Intro to Teradata

In this lecture:

- Teradata architecture:
  - Overview.
  - Storage architecture.
  - Retrieval architecture.
- Getting started.

Quick RDMBS reminder

- Data stored in **tables**, which consist of **rows** and **columns**.
- Tables can communicate with each other, so that combined information can be retrieved and analyzed.
- The way the tables and their relationships are organized is called a **schema**.

Quick RDMBS reminder (cont.)

- **Primary Key:** Primary key is used to uniquely identify a row in a table.
  - No duplicate values are allowed in a primary key column and they cannot accept NULL values.
  - It is a mandatory field in a table.
- **Foreign Key:** Foreign keys are used to build a relationship between the tables.
  - A foreign key in a child table is defined as the primary key in the parent table.
  - A table can have more than one foreign key.
  - It can accept duplicate values and also null values.
  - Foreign keys are optional in a table.

What is Teradata?

- A global leader in enterprise data warehousing and analytic technologies.
- In data warehousing arena since 1979 in over 60 countries delivering data warehouse appliance solutions.
- Has about 1,000 customers, with annual revenue of about $1.6 billion from data warehousing solutions.
- Provides functionality for large, complex, mixed workload environments.
- Newer products (Teradata Vantage) that support relational and non-relational data.

What is Teradata (cont.)?

- It has specific strengths (e.g., strong penetration, data models and professional services) in the vertical markets such as retail, financial and banking, telecom and manufacturing.
- Its largest and most prominent customer is Wal-Mart. Other customers include companies like O2, FedEx and eBay.
- Main competitors are other mature DBMS solutions such as IBM's Netezza, Microsoft SQL Server and Oracle.
- Latest data warehouse release is Teradata 16.

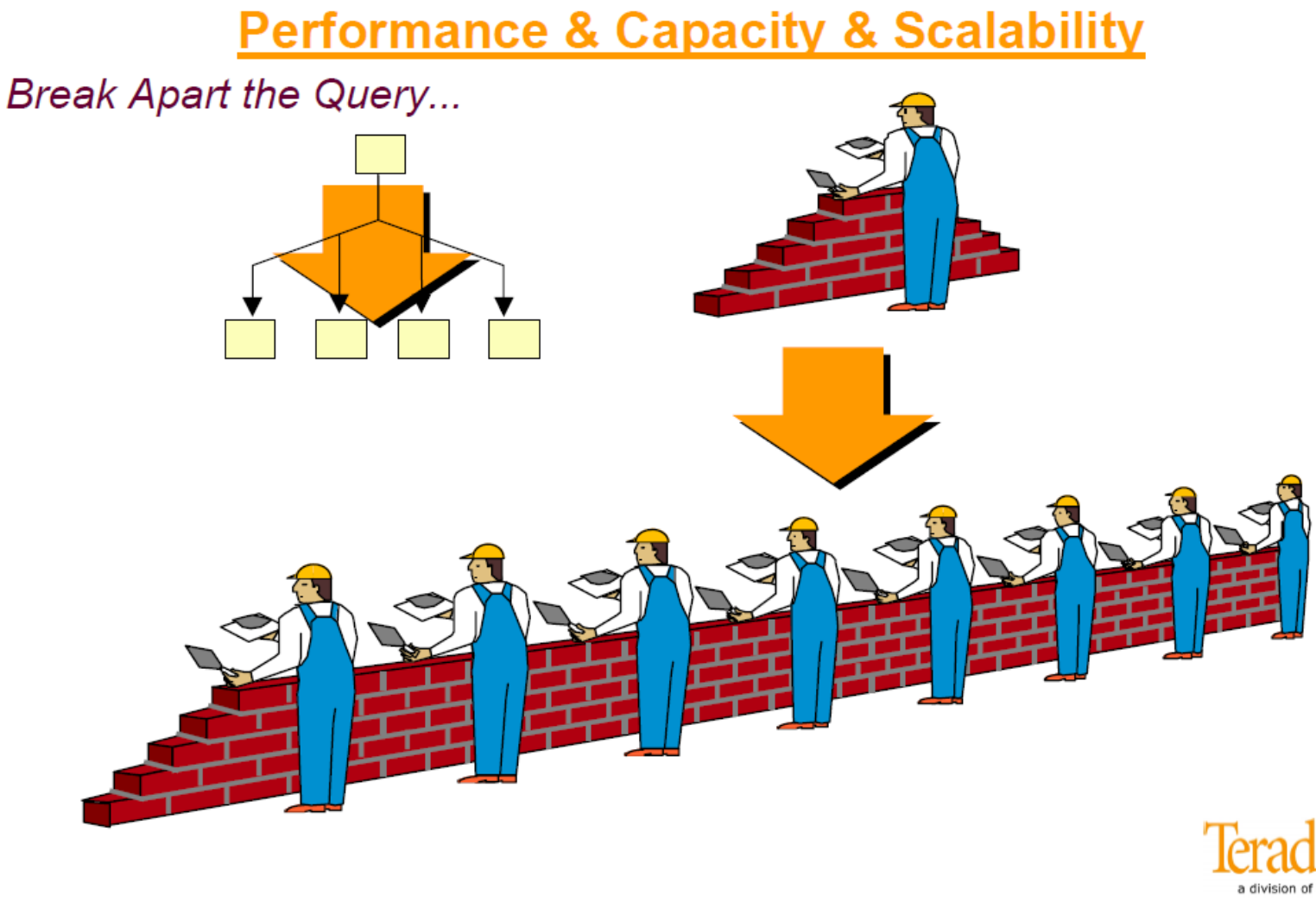
What are Teradata features?

