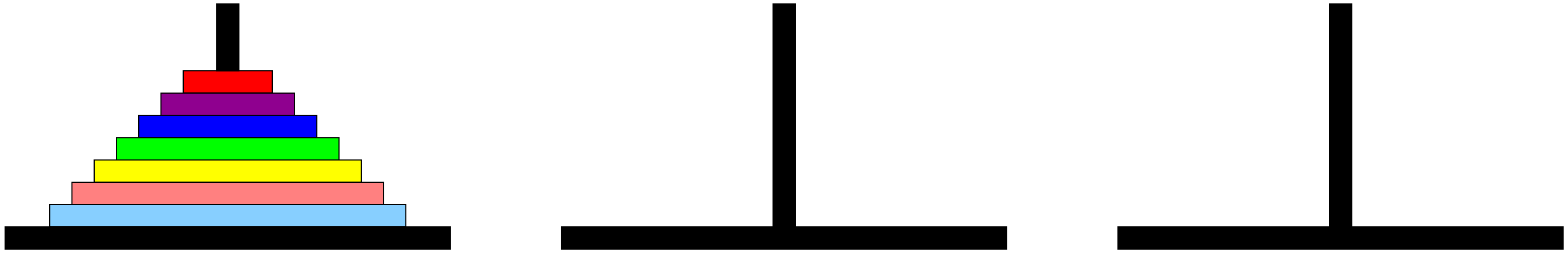
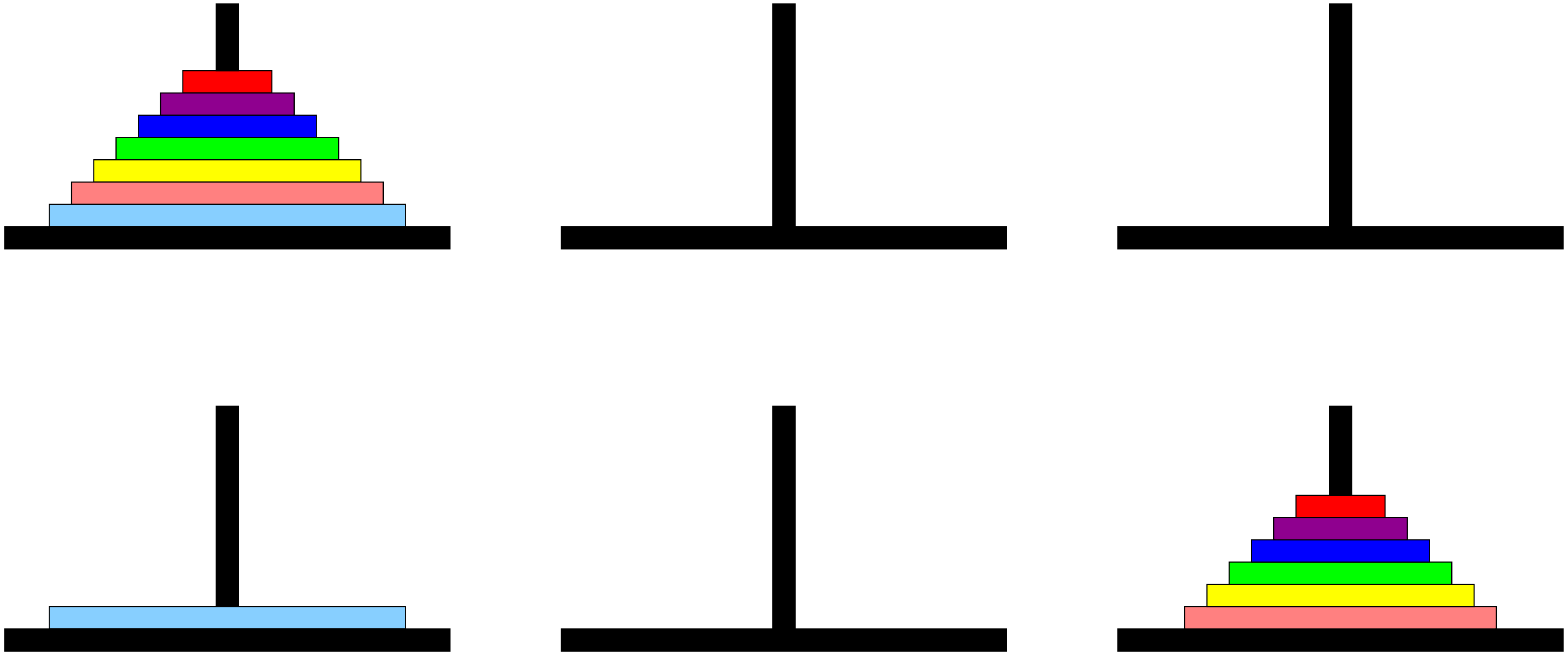
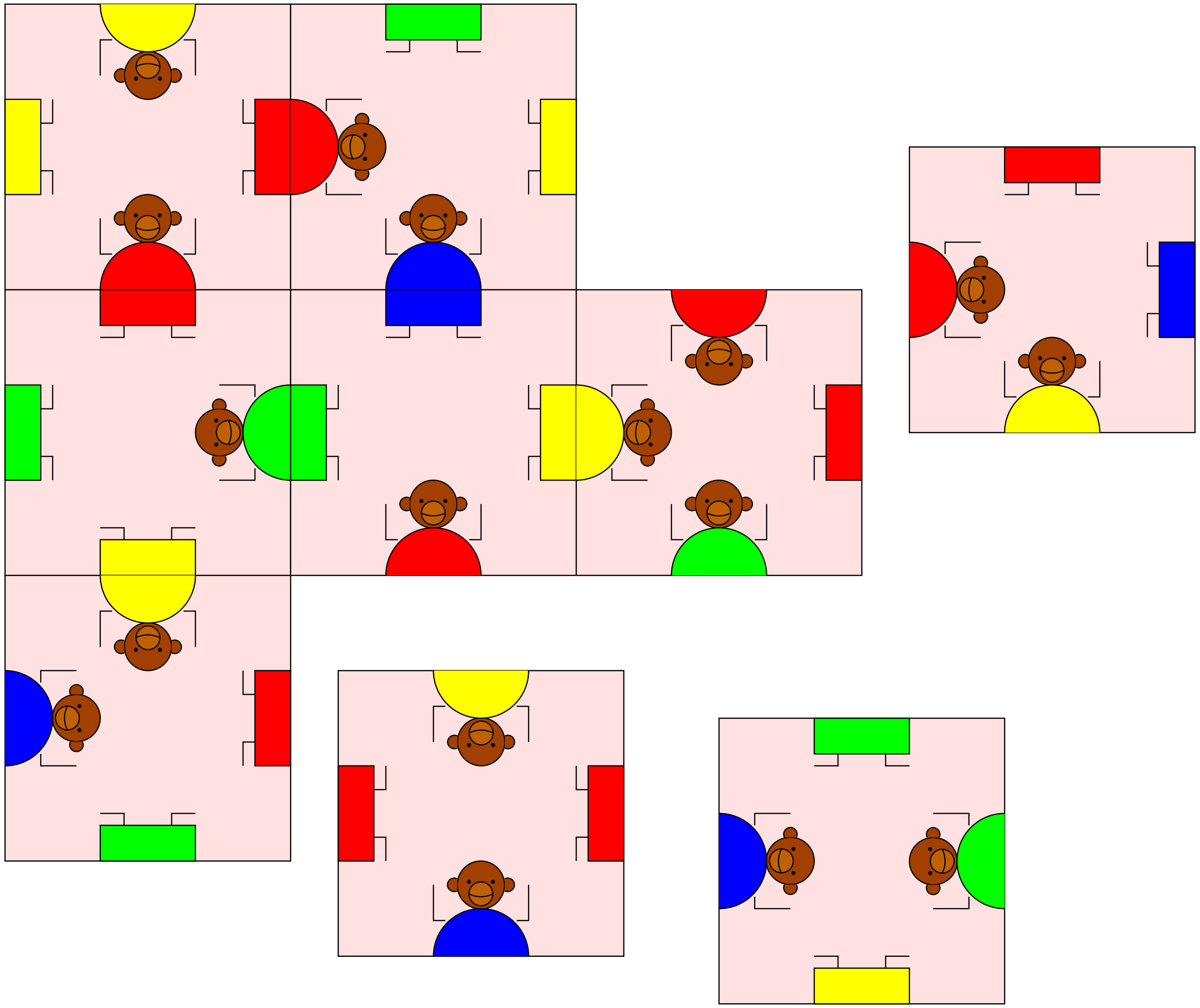
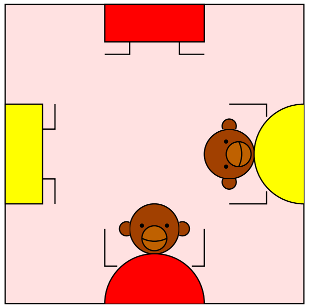
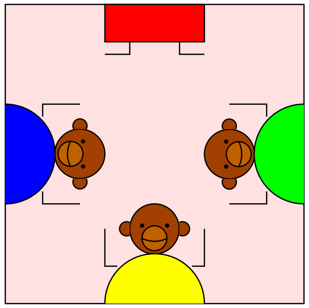








