A GENERAL CLASS OF COMBINATORIAL FILTERS THAT CAN BE MINIMIZED EFFICIENTLY

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*This work was done prior to joining Amazon.

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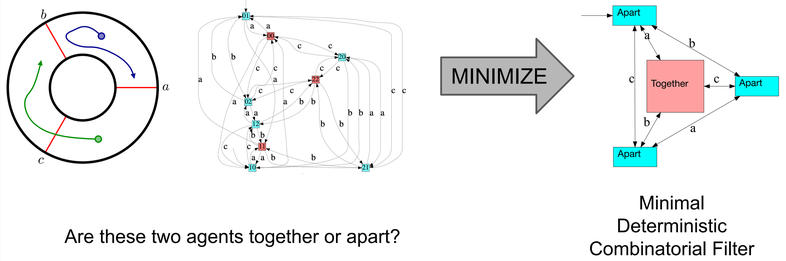
What is a combinatorial filter?



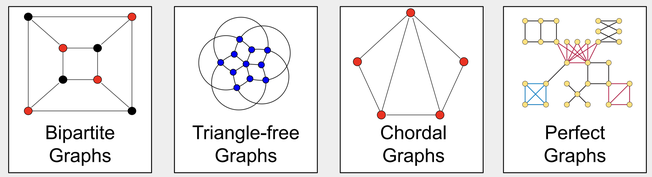
Are these two agents together or apart?

Minimal Deterministic Combinatorial Filter

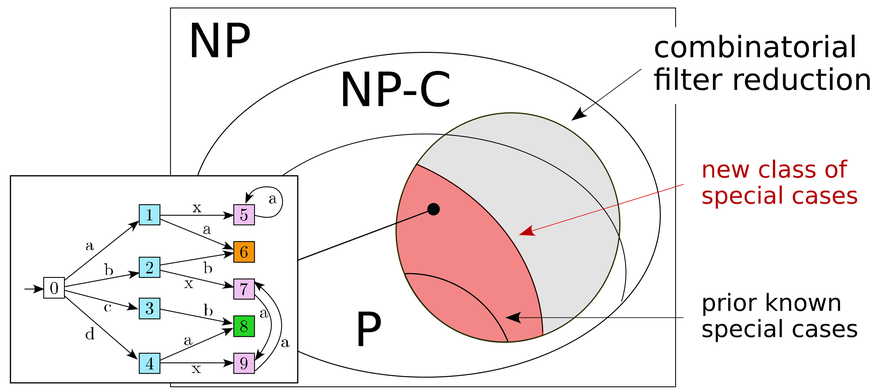
Standard clique cover problem

Task: find the minimum clique cover of a given graph
One of Karp's original 21 NP-complete problems

Several *special cases* are solvable in polynomial time:

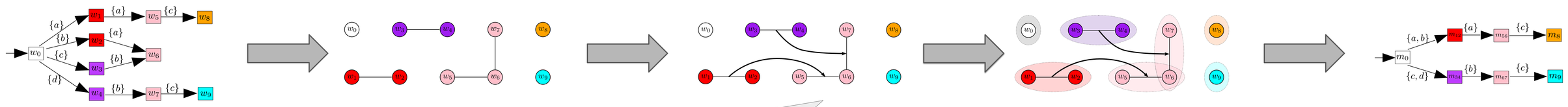


Special cases for filter minimization



MINIMIZE

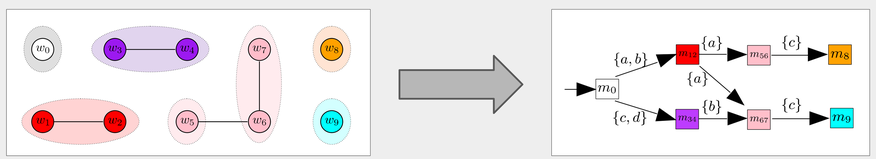
Input filter | **Compatibility graph** | **Zipper constraints** | **Clique cover satisfying zipper constraints** | **Resulting filter**



Zipper constraints

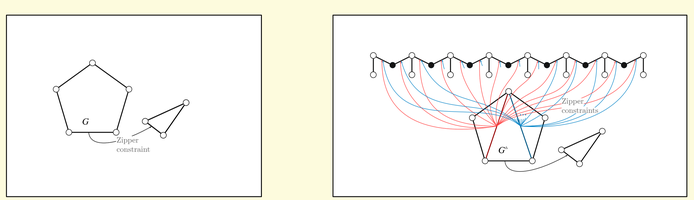
Definition: If two compatible states are merged, their downstream "children" must also be merged.

Purpose: Ensure the result is deterministic.



Zipper constraints are a complete source of NP hardness on their own

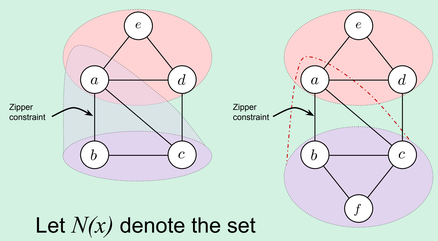
Necklace construction that adds chords which are prohibitively costly



Compatibility Clique Cover × **Zipper Constraints**

	None	Repairable	General
Easy Special Case	P	P	NP
General	NP	NP	NP

Constraint repair



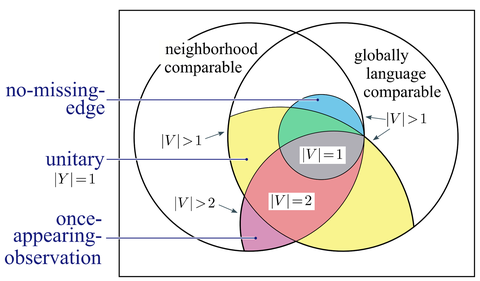
Let $N(x)$ denote the set of vertices that are the neighbors of x.

Neighborhood comparable states:
Two vertices x and y have comparable neighborhoods if either

$N(x) \subseteq N(y)$ or $N(x) \supseteq N(y)$.

This is a sufficient condition to "repair" a cover that fails to satisfy a zipper constraint.

Prior Special Cases



Special cases with efficient minimization:

(1) No-missing-edge;

(2) Unitary;

(3) Once-appearing-observations

These three have structure that means their compatibility graphs are always **chordal**, and their zipper constraints can be **repaired**.