The value of merge join and hash join in Microsoft SQL Server and relational query processing

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Microsoft SQL Server

Why this study?

- Blasgen & Eswaran – 20 years ago

  Merge join & (index) nested loops cover all cases pretty well

- DeWitt, Sacco, others – 10-15 years ago

  Hash join is great for large unsorted inputs

- Analytical studies, simulation, experiments

Success without merge/hash join

- Sybase & Microsoft SQL Server
  - Until recently used only nested loops
  - Successful for over 10 years!
  - Even used in data warehousing!
- Focus on OLTP
  - Sybase invented stored procedures
  - Microsoft leads SMP TPC-C efficiency
- Focus on canned reports
  - Perfectly possible with tuned index sets

Are the prior studies wrong?

- Small evaluation sets
  - Few tables, few queries
- Insufficient credit to index tuning
  - Fixed set of indexes
- This study:
  - Still limited yet non-trivial queries & tables
  - Indexes tuned using a “tuning wizard” tool
    - Large set of possible indexes, integrated with query optimizer
- Next study
  - Indexes tuned specifically for available algorithms

SQL Server 7.0 query processor

- Nested loops with stored or temporary indexes
- Merge join & hash join (incl. hash teams)
- Index intersection, union, difference, & join
- Star joins: star indexes, cross-product, & semi-join reduction
- Constraints exploited for selectivity estimation & cost calculation & query simplification
- Parallelism on SMPs
- Content queries (“contains”, “near”, “about”)
- Optimized update plans (indexes, constraints)
- Heterogeneous & distributed queries

Relevant SQL Server tools

- Graphical show plan
- Profiler

  Captures workloads & events (e.g., deadlocks)

  Filters on application, database, user, operation, elapsed time, etc.
- Index tuning wizard

  Optimizes a workload captured with the profiler

  Reconsider all indexes – only add indexes

  Increase / decrease database size

  Uses query optimizer to assess choices

Experimental setup

- TPC-D database

  scale factor = 1 (1 GB raw data)