arrangements
always exist



arrangements
never exist

N	10	50	100	300	1000
$5N$	50	250	500	1500	5000
$N \cdot \log_2 N$	33	282	665	2469	9966
N^2	100	2500	10 000	90 000	7 digits
N^3	1000	125000	7 digits	8 digits	10 digits
2^N	1024	16 digits	31 digits	91 digits	302 digits
$N!$	7 digits	65 digits	161 digits	623 digits	unimaginably
N^N	11 digits	85 digits	201 digits	744 digits	unimaginably

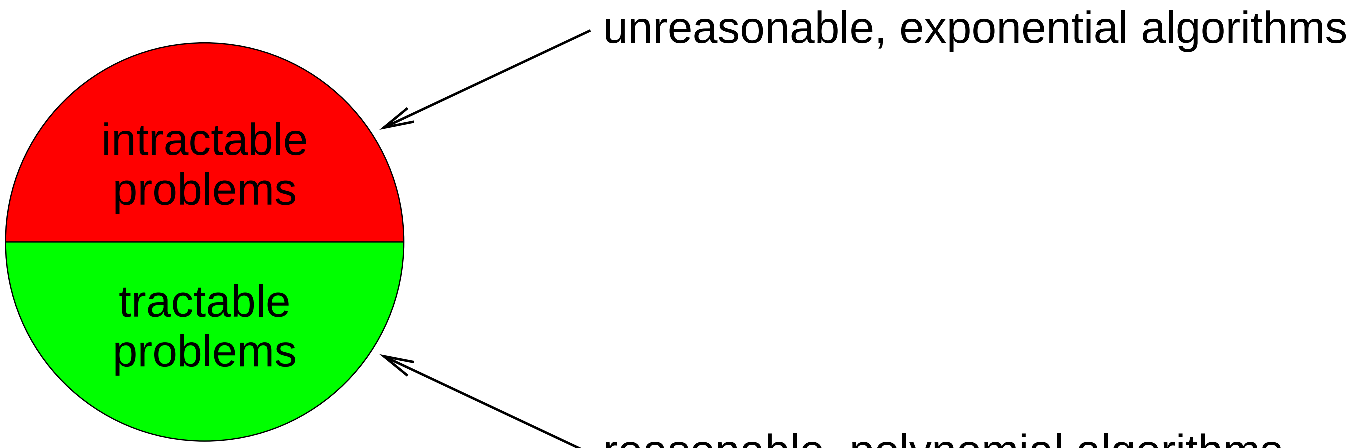
the number of protons in the universe has 79 digits

the number of microseconds since the Big Bang has 24 digits

N	10	20	50	100	300
N^2	$\frac{1}{10000}$sec	$\frac{1}{2500}$sec	$\frac{1}{400}$sec	$\frac{1}{100}$sec	$\frac{9}{100}$sec
N^5	$\frac{1}{10}$sec	3.2sec	5.2min	2.8hour	28.1 day
2^N	$\frac{1}{1000}$sec	1sec	35.7year	400trillion centuries	75digit many centuries
N^N	2.8hour	3.3trillion years	70digit many centuries	185digit many centuries	728digit centuries

