# X-Device Query Processing by Bitwise Distribution

Holger Pirk
Stefan Manegold

Thibault Sellam
Martin Kersten

**CWI, Amsterdam, Netherlands**

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# The Problem

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# The Data

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# The Data

- A moving objects database of vehicles in NW Europe
  - 240M Tuples (lat int, long int, trip bigint, timestamp bigint)
- Applications like traffic monitoring, forecasting or planing

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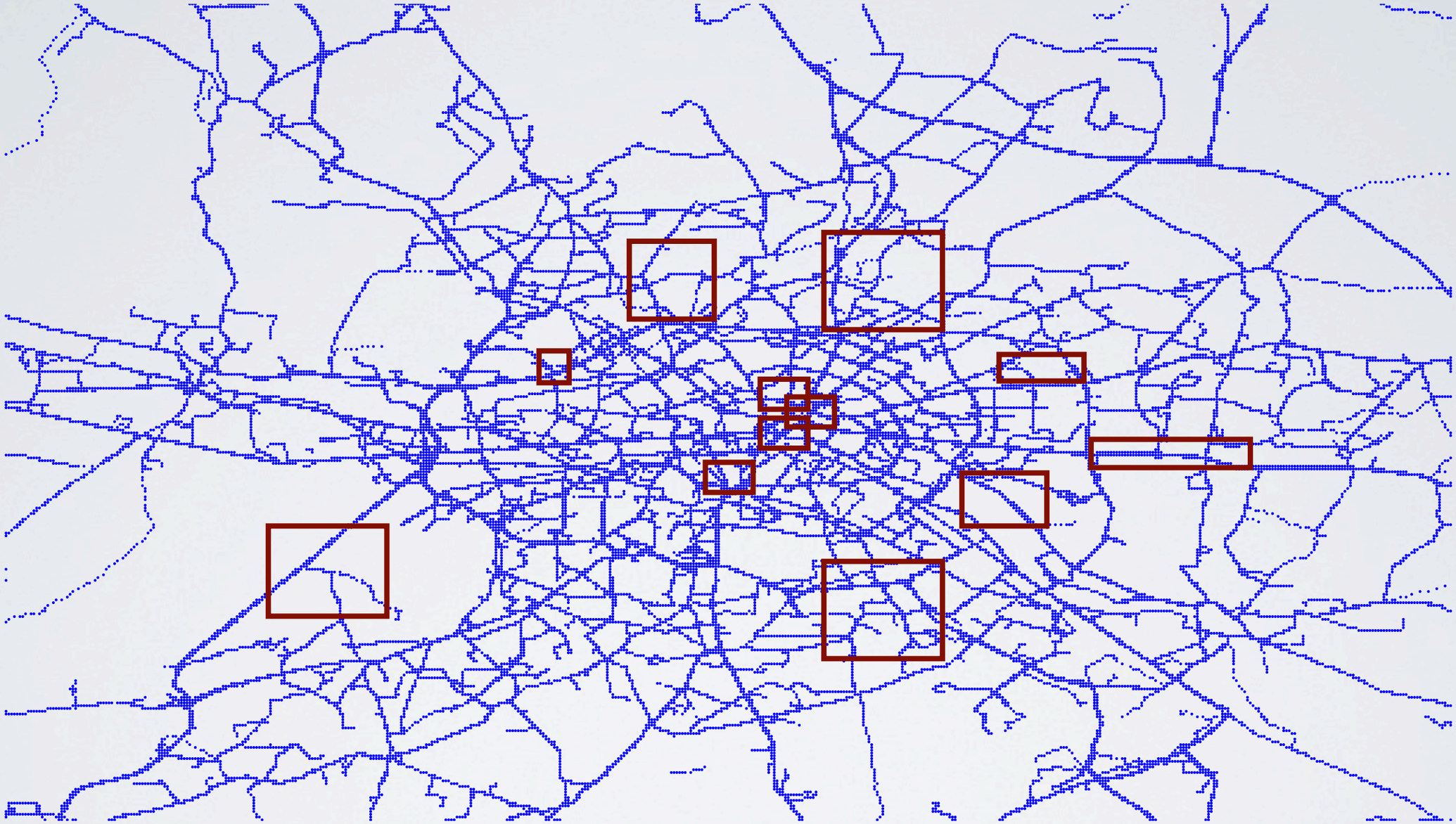
# The Queries



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# The Queries

- Lot's of spatial range queries:

  select * where x between $x_{low}$ and $x_{high}$ and

  y between $y_{low}$ and $y_{high}$

- Focus on Query Throughput

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# Let's kill it with Hardware

- GPUs have high bandwidth and are massively parallel

➡Many queries can be evaluated concurrently

- GPU memory is never large enough

# What can you do?

- Host-to-Device Streaming suffers from PCI bottleneck
- Horizontal Distribution leaves most data/costs on the CPU
- Sampling only yields approximate results
- Decomposed Storage is not enough

➡**The existing techniques just don't suffice**

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# Approach

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# Remember gifs through a modem connection?


