Fast Reduction of Ground Markov Logic Networks

Shavlik & Natarajan, IJCAI 2009

Markov Logic Networks

- Weighted logic

1.5	$\forall x\ Smokes(x) \Rightarrow Cancer(x)$
1.1	$\forall x, y\ Friends(x, y) \Rightarrow \left(Smokes(x) \Leftrightarrow Smokes(y)\right)$

$$P(x) = \frac{1}{Z} \exp\left(\sum_i w_i n_i(x)\right)$$

Weight of formula *i*

No. of true groundings of formula *i* in *x*

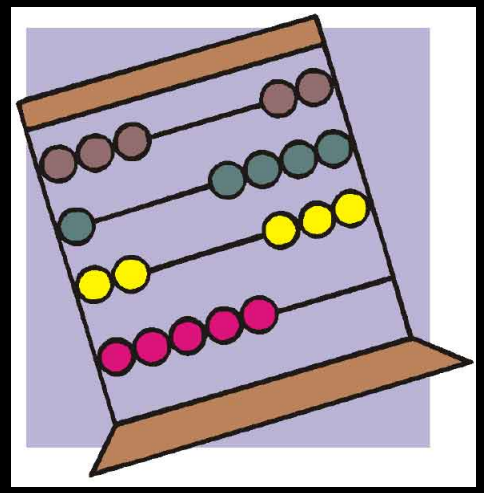
- Standard approach
  1) Assume finite number of constants
  2) Create all possible groundings
  3) Perform statistical inference (often via sampling)

(Richardson & Domingos, MLJ 2005)

Counting Satisfied Groundings

Typically lots of redundancy in FOL sentences

$$\forall\, x, y, z \quad p(x) \wedge q(x, y, z) \wedge r(z) \rightarrow w(x, y, z)$$