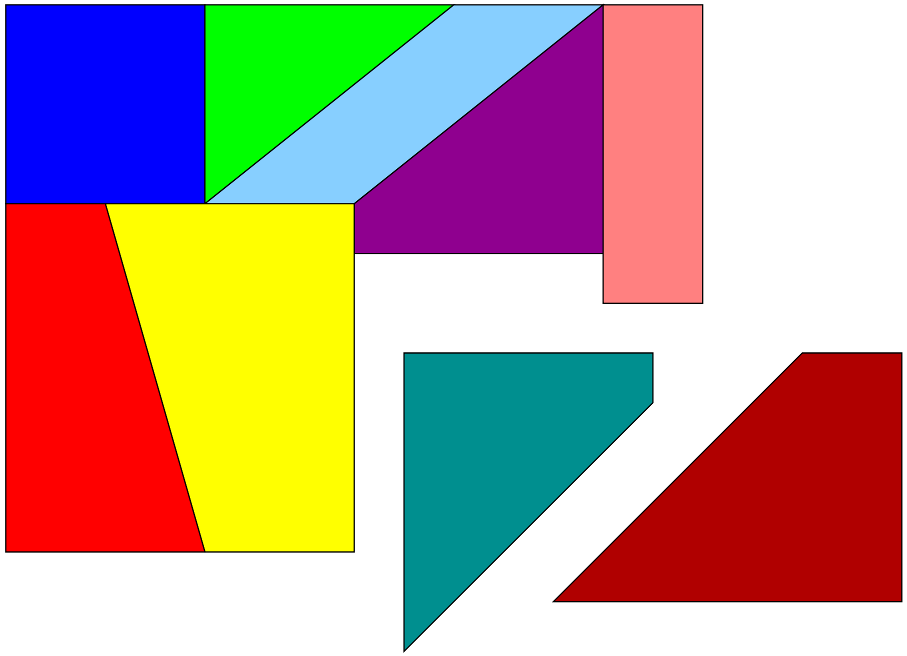
the Big Bang was about 15 billion year ago

- the sphere of algorithmic problems (version I)

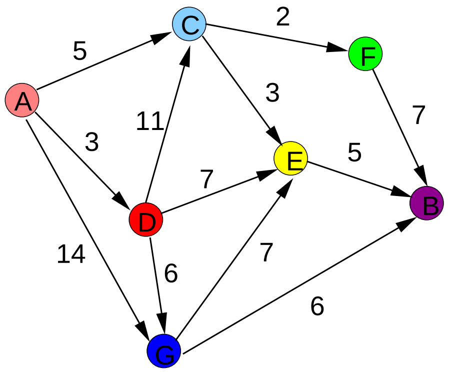


	maximal number of cards solvable in one hour		
	with today's computer	with computer 100 times faster	with computer 1000 times faster
N	A	100 x A	1000 x A
N^2	B	10 x B	31.6 x B
2^N	C	C + 6.64	C + 9.97

