Graphical-model based estimation and inference for differential privacy

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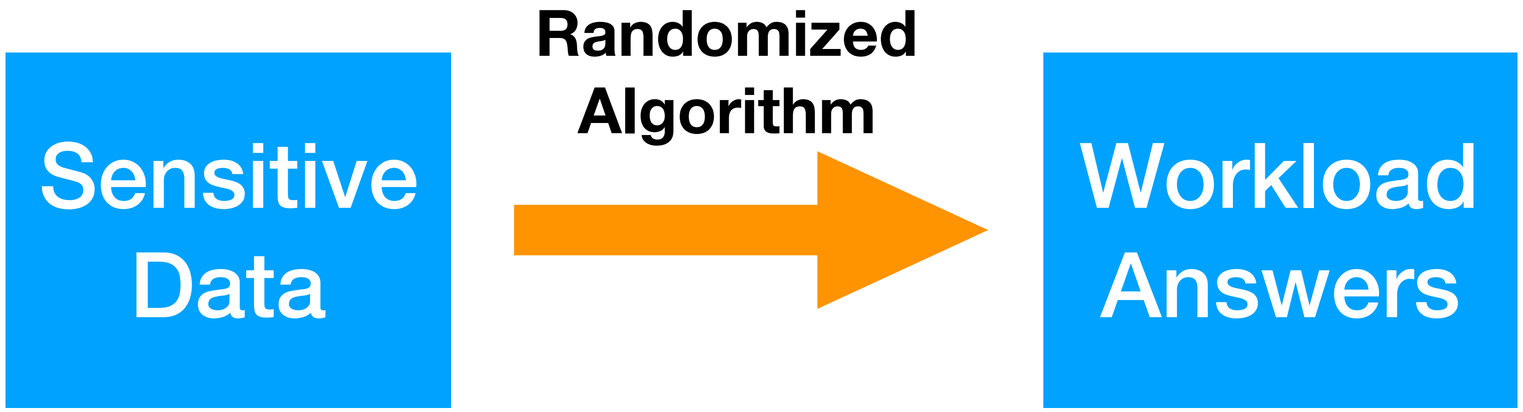
Inference in Privacy Mechanisms

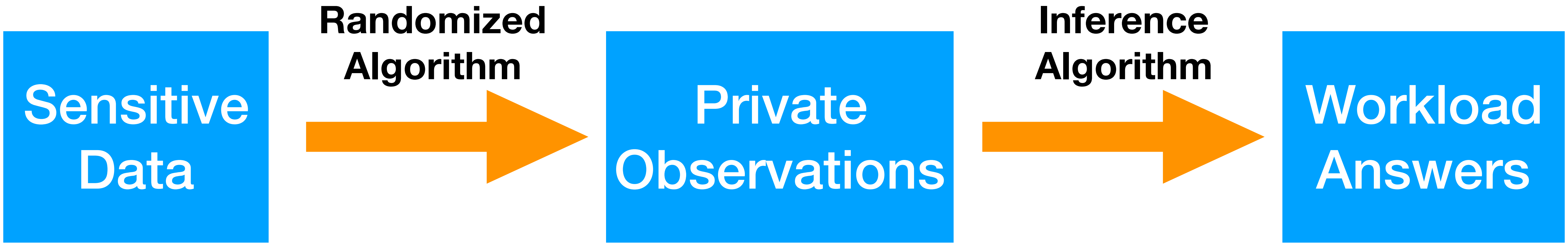


Sensitive Data

Randomized Algorithm

Workload Answers

Inference in Privacy Mechanisms



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Private Observations

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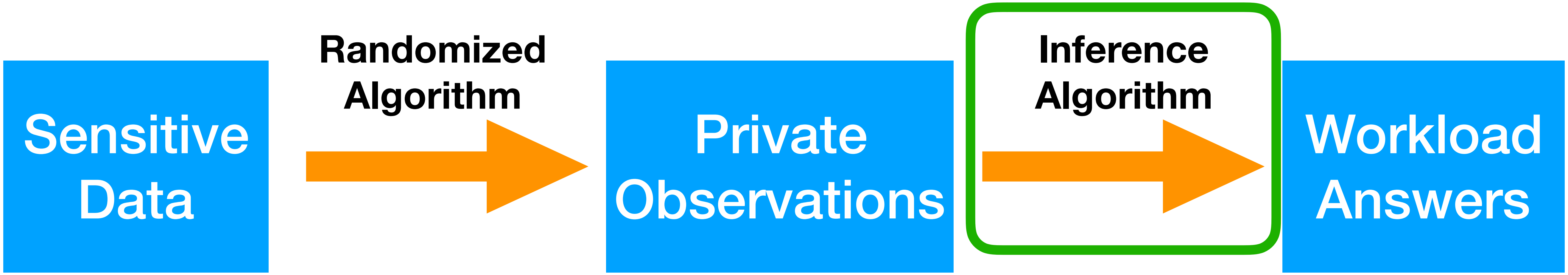
Sensitive Data

