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Evolving the architecture of a DBMS for modern hardware

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Time travel back to circa 1980

Typical machine was VAX 11/780

1 MIPS CPU with 1KB of cache memory

8 MB memory (maximum)

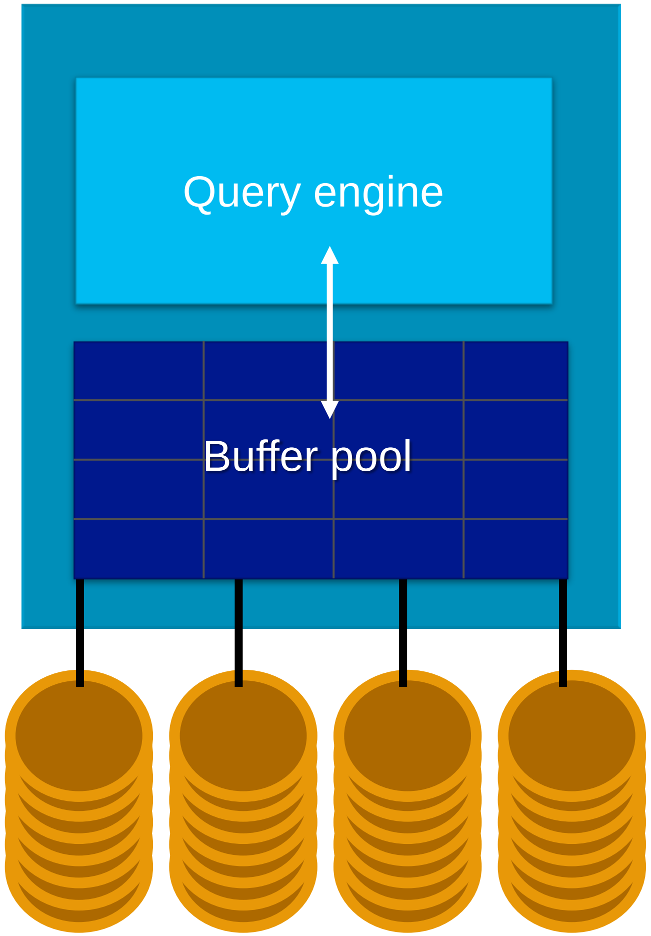
80 MB disk drives, 1 MB/second transfer rate

$250K purchase price!