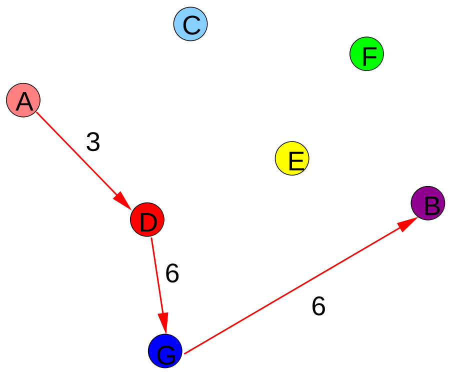
- an airline puzzle



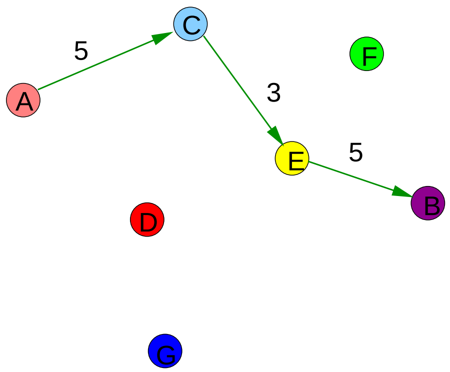
- for weary travelers greed does not pay



the graph

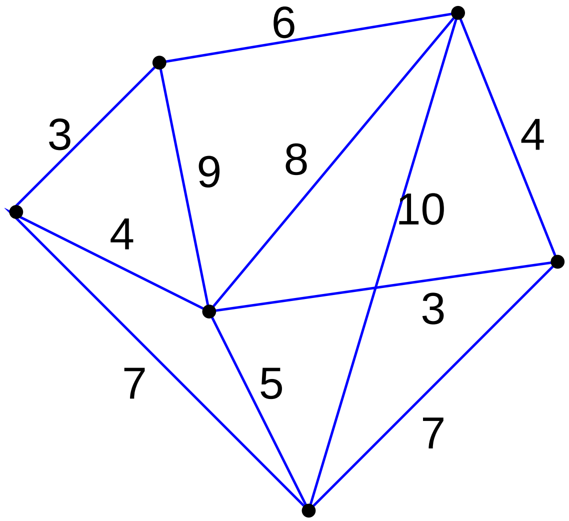


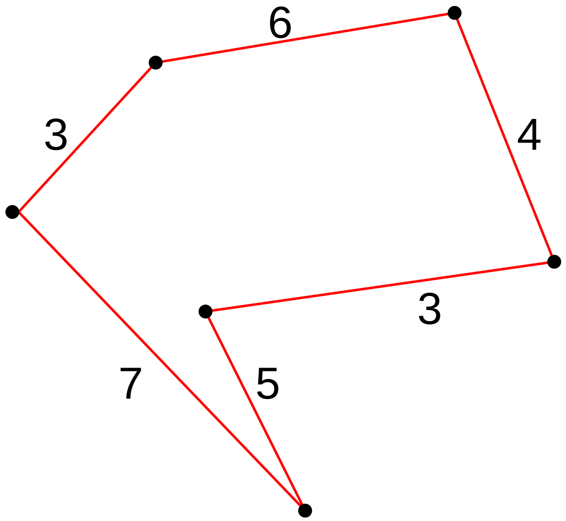
greedy solution
total cost 15
(non-optimal)

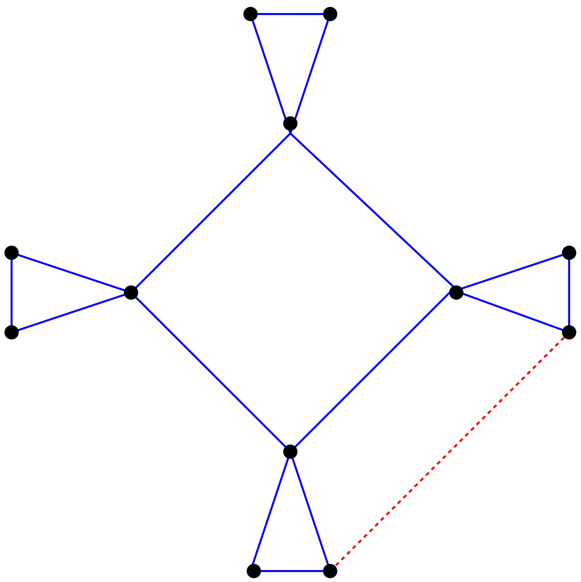


dynamic planning
total cost 13
(optimal)