- Old & new TPC queries

  22 queries total

- Flags to disable

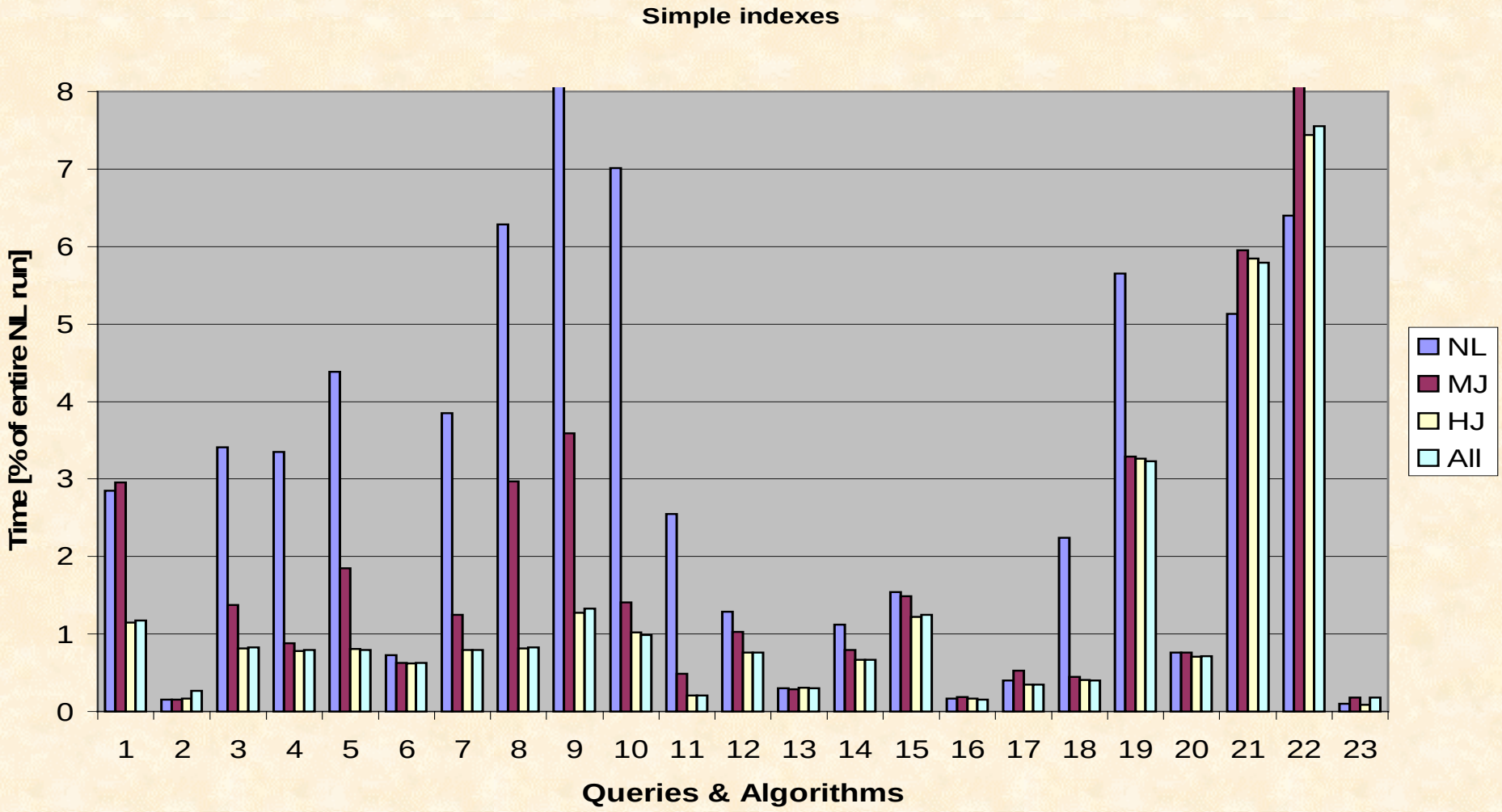
  Index join, merge join, hash join, hash teams

