Not Your Father’s
Transaction Processing

Michael Stonebraker, CTO
VoltDB, Inc.
How Does This Fit into “Big Data”?

- Big volume
  - I have too much data

- Big velocity
  - Data is coming at me too fast

- Big variety
  - I have too many data sources
High Velocity Applications

- Traditional transaction processing
- “New” transaction processing
- High velocity ingest
Traditional Transaction Processing

- Remember how we used to buy airplane tickets in the 1980s
  - By telephone
  - Through an intermediary (professional terminal operator)
- Commerce at the speed of the intermediary
- In 1985, 1,000 transactions per second was considered an incredible stretch goal!!!!
  - HPTS (1985)
Traditional Transaction Processing

- Workload was a mix of updates and queries
- To an ACID data base system
  - Make sure you never lose my data
  - Make sure my data is correct
- At human speed
- Bread and butter of RDBMSs (OldSQL)
How has TP Changed in 25 Years?

The internet

+ Client is no longer a professional terminal operator
+ Instead Aunt Martha is using the web herself

+ Sends TP volume through the roof
+ Serious need for scalability and performance
How has TP Changed in 25 Years?

PDAs
  + Your cell phone is a transaction originator
  + Sends TP volume through the roof
  + Serious need for scalability and performance

Need in some traditional markets for much higher performance!
And TP is Now a Much Broader Problem (New TP)

The internet enables a green field of new TP applications

+ Massively multiplayer games (state of the game, leaderboards, selling virtual goods are all TP problems)
+ Social networking (social graph is a TP problem)
+ Real time ad placement
+ Real time couponing

+ And TP volumes are ginormous!!
+ Serious need for speed and scalability!
And TP is Now a Much Broader Problem

Sensor Tagging generates new TP applications

+ Marathon runners (fraud detection, leaderboards)
+ Taxicab (scheduling, fare collection)
+ Dynamic traffic routing
+ Car insurance “by the drink”
+ Mobile social networking

+ And TP volumes are ginormous!!
+ Serious need for speed and scalability!
And TP is Now a Much Broader Problem

Electronic commerce is here

+ Wall Street electronic trading
+ Real-time fraud detection
+ Micro transactions (through your PDA)

+ And TP volumes are ginormous!!
+ Serious need for speed and scalability!
Add in High Velocity Ingest

+ Real time click stream analysis
+ Most anything upstream from Hadoop
+ Or your data warehouse
+ Real time risk assessment on Wall Street

+ And TP volumes are ginormous!!
+ Serious need for speed and scalability!
In all cases.....

- Workload is a mix of updates and queries
- Coming at you like a firehose
- Still an ACID problem
  - Don’t lose my data
  - Make sure it is correct
- Tends to break traditional solutions
  - Scalability problems (volume)
  - Response time problems (latency)
Put Differently

High velocity and you

You need to **ingest** a firehose in real time

You need to **process, validate, enrich** and **respond** in real-time (i.e. update)

You often need **real-time** analytics (i.e. query)
Reality Check -- Size

- TP database size grows at the rate transactions increase
- 1 Tbyte is a really big TP data base
- 1 Tbyte of main memory buyable for around $50K
  + (say) 64 Gbytes per server in 16 servers
- I.e. Moore’s law has eclipsed TP data base size
- If your data doesn’t fit in main memory now, then wait a couple of years and it will...
Reality Check -- Performance

- TPC-C CPU cycles
- On the Shore DBMS prototype
- Elephants should be similar
To Go a Lot Faster You Have to……

- **Focus on overhead**
  - Better B-trees affects only 4% of the path length

- **Get rid of ALL major sources of overhead**
  - Main memory deployment – gets rid of buffer pool
    - Leaving other 75% of overhead intact
    - i.e. win is 25%
Solution Choices

- **OldSQL**
  - + Legacy RDBMS vendors

- **NoSQL**
  - + Give up SQL and ACID for performance

- **NewSQL**
  - + Preserve SQL and ACID
  - + Get performance from a new architecture
OldSQL

Traditional SQL vendors (the “elephants”)

+ Code lines dating from the 1980’s
+ “bloatware”
+ Mediocre performance on New TP
The Elephants

- Are slow because they spend all of their time on overhead!!!
  - Not on useful work
- Would have to re-architect their legacy code to do better
Long Term Elephant Outlook

- Up against “The Innovators Dilemma”
  - Steam shovel example
  - Disk drive example
  - See the book by Clayton Christenson for more details

- Long term drift into the sunset
  - The most likely scenario
  - Unless they can solve the dilemma
NoSQL

- Give up SQL
- Give up ACID
Give Up SQL?