- a city network and minimal roundtour

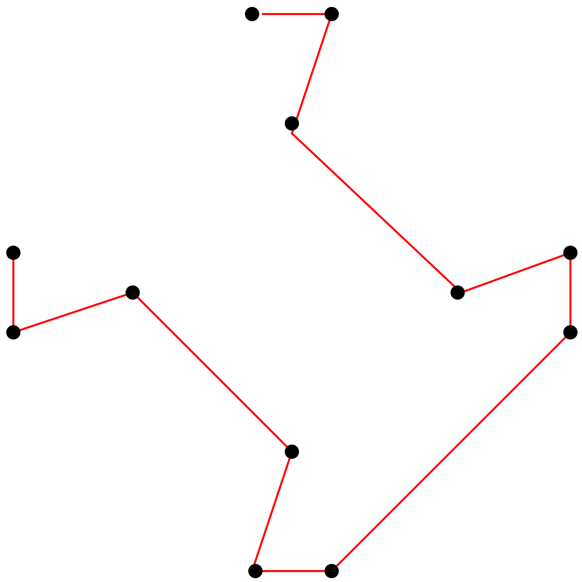






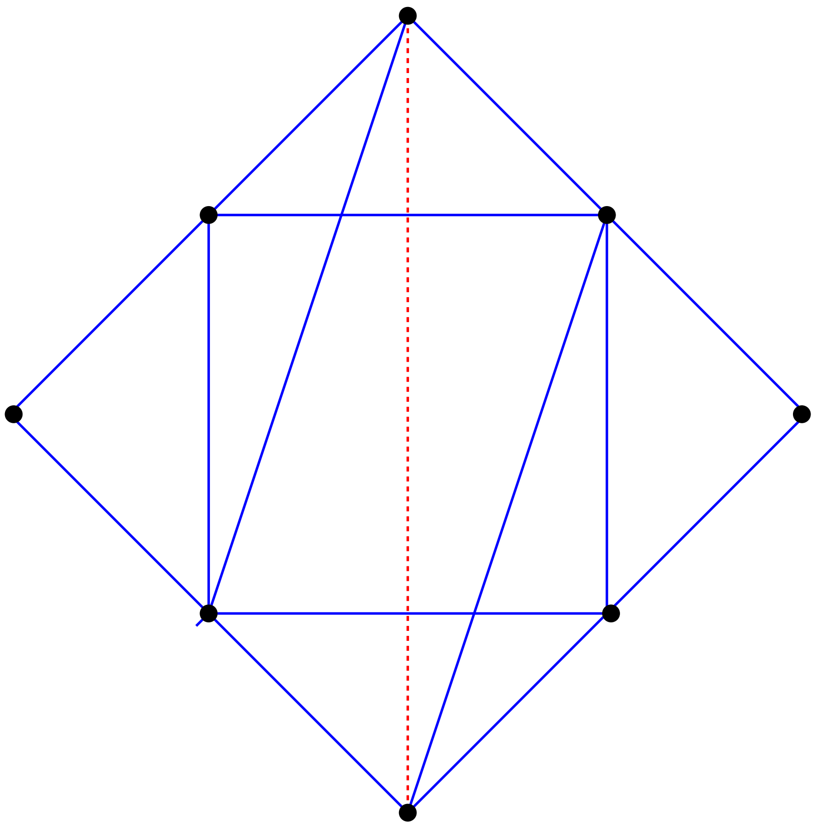
no Hamiltonian path

without extra edge

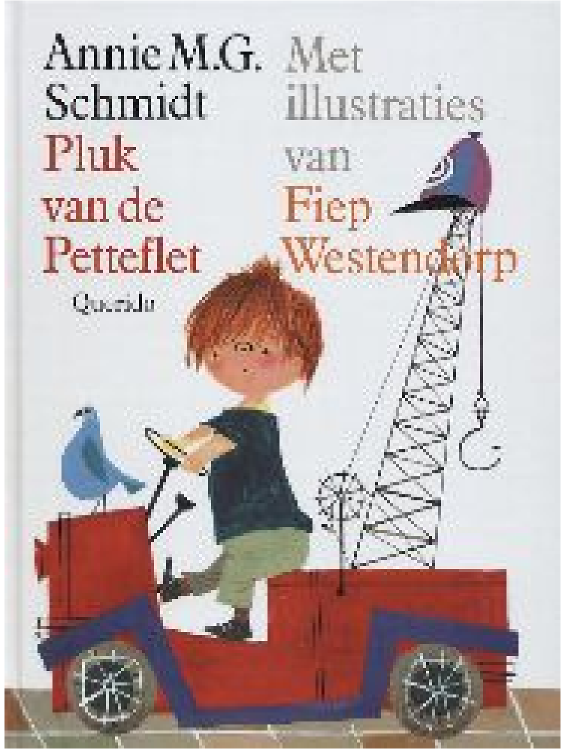


a Hamiltonian path

- Eulerian paths

