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The Power to Question Everything™

A Data Warehouse Approach to Analyzing All the Data All the Time

Bill Blake

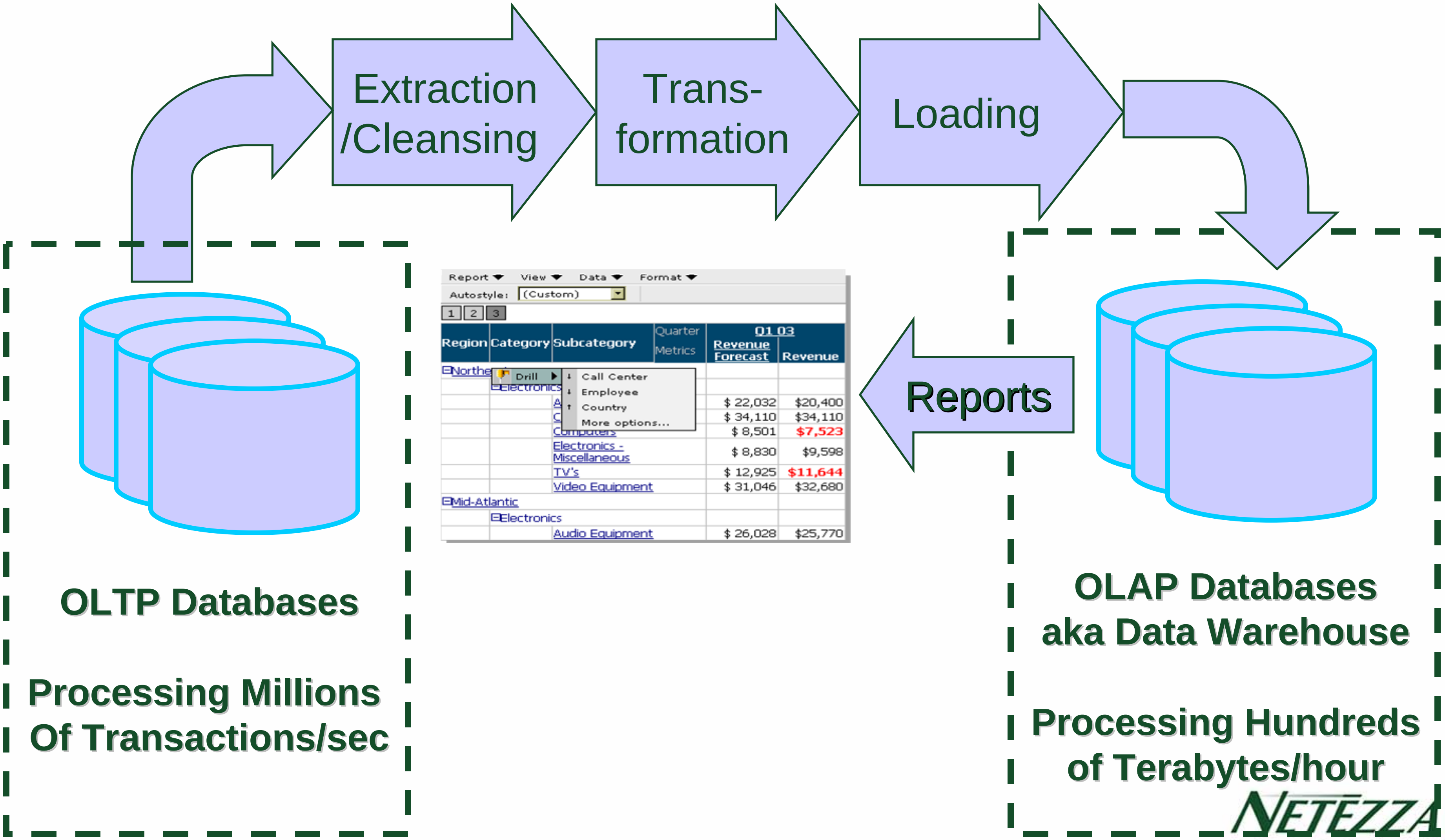
Netezza Corporation

April 2006

Sometimes A Different Approach Is Useful

- The challenge of scaling up systems where many applications need to access large data in global parallel file systems is well documented
- At the Multi Terabyte scale, It is hard to move the data from where it is stored to where it is processed …
- But if moving data to processing is so difficult, why not try an approach where the application owns the data and processing is moved to where the data is stored?
- The application in this case is the relational database, a very useful tool for data intensive computing

Operational vs. Analytical RDBMS



Extraction /Cleansing

Trans-formation

Loading

Reports

Region	Category	Subcategory	Quarter Metrics	Q1 03 Revenue Forecast	Revenue
Northe					
	Electronics				
		A		$ 22,032	$20,400
		C		$ 34,110	$34,110
		Computers		$ 8,501	$7,523
		Electronics - Miscellaneous		$ 8,830	$9,598
		TV's		$ 12,925	$11,644
		Video Equipment		$ 31,046	$32,680
Mid-Atlantic					
	Electronics				
		Audio Equipment		$ 26,028	$25,770

OLTP Databases

Processing Millions Of Transactions/sec

OLAP Databases aka Data Warehouse

Processing Hundreds of Terabytes/hour

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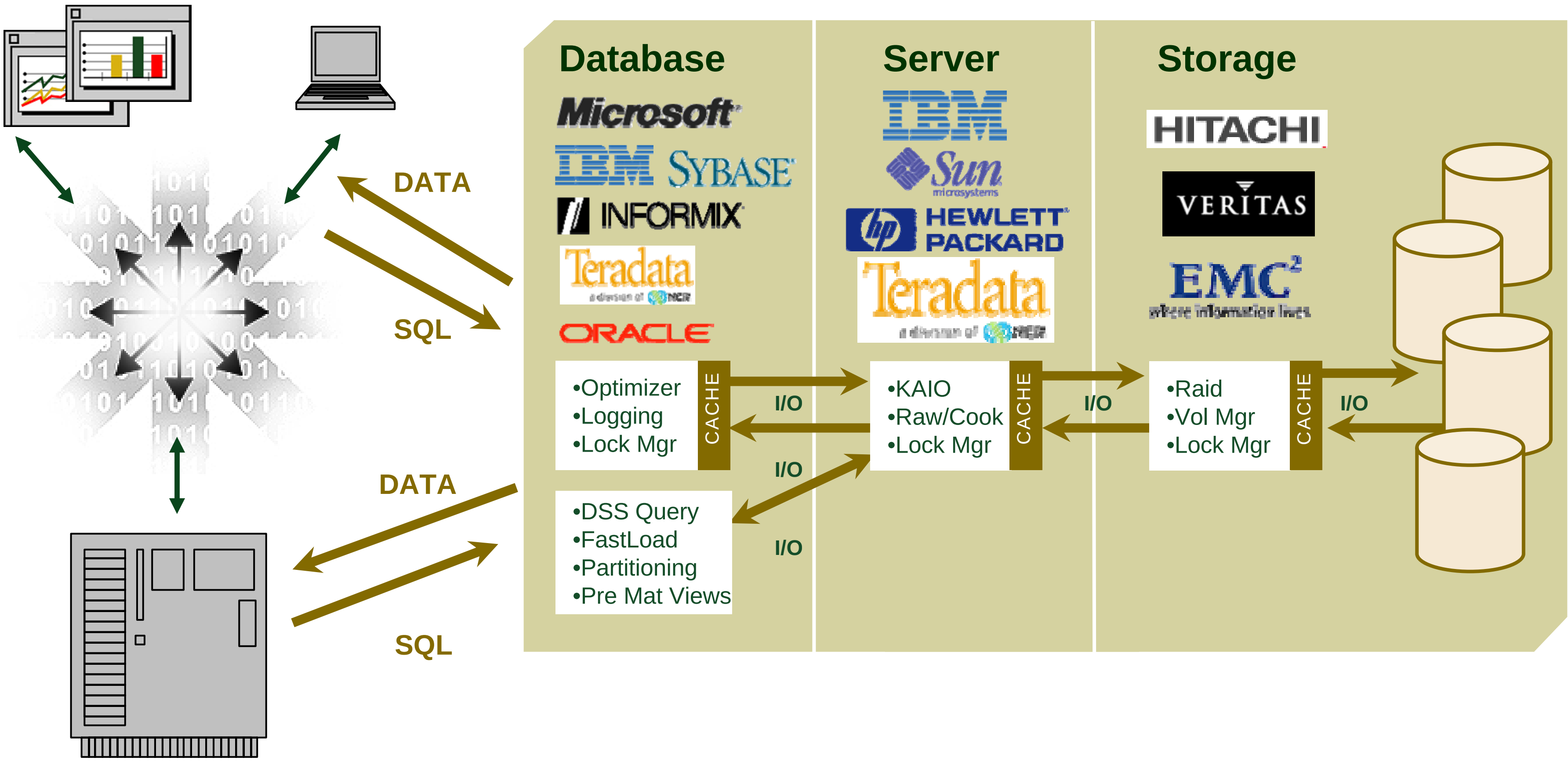
The Legacy Focus: Transaction Processing



Applications

Client

Local Applications

DATA

SQL

DATA

SQL

Database

Microsoft

IBM SYBASE

INFORMIX

Teradata a division of NCR

ORACLE

- Optimizer
- Logging
- Lock Mgr

CACHE

- DSS Query
- FastLoad
- Partitioning
- Pre Mat Views

I/O

I/O

I/O

Server

IBM

Sun microsystems

HEWLETT PACKARD

Teradata a division of NCR

- KAIO
- Raw/Cook
- Lock Mgr

CACHE

I/O

Storage

HITACHI

VERITAS

EMC² where information lives

- Raid
- Vol Mgr
- Lock Mgr

CACHE

I/O

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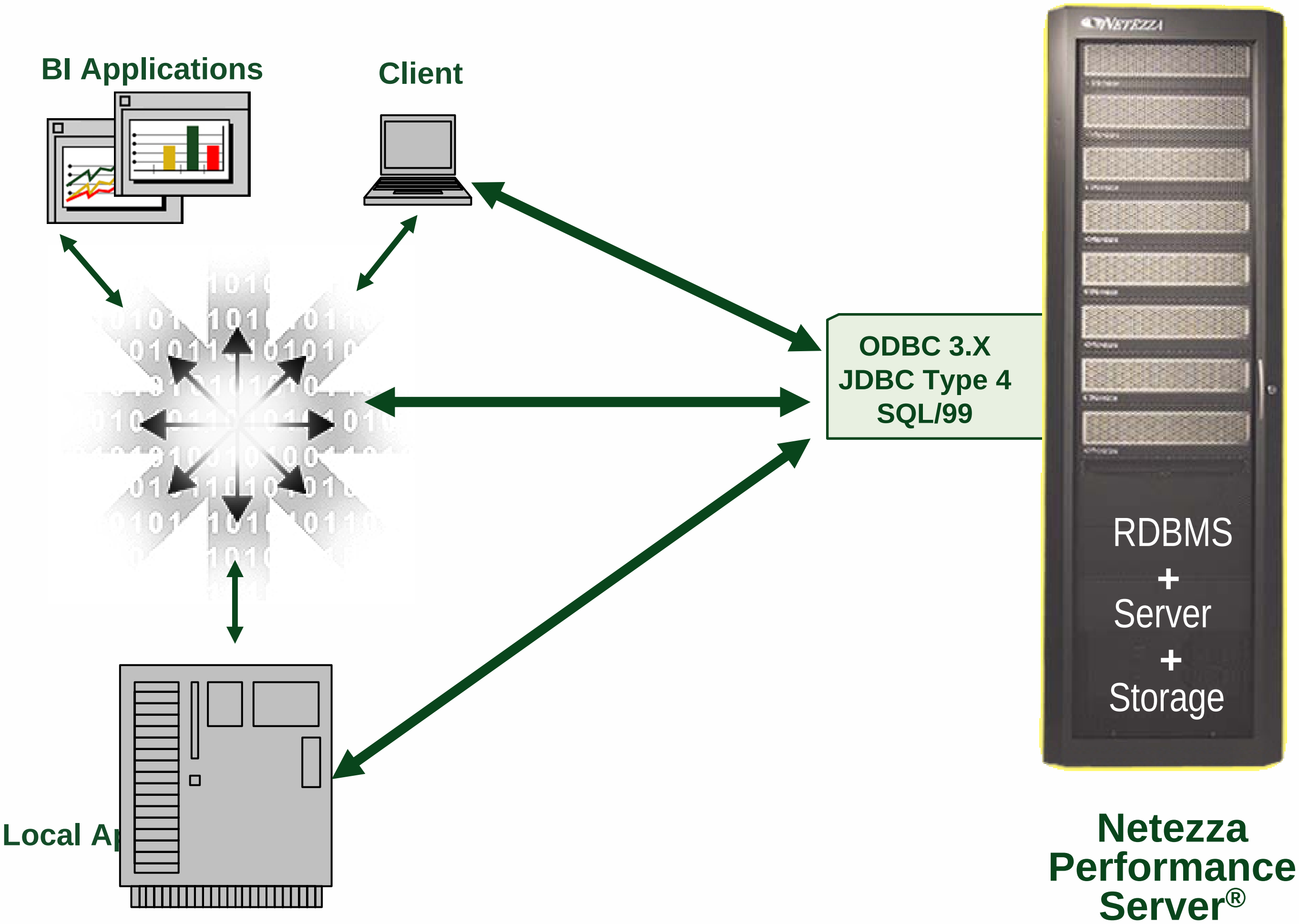
Netezza's Data Warehouse Appliance