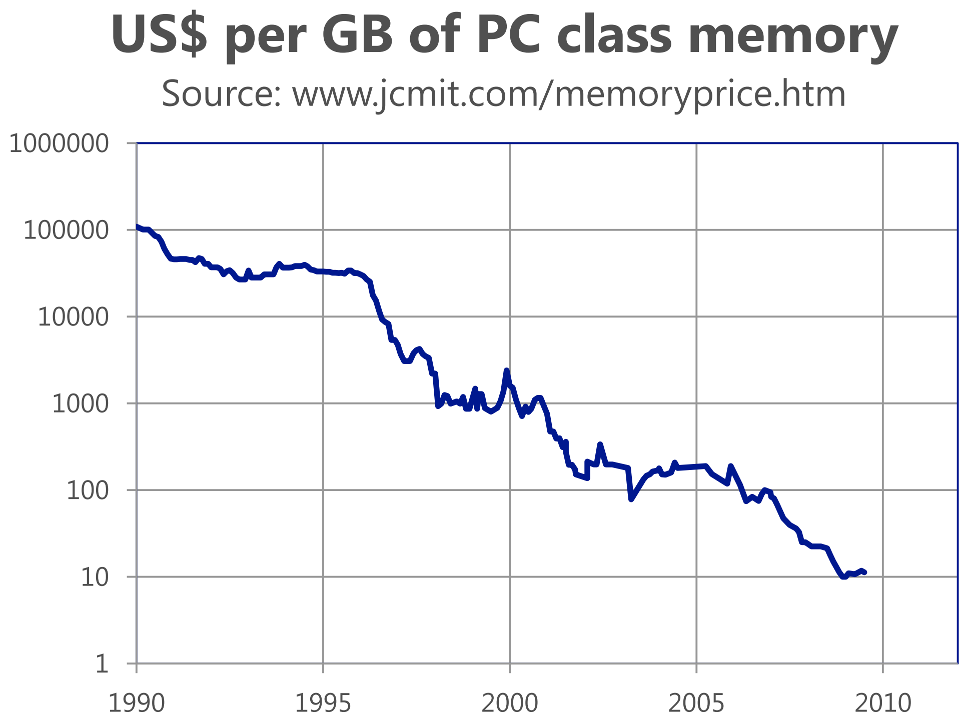
Basic DBMS architecture established

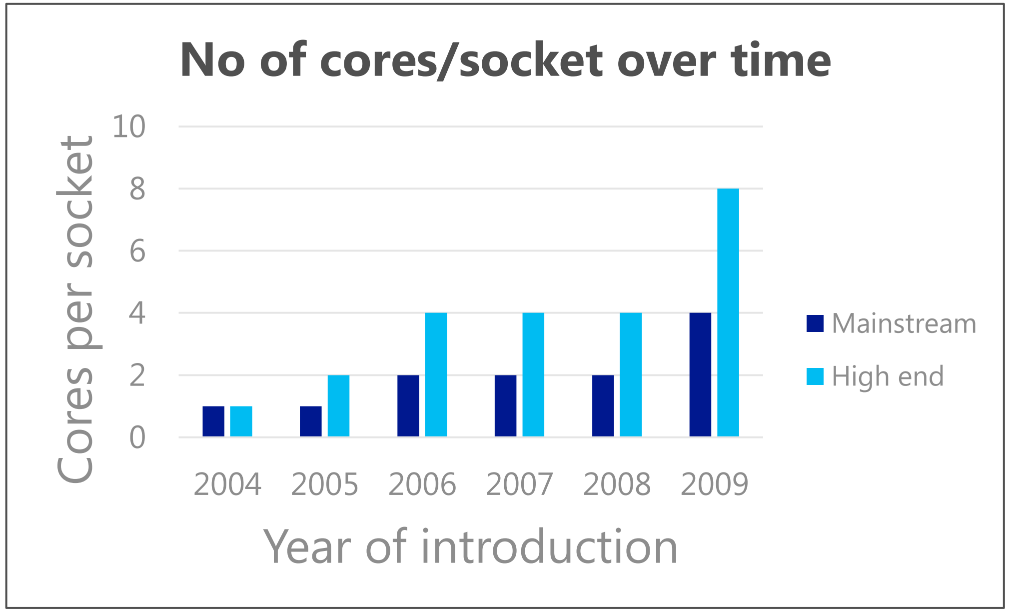
Rows, pages, B-trees, buffer pools, lock manager, ….

Still using the same basic architecture!



But hardware has evolved dramatically





Shrinking memory prices

More and more cores

How to evolve SQL Server's architecture?

Apollo column store

Column store technology integrated into SQL Server

Targeted for data warehousing workloads

First installment in SQL 2012, enhancements in SQL 2014

Hekaton main-memory engine

Main-memory database engine integrated into SQL Server

Targeted for OLTP workloads

Will ship in SQL 2014

Hekaton architectural pillars

Main-Memory Optimized

- Optimized for in-memory data
- Indexes (hash, range) exist only in memory
- No buffer pool
- Stream-based storage (log and checkpoints)

Steadily declining memory price

Designed for High Concurrency

- Multi-version optimistic concurrency control with full ACID support
- Core engine using lock-free algorithms
- No lock manager, latches or spinlocks

Many-core processors

T-SQL Compiled to Machine Code

- T-SQL compiled to machine code via C code generator and VC
- Invoking a procedure is just a DLL entry-point
- Aggressive optimizations @ compile-time

Stalling CPU clock rate

Integrated into SQL Server

- Integrated queries & transactions
- Integrated HA and backup/restore
- Familiar manageability and development experience