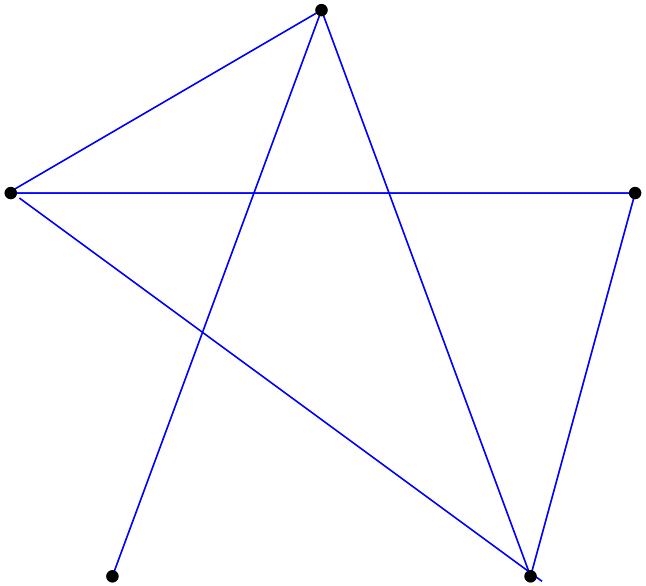


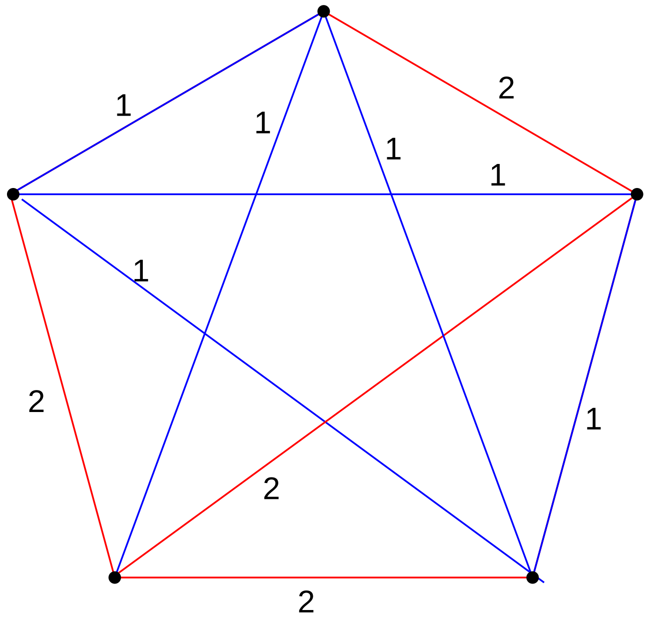
- satisfiability of propositional formulae
  - $\neg(E \to F) \wedge (F \vee (D \to \neg E))$
  - $\neg((D \wedge E) \to F) \wedge (F \vee (D \to \neg E))$