BI Applications

Client

Local Ap

ODBC 3.X
JDBC Type 4
SQL/99

RDBMS
+
Server
+
Storage

Netezza Performance Server®

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The Challenges Driving Us At Netezza

Forces driving disruptive change

- Sub-transactional data in a fully-connected world
- Ever-increasing need for speed
- Increasing regulatory requirements
- Market mandate for operational simplicity
- Need for actionable intelligence from unlimited data at real-time speeds

This Need Cannot be Met by Today's Systems

✓ ***Linux cluster scaling limited by network performance & system management complexity***

✓ ***Scaling with large NUMA SMP servers limited by I/O, network performance & operating system complexity***

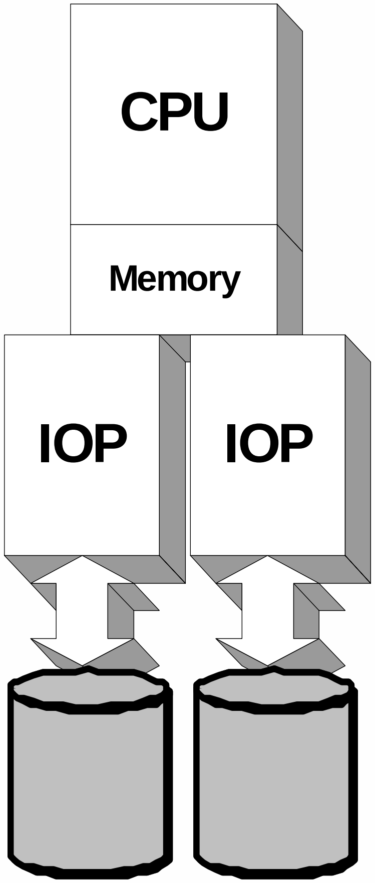
Not All Computing Tasks Fit into Memory – The Analytic DB Challenge

There are benefits to scaling up analytic DBs:

- Transactional and referential integrity
- High level query language (with parallel run time optimization performed by application’s query planner)
- Operation on sets of records in tables (vs sequential access of records in files)
- Database standards have matured and are now consistent across the industry
- Data volumes have grown from gigabytes to hundreds of terabytes
- Disk storage is now less than $1 per Gigabyte!

For Perspective (1980's) ...

- The relational database was invented on a system that merged server, storage and database
- It was called a mainframe!



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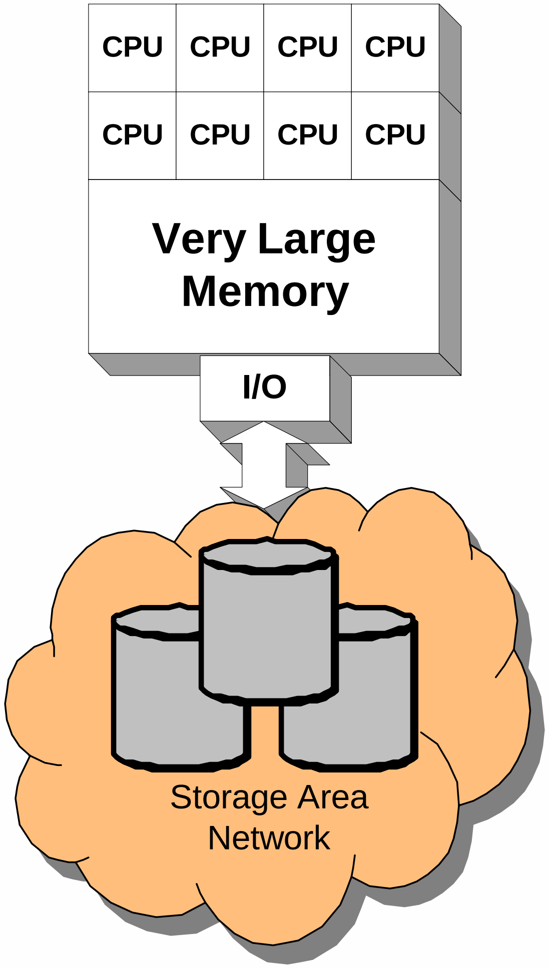
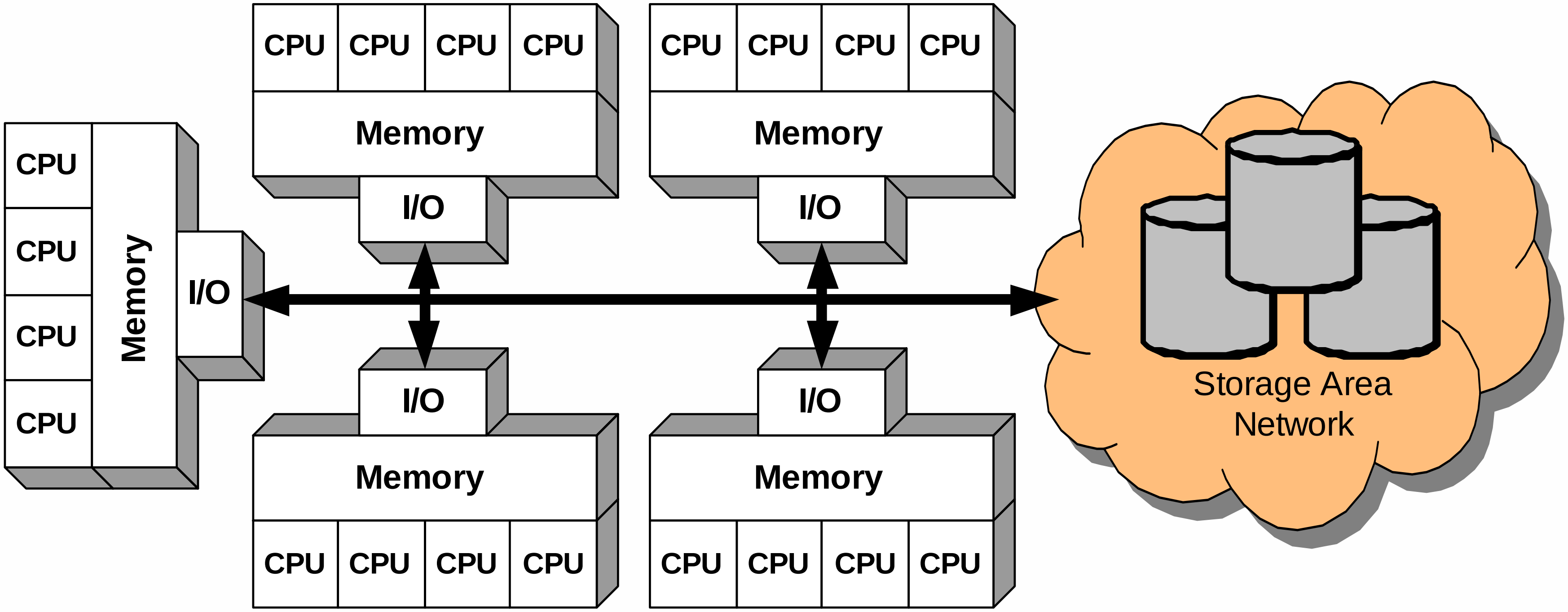
By The 1990’s, Rules Changed

- Mainframes attacked by killer micros!
- Memory grew large
- I/O became weak
- System costs dropped
- Storage moved off to the network



Capacity Was Added By Clustering



SAN limits Moving Data to the Processors

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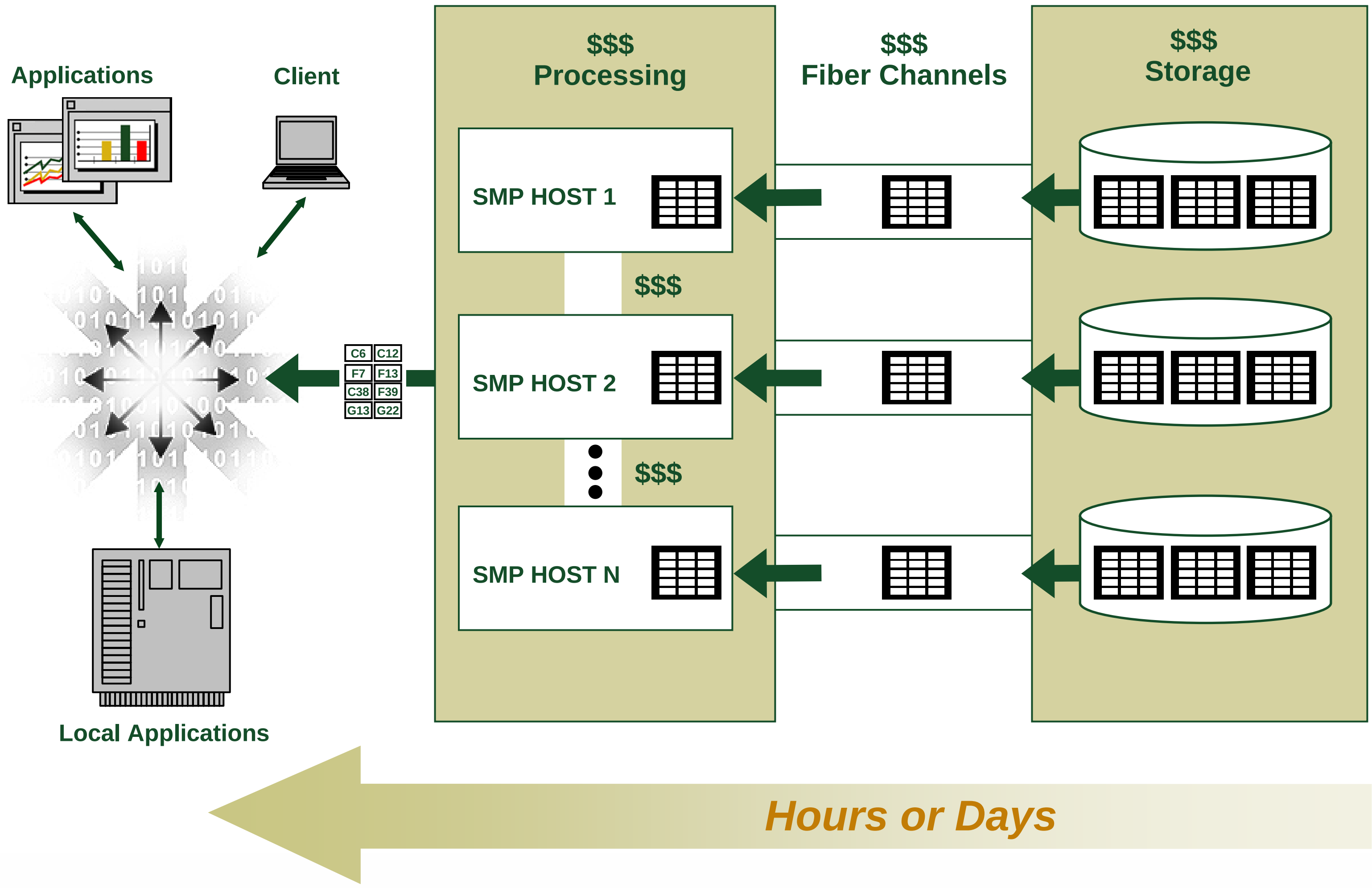
Data Flow – The Traditional Way