Total Cost of Ownership

Hardware trends

Business Driver

Non-blocking execution

Goal: highly concurrent execution, full CPU utilization

No thread switching, waiting, or spinning during execution of a transaction

Lead to three design choices

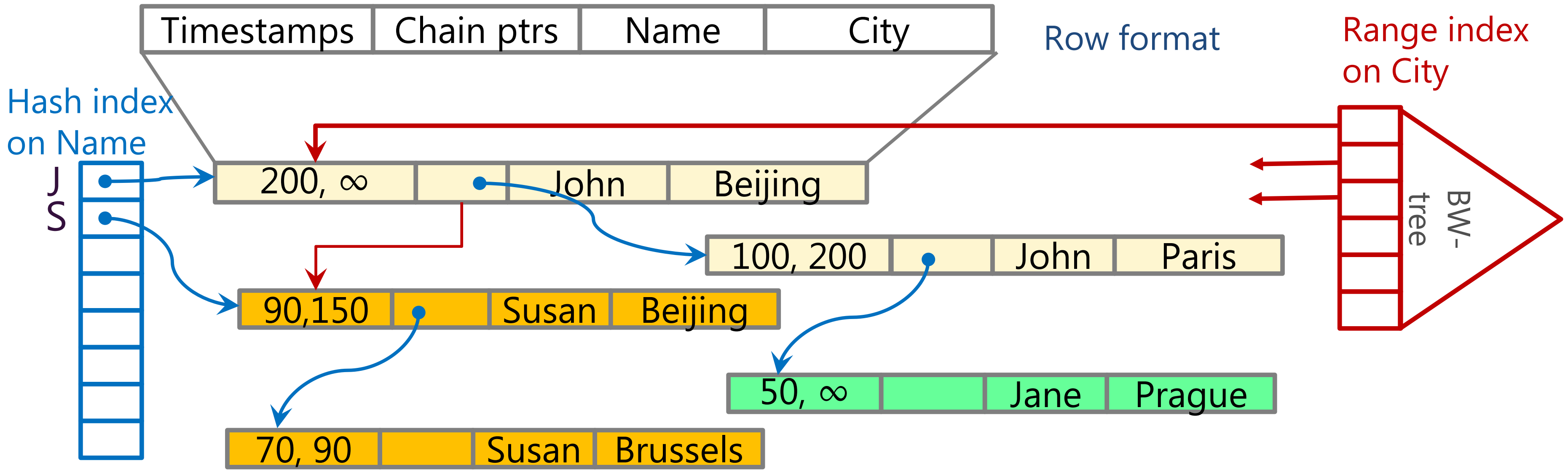
Use only latch-free data structure

Multi-version optimistic concurrency control

Allow certain speculative reads (with commit dependencies)

Result: great majority of transactions run up to final log write without ever blocking or waiting

In-memory data organization



Rows are multi-versioned

Each row version has a valid time range indicated by two timestamps

A version is visible if transaction read time falls within version's valid time

Why MV optimistic concurrency control?

Readers don't block writers and vice versa

No lock manager, no deadlocks

Highly parallel

A single synchronization point: get transaction end timestamp

Lower isolation level => less work

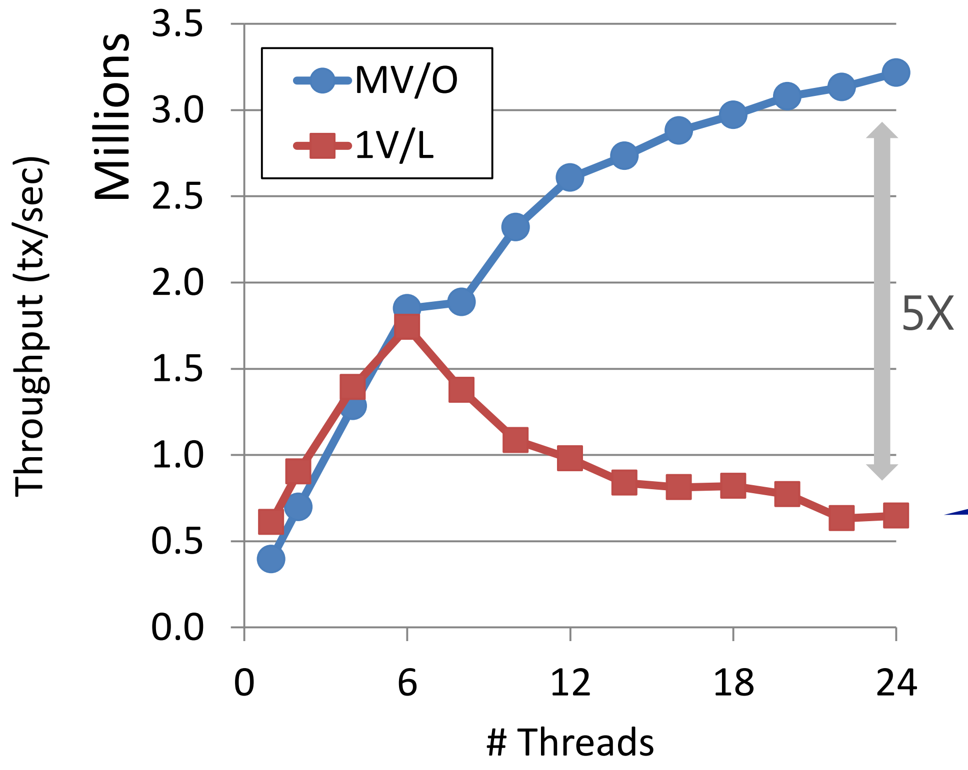
Snapshot Isolation: no validation, minimal overhead