If p(John) = false,
then formula = true
for all Y and Z values

Factoring Out the Evidence

Let A = weighted sum of formula satisfied by evidence

Let B_i = weighted sum of formula in world i **not** satisfied by evidence

$$\text{Prob(world i)} = \frac{e^{A} e^{B_i}}{e^{A} e^{B1} + \ldots + e^{Bn}}$$

Efficiently **factor out** those formula groundings that **evidence** satisfies

Can potentially eliminate the need for approximate inference

Worked Example

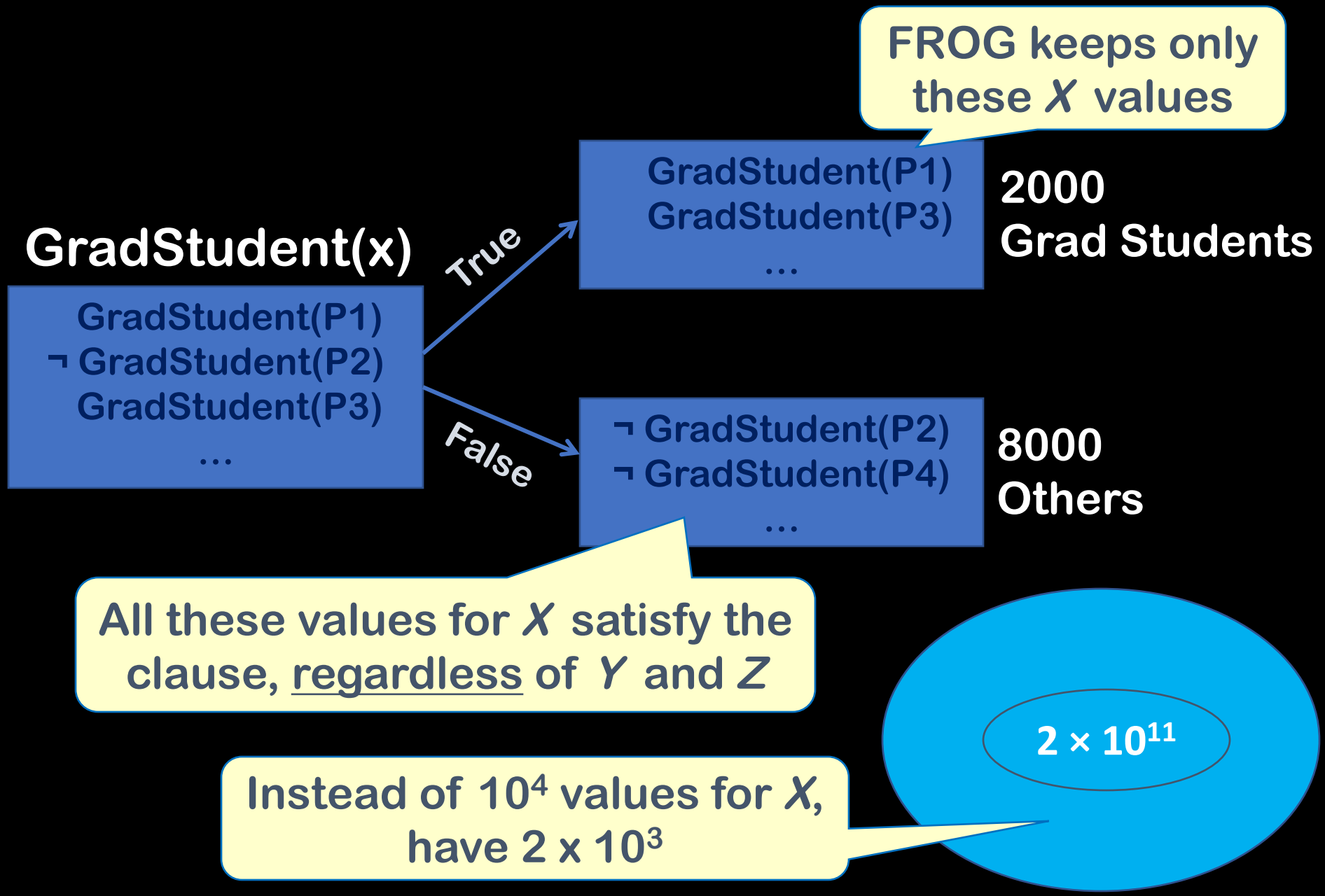
$$\forall x, y, z \quad \text{GradStudent}(x) \land \text{Prof}(y) \land \text{Prof}(z) \land \text{TA}(x, z) \land \text{SameGroup}(y, z) \rightarrow \text{AdvisedBy}(x, y)$$

10,000	People at some school	The Evidence
2000	Graduate students	
1000	Professors	
1000	TAs	
500	Pairs of professors in the same group	

Total Num of Groundings = $|x| \times |y| \times |z| = 10^{12}$

10^{12}

GradStudent(x) ∧ Prof(y) ∧ Prof(z) ∧ TA(x,z) ∧ SameGroup(y,z) → AdvisedBy(x,y)



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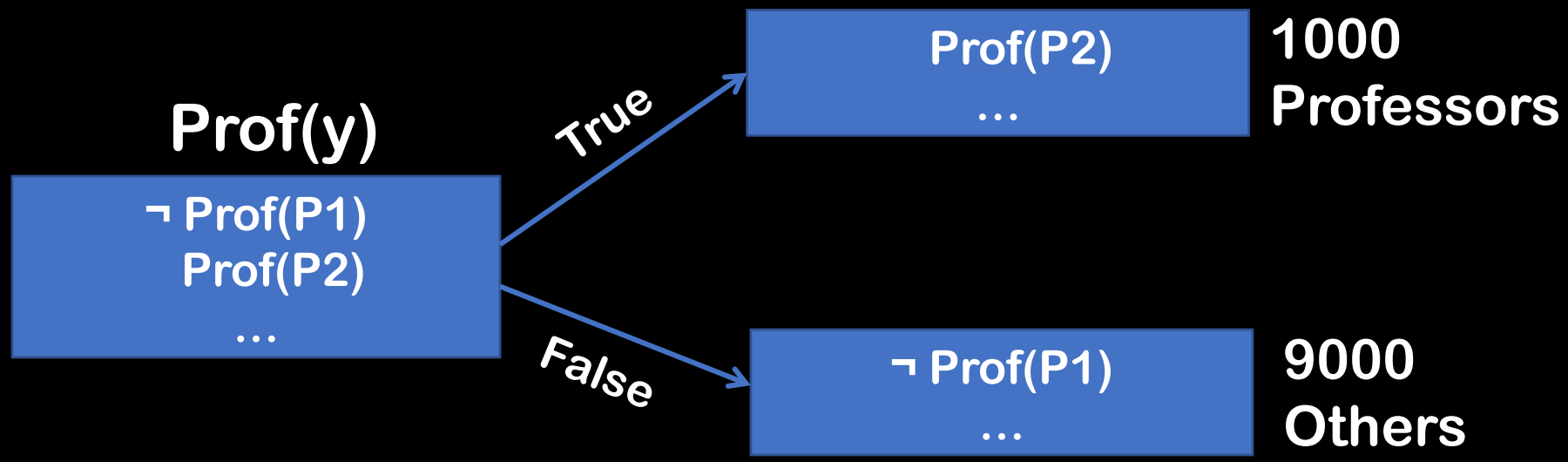