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Moving Processing to the Data

- **Active Disk architectures**
  - Integrated processing power and memory into disk units
  - Scaled processing power as the dataset grew
- **Decision support algorithms offloaded to Active Disks to support key decision support tasks**
  - Active Disk architectures use stream-based model ideal for the software architecture of relational databases

In Netezza's NPS® System: "Snippet Processing Units" take streams as inputs and generate streams as outputs

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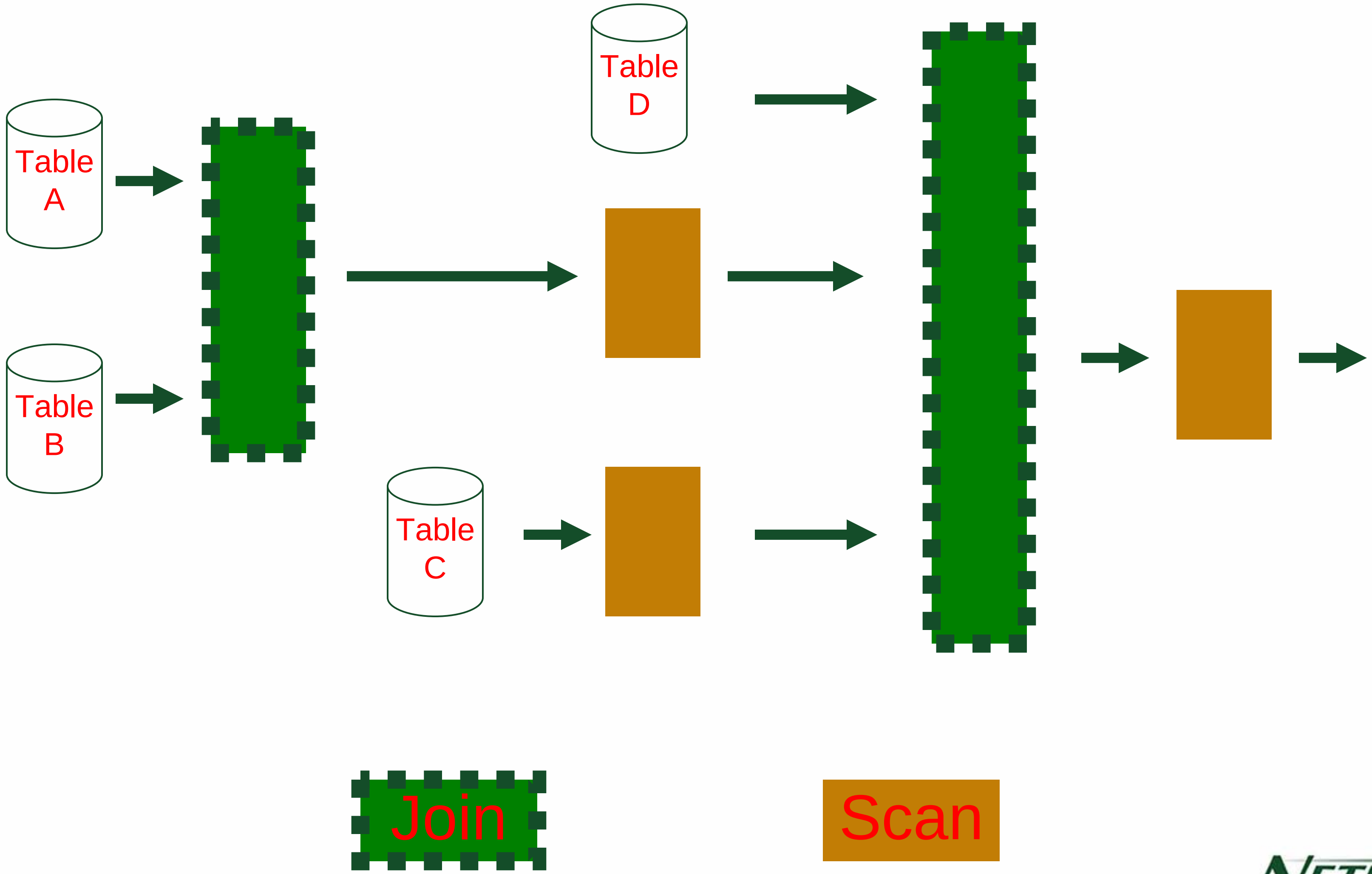
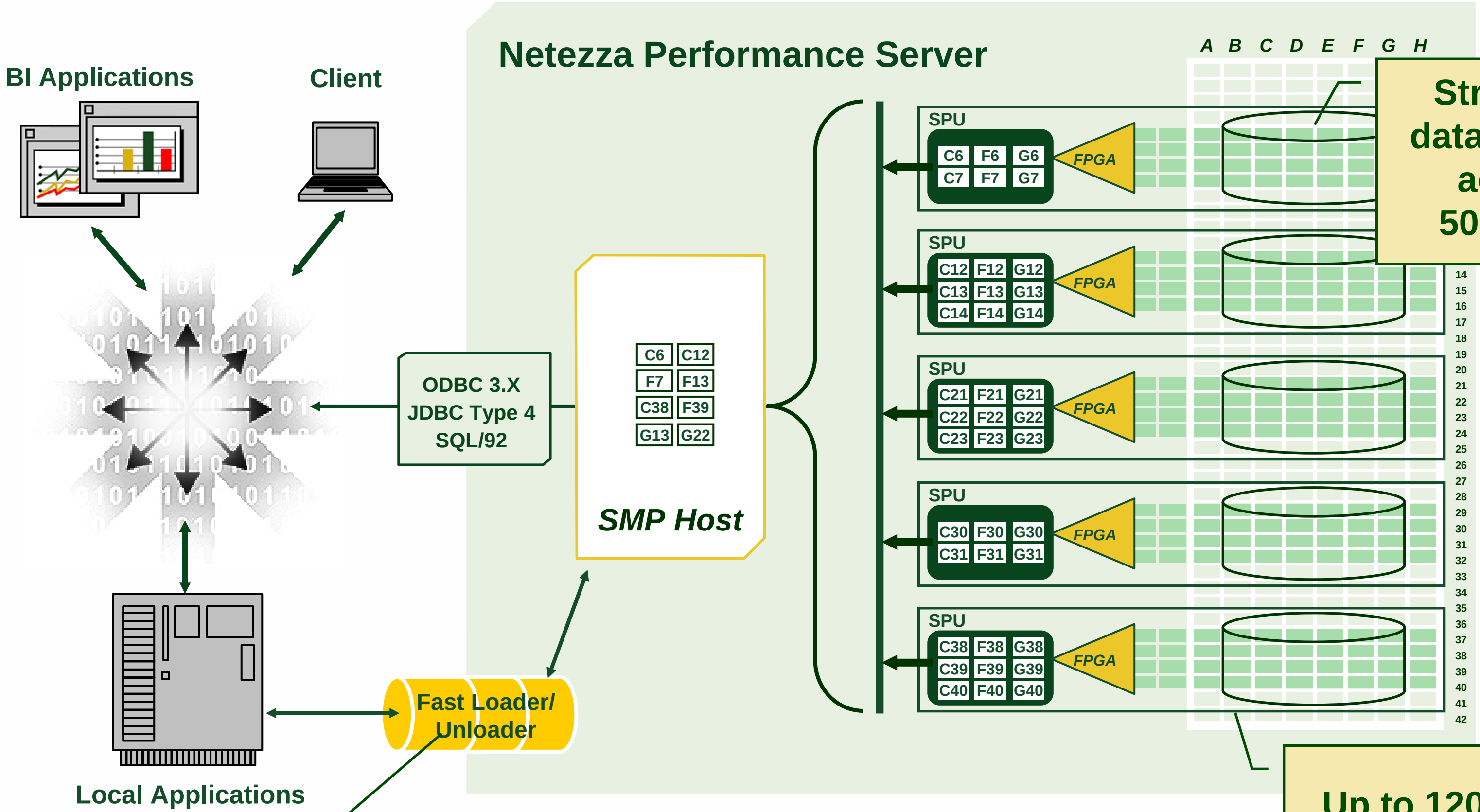
SQL Query Flow Diagram



Streaming Data Flow



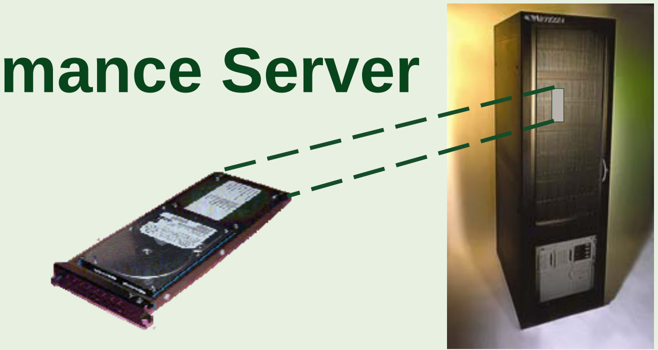
Streaming data, joins, & aggs @ 50MB/sec

Up to 120 TB/hour Cross Section BW per 8650 system

Bulk data movement: 250 GB/hour - uncompressed
(1 TB/hour Target)

Active Disks as Intelligent Storage Nodes

Netezza Performance Server



<u>Netezza added</u>:

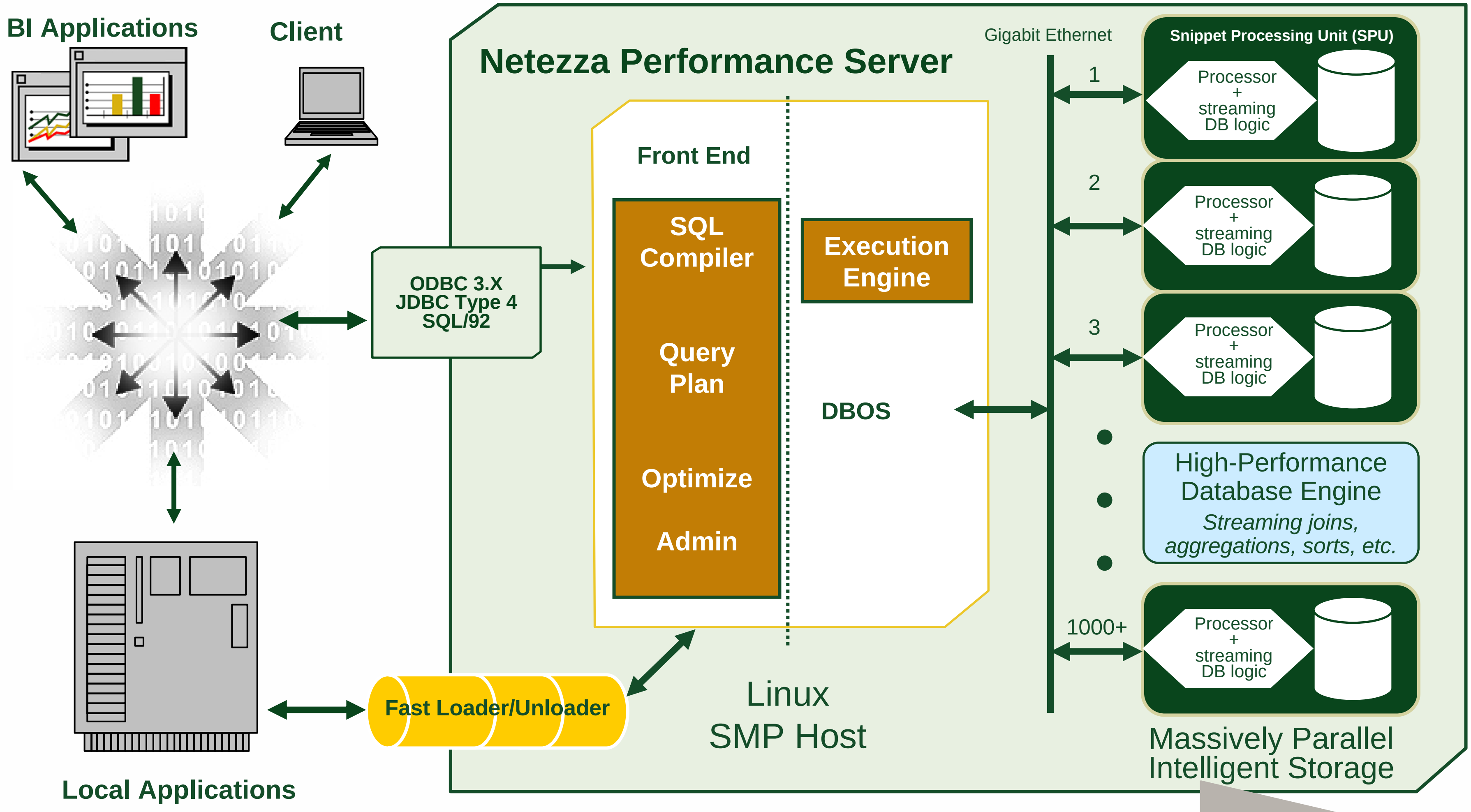
- Highly optimized query planning
- Code generation
- Stream processing

<u>Result</u>: 10X to 100X performance speedup over existing systems

Snippet Processing Unit (SPU)

A compute node for directly processing SQL queries on tables

Asymmetric Massively Parallel Processing™



BI Applications

Client

Local Applications

ODBC 3.X
JDBC Type 4
SQL/92

Fast Loader/Unloader

Netezza Performance Server

Front End

SQL Compiler

Query Plan

Optimize

Admin

Execution Engine

DBOS

Linux
SMP Host

Gigabit Ethernet

1

2

3

1000+

Snippet Processing Unit (SPU)

Processor + streaming DB logic

Processor + streaming DB logic

Processor + streaming DB logic

Processor + streaming DB logic

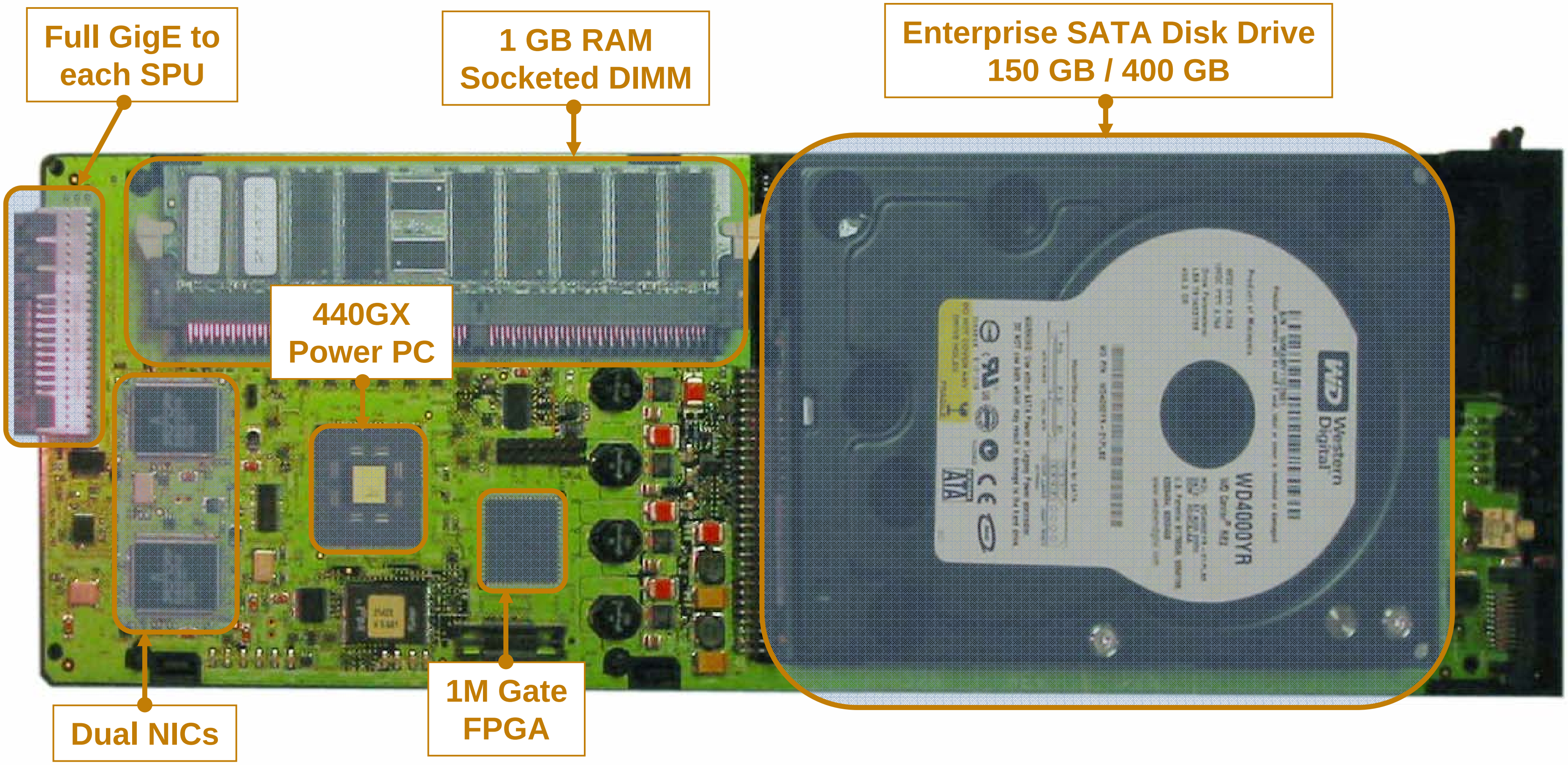
High-Performance Database Engine

Streaming joins, aggregations, sorts, etc.

Massively Parallel Intelligent Storage

Move processing to the data (maximum I/O to a single table)

Packaging For High Density And Low Power



Full GigE to each SPU

1 GB RAM Socketed DIMM

Enterprise SATA Disk Drive 150 GB / 400 GB

440GX Power PC

Dual NICs

1M Gate FPGA

AFTER

Higher Performance – Greater Scalability – Higher Reliability

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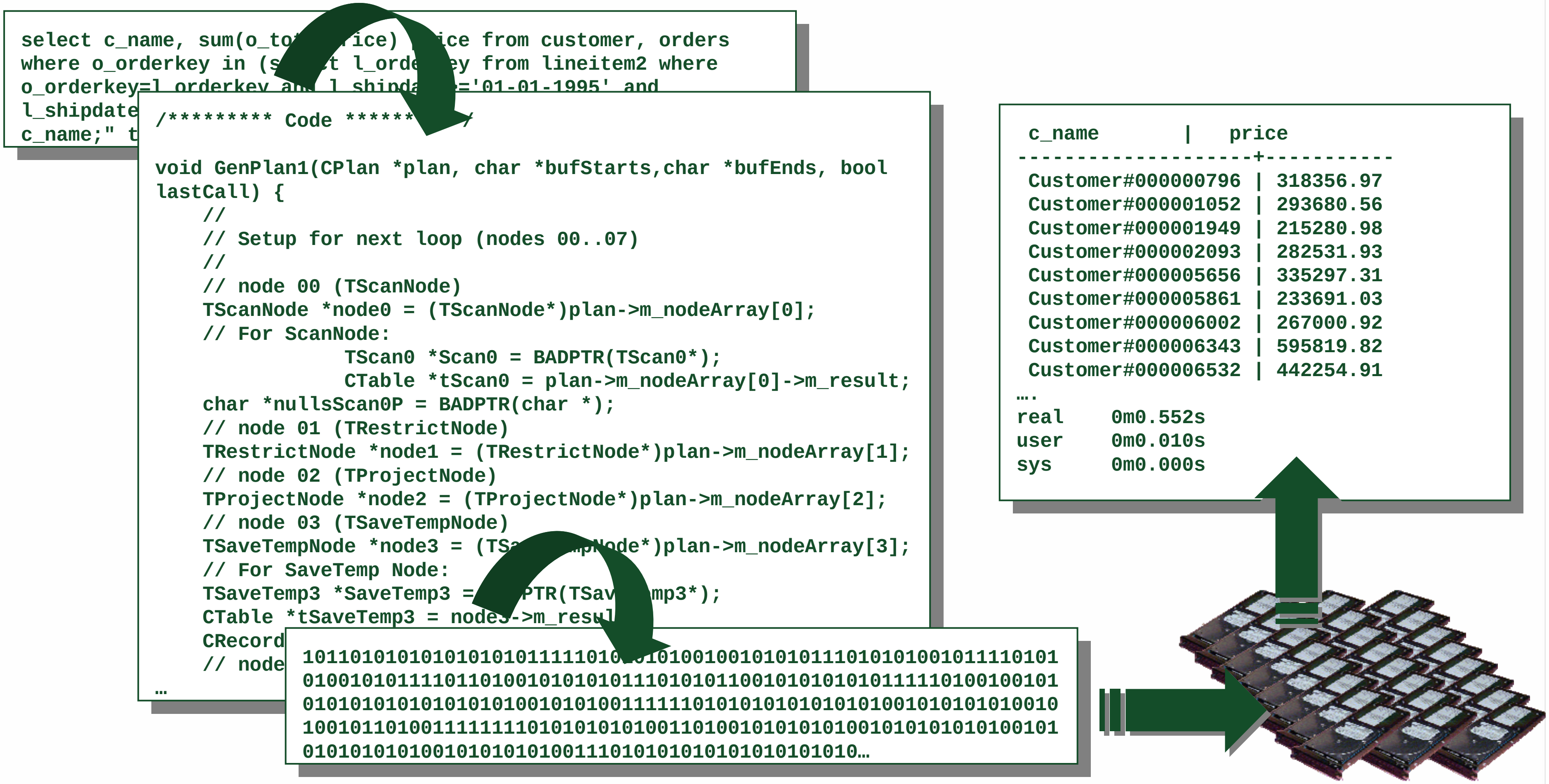
Binary Compiled Queries
Executed on a Massively Parallel Grid



```
select c_name, sum(o_tot  rice)   ice from customer, orders
where o_orderkey in (s    t l_orde  ey from lineitem2 where
o_orderkey=l_orderkey and l_shipda  ='01-01-1995' and
l_shipdate
c_name;" t
```

```
/********* Code ******   /

void GenPlan1(CPlan *plan, char *bufStarts,char *bufEnds, bool
lastCall) {
    //
    // Setup for next loop (nodes 00..07)
    //
    // node 00 (TScanNode)
    TScanNode *node0 = (TScanNode*)plan->m_nodeArray[0];
    // For ScanNode:
                TScan0 *Scan0 = BADPTR(TScan0*);
                CTable *tScan0 = plan->m_nodeArray[0]->m_result;
    char *nullsScan0P = BADPTR(char *);
    // node 01 (TRestrictNode)
    TRestrictNode *node1 = (TRestrictNode*)plan->m_nodeArray[1];
    // node 02 (TProjectNode)
    TProjectNode *node2 = (TProjectNode*)plan->m_nodeArray[2];
    // node 03 (TSaveTempNode)
    TSaveTempNode *node3 = (TSa     mpNode*)plan->m_nodeArray[3];
    // For SaveTemp Node:
    TSaveTemp3 *SaveTemp3 =    PTR(TSav   mp3*);
    CTable *tSaveTemp3 = node3->m_resul
    CRecord
    // node
…
```

```
10110101010101010101111101 0 010100100101010111010101001011110101
0100101011110110100101010101110101011001010101010111110100100101
0101010101010101010010101001111110101010101010101001010101010010
1001011010011111111010101010100110100101010101001010101010100101
010101010100101010101001110101010101010101010101010…
```

```
 c_name           |   price
-------------------+-----------
 Customer#000000796 | 318356.97
 Customer#000001052 | 293680.56
 Customer#000001949 | 215280.98
 Customer#000002093 | 282531.93
 Customer#000005656 | 335297.31
 Customer#000005861 | 233691.03
 Customer#000006002 | 267000.92
 Customer#000006343 | 595819.82
 Customer#000006532 | 442254.91
….
real    0m0.552s
user    0m0.010s
sys     0m0.000s
```