de Lispeltuut

- reducing Hamiltonian path to travelling salesman





- three-coloring reduces to satisfiability

  countries $C_1, C_2, \ldots, C_N$

  - uniqueness of color

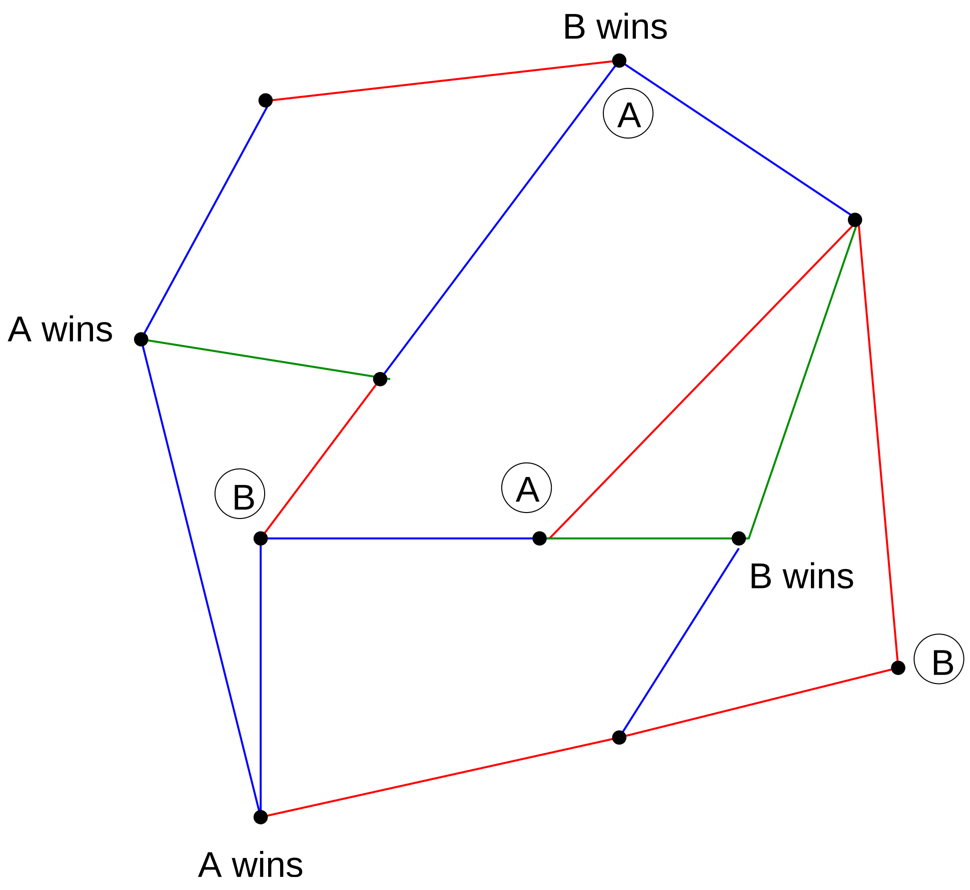
$$
\begin{aligned}
&(\ \ C_i - is - red \wedge \neg C_i - is - blue \wedge \neg C_i - is - yellow) \\
\vee\ &(\neg C_i - is - red \wedge \ \ C_i - is - blue \wedge \neg C_i - is - yellow) \\
\vee\ &(\neg C_i - is - red \wedge \neg C_i - is - blue \wedge \ \ C_i - is - yellow)
\end{aligned}
$$

  - no conflicting colors

$$
\begin{aligned}
&\neg(C_i - is - red \wedge C_j - is - red) \\
\wedge&\neg(C_i - is - blue \wedge C_j - is - blue) \\
\wedge&\neg(C_i - is - yellow \wedge C_j - is - yellow)
\end{aligned}
$$

    for adjacent countries C_i and C_j

- the roadblock game



- Presburger arithmetic

  $\forall X \exists Y \exists Z\colon X + Z = Y \wedge \exists W\colon W + W = Y$

  double exponential complexity $O(2^{2^N})$

- WS1S

  $$\forall B\colon 0 \in B \wedge (\forall X\colon X \in B \rightarrow X + 2 \in B) \rightarrow$$
  $$\forall Y\colon (\exists W\colon (Y = W + W \rightarrow Y \in B))$$

  non-elementary complexity: no K-fold exponential algorithm

- some complexity classes with sample problems