Randomized Algorithm

Private Observations

Inference Algorithm

Workload Answers

- Existing techniques for inference either don’t scale or don’t extract the most utility from the private observations

- Proper inference has many benefits:
  - Resolves inconsistencies
  - Improves utility
  - Answers new queries
  - Supports synthetic data generation

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Problem Statement

- Given:

  an unknown discrete data distribution $\mathbf{p} \in \mathbb{R}^{\mathrm{n}}$

  a query matrix $\mathbf{Q} \in \mathbb{R}^{\mathrm{m \times n}}$

- Our observation model is:

Random Laplace or Gaussian noise

$$\mathbf{y} = \mathbf{Q}\mathbf{p} + \varepsilon$$

- We want to recover an estimate of $\mathbf{p}$ from $\mathbf{y}$

$$\hat{\mathbf{p}} \in \arg\min_{\mathbf{p} \in S} ||\mathbf{Q}\mathbf{p} - \mathbf{y}||$$

Size of p is intractably large

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Approach

- Reformulate problem to find a graphical model $\mathbf{p}_\theta$ instead

$$\hat{\theta} \in \arg\min_{\theta} ||\mathbf{Q}\mathbf{p}_{\theta} - \mathbf{y}||$$

Much smaller than p

- If $\mathbf{Q}$ only depends on $\mathbf{p}$ though its marginals,
  - We can solve this problem efficiently
  - Solution to reformulated problem is the maximum entropy solution to the original problem

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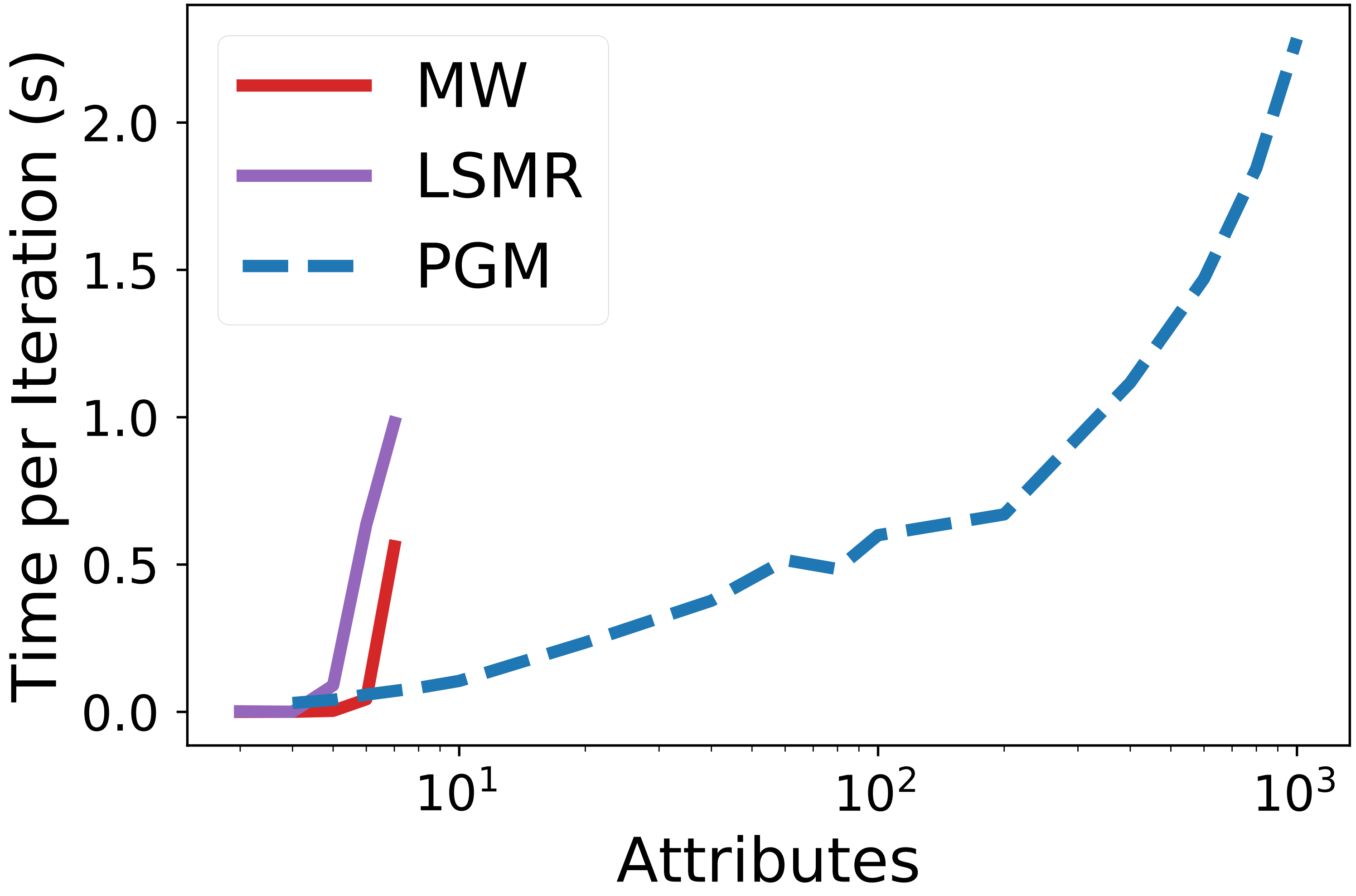
Scalability Improvements of PGM

- Graphical-model inference scales much better than traditional approaches.