  Stream aggregation, hash aggregation

- Indexes in simple database design

  Primary keys, foreign keys, dates

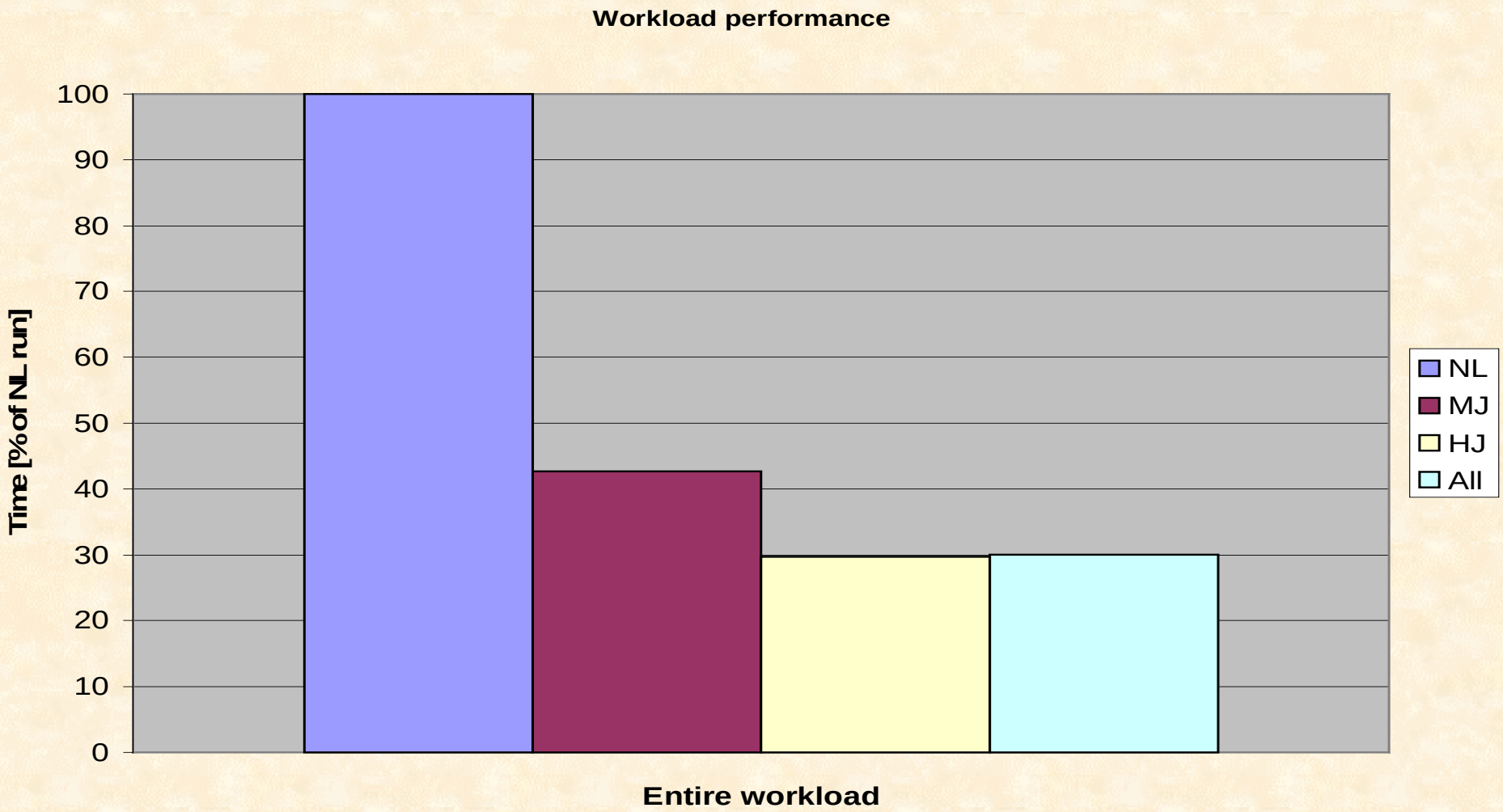
Performance with simple indexes



Performance with simple indexes

- NL=MJ >> HJ=All: #1, #15
  - Hashing improves performance
  - Aggregation, not join, make the difference
  - Early aggregation missing in sort code
- NL=MJ=HJ=All: #2, #13, #16, #17
  - No really meaningful difference
  - Indexes are sufficient to select & retrieve rows
- NL > MJ > HJ=All: #3, #5, #7, #8, #9, #11
- NL >> MJ=HJ=All: #4, #14, #19
  - Need some method for large unindexed inputs

Workload performance



Workload performance

- Only NLJ is not competitive
  - Due to simplistic index design
- Hash-based query processor performs best
- NLJ + MJ are very competitive
  - 40% difference to full QP with hash join
  - That's 9 month of hardware improvements
    - Presuming 2x CPU speed in 18 months
  - Poor indexing strongly favors hash join
  - Blasgen & Eswaran were right all along …?