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# The Approach

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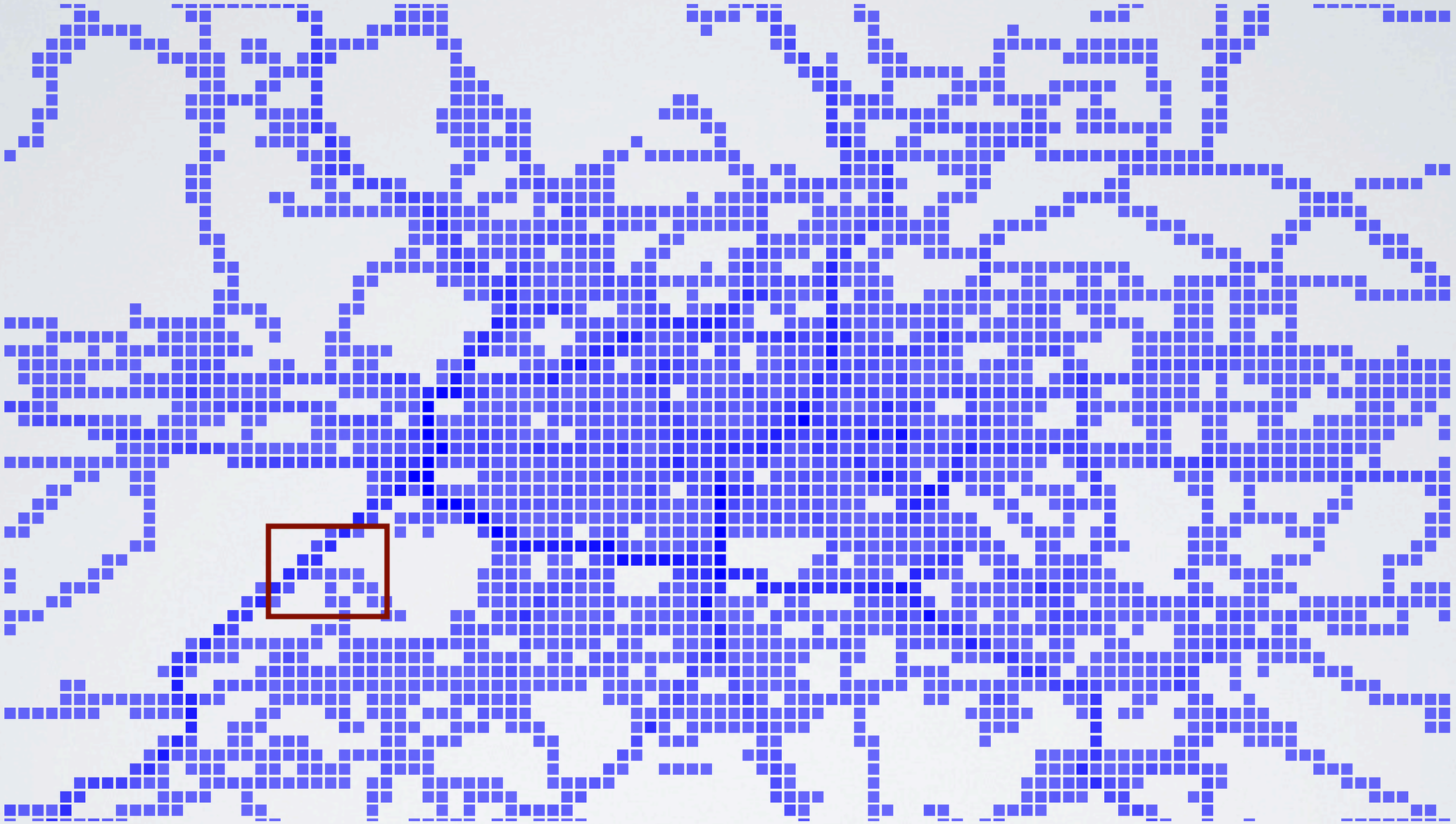
# The Approach