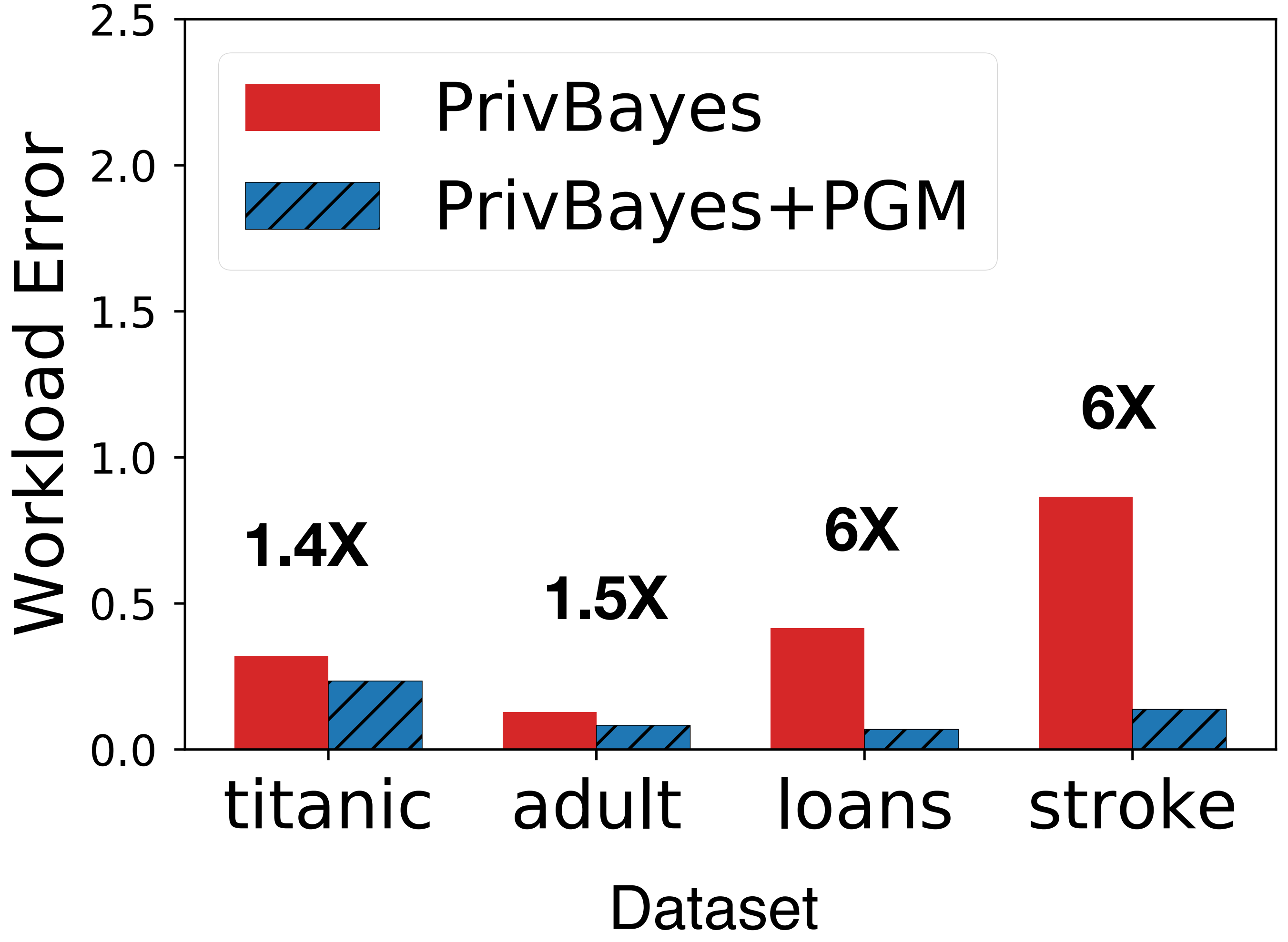


Traditional approaches fail at 10 dimensions

PGM scales to 1000 dimensions

Utility Improvements of PGM

- Graphical-model inference improves the utility of several state-of-the-art privacy mechanisms.



Error reduction up to 6X

We offer similar improvements for DualQuery, HDMM, and MWEM as well (see poster)

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Poster #171

Code available on GitHub:

https://github.com/ryan112358/private-pgm

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