Think Like the Cardinality Estimator

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Work

- 11 years as DBA
- MCSA SQL Server 2012/2014
- 10 years in Merchant Marine

Outside Work

- Running—One 26.2 and Many 13.1
- Shuttling 3 kids

Giving Back

- Frequent speaker local user groups & SQL Saturdays
- Answering question at #sqlhelp & dba.stackexchange
- Blog at sqlworldwide.com

Agenda

- Predicate, Density, Predicate Selectivity
- What is Cardinality
- Why Cardinality Matters
- DBCC SHOW_STATISTICS
- Magic Numbers

Predicate

Is an expression that evaluates to TRUE, FALSE, or UNKNOWN

- Join
- Filter
  - Where
  - Having

Predicate

```
SELECT
    cus.CustomerID,
    COUNT(0) AS [NumOfOrders]
FROM
    sales.Orders AS ord
JOIN
    sales.Customers AS cus
ON
    ord.CustomerID=cus.CustomerID
WHERE
    ord.OrderDate='2013-01-01'
GROUP BY cus.CustomerID
HAVING COUNT(0) > 2 ;
GO
```

Join Predicate

Filter Predicate
Where/Having

Density

How often duplicate values occur in a column.

$$\frac{1}{[\#\text{ of distinct values in a column}]}$$

```
SELECT
    COUNT(DISTINCT customerID) AS [DistinctCusId]
FROM
    sales.Orders;
GO
```

Density
663 distinct customerID
1/663=0.00150830

Predicate Selectivity

Most commonly used to describe a predicate.

$$\frac{[\text{ \# rows that pass the predicate }]}{[\text{total number of rows}]}$$

```
SELECT
    COUNT(0) AS [NumOfOrders]
FROM
    sales.Orders
WHERE
    CustomerID=577;
GO
```

75 rows for customerID 577
73595 total number of rows.
75/73595=.0010

Cardinality

For Us

- Number of rows returned by a query operator.

Structured Query Language

- Uniqueness of data values contained in a particular column (attribute) of a database table.

Math

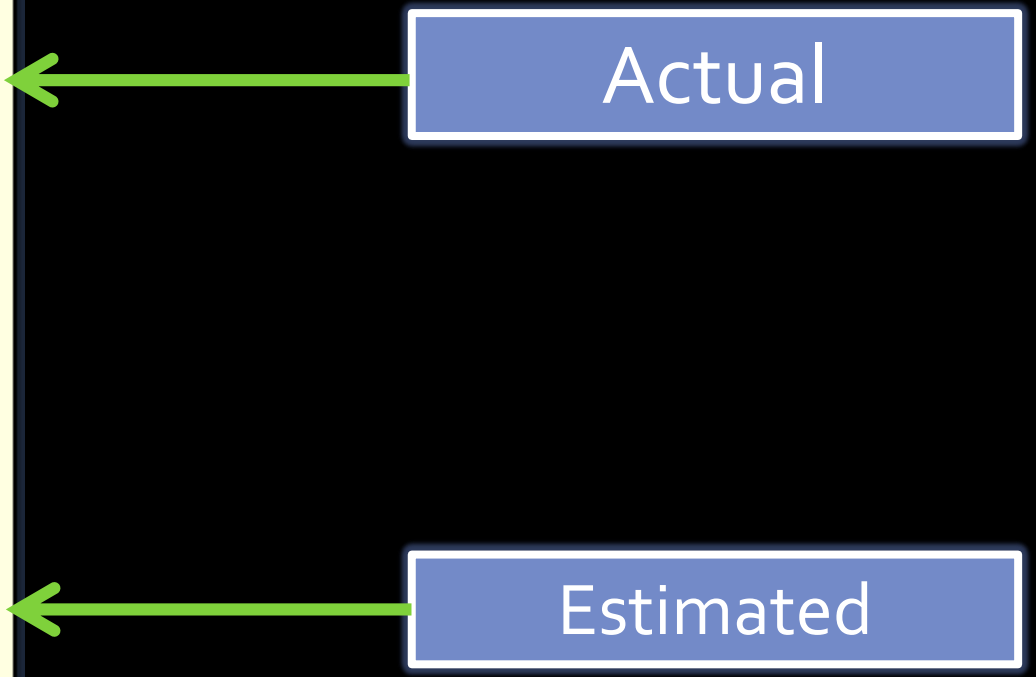
- Cardinality of a set is a measure of the "number of elements of the set".