- An RDBMS designed for enterprise data warehousing.
- A massively parallel processing system to ensure that tasks are processed quickly.
- A **shared nothing** architecture.
- **Linear scalability** in all dimensions of a database system workload (i.e., data volume, breadth, number of users, complexity of queries). Can scale up to 2048 nodes.

What are Teradata features (cont.)?

- **Connectivity:** to channel-attached systems such as Mainframe or Network-attached systems.
- **Mature Optimizer:** Quite good from the start, it has been refined for each release.
- **SQL:** Industry standard SQL. In addition to this, it provides its own extension.
- **Robust Utilities:** for import/export data from/to such as `FastLoad`, `MultiLoad`, `FastExport` and `TPT`.
- **Automatic Distribution:** No manual intervention for data redistribution.

Parallelism, the secret sauce

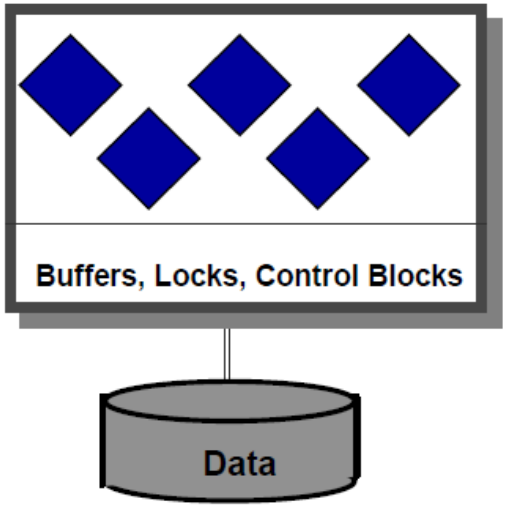


Parallel Architectures

Shared Everything

well known RDBMS

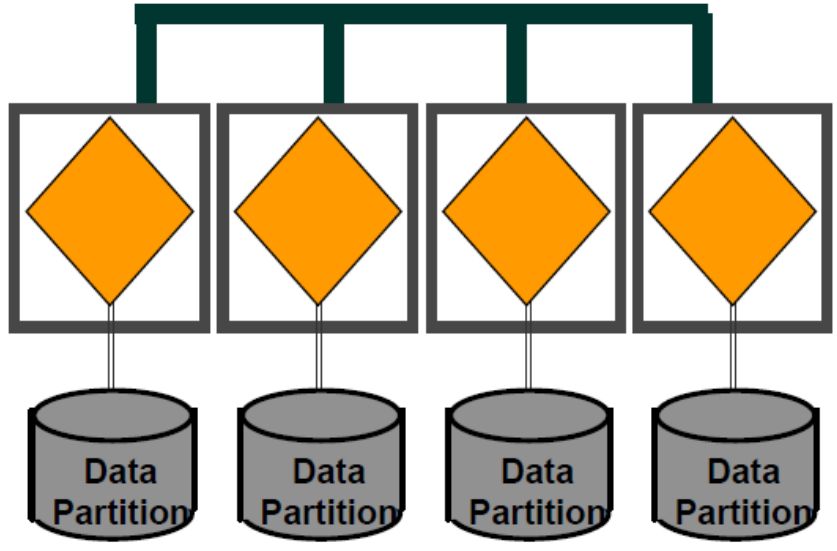
- A single database buffer used by all UoP's
- A single logical data store accessed by all UoP's
- Scalability limited due to control bottlenecks and scalability of single SMP platform



