Text Processing with Hive

In this chapter, you will learn

- **How to use Hive's most important string functions**
- **How to format numeric values**
- **How to use regular expressions in Hive**
- **What n-grams are and why they are useful**
- **How to estimate how often words or phrases occur in text**

Chapter Topics

Text Processing with Hive

- **Overview of Text Processing**
- Important String Functions
- Using Regular Expressions in Hive
- Sentiment Analysis and n-grams
- Optional Hands-On Exercise: Gaining Insight with Sentiment Analysis
- Conclusion

Text Processing Overview

- **Traditional data processing relies on highly-structured data**
  - Carefully curated information in rows and columns
- **What types of data are we producing today?**
  - Free-form notes in electronic medical records
  - Application and server log files
  - Social network connections
  - Electronic messages
  - Product ratings
- **These types of data also contain great value**
  - But extracting it requires a different approach

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Basic String Functions

- **Hive supports many string functions often found in RDBMSs**

Function Description	Example Invocation	Input	Output
Convert to uppercase	`UPPER(name)`	`Bob`	`BOB`
Convert to lowercase	`LOWER(name)`	`Bob`	`bob`
Remove whitespace at start/end	`TRIM(name)`	`␣Bob␣`	`Bob`
Remove only whitespace at start	`LTRIM(name)`	`␣Bob␣`	`Bob␣`
Remove only whitespace at end	`RTRIM(name)`	`␣Bob␣`	`␣Bob`
Extract portion of string *	`SUBSTRING(name, 0, 3)`	`Samuel`	`Sam`

* *Unlike SQL, starting position is zero-based in Hive*

Parsing URLs with Hive

- **Hive offers built-in support for parsing Web addresses (URLs)**
- **The following examples assume the following URL as input**
  - `http://www.example.com/click.php?A=42&Z=105`

Example Invocation	Output
`PARSE_URL(url, 'PROTOCOL')`	`http`
`PARSE_URL(url, 'HOST')`	`www.example.com`
`PARSE_URL(url, 'PATH')`	`/click.php`
`PARSE_URL(url, 'QUERY')`	`A=42&Z=105`
`PARSE_URL(url, 'QUERY', 'A')`	`42`
`PARSE_URL(url, 'QUERY', 'Z')`	`105`

Numeric Format Functions

- **Hive offers two functions for formatting a number**
  - Simple: `FORMAT_NUMBER` (0.10.0 and later)
  - Versatile: `PRINTF` (0.9.0 and later)

Example Invocation	Input	Output
`FORMAT_NUMBER(commission, 2)`	`2345.519728`	`2,345.52`
`PRINTF("$%1.2f", total_price)`	`356.9752`	`$356.98`
`PRINTF("%s owes $%1.2f", name, amt)`	`Bob, 3.9`	`Bob owes $3.90`
`PRINTF("%.2f%%", taxrate * 100)`	`0.47314`	`47.31%`

- **Caution: avoid storing precise values as floating point numbers!**
  - These functions are best used for formatting results

Splitting and Combining Strings

- **`CONCAT` combines one or more strings**
  - The `CONCAT_WS` variation joins them with a separator
- **`SPLIT` does nearly the opposite**
  - Difference: return value is `ARRAY<STRING>`

Example Invocation	Output
`CONCAT('alice', '@example.com')`	`alice@example.com`
`CONCAT_WS(' ', 'Bob', 'Smith')`	`Bob Smith`
`CONCAT_WS('/', 'Amy', 'Sam', 'Ted')`	`Amy/Sam/Ted`
`SPLIT('Amy/Sam/Ted', '/')`	`["Amy","Sam","Ted"]` *

* *Representation of* ***`ARRAY<STRING>`***

Converting Array to Records with EXPLODE

- **The EXPLODE function creates a record for each element in an array**
  - An example of a *table generating function*
  - The alias is required when invoking table generating functions

```
hive> SELECT people FROM example;
Amy,Sam,Ted

hive> SELECT SPLIT(people, ',') FROM example;
["Amy","Sam","Ted"]

hive> SELECT EXPLODE(SPLIT(people, ',')) AS x FROM example;
Amy
Sam
Ted
```

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Regular Expressions

- **A regular expression (*regex*) matches a pattern in text**
  - Useful when exact matching is not practical

Regular Expression	String (matched portion in bold)
Dualcore	I wish **Dualcore** had 2 stores in 90210.
\\d	I wish Dualcore had **2** stores in 90210.
\\d{5}	I wish Dualcore had 2 stores in **90210.**
\\d\\s\\w+	I wish Dualcore had **2 stores** in 90210.
\\w{5,9}	I wish **Dualcore** had 2 stores in 90210.
.?\\.	I wish Dualcore had 2 stores in 9021**0.**
.*\\.	**I wish Dualcore had 2 stores in 90210.**