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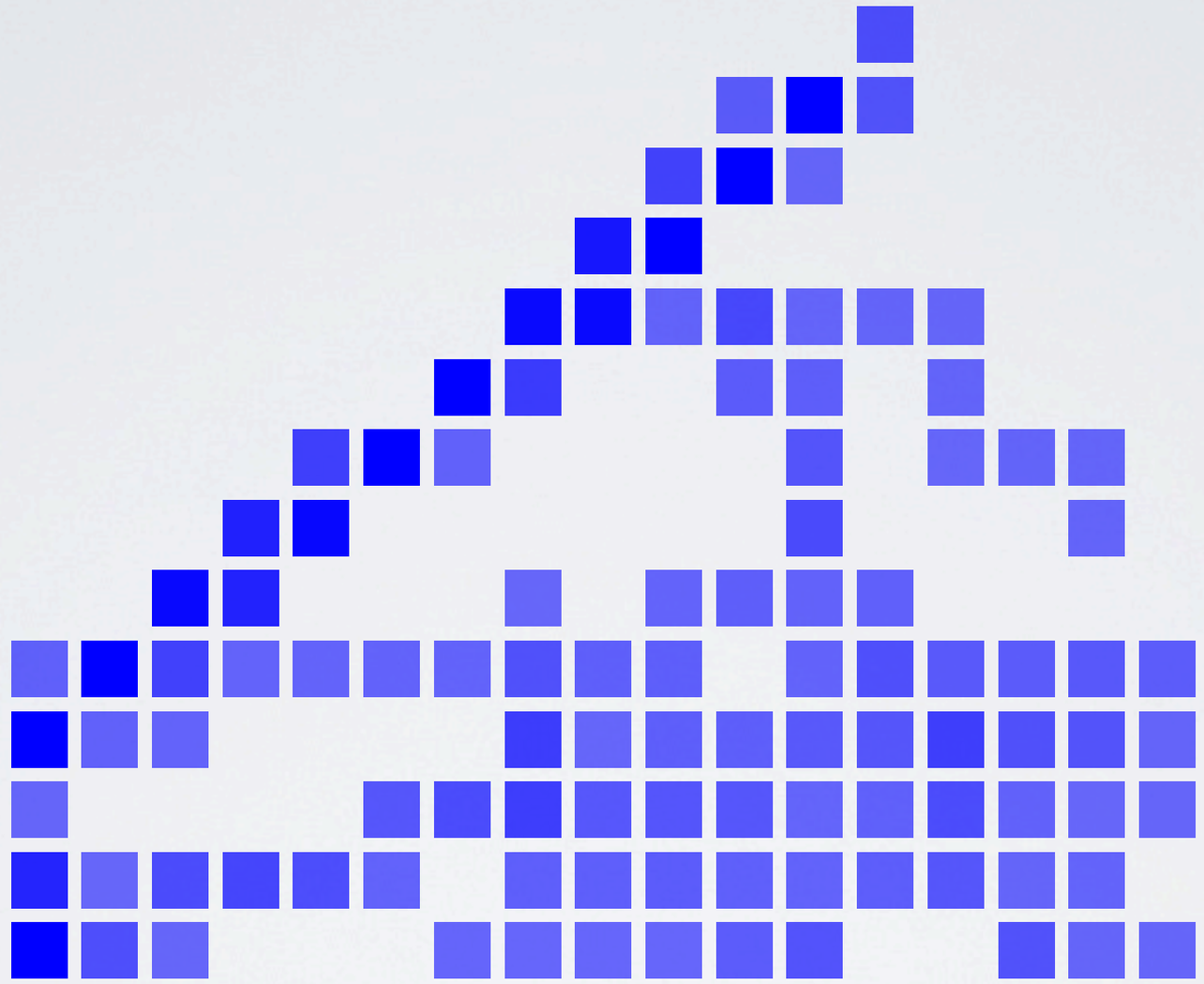
# Approximate



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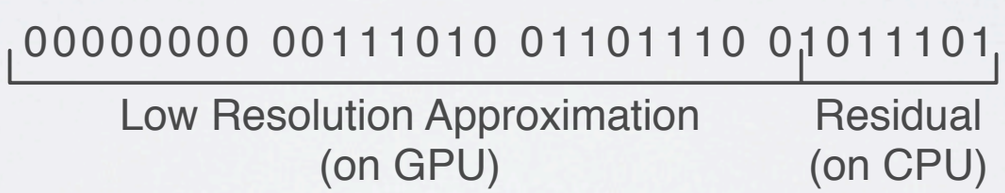
# Refine

# Implementation

- Vertical Partitioning and Distribution
  - But with finer slices: Bitwise Decomposition & Distribution




- Precision on GPU is selected appropriately (see paper)
- Low Resolution Data is well compressible