Shared Nothing

Teradata

- Each UoP is assigned a data portion
- Query Controller ships functions to UoP's that own the data
- Locks, buffers, etc. not shared
- Highly scalable data volumes



◆ - Unit of Parallelism

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- Old picture: most RDBMS follow a shared-nothing architecture.

Teradata Architecture

- **Massively parallel processing (MPP)**: Multiple SMP nodes working together.
- The nodes are connected using a message passing layer called **BYNET**, which allows multiple virtual processors on multiple nodes to communicate with each other.
- The major components of Teradata are **Parsing Engine**, **BYNET** and Access Module Processors (**AMPs**).

Physical components of Teradata

- **Node:** It is the basic unit in Teradata System. Each individual server in a Teradata system is referred as a Node.
- A node consists of its own operating system, CPU, memory, own copy of Teradata RDBMS software and disk space.
- A node can contain several AMPs.
- A **cabinet** consists of one or more Nodes.

Components of Teradata

- **Parsing Engine:** Parsing Engine is responsible for receiving queries from the client and preparing an efficient execution plan.
- The responsibilities of parsing engine are:
  - Receive the SQL query from the client.
  - Parse the SQL query check for syntax errors.
  - Check if the user has required privilege against the objects used in the SQL query.
  - Check if the objects used in the SQL actually exists.
  - Prepare the execution plan to execute the SQL query and pass it to BYNET.
  - Receives the results from the AMPs and send to the client.

Components of Teradata (cont.)

- **Message Passing Layer:** Message Passing Layer called **BYNET**, is the networking layer in Teradata system.
- BYNET allows the communication between PE and AMP and also between the nodes.
- It receives the execution plan from PE and sends to AMP.
- Similarly, receives the results from the AMPs and sends to PE.

Components of Teradata (cont.)

- **Access Module Processor (AMP):** AMPs, called as Virtual Processors (vprocs) are the one that actually stores and retrieves the data.
- AMPs receive the data and execution plan from Parsing Engine, performs any data type conversion, aggregation, filter, sorting and stores the data in the disks associated with them.
- Records from the tables are evenly distributed among the AMPs in the system.
- Each AMP is associated with a set of disks on which data is stored. Only that AMP can read/write data from the disks.

Storage Architecture

Storage Architecture

Row Storage - Hashing algorithm

- A row is assigned to a particular AMP based on the primary index value. Teradata uses **hashing algorithm** to determine which AMP gets the row.
- A hash function is any function that can be used to map data of arbitrary size onto data of a fixed size.
- Hash functions are used in **hash tables** or **hash maps** to quickly locate a data record.
- They are often random and suffer of **collisions**: multiple values are mapped to the same hash value.

Storage - Steps

- The client submits a query.
- The parser receives the query and passes the PI value of the record to the hashing algorithm.
- The hashing algorithm hashes the primary index value and returns a 32 bit number,called **Row Hash.**
- The higher order bits of the row hash (first 16 bits) is used to identify the hash map entry.
- The hash map contains one AMP number.
- The hash map is an array of buckets which contains specific AMP number.

Storage - steps (cont.)

- BYNET sends the data to the identified AMP.
- AMP uses the 32 bit Row hash to locate the row within its disk.
- If there is any record with same row hash, then it increments the uniqueness ID which is a 32 bit number. For new row hash, uniqueness ID is assigned as 1 and incremented whenever a record with same row hash is inserted.
- The combination of Row hash and Uniqueness ID is called as **Row ID**.
- Row ID prefixes each record in the disk.
- Each table row in the AMP is logically sorted by their Row IDs.