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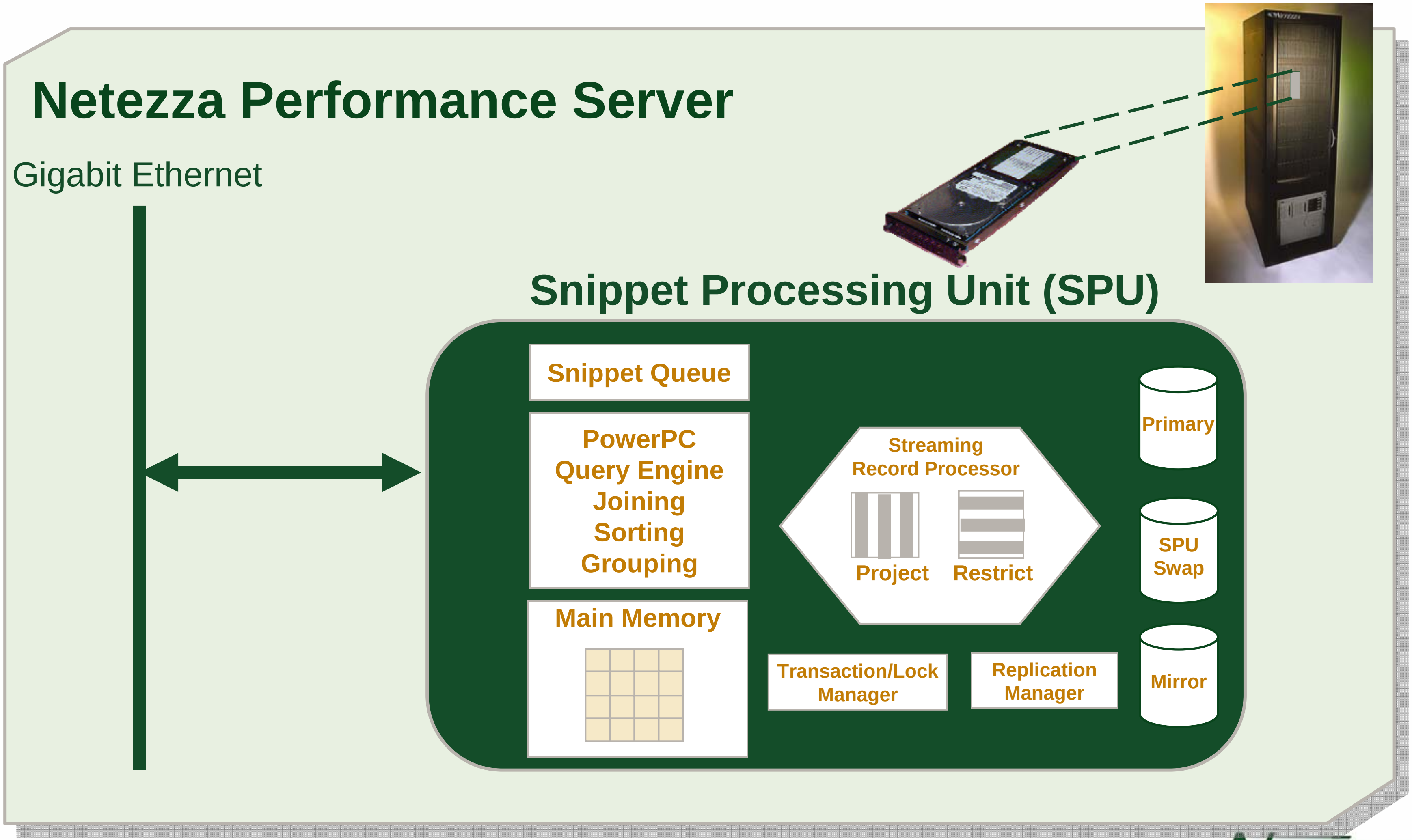
A Look Inside the SPU



Netezza Performance Server

Gigabit Ethernet

Snippet Processing Unit (SPU)

Snippet Queue

PowerPC
Query Engine
Joining
Sorting
Grouping

Main Memory

Streaming
Record Processor

Project

Restrict

Transaction/Lock Manager

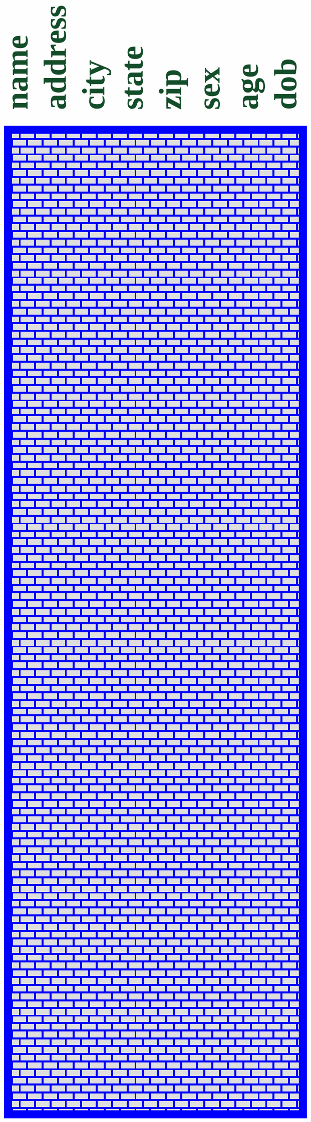
Replication Manager

Primary

SPU Swap

Mirror

SELECT count (*) , sex , age FROM emp WHERE state = ‘VA’ and age > 18 GROUP BY sex , age ORDER BY age ;



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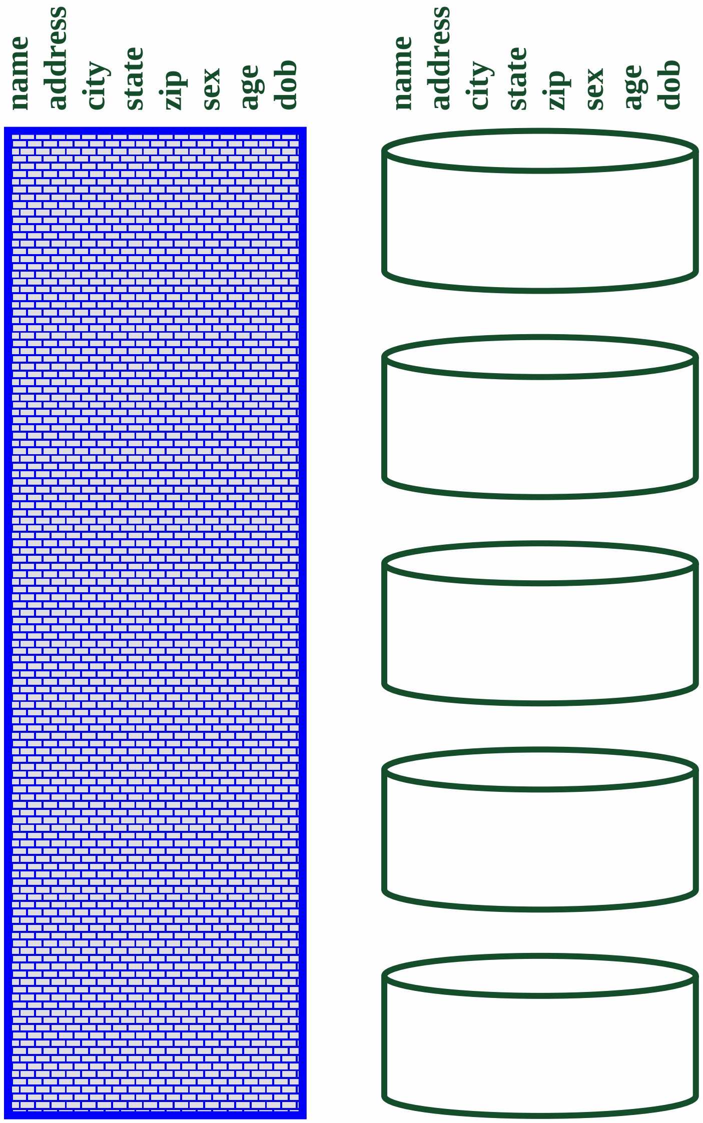
SELECT count (*) , sex , age FROM emp WHERE state = ‘VA’ and age > 18 GROUP BY sex , age ORDER BY age ;



First things first. The table is distributed amongst all of the SPU’s in the system so that is can be processed in parallel.

When the table is read, your scan speed is the SUM of the speed of all of the disk drives combined.

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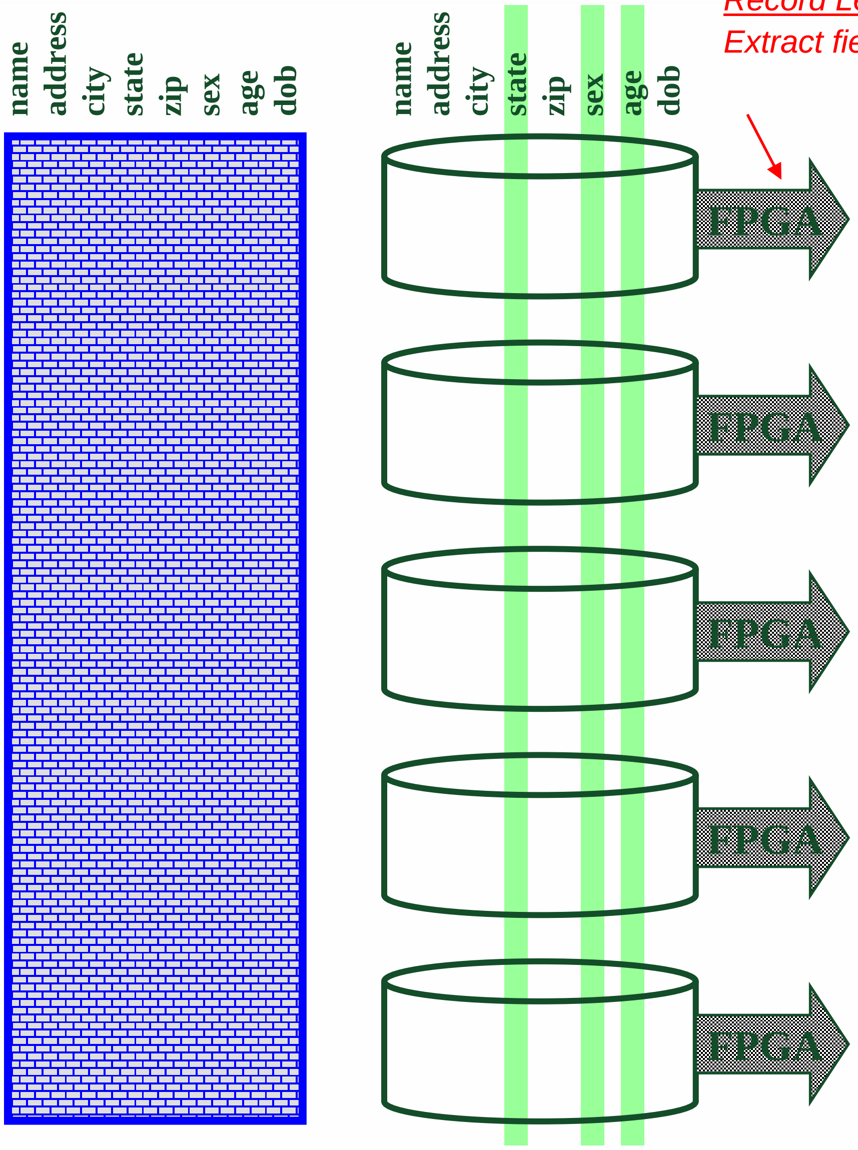
SELECT count (*) , sex , age FROM emp WHERE state = ‘VA’ and age > 18 GROUP BY sex , age ORDER BY age ;