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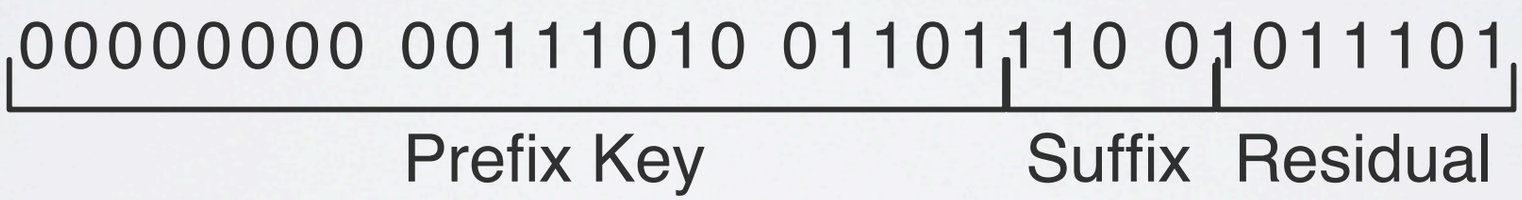
# Compression

- Has to be Lightweight and parallel decompression friendly:
  - Prefix Compression




- Values are split into:
- Spatial Locality helps compression

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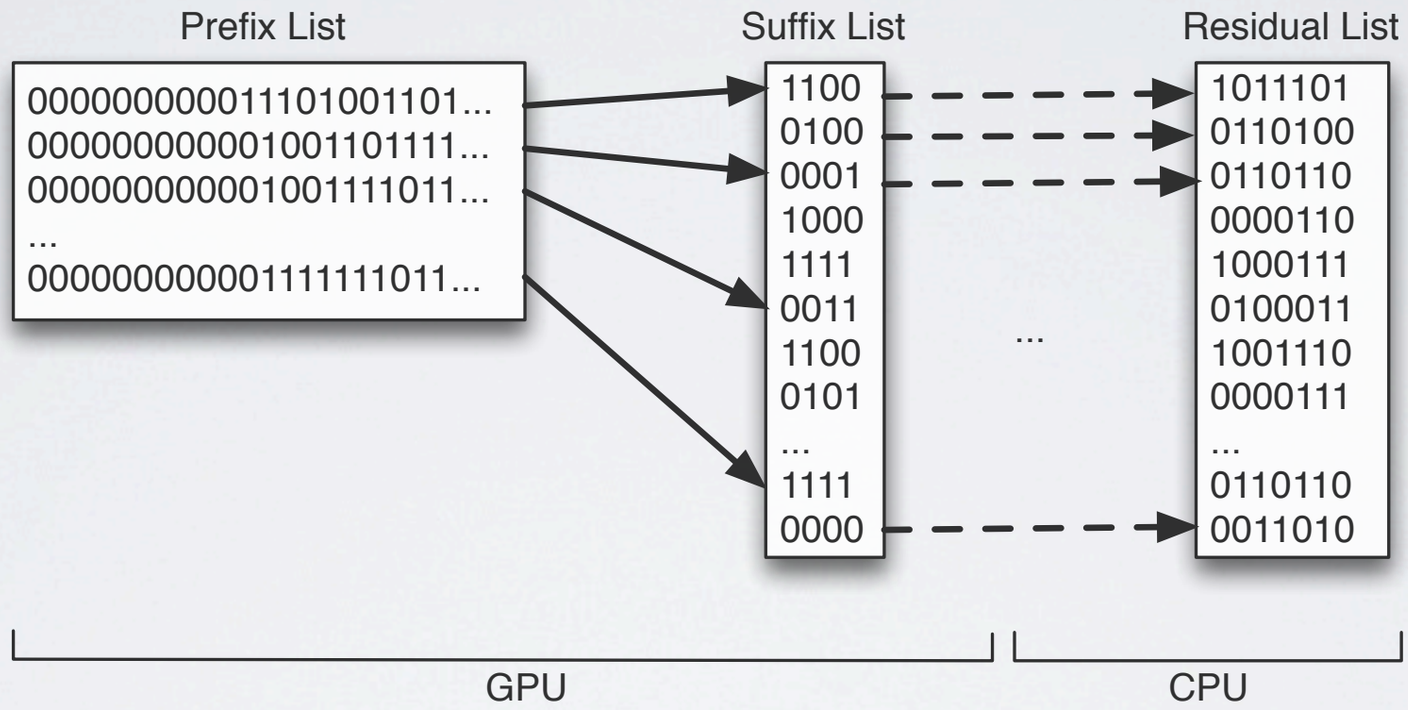
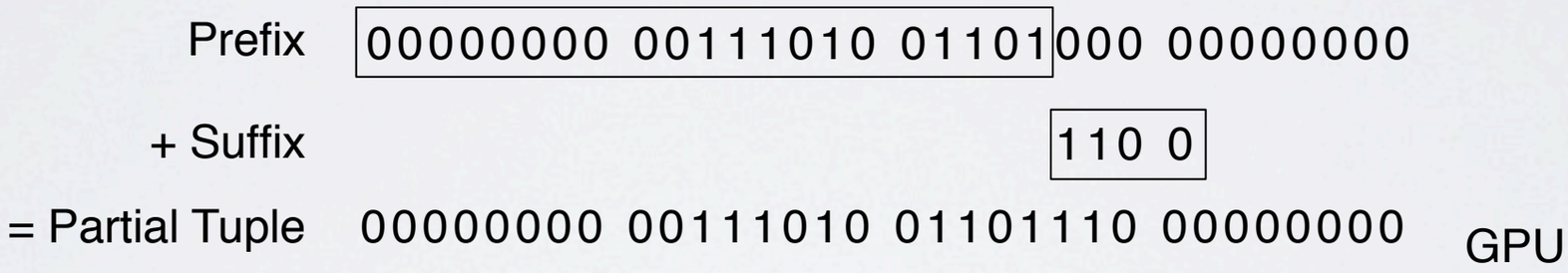
# Compression