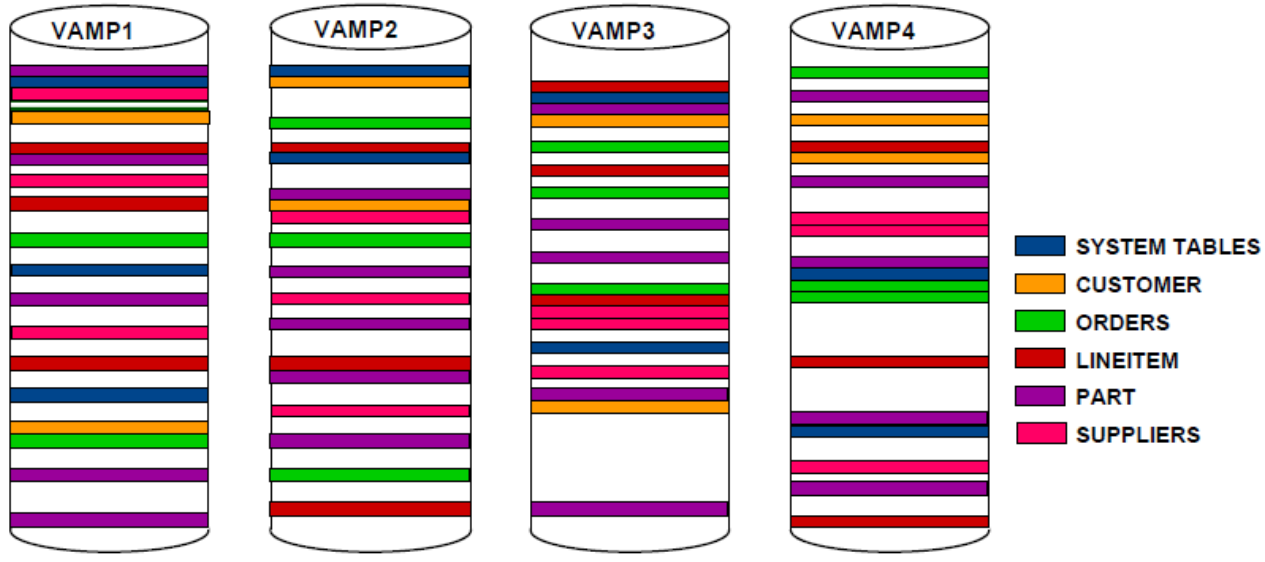
How Tables are Stored

- Tables are sorted by their Row ID (Row hash + uniqueness id) and then stored within the AMPs. Row ID is stored with each data row.

RowHash	UniquenessID	EmployeeNo	Name
2A01 2611	0000 0001	101	Mike James
2A01 2612	0000 0001	104	Alex Stuart
2A01 2613	0000 0001	102	Robert Williams
2A01 2614	0000 0001	105	Robert James
2A01 2615	0000 0001	103	Peter Paul

How does Teradata store rows?

- **Random, automatic data distribution & placement**
- **Real-time, automatic data reorganization**



With Teradata there is no sense of ORDER, therefore there is no sense of DISORDER, eliminating the need to REORDER!

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Space

- **Permanent Space:** the maximum amount of space available for the user/database to hold data rows. Permanent tables, journals, fallback tables and secondary index sub-tables use permanent space. Not pre-allocated for user/database, rather defined as an upper bound.
- **Spool Space:** Spool space is the unused permanent space which is used by the system to keep the intermediate results of the SQL query. Users without spool space cannot execute any query.
- **Temp Space:** Temp space is the unused permanent space which is used by Global Temporary tables.

Retrieval Architecture

Retrieval Architecture

- When the client runs queries to retrieve records, Parsing Engine sends a request to BYNET.
- BYNET sends the retrieval request to appropriate AMPs.
- Then AMPs search their disks in parallel and identify the required records and sends to BYNET.
- BYNET then sends the records to Parsing Engine which in turn will send to the client.

Easier said than done

- Suppose you are visiting a friend in an unknown city. How would you find their place faster:
  - Knocking on all the doors in the city.
  - Using a XII century map.
  - Using a new, high quality map?