Performs well even under high contention

Handles long read-only transaction well

Scalability under extreme contention

(1000 row table, core Hekaton engine only)



Work load

80% read-only txns (10 reads/txn)
20% update txns (10 reads+ 2 writes/txn)

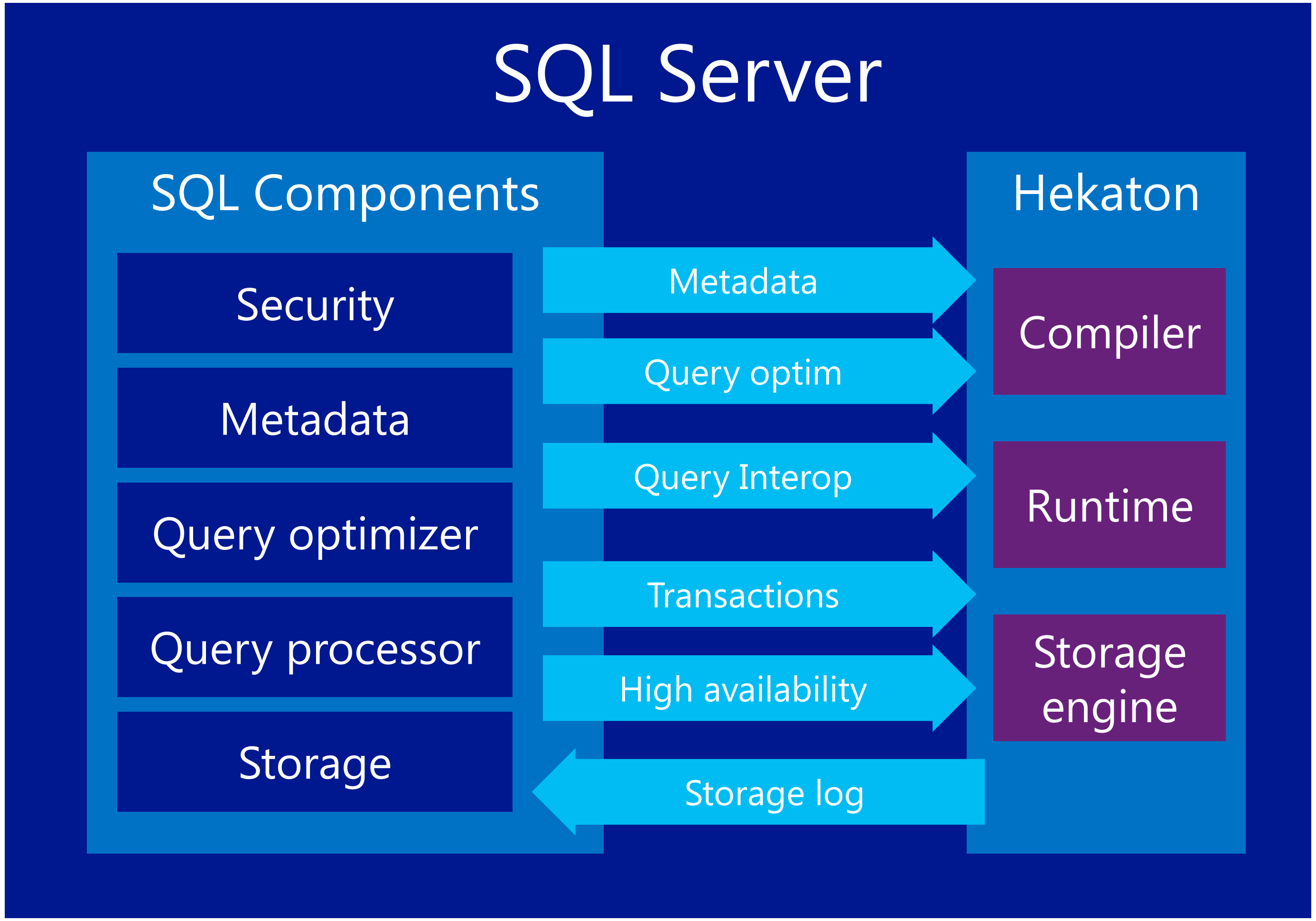
Serializable isolation level

Processor: 2 sockets, 12 cores

Standard locking but optimized for main memory

1V/L thruput limited by lock thrashing

Hekaton components and SQL integration



Query and transaction interop

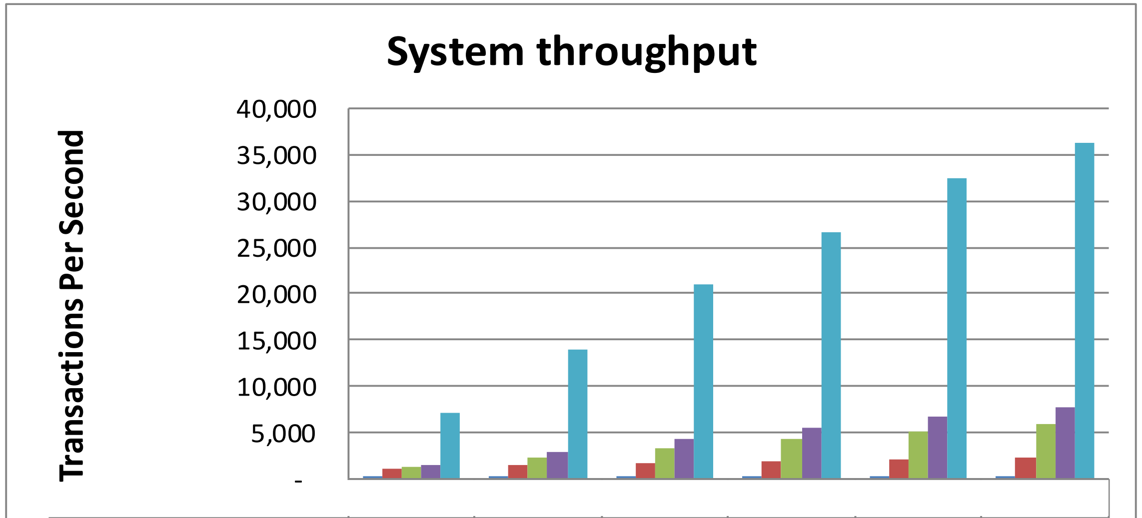
Regular SQL queries can access Hekaton tables like any other table

Slower than through a compiled stored procedure

A query can mix Hekaton tables and SQL tables

A transaction can update both types of tables

Throughput under high contention



Number of cores	2	4	6	8	10	12
SQL with contention	984	1,363	1,645	1,876	2,118	2,312
SQL without contention	1,153	2,157	3,161	4,211	5,093	5,834
Interop	1,518	2,936	4,273	5,459	6,701	7,709
Native	7,078	13,892	20,919	26,721	32,507	36,375

Throughput improvements

Converting table but using interop:
- 3.3X higher throughput

Converting table and stored procedure:
- 15.7X higher throughput

Workload: read/insert into a table with a unique index
Insert txn (50%): append a batch of 100 rows
Read txn (50%): read last inserted batch of rows

Initial customer experiences

Bwin – large online betting company

Application: HTTPS session state
Current max throughput: 15,000 requests/sec
Throughput with Hekaton: 250,000 requests/sec

EdgeNet – provides up-to-date inventory information

Application: rapid ingestion of inventory data from retailers
Current max ingestion rate: 7,450 rows/sec
Hekaton ingestion rate: 126,665 rows/sec
Enables moving to continuous, online ingestion from once-a-day batch ingestion

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