- Radix-Clustering clustering improves compression further

# Query Evaluation

- Queries are evaluated in phases, tuples reconstructed lazily
- Every device does it's best with the available data



# GPU-Phase

- Geared towards throughput
- Parallelized over Queries and Prefixes
- Prefix-Clusters are skipped
  - This may cause thread divergence
- Output-Regions are overallocated

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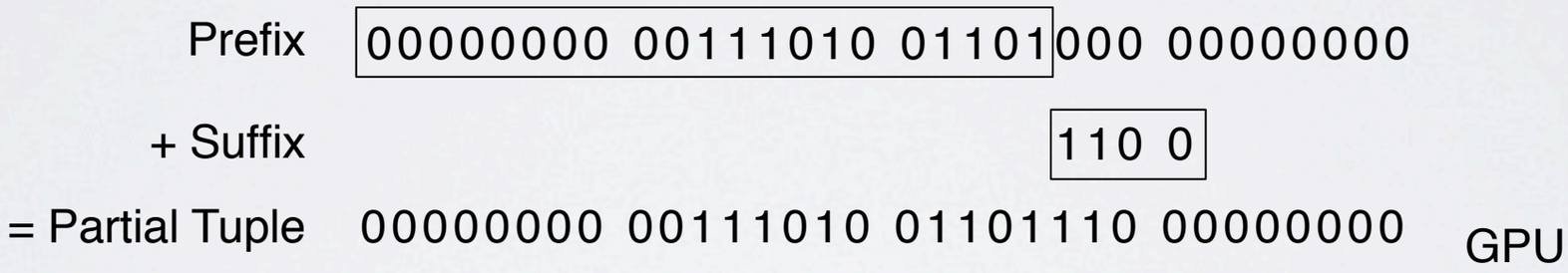

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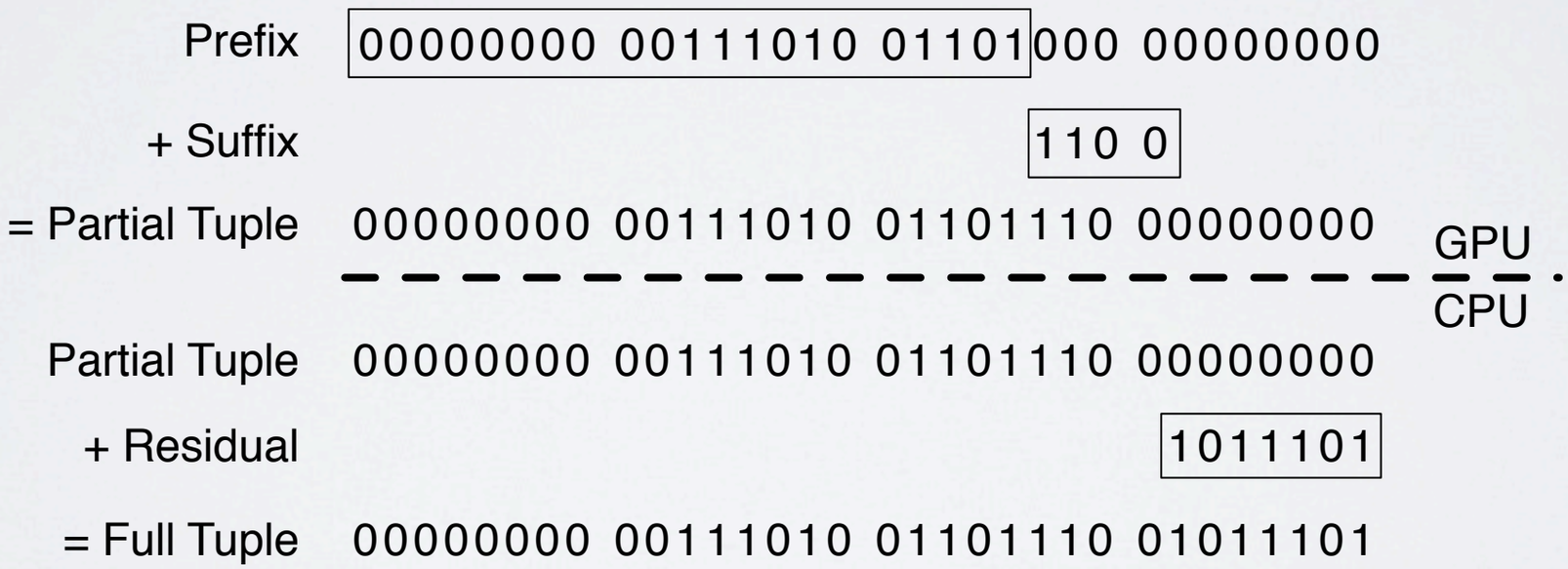