Easier said than done

- Suppose you are visiting a friend in an unknown city. How would you find their place faster:
  - Knocking on all the doors in the city. **Full table scan**
  - Using a XII century map. **Outdated statistics**
  - Using a new, high quality map? **Good index/updated stats**

Primary Indexes

- The mechanism used to assign a row to an AMP.
- A table ~~must~~ have a **Primary Index** that cannot be changed.
  - From Teradata 13.00 tables may *not* have a primary index. Rows are randomly distributed to AMPs.
  - No PI tables are typically used as staging tables for initial load by FastLoad or TPump Array Inserts (because load is faster).
- Primary Index can be unique (**UPI**) or non-unique (**NUPI**).
- Primary Indexes are not the same as primary keys

Quick quiz:

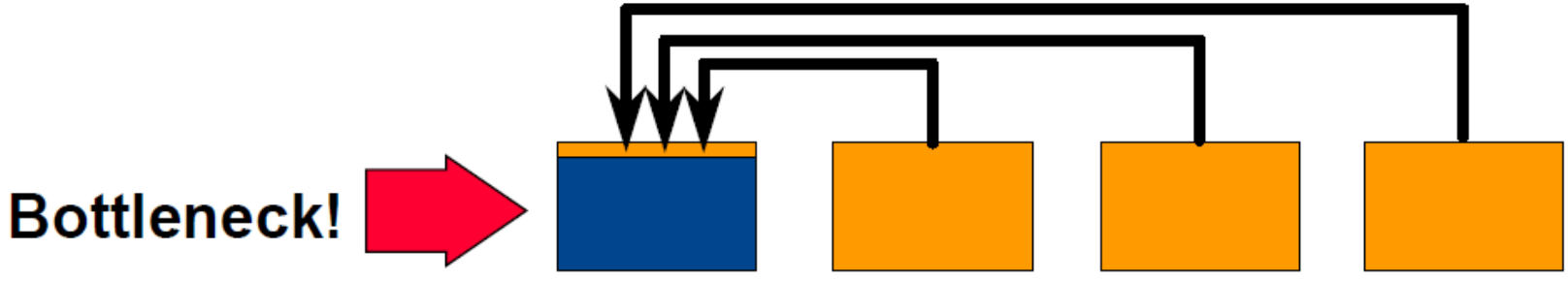
- Consider a transaction table with columns `OrderNumber`, `CustomerId`, `OrderDate` and `Total`.
- How would you assign primary keys and primary indices to make your life happier?
- **Happiness** is defined as fast running queries.

Solution

- **It depends**.
- Rows can be distributed using a `UPI` (in this case, `OrderNumber`, which is also the PK) or a `NUPI` (in this case, `CustomerId` or `OrderDate`).
- In the first case, the distribution of the rows is non-skewed across AMPs, while in the second case we will have a less even row distribution.
- But the catch is on **what level of granularity do you need for analysis**.

Why this matters?

- A sane index structure determines greatly the speed of our queries.
    - Indices determine storage, storage determines retrieval speed.
- In order to process records in a `JOIN`, they have to be on the same processing unit
- The records have to be sent very often to a single processing unit, to perform the `JOIN`



Avoiding bottlenecks

- The `JOIN` is performed balanced on all nodes if the primary index is chosen properly.
- Each node performs a smaller part of the `JOIN`.
- Similar bottlenecks (and solutions) apply for `GROUP BY` and `ORDER` queries.

Setting up the environment

Pre-requisites

To get started, you need to download:

- Teradata Express 16.20 VM Image.
- VMWare Workstation 15 Player.
- Teradata tools and utilities.
- JDK 8 and other dependencies (see the download page for TD Express).
- You can download these from: Teradata Downloads page.
- An account is required, you can create one for free.