- Compiler translates SQL at compile time into a sequence of low level operations
- Similar to what the NoSQL products make you program in your application
- 30 years of RDBMS experience
  - Hard to beat the compiler
  - High level languages are good (data independence, less code, ...)
  - Stored procedures are good!
    - One round trip from app to DBMS rather than one one round trip per record
    - Move the code to the data, not the other way around
Give Up ACID

- If you need data consistency, giving up ACID is a decision to tear your hair out by doing database “heavy lifting” in user code.
- Can you guarantee you won’t need ACID tomorrow?

ACID = goodness, in spite of what these guys say.
Who Needs ACID?

- Funds transfer
  - Or anybody moving something from X to Y

- Anybody with integrity constraints
  - Back out if fails
  - Anybody for whom “usually ships in 24 hours” is not an acceptable outcome

- Anybody with a multi-record state
  - E.g. move and shoot
Who needs ACID in replication

- Anybody with non-commutative updates
  - For example, + and * don’t commute

- Anybody with integrity constraints
  - Can’t sell the last item twice....

- Eventual consistency means “creates garbage”
NoSQL Summary

- Appropriate for non-transactional systems
- Appropriate for single record transactions that are commutative
- Not a good fit for New TP
- Use the right tool for the job

Interesting ...

Two recently-proposed NoSQL language standards – CQL and UnQL – are amazingly similar to (you guessed it!) SQL
NewSQL

- SQL
- ACID
- Performance and scalability through modern innovative software architecture
NewSQL

- Needs something other than traditional record level locking (1st big source of overhead)
  + timestamp order
  + MVCC
  + Your good idea goes here
NewSQL

- Needs a solution to buffer pool overhead (2\textsuperscript{nd} big source of overhead)
  + Main memory (at least for data that is not cold)
  + Some other way to reduce buffer pool cost
NewSQL

- Needs a solution to latching for shared data structures (3rd big source of overhead)
  - Some innovative use of B-trees
  - Single-threading
  - Your good idea goes here
NewSQL

- Needs a solution to write-ahead logging (4th big source of overhead)
  
  + Obvious answer is built-in replication and failover
  + New TP views this as a requirement anyway

- Some details
  
  + On-line failover?
  + On-line failback?
  + LAN network partitioning?
  + WAN network partitioning?
A NewSQL Example – VoltDB

- Main-memory storage
- Single threaded, run Xacts to completion
  - + No locking
  - + No latching
- Built-in HA and durability
  - + No log (in the traditional sense)
Yabut: What About Multicore?

- For a K-core CPU, divide memory into K (non-overlapping) buckets
- i.e. convert multi-core to K single cores
Where all the time goes... revisited

Before

- Latching 24%
- Recovery 24%
- Locking 24%
- Buffer Pool 24%
- Useful Work 4%

VoltDB

- Useful Work 95%
- Locking 5%
Current VoltDB Status

- Runs a subset of SQL (which is getting larger)
- On VoltDB clusters (in memory on commodity gear)
- With LAN and WAN replication
- 70X a popular OldSQL DBMS on TPC-C
- 5-7X Cassandra on VoltDB K-V layer
- Scales to 384 cores (biggest iron we could get our hands on)
- Clearly note this is an open source system!
Summary

Old TP

Old SQL for New OLTP
- Too slow
- Does not scale

NoSQL for New OLTP
- Lacks consistency guarantees
- Low-level interface

New SQL for New OLTP
- Fast, scalable and consistent
- Supports SQL

New TP
Thank You