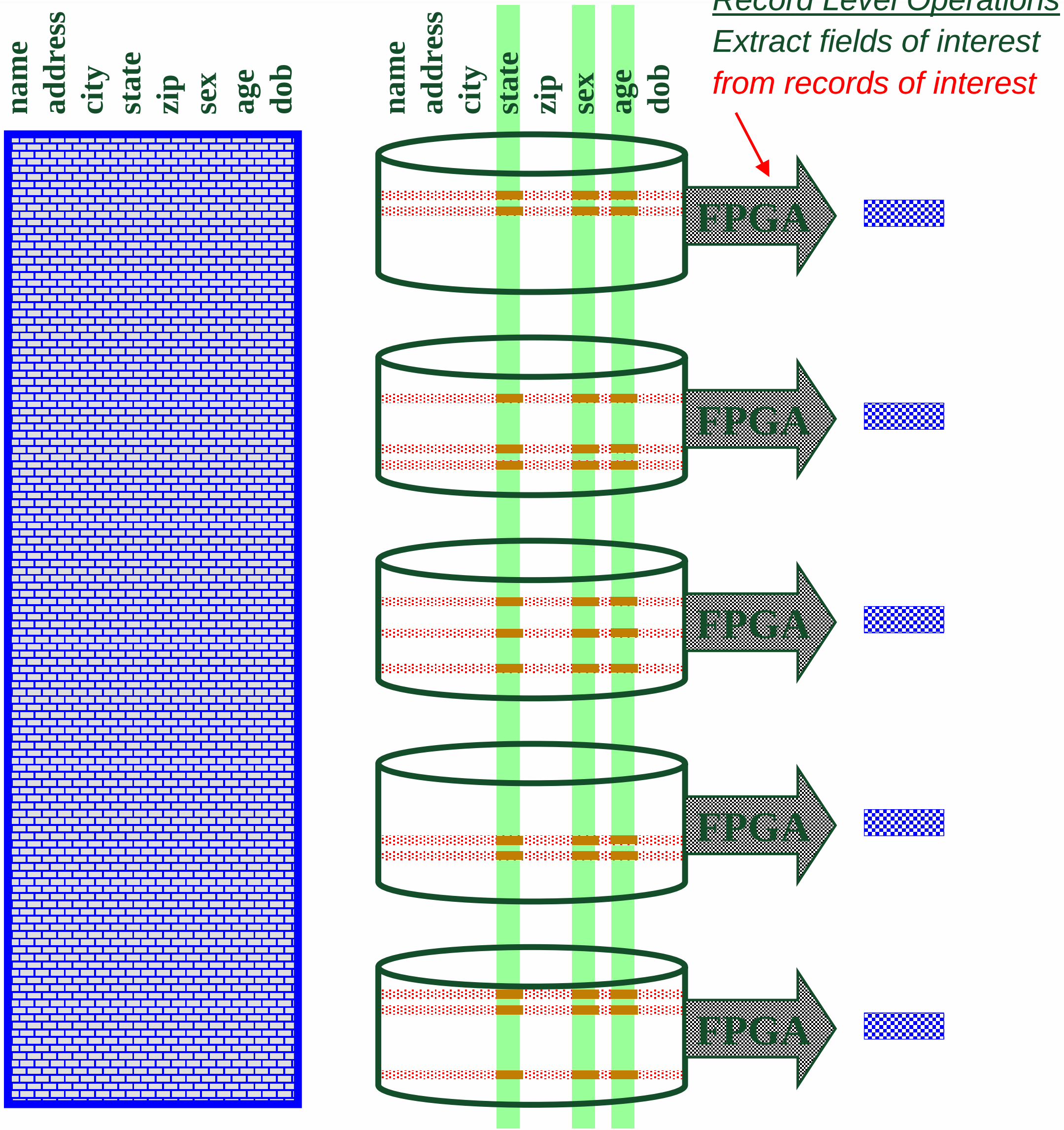
Record Level Operations

Extract fields of interest

PROJECTION

On each SPU, the FPGA / disk controller SELECTs just the columns of interest.

SELECT count (*) , sex , age FROM emp **WHERE state = ‘VA’ and age > 18** GROUP BY sex , age ORDER BY age ;



Record Level Operations

Extract fields of interest

from records of interest

RESTRICTION

The FPGA is also responsible for choosing the records of interest – applying the conditions of the WHERE clause.

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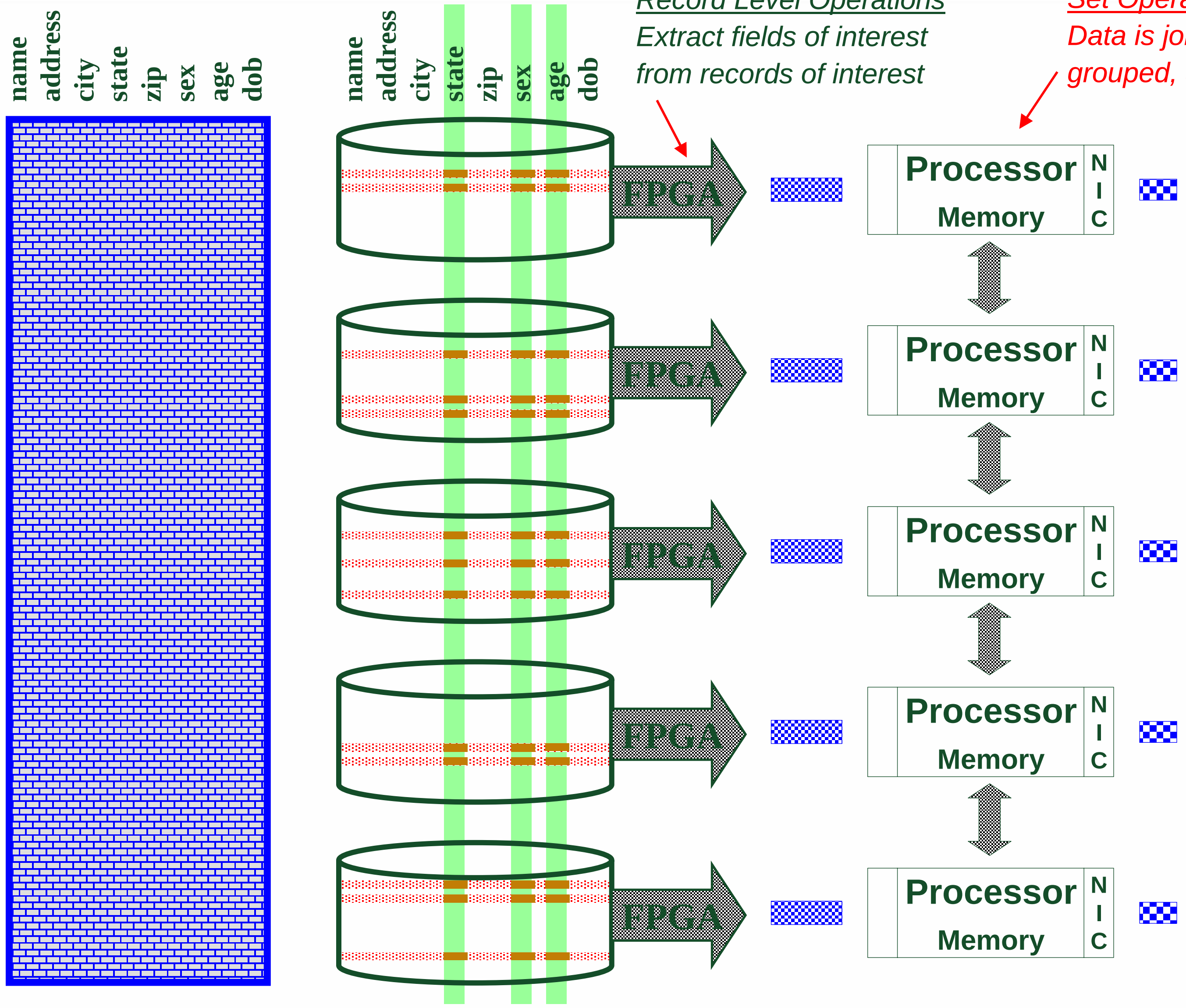
SELECT **count (*)** , sex , age FROM emp WHERE state = ‘VA’ and age > 18 **GROUP BY sex , age ORDER BY age** ;