Course repository:

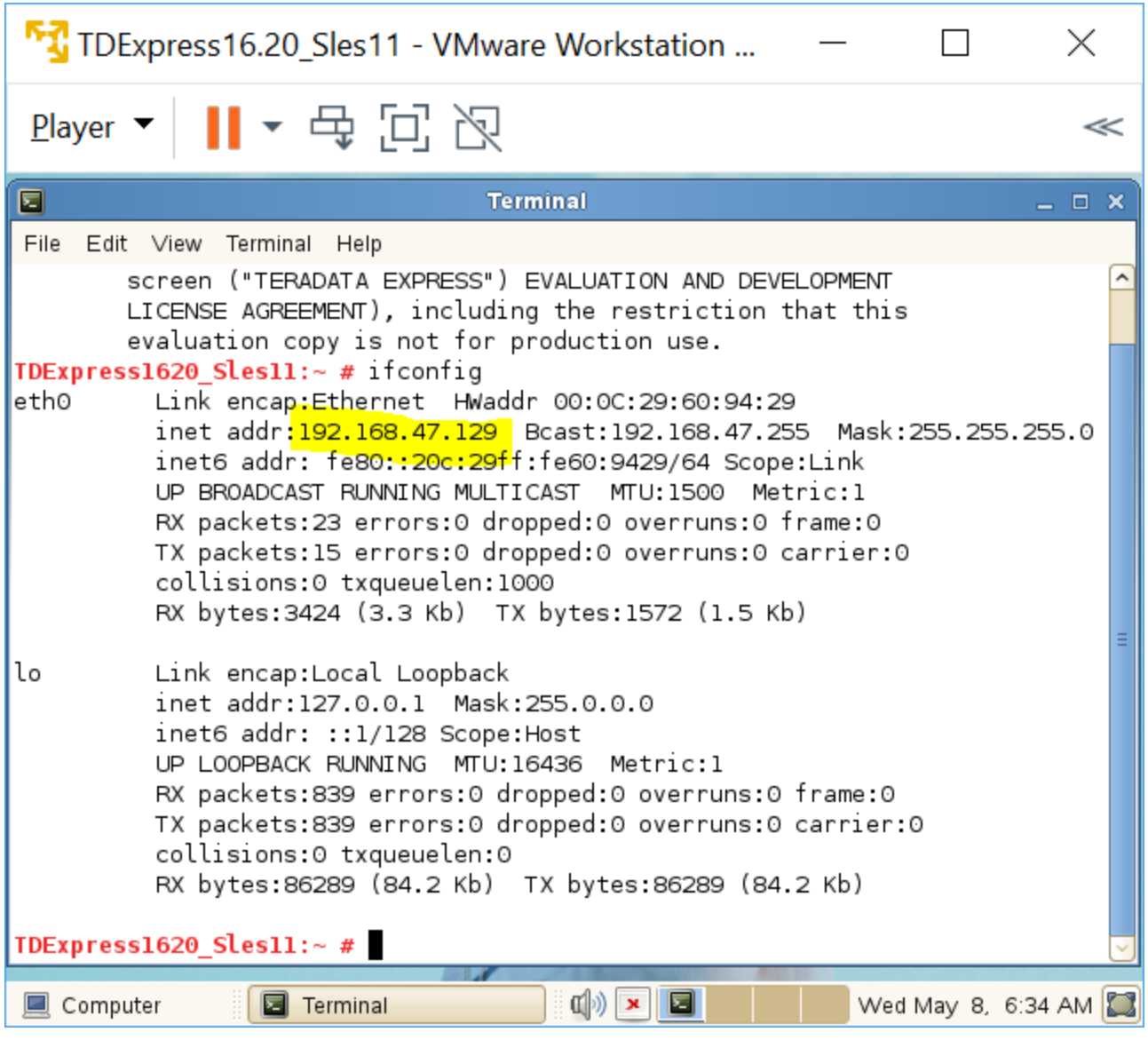
- Slides, scripts and data sources: www.github.com/jpmaldonado/np-teradata

Launch your VM

- In VMWare Player's main window, right click on the VM name and select "Virtual Machine Settings".
- In the settings window, click on "Network Adapter" and among the options on the right, select "Host-only: a private network shared with the host".
- Click ok and boot your virtual machine.
- Login credentials are root/root