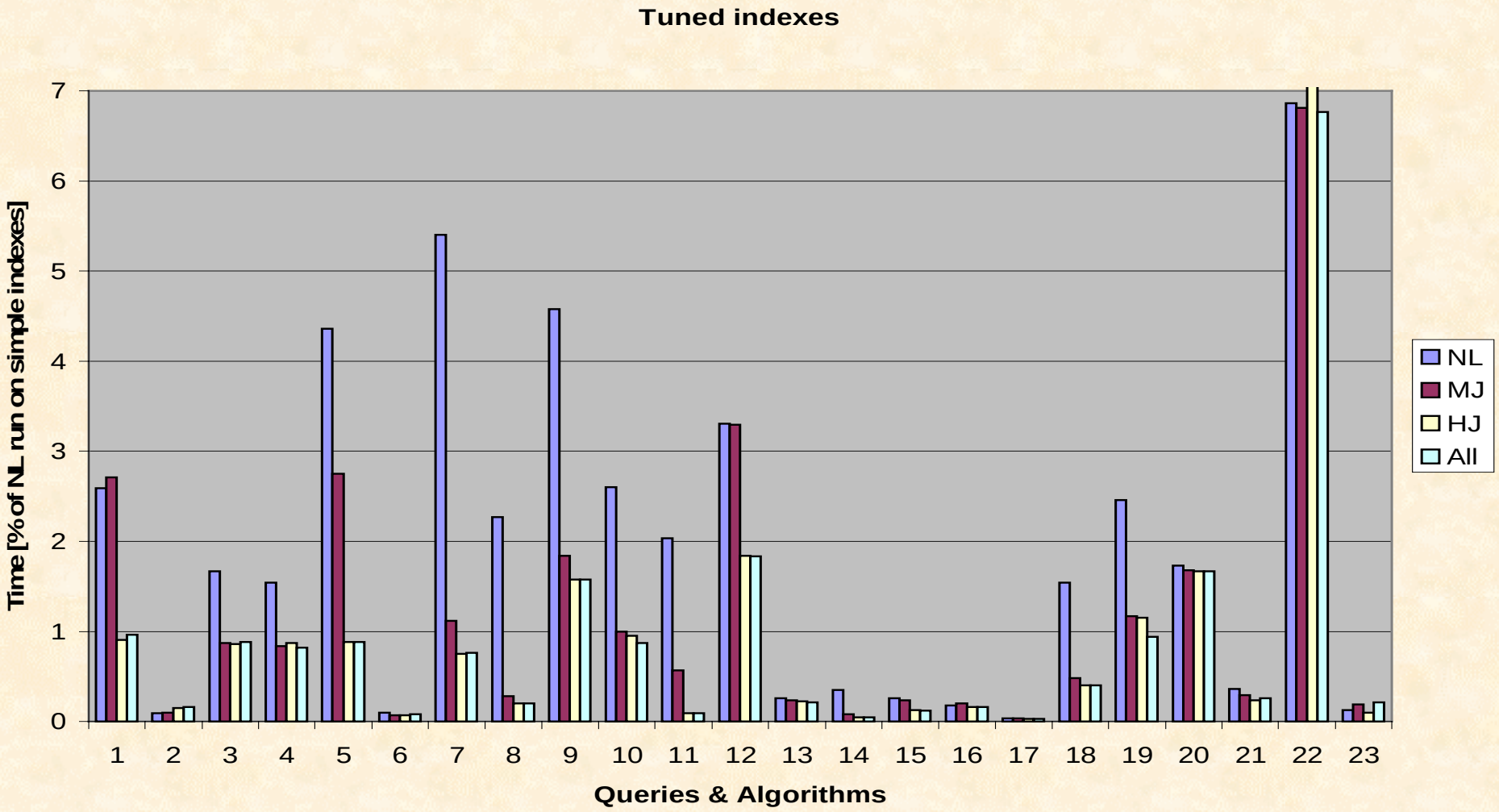
Tuned index set

Tuning wizard retains primary keys indexes

- 7 indexes on *line item*, up to 7 columns

  Total 26 columns indexes
- 4 indexes on *orders*, lots of redundant keys
- 2 indexes on *part supply*