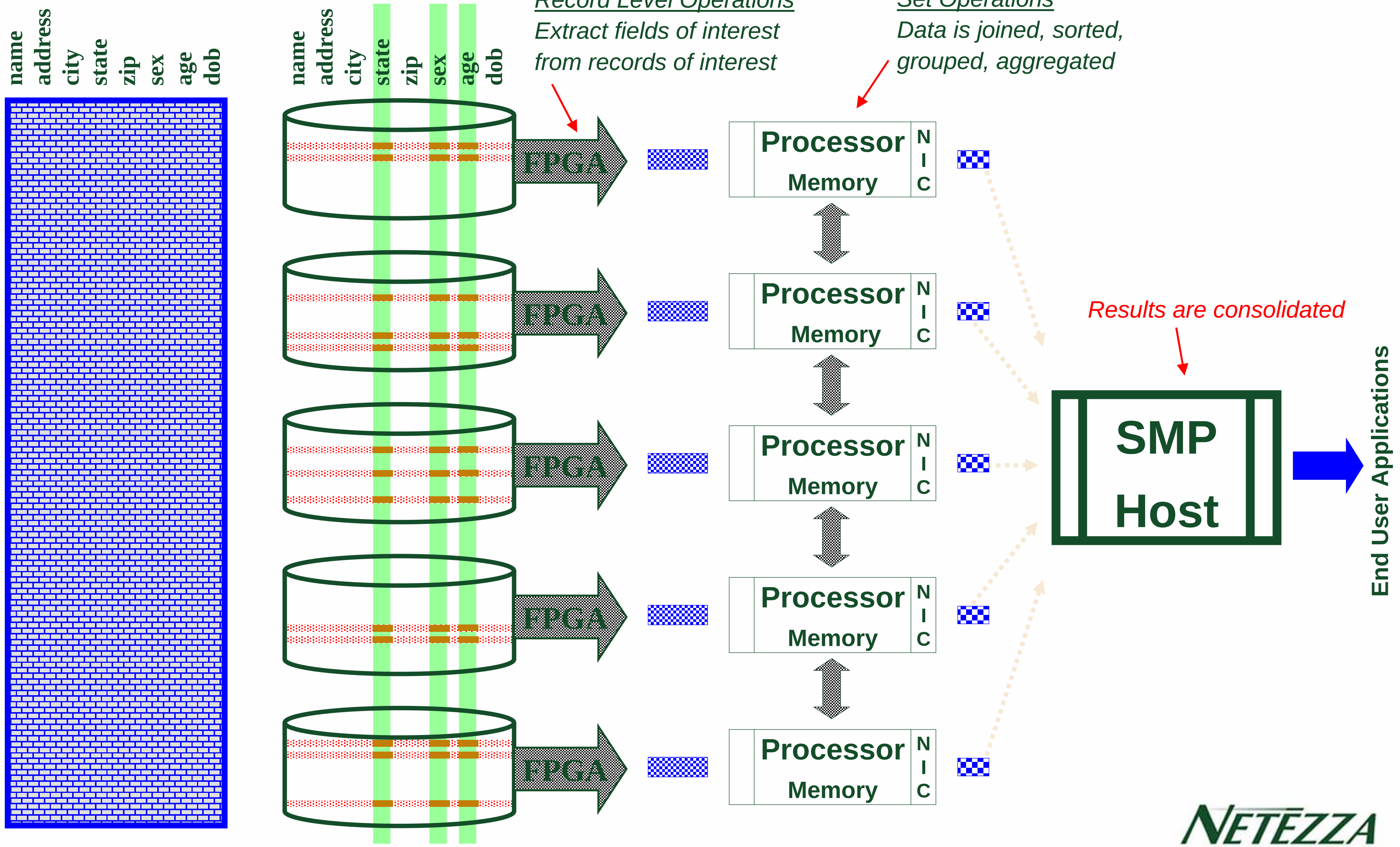
Record Level Operations

Extract fields of interest from records of interest

Set Operations

Data is joined, sorted, grouped, aggregated

SELECT count (*) , sex , age FROM emp WHERE state = ‘VA’ and age > 18 GROUP BY sex , age ORDER BY age ;



Record Level Operations

Extract fields of interest from records of interest

Set Operations

Data is joined, sorted, grouped, aggregated

Results are consolidated

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What about scientific data and non-SQL heuristics?

- BLAST is a widely used tool for finding similar sequences in large databases of sequences
- Netezza has integrated the BLAST heuristic algorithms into a new type of SQL Join:

The syntax is an extension of the SQL92 generalized join syntax:

```
   SQL92:  SELECT <cols> FROM <t1> <jointype> <t2> ON <join-condition>
```

The blast join syntax where the controls is a literal string is:

```
SELECT <cols>
FROM <haystack> [ALIGN <needles>] [WITH <controls>]
ON BLASTX(<haystack.seq>,<needles.seq>,<controls.args>)
```

Thus a simple literal protein blast looks like:

```
   SELECT <cols> FROM haystack ON BLASTP(haystack.seq, 'ZZAADEDAAM', '-e.001')
```

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Netezza Performance Server® Family

NPS 8000z-Series High-Performance Products

8000z Series:
1-33 TB

	8050z	8150z	8250z	8450z	8650z
Processors	56	112	224	448	672
User Space	2.75 TB	5.5 TB	5.5 – 11 TB	5.5 – 22 TB	5.5 – 33 TB

Continued Innovation in the 8000 Family

- Built & Priced for PERFORMANCE
- Enhanced performance, reliability and system capacity
- Simple, scalable capacity expansion across the product range

Netezza Performance Server® Family
NPS 10000-Series High-Density Products

10000 Series:
Up to 100 TB

0.9 Terabyte
Total DRAM
0.3 Petabyte
Total Storage

	10400 HD	10800 HD
Processors	448	896
User Space	10 – 50 TB	10 – 100 TB

Introducing the 10000 Product Family

- HIGH PERFORMANCE & HIGH DATA DENSITY in a single NPS appliance
- Simple, cost-effective, scalable capacity expansion
- Up to 12.5 TB of user space per rack

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Some of Our Customers by Vertical Market…

Retail

Ahold USA

Albertsons

CATALINA MARKETING

DEBENHAMS

Neiman Marcus

RESTORATION HARDWARE

ROSS
DRESS FOR LESS

Ryder

SHOPPERS
DRUG MART

SYSCO

Telecom

at&t

THE Carphone Warehouse
…for a better mobile life

caudwell
communications

cingular
raising the bar

iBasis

Sprint

orange

ROGERS

TELUS

Online

Advertising•com

amazon.com

AMERICA Online

CNET
NETWORKS

Financial Services

Bank of America

Capital One

LOANPERFORMANCE

Nationwide

OPTION ONE
MORTGAGE

Analytic Services

ACNielsen

ACXIOM

ClarityBlue
Customer Intelligence

epsilon

MERKLE

Healthcare

American
Red Cross

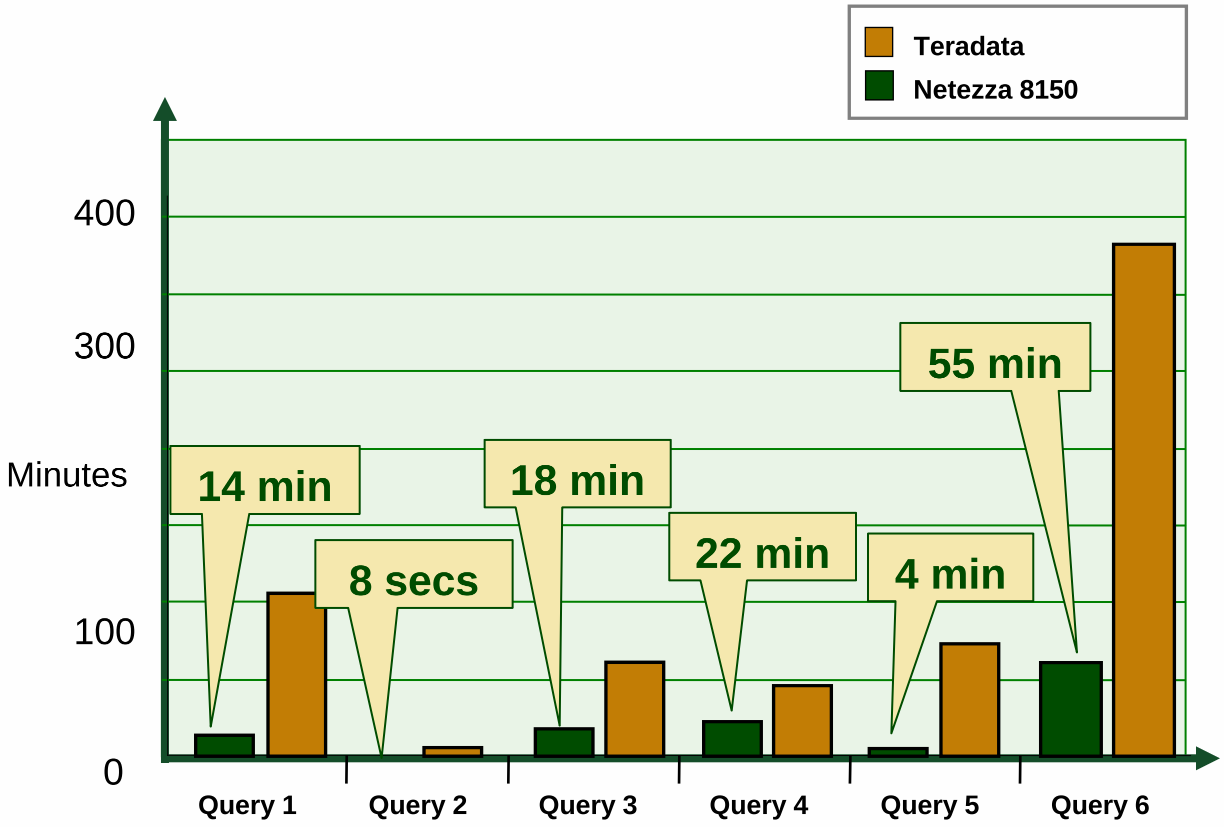
NDCHEALTH

PREMIER

Other

CenterParcs

Proven Results: Leading Food & Drug Retailer



**Netezza results based on an NPS 8150.*
Teradata queries run on a 40-node system (5200 &5300)

Situation

- Competed against a **Teradata system 25x more expensive**
- Total amt of data loaded: 3.5TB
- Time to load: 28 hours
- 118GB/hour
- Queries included market basket penetration, Y/Y comparisons, top UPC by movements, price optimization tracking, etc.
- Running SQL

Results

- NPS system went from loading dock to installed, configured and running in three hours
- Queries were run substantially faster, including one that was over five times faster

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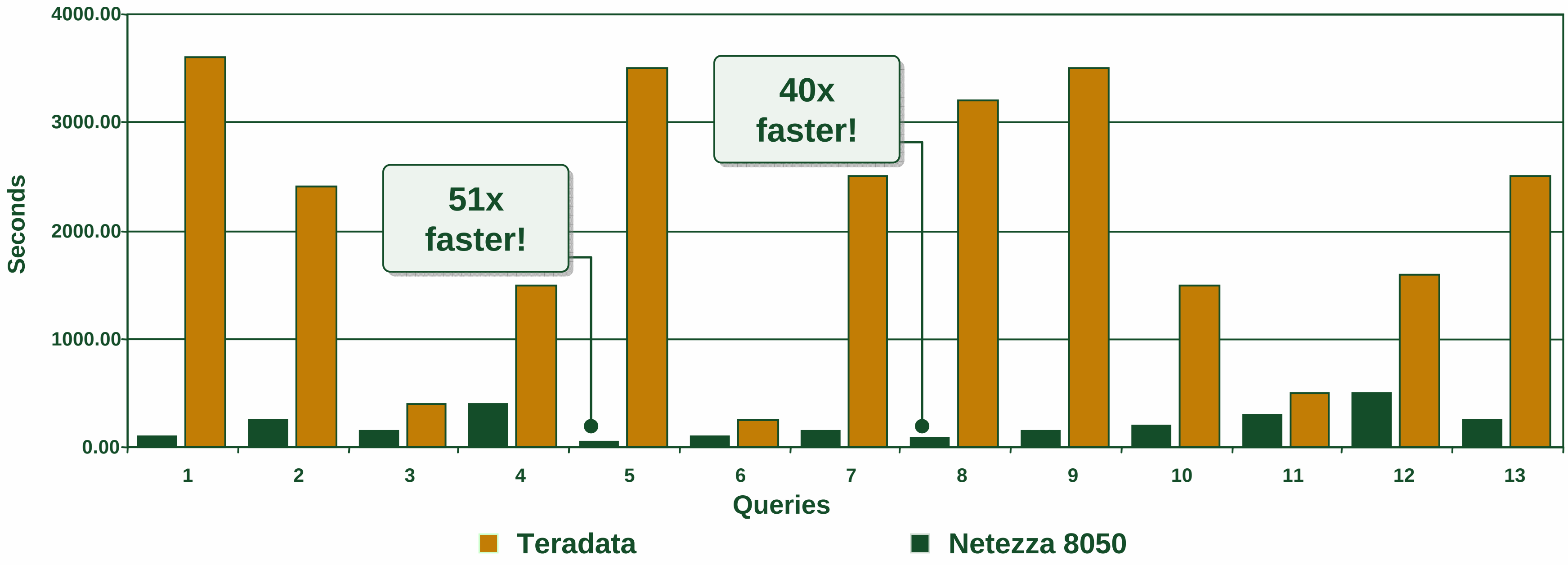
Proven Results:
Report Execution from a Government POC

Situation

- Competed against a very large Teradata system (96 nodes)
- Total amount of data loaded: 2.5 TB
- 200+GB/hour load rates (single stream)
- Representative set of resource-intensive production MicroStrategy reports