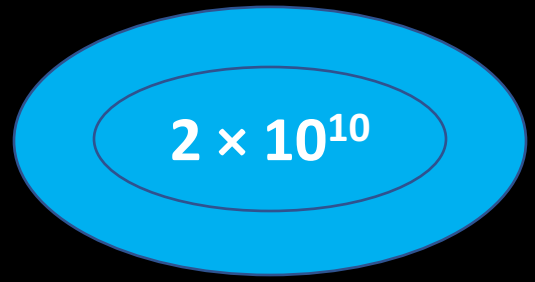

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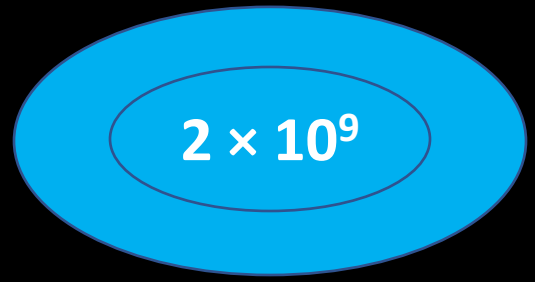
<<< Same as Prof(y) >>>



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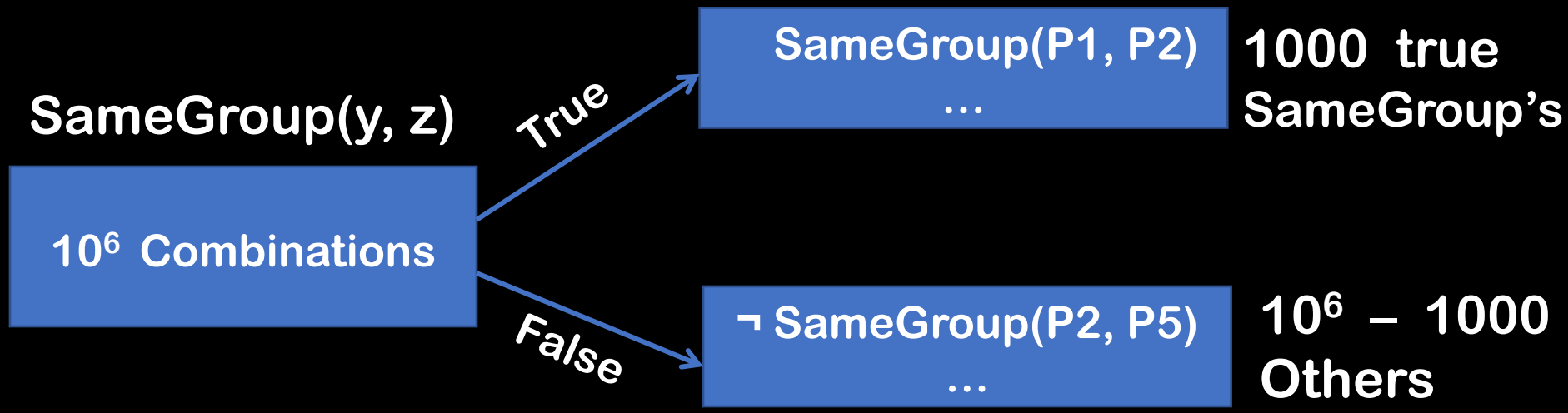