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# CPU-Phase

- Approximation may include false positives
- Post-filtering is done on the CPU
- **But**: they have to be transferred to the CPU
- We found around 25% false positives in the first phase

# Evaluation

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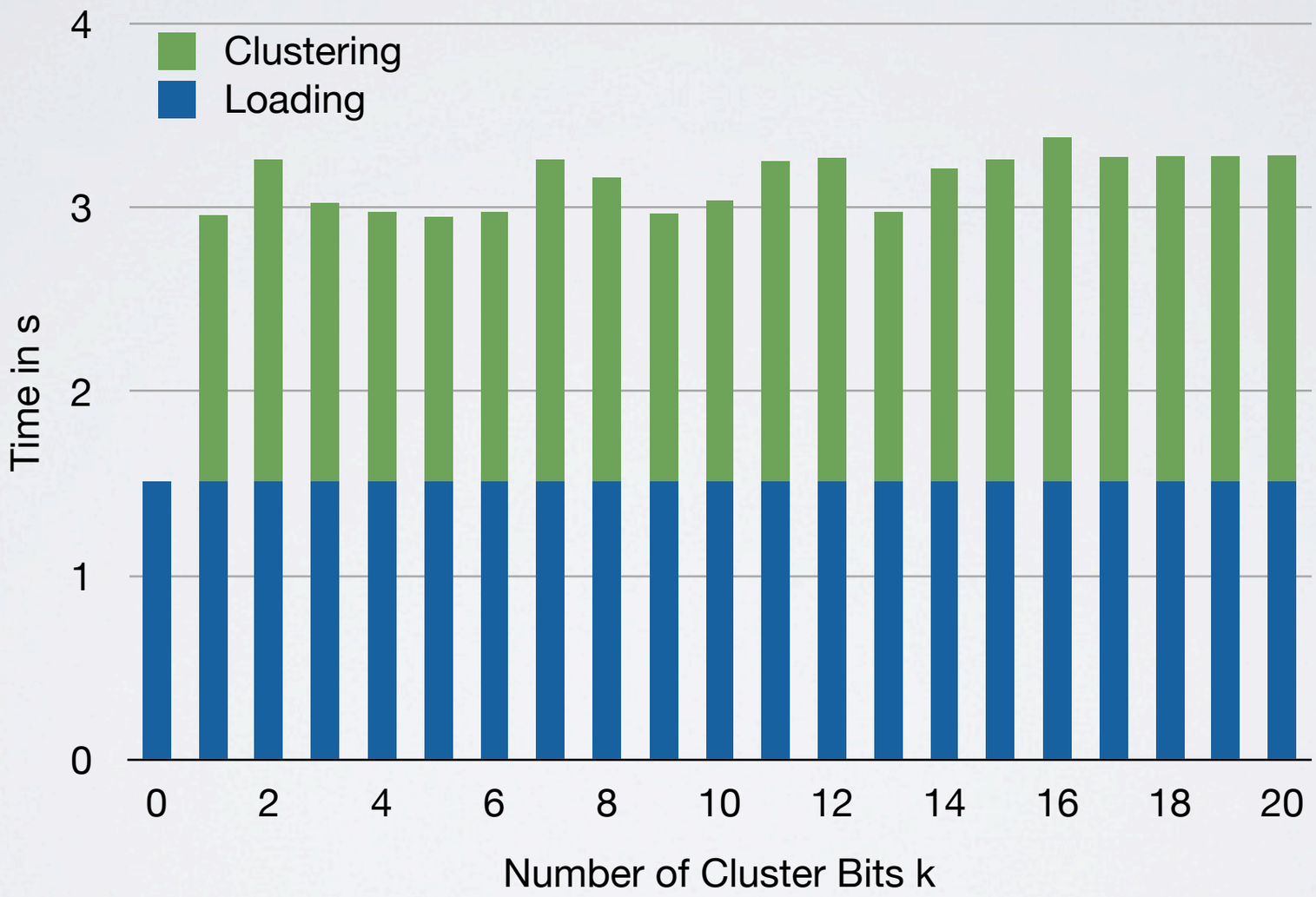
# Loading Performance