Hive's Regular Expression Functions

- **Hive has two important functions that use regular expressions**
  - `REGEXP_EXTRACT` returns the matched text
  - `REGEXP_REPLACE` substitutes another value for the matched text
- **These examples assume that `txt` has the following value**
  - `It's on Oak St. or Maple St in 90210`

```
hive> SELECT REGEXP_EXTRACT(txt, '(\\d{5})', 1)
      FROM message;
90210

hive> SELECT REGEXP_REPLACE(txt, 'St.?\\s+', 'Street ')
      FROM message;
It's on Oak Street or Maple Street in 90210
```

Regex SerDe

- **We sometimes need to analyze data that lacks consistent delimiters**
  - Log files are a common example of this

```
05/23/2013 19:45:19 312-555-7834 CALL_RECEIVED ""
05/23/2013 19:45:23 312-555-7834 OPTION_SELECTED "Shipping"
05/23/2013 19:46:23 312-555-7834 ON_HOLD ""
05/23/2013 19:47:51 312-555-7834 AGENT_ANSWER "Agent ID N7501"
05/23/2013 19:48:37 312-555-7834 COMPLAINT "Item not received"
05/23/2013 19:48:41 312-555-7834 CALL_END "Duration: 3:22"
```

- **`RegexSerDe` will read records based on supplied regular expression**
  - Allows us to create a table from this log file

Creating a Table with Regex SerDe (1)

Log excerpt

```
05/23/2013 19:45:19 312-555-7834 CALL_RECEIVED ""
05/23/2013 19:48:37 312-555-7834 COMPLAINT "Item not received"
```

RegexSerDe

```
CREATE TABLE calls (
   event_date STRING,
   event_time STRING,
   phone_num STRING,
   event_type STRING,
   details STRING)
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.RegexSerDe'
WITH SERDEPROPERTIES ("input.regex" =
       "([^ ]*) ([^ ]*) ([^ ]*) ([^ ]*) \"([^\"]*)\"");
```

- **Each pair of parentheses denotes a field**
  - Field value is text matched by pattern within parentheses

Creating a Table with Regex SerDe (2)

Log excerpt

```
05/23/2013 19:45:19 312-555-7834 CALL_RECEIVED ""
05/23/2013 19:48:37 312-555-7834 COMPLAINT "Item not received"
```

RegexSerDe

```
CREATE TABLE calls (
   event_date STRING,
   event_time STRING,
   phone_num STRING,
   event_type STRING,
   details STRING)
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.RegexSerDe'
WITH SERDEPROPERTIES ("input.regex" =
      "([^ ]*) ([^ ]*) ([^ ]*) ([^ ]*) \"([^\"]*)\"");
```

Table excerpt

event_date	event_time	phone_num	event_type	details
05/23/2013	19:45:19	312-555-7834	CALL_RECEIVED	
05/23/2013	19:45:37	312-555-7834	COMPLAINT	Item not received

Regex SerDe in Older Versions of Hive

- **The Regex SerDe wasn't formally part of Hive prior to 0.10.0**
  - It shipped with Hive, but was part of the "hive-contrib" library
- **To use Regex SerDe in 0.9.x and earlier versions of Hive**
  - Add this JAR file to Hive
  - Change the SerDe's package name, as shown below

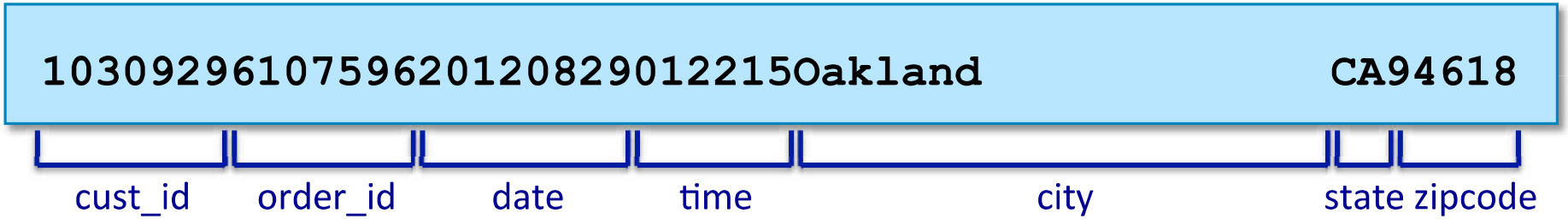
```
CREATE TABLE calls (
  details STRING)
ROW FORMAT SERDE 'org.apache.hadoop.hive.serde2.RegexSerDe'
WITH SERDEPROPERTIES ("input.regex" =
      "([^ ]*) ([^ ]*) ([^ ]*) ([^ ]*) \"([^\"]*)\"");
```