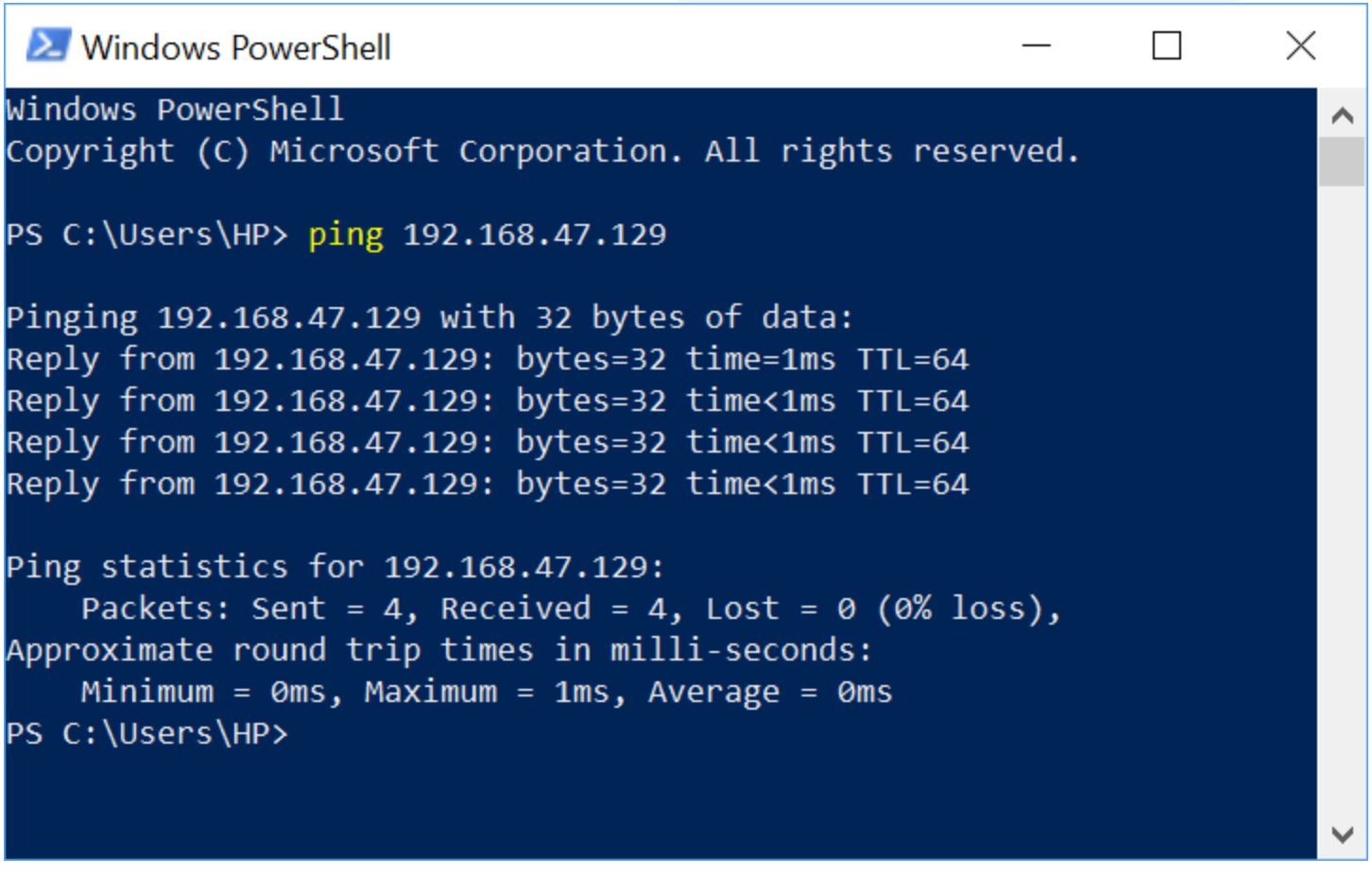
Connect to your DB

- Open a terminal and type `ifconfig`. You should see an `inet addr` value as below.