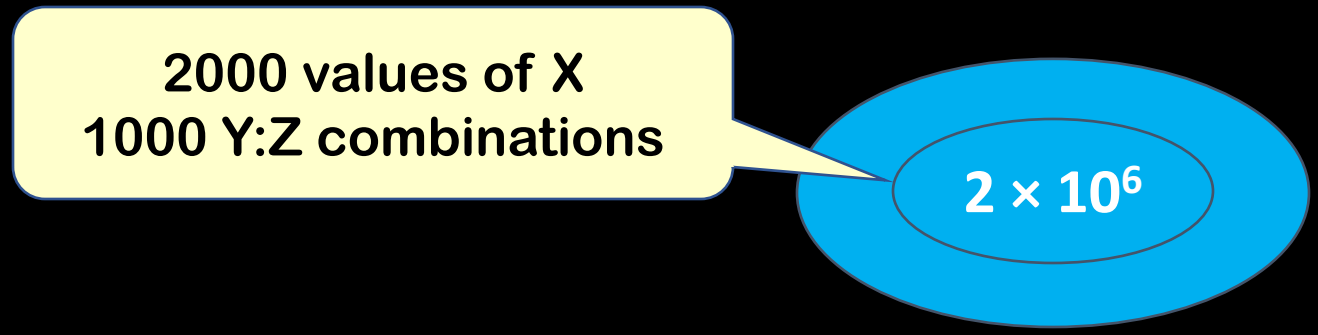

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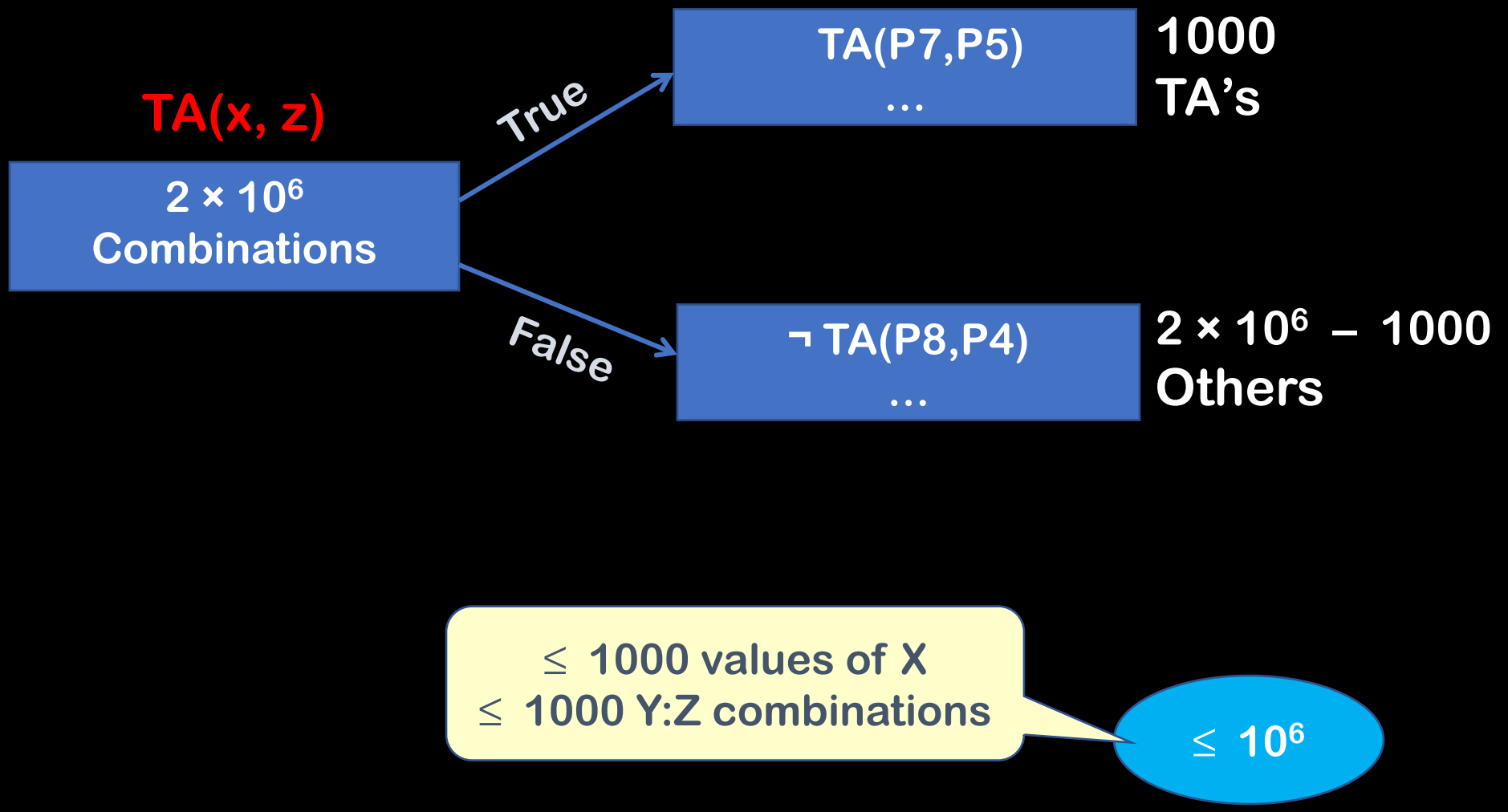