The package name used in older versions is slightly different:

`org.apache.hadoop.hive.contrib.serde2.RegexSerDe`

Fixed-Width Formats in Hive

- **Many older applications produce data in fixed-width formats**



- **Unfortunately, Hive doesn't directly support these**
  - But you can overcome this limitation by using `RegexSerDe`
- **Caveat: all fields in `RegexSerDe` are of type `STRING`**
  - May need to cast numeric values in your queries

Fixed-Width Format Example

Input data

```
10309296107596201208290122150akland                    CA94618
```

RegexSerDe

```
CREATE TABLE fixed (
   cust_id STRING,
   order_id STRING,
   order_dt STRING,
   order_tm STRING,
   city STRING,
   state STRING,
   zip STRING)
  ROW FORMAT SERDE
    'org.apache.hadoop.hive.serde2.RegexSerDe'
    WITH SERDEPROPERTIES ("input.regex" =
       "(\\d{7})(\\d{7})(\\d{8})(\\d{6})(.{20})(\\w{2})(\\d{5})");
```

cust_id	order_id	order_dt	order_tm	city	state	zipcode
1030929	6107596	20120829	012215	Oakland	CA	94618

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Parsing Sentences into Words

- **Hive's `SENTENCES` function parses supplied text into words**
- **Input is a string containing one or more sentences**
- **Output is a two-dimensional array of strings**
  - Outer array contains one element per sentence
  - Inner array contains one element per word in that sentence

```
hive> SELECT txt FROM phrases WHERE id=12345;
I bought this computer and really love it! It's very fast and
does not crash.

hive> SELECT SENTENCES(txt) FROM phrases WHERE id=12345;
[["I","bought","this","computer","and","really","love","it"],
 ["It's","very","fast","and","does","not","crash"]]
```

Sentiment Analysis

- **Sentiment analysis is an application of text analytics**
  - Classification and measurement of opinions
  - Frequently used for social media analysis
- **Context is essential for human languages**
  - Which word combinations appear together?
  - How frequently do these combinations appear?
- **Hive offers functions that help answer these questions**

n-grams

- **An n-gram is a word combination (n=number of words)**
  - Bigram is a sequence of two words (n=2)
- **n-gram frequency analysis is an important step in many applications**
  - Suggesting spelling corrections in search results
  - Finding the most important topics in a body of text
  - Identifying trending topics in social media messages

Calculating n-grams in Hive (1)

- **Hive offers the `NGRAMS` function for calculating n-grams**
- **The function requires three input parameters**
  - Array of strings (sentences), each containing an array (words)
  - Number of words in each n-gram
  - Desired number of results (top-N, based on frequency)
- **Output is an array of `STRUCT` with two attributes**
  - `ngram`: the n-gram itself (an array of words)
  - `estfrequency`: estimated frequency at which this n-gram appears

Calculating n-grams in Hive (2)

- **The NGRAMS function is often used with the SENTENCES function**
  - We also used LOWER to normalize case
  - And EXPLODE to convert the resulting array to a series of rows

```
hive> SELECT txt FROM phrases WHERE id=56789;
This tablet is great. The size is great. The screen is
great. The audio is great. I love this tablet! I love
everything about this tablet!!!

hive> SELECT EXPLODE(NGRAMS(SENTENCES(LOWER(txt)), 2, 5))
      AS bigrams FROM phrases WHERE id=56789;
{"ngram":["is","great"],"estfrequency":4.0}
{"ngram":["great","the"],"estfrequency":3.0}
{"ngram":["this","tablet"],"estfrequency":3.0}
{"ngram":["i","love"],"estfrequency":2.0}
{"ngram":["tablet","i"],"estfrequency":1.0}
```