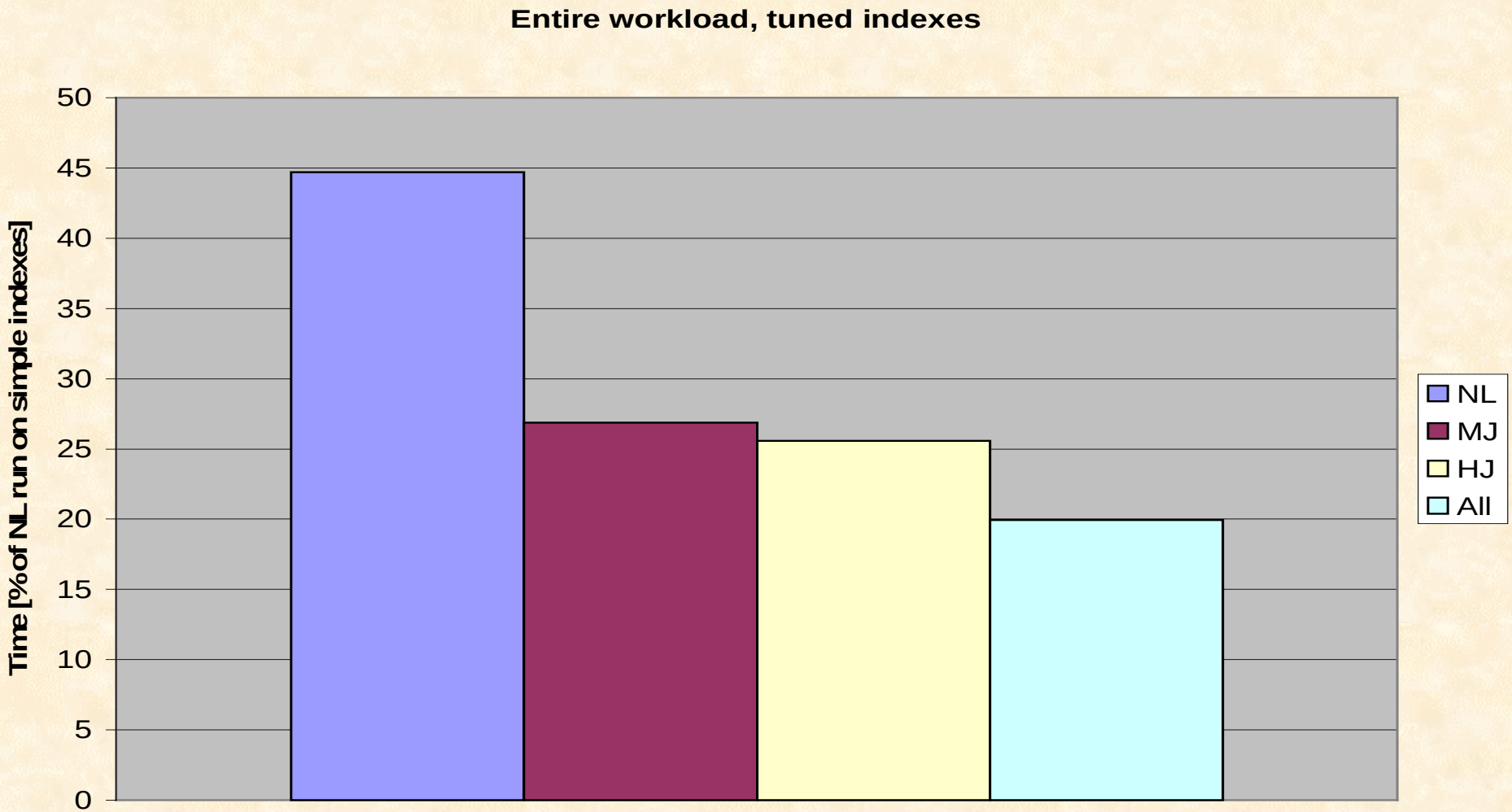
Performance with tuned indexes



Performance with tuned indexes

- Overall performance improvements
  - Except queries 6, 12, 19
  - Tuning wizard minimizes workload time
    - Not the time for each individual query
- More queries in these patterns
  - NL > MJ=HJ=All
  - NL=MJ=HJ=All

Workload performance



Workload performance

- All algorithm combinations are fast
  - Maximal difference 45 vs. 20, or 21 months
- Either MJ or HJ serve well
  - Having both adds 20% performance – 5 months

Conclusions

- Either indexing or merge / hash join
- Are hash join & merge join just an excuse for poor (non-automatic) indexes?
- Next steps

  Tune & analyze for specific algorithms

  Analyze bitmap operations & star joins

  Look for orders of magnitude – multiple years

  - Pre-computed query result – indexed views
  - Fully automatic indexing & tuning
  - Caching data & query results on desktops

More information

- www.microsoft.com/sql
- Msdn.microsoft.com
- Technet.microsoft.com
- Research.microsoft.com