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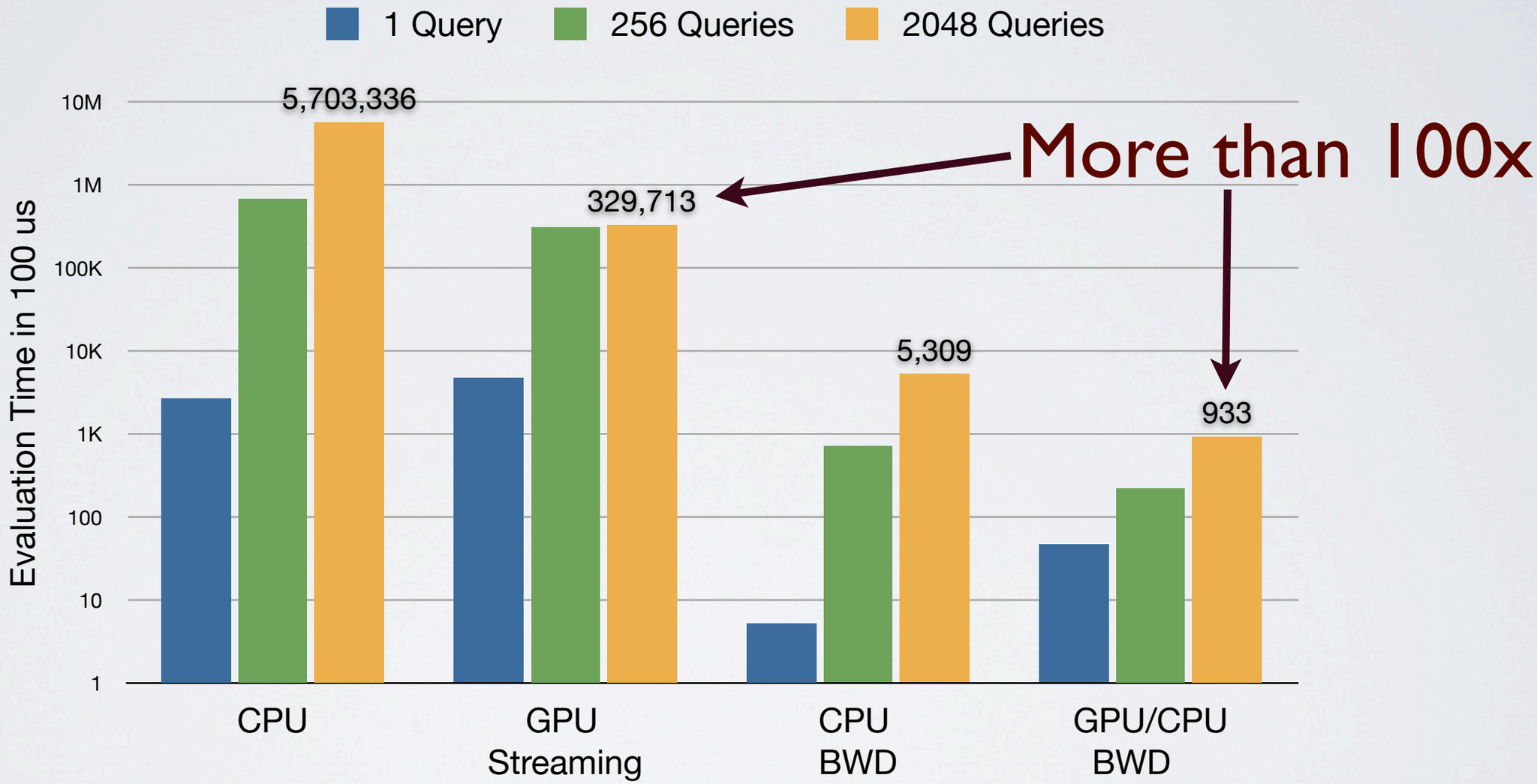
# Query Performance