Finding Specific n-grams in Text

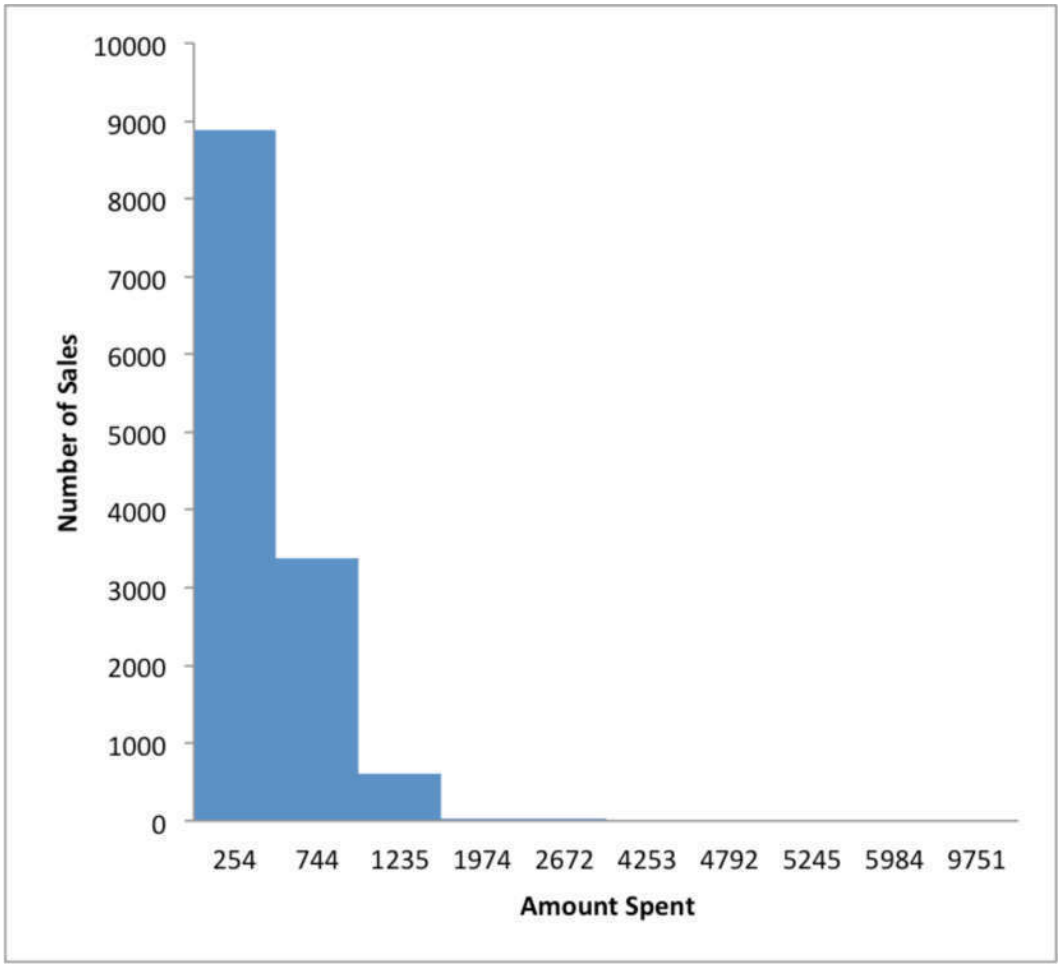
- **CONTEXT_NGRAMS is similar, but considers only specific combinations**
  - Additional input parameter: array of words used for filtering
  - Any NULL values in the array are treated as placeholders

```
hive> SELECT txt FROM phrases
      WHERE txt LIKE '%new computer%';
My new computer is fast! I wish I'd upgraded sooner.
This new computer is expensive, but I need it now.
I can't believe her new computer failed already.

hive>SELECT EXPLODE(CONTEXT_NGRAMS(SENTENCES(LOWER(phrase)),
     ARRAY("new", "computer", NULL, NULL), 4, 3)) AS ngrams
     FROM phrases;
{"ngram":["is","expensive"],"estfrequency":1.0}
{"ngram":["failed","already"],"estfrequency":1.0}
{"ngram":["is","fast"],"estfrequency":1.0}
```

Histograms

- **Histograms illustrate how values in the data are distributed**
  - This helps us estimate the overall shape of the data distribution



Calculating Data for Histograms

- **HISTOGRAM_NUMERIC creates data needed for histograms**
  - Input: column name and number of "bins" in the histogram
  - Output: coordinates representing bin centers and heights

```
hive> SELECT EXPLODE(HISTOGRAM_NUMERIC(
        total_price, 10)) AS dist FROM cart_orders;
{"x":25417.336745023003,"y":8891.0}
{"x":74401.5041469194,"y":3376.0}
{"x":123550.04418985262,"y":611.0}
{"x":197421.12500000006,"y":24.0}
{"x":267267.53846153844,"y":26.0}
{"x":425324.0,"y":4.0}
{"x":479226.38461538474,"y":13.0}
{"x":524548.0,"y":6.0}
{"x":598463.5,"y":2.0}
{"x":975149.0,"y":2.0}
```

Import this data into charting software to produce a histogram

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Hands-on Exercise: Gaining Insight with Sentiment Analysis

- **In this Hands-On Exercise, you will analyze comments in product rating data with Hive**
- **Please refer to the Hands-On Exercise Manual for instructions**

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Essential Points

- **Most data produced these days lacks rigid structure**
  - Text processing can help us analyze loosely-structured data
- **The `SPLIT` function creates an array from a string**
  - `EXPLODE` creates individual records from an array
- **Hive has extensive support for regular expressions**
  - You can extract or substitute values based on patterns
  - You can even create a table based on regular expressions
- **An n-gram is a sequence of words**
  - Use `NGRAMS` and `CONTEXT_NGRAMS` to find their frequency