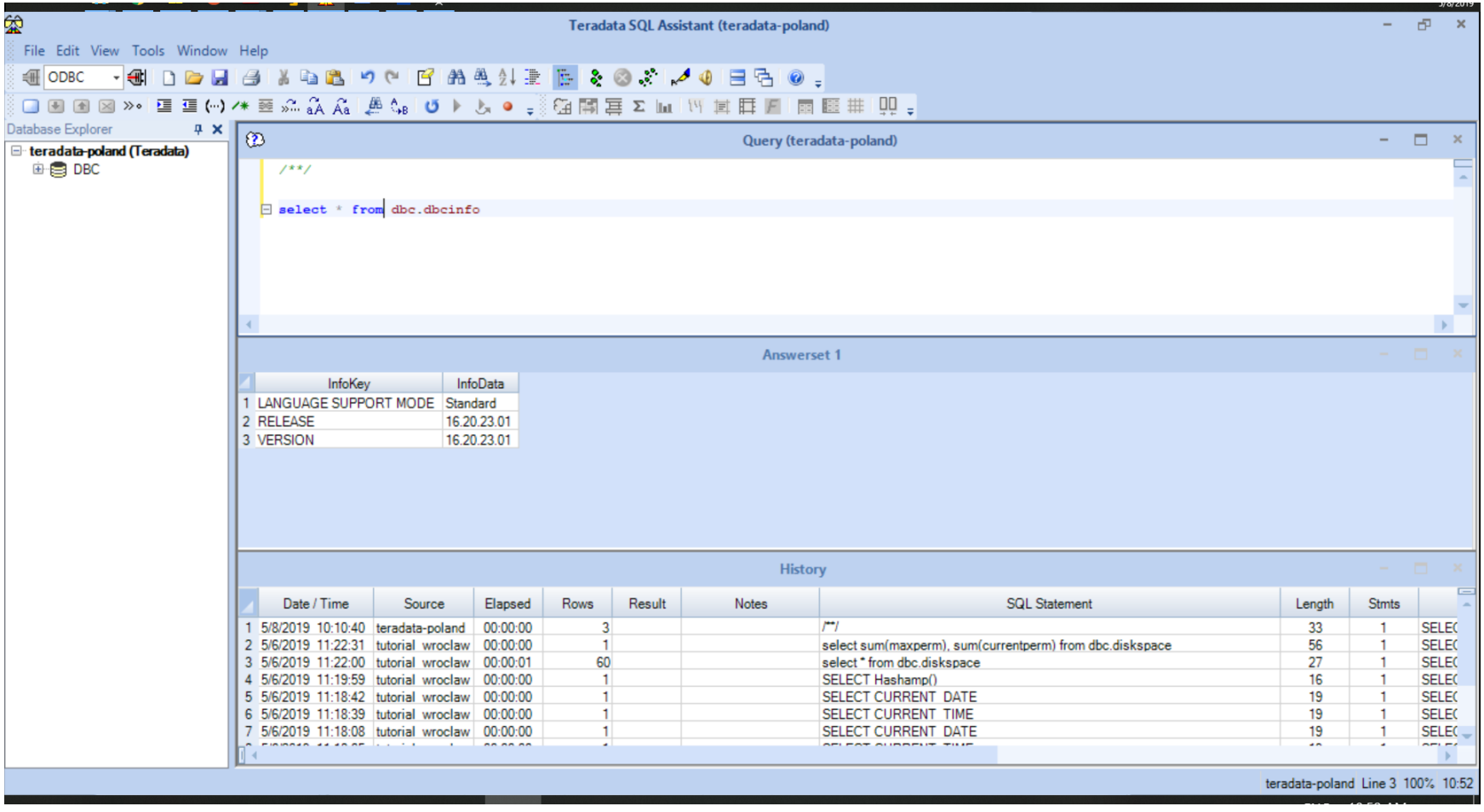
Test connection

- On your `PowerShell` or `UNIX` console, ping the IP address of your DB with the command `ping 192.168.47.129`



Connect with SQLA

- Now open SQL Assistant, and create a new connection using the IP address of your DB.
- Default credentials are dbc/dbc.
- Run a simple query.



SQLA Shortcuts

- **F2**: It will open query builder, with syntax for all SQL queries.
- **F5**: Execute SQL query.
- **F6**: Explain plan for SQL query.
- **F9**: Execute SQL queries in parallel.
- **F10**: Abort SQL query.
- **F11**: Display last error encountered.
- **Ctrl + N**: New SQL query window.
- **Ctrl + Q**: Format SQL query.
- **Ctrl + U**: Convert to UPPERCASE.
- **Ctrl + H**: Find and replace.

More inside SQLA

- Go to **Tools | Options | Query** to change the behavior if needed.
- **Query Builder.**
- **Beyond SQLA:** Teradata Studio / Teradata Studio Express.