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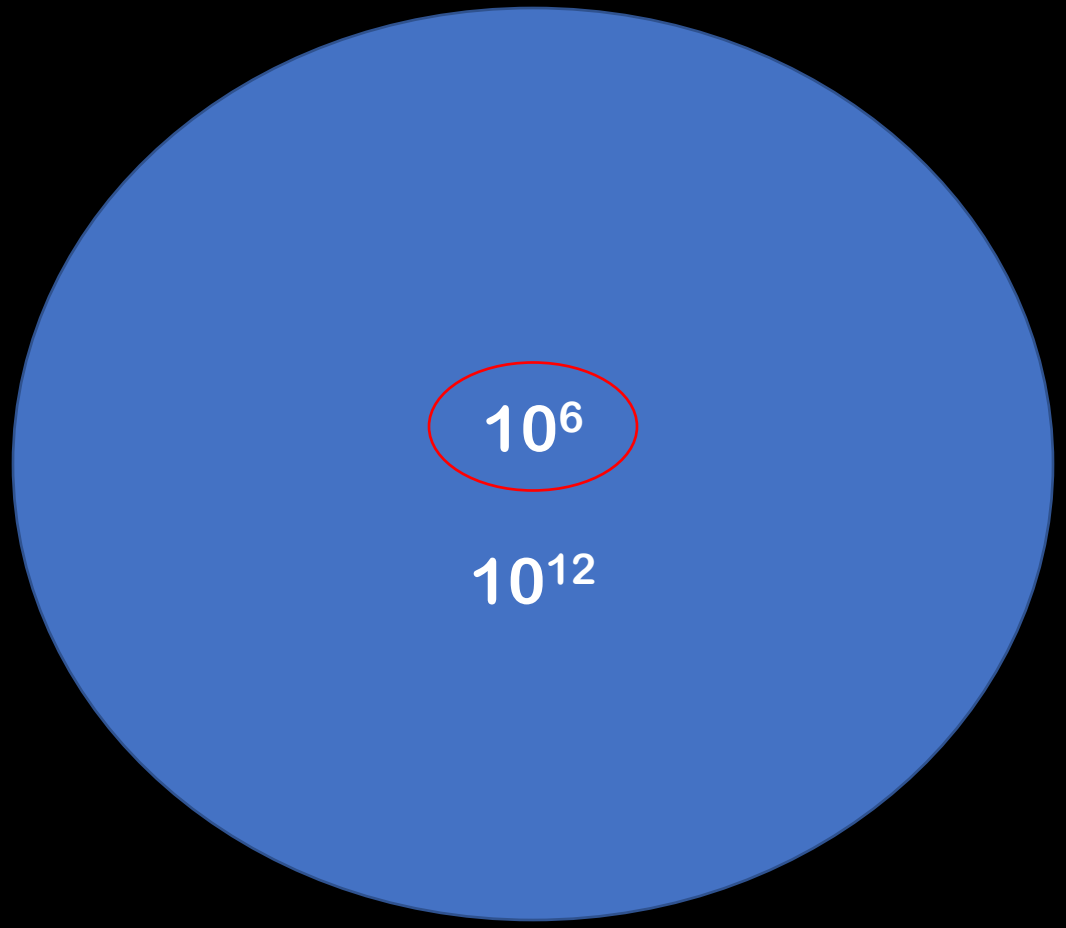
Original number of groundings = 10^{12}

Final number of groundings ≤ 10^{6}



Sample Results: UWash-CSE