Impact

- NPS system went from loading dock to installed, configured and running in five hours
- Queries showed substantial improvement on Netezza – **15 times faster** on average!
- Total execution time (13 reports) was ~7 ½ hours on TD vs. only 47 min on Netezza



* *Netezza results based on an NPS 8250.*
Teradata queries run on a 96-node system (52xx and 53xx)

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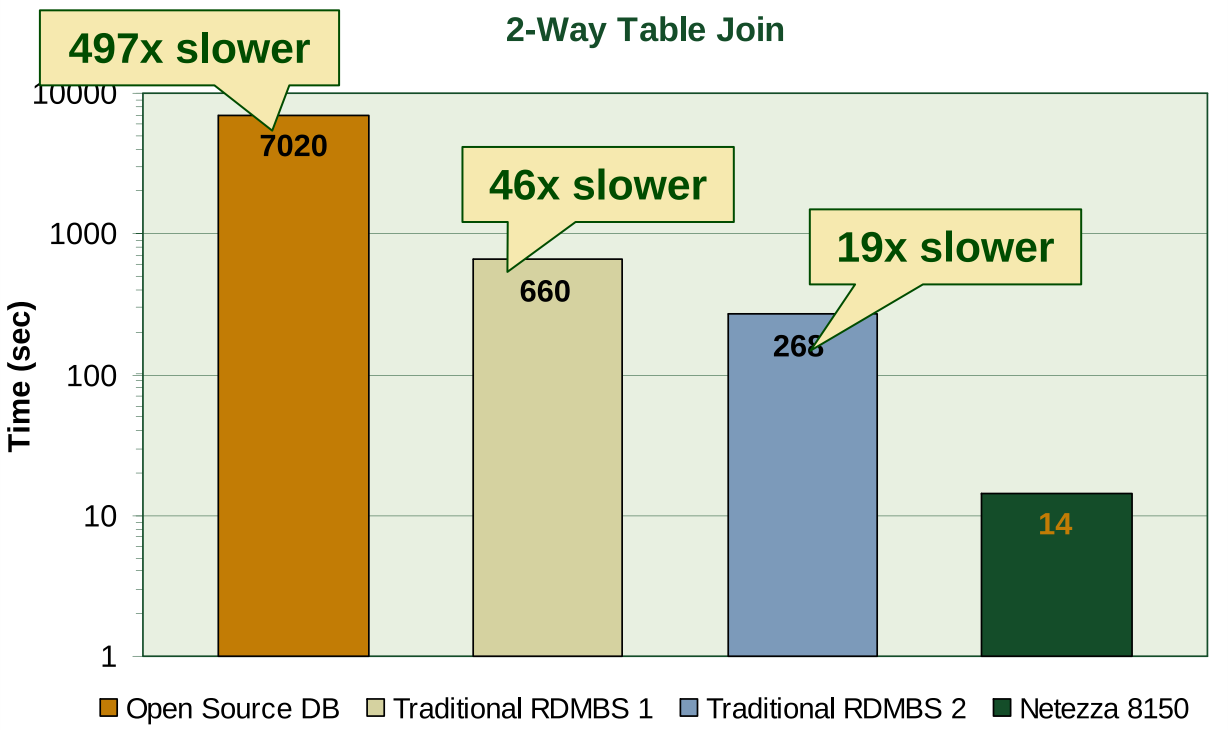
Proven Results: Analytic Service Provider



POC Performance

- 2-way Cartesian Join Mixed Read/Write Test
- 37.6M rows with 122.9M rows
- Performance Improvement with Netezza
  - 497x v. Open Source DB
  - 46x v. Traditional RDMBS 1
  - 19x v. Traditional RDMBS 2

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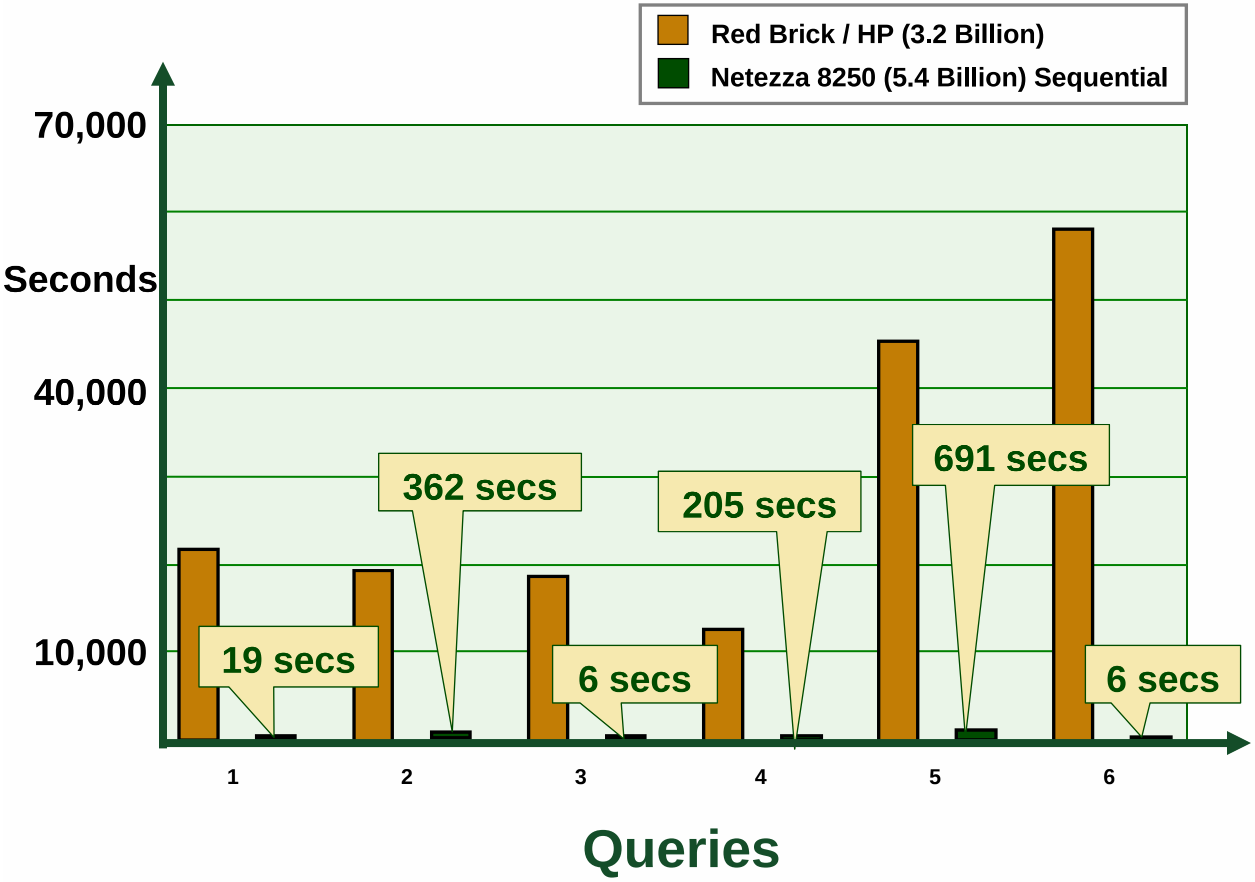
Proven Results: E-Business Customer



**Netezza results based on an NPS 8250.*
Red Brick results on HP SuperDome 32 CPU/32GB RAM and EMC SAN

Situation

- Red Brick: 3.2 billion rows
- NPS: 5.4 billion rows
- 6 queries–load, expansion and test
- Business Objects and SQL

Query Performance

- NPS system handled 69% more data volume but was able to complete the total workload in 21 minutes vs. 50 hours, 143x faster!

Load Performance

- 140+ GB/hr

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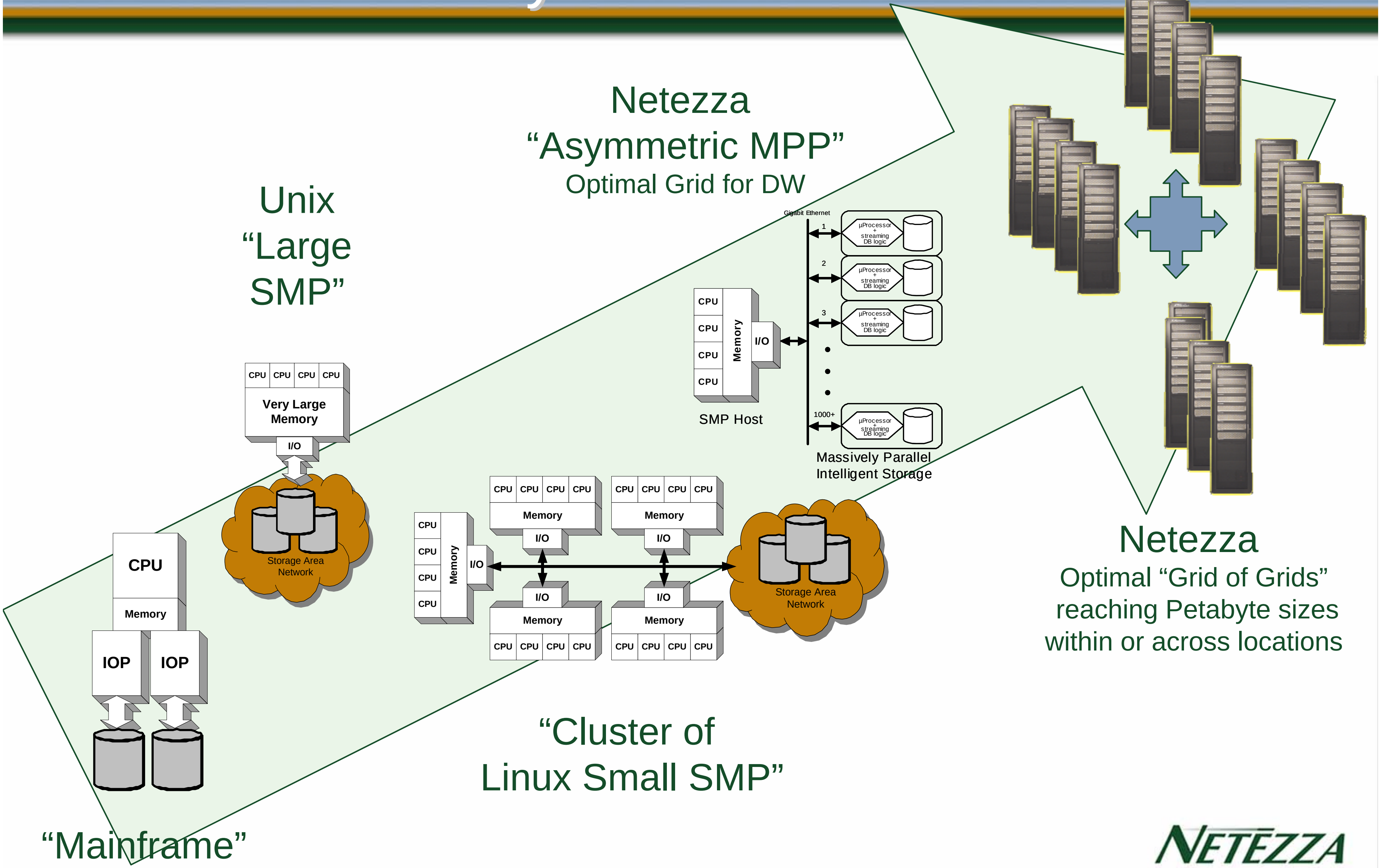
Netezza's DW System Architecture Evolution



"Mainframe"

Unix
"Large
SMP"

"Cluster of
Linux Small SMP"

Netezza
"Asymmetric MPP"
Optimal Grid for DW

SMP Host

Massively Parallel
Intelligent Storage

Netezza
Optimal "Grid of Grids"
reaching Petabyte sizes
within or across locations

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Thank You!