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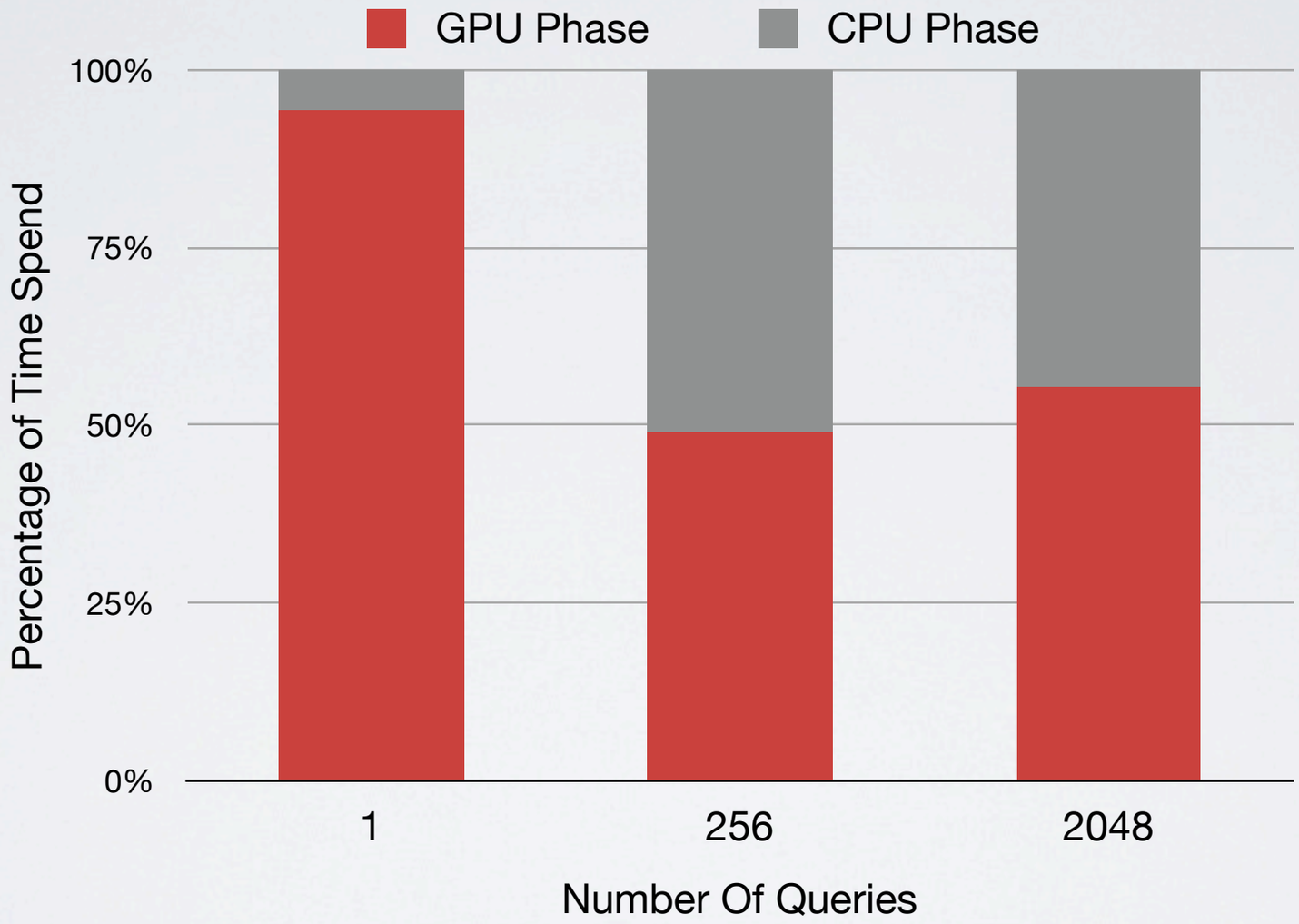
# Load Balancing

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# Conclusions and Outlook

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# Conclusion

- **Bitwise Decomposition** offers high query throughput on devices with different characteristics like GPUs and CPUs
- Largely targeted at scans
  - Doesn't really compete with indices in latency

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# Outlook

- Other X-Device Setups:
  - SSD-HDD *(remember the Keynote?)*
  - Mobile - Server
  - GPU - CPU - SSD - HDD - Server
- Other Applications:
  - Relational Queries (Joins, Aggregations, ...)
- Other Data: Categorical, Float, ...

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# Thank you !

Visit us at the poster session on Wednesday 2pm

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# Questions?

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