Cardinality

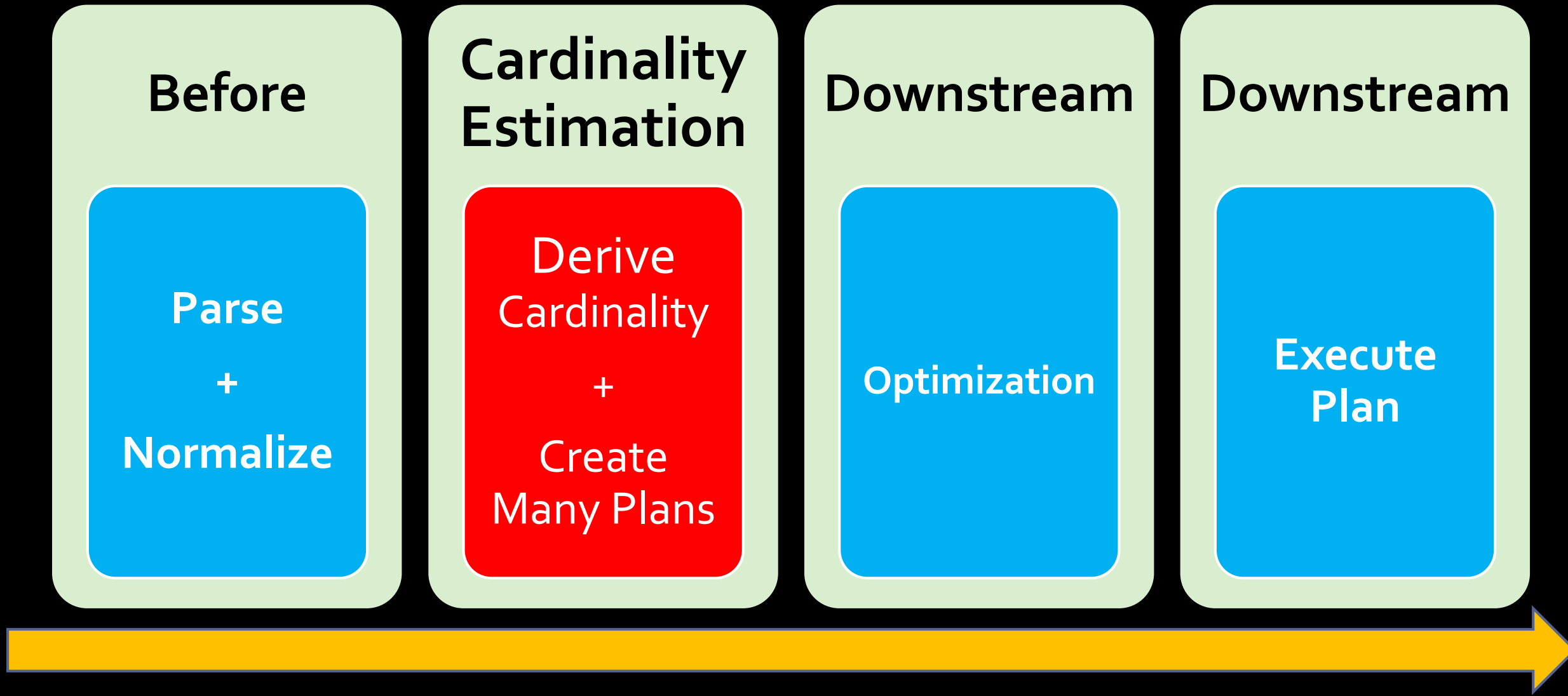
Clustered Index Seek (Clustered)

Scanning a particular range of rows from a clustered index.

Physical Operation	Clustered Index Seek
Logical Operation	Clustered Index Seek
Actual Execution Mode	Row
Estimated Execution Mode	Row
Storage	RowStore
Actual Number of Rows	12
Actual Number of Batches	0
Estimated Operator Cost	0.0032904 (8%)
Estimated I/O Cost	0.003125
Estimated Subtree Cost	0.0032904
Estimated CPU Cost	0.0001654
Estimated Number of Executions	1
Number of Executions	1
Estimated Number of Rows	7.61577
Estimated Row Size	143 B



Why Cardinality Matters



Why Cardinality Matters

Cost	Memory Grant	Access Method	Algorithm
Parallel	In Memory	Seek	Join
Serial	Spill to Disk	Scan	Aggregate
		Seek + Scan	Sort

DBCC SHOW_STATISTICS

Header

- Meta data about the statistics.

Density Vector

- How many unique values are present within a column or columns?

Histogram

- Frequency of data within the first key column of the statistics.

DBCC SHOW_STATISTICS

❑ STAT_HEADER

Name	Updated	Rows	Rows Sampled	Steps	Density	Average key length	String Index	Filter Expression	Unfiltered Rows
FK_Sales_Orders_ContactPersonID	Jun 2 2016 10:45AM	71583	71583	200	0.009388237	8	NO	NULL	71583

❑ DENSITY_VECTOR

	All density	Average Length	Columns
1	0.001512859	4	ContactPersonID
2	1.39698E-05	8	ContactPersonID, OrderID

❑ HISTOGRAM

	RANGE_HI_KEY	RANGE_ROWS	EQ_ROWS	DISTINCT_RANGE_ROWS	AVG_RANGE_ROWS
1	1001	0	128	0	1
2	1007	248	107	2	124
3	1013	231	130	2	115.5
4	1021	327	111	3	109
5	1025	101	85	1	101
6	1031	237	133	2	118.5

STAT_HEADER

Name	Updated	Rows	Rows Sampled	Steps
NCI_FilteredContactPersonID	Mar 31 2017 4:55PM	50299	50299	200

Deprecated

Density	Average key length	String Index	Filter Expression	Unfiltered Rows
0.00945746	8	NO	([contactpersonid]>(2000))	73595

DENSITY_VECTOR

1/Number of distinct values in column

Names of columns in the prefix

All density	Average Length	Columns
0.002164502	4	ContactPersonID
1.988111E-05	8	ContactPersonID, OrderID

Histogram

	RANGE_HI_KEY	RANGE_ROWS	EQ_ROWS	DISTINCT_RANGE_ROWS	AVG_RANGE_ROWS
1	1001	0	129	0	1
2	1007	255	107	2	127.5
3	1013	236	133	2	118
4	1021	338	113	3	112.6667
5	1025	103	89	1	103
6	1031	241	138	2	120.5
7	1037	226	108	2	113
8	1043	211	95	2	105.5
9	1047	107	106	1	107
10	1055	371	126	3	123.6667
11	1063	356	139	3	118.6667
12	1069	225	136	2	112.5
13	1075	231	133	2	115.5
14	1081	193	112	2	96.5
15	1089	353	125	3	117.6667

Histogram

RANGE_HI_KEY	RANGE_ROWS	EQ_ROWS	DISTINCT_RANGE_ROWS	AVG_RANGE_ROWS
1055		126		
Between 1056 and 1062	356		3	118.6667
1063		139		

Magic Numbers

- Single Predicate
  - Histogram direct hit
  - Histogram intra step
  - Scaling
  - Distinct

Magic Numbers

- Multiple Predicates
  - Conjunction
  - Disjunction
- Parameter Sniffing
- Unknown
- Ascending Key


Demo

Adaptive Query Processing

- Announced on April 19, 2017
- Joe Sack (Microsoft Program Manager)
  - Blog
  - Video

Resource

- Query Tuning Fundamentals
- DBCC SHOW_STATISTICS (Transact-SQL)
- 13 Things You Should Know About Statistics and the Query Optimizer
- Cardinality Estimation for Multiple Predicates
- New Trace Flag to Fix Table Variable Performance
- Ascending key Issue TF 2389 and 2390
- Optimizing Query Plans with the SQL Server 2014 Cardinality Estimator

Resource

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Resource-Adaptive Query Processing

- **Blog-Introducing Batch Mode Adaptive Joins**
- **Video-**SQL Server 2017: Adaptive Query Processing

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THANK
YOU