Manipulating the granularity of time series data

TIME SERIES ANALYSIS IN POSTGRESQL

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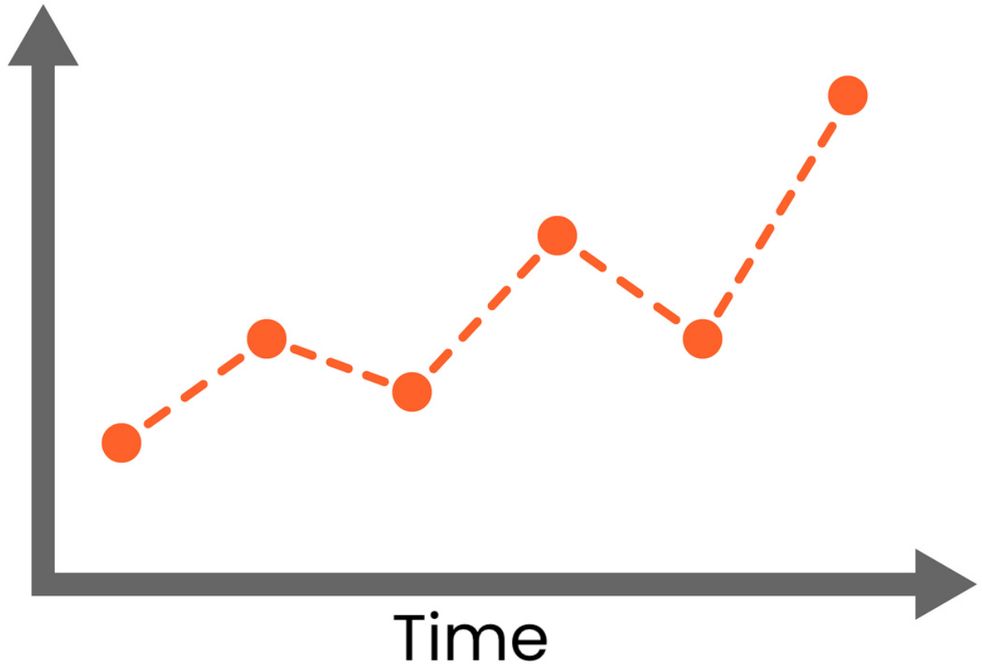
Time series data

- Type of data and time data
- Ordered
- Collected over a period of time
- Common examples: stock prices, temperature



Time series data: train times

```
SELECT station, arrival_time
FROM train_schedule
WHERE train_id = 324
```

```
|station      |arrival_time|
|-------------|------------|
|San Francisco|    07:59:00|
|22nd Street  |    08:03:00|
|Millbrae     |    08:16:00|
|Hillsdale    |    08:24:00|
|Redwood City |    08:31:00|
|Palo Alto    |    08:37:00|
...
```

Multivariate time series

```
SELECT year_month, t_monthly_min, t_monthly_max, t_monthly_avg
FROM temperature_stations AS ts
JOIN temperatures_monthly AS tm USING(station_id)
WHERE station_id = 1
```

```
|year_month|t_monthly_min|t_monthly_max|t_monthly_avg|
|----------|-------------|-------------|-------------|
|2010-01-01|          6.7|         20.3|         13.6|
|2010-02-01|          8.3|         20.8|         14.8|
|2010-03-01|          9.1|         23.9|         17.0|
|2010-04-01|         11.3|         27.1|         20.0|
|2010-05-01|         15.0|         32.1|         24.8|
...
```

Time granularity

- More granularity = more precise measurements
- Common granularities: seconds, minutes, hours, days, weeks, months, quarters, and years

```
SELECT ts, views
FROM dc_news_fact
WHERE id = '12561'
ORDER BY ts;
```

```
|ts                   |views|
|---------------------|-----|
|2015-12-29 11:40:23| 4161|
|2015-12-29 12:00:23|  407|
|2015-12-29 12:20:23|    0|
|2015-12-29 12:40:23|  778|
|2015-12-29 13:00:23|  396|
...
```

Changing time granularity

- `DATE_TRUNC()` : alters granularity of time series data
  - Such as: century, decade, quarter, microseconds and more

- `DATE_TRUNC(field, source, time zone)`
  - field = granular value (eg. "hour")
  - source = the data
  - time zone = defaults to current setting

Changing time granularity

```
SELECT
    DATE_TRUNC('hour', ts) AS hour,
    SUM(VIEWS) AS views
FROM dc_news_fact
WHERE id = '12561'
GROUP BY hour
ORDER BY hour;
```

```
|hour                 |views|
|---------------------|-----|
|2015-12-29 09:00:00|    0|
|2015-12-29 10:00:00|    0|
|2015-12-29 11:00:00| 4161|
|2015-12-29 12:00:00| 1185|
|2015-12-29 13:00:00| 1146|
|2015-12-29 14:00:00|  697|
|2015-12-29 15:00:00| 1013|
|2015-12-29 16:00:00|  956|
|2015-12-29 17:00:00| 1307|
|2015-12-29 18:00:00|  700|
...
```

Extracting time granularity

- `DATE_PART()` : extracts specific data

- `DATE_PART(field, source)`
  - field = granular value (eg. "hour")
  - source = the data: a timestamp or interval

- `EXTRACT()` also extracts specific data
  - Recommended instead of `DATE_PART()`
  - `DATE_PART()` returns a result in double precision which is imprecise

Hour granularity

```
SELECT
    DATE_PART('hour', ts)
    AS hour_of_day,
    SUM(VIEWS) AS views
FROM dc_news_fact
WHERE id = '12561'
GROUP BY hour_of_day
ORDER BY hour_of_day;
```

```
|hour_of_day|views|
|-----------|-----|
|          0|  500|
|          1|  500|
|          2|  400|
|          3|  400|
|          4| 1200|
|          5|  100|
|          6|  100|
|          7| 2000|
|          8|  200|
|          9| 2500|
...
```

Day of week granularity

```
SELECT
    EXTRACT(dow FROM ts)
    AS day_of_week,
    SUM(VIEWS) AS views
FROM dc_news_fact
WHERE id = '12561'
GROUP BY day_of_week
ORDER BY day_of_week;
```

```
|day_of_week|views|
|-----------|-----|
|          2|15265|
|          3|13100|
|          4| 1200|
```

- Day of week: Sunday (0) to Saturday (6)

Let's practice!

TIME SERIES ANALYSIS IN POSTGRESQL

Adding and subtracting date and time data

TIME SERIES ANALYSIS IN POSTGRESQL

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Time differences

- `AGE()` : subtracts the second argument from the first argument or the current date
- `AGE(timestamp, timestamp)` or `AGE(timestamp)`

```
SELECT
AGE('2018-01-02','2017-01-01') AS "2017",
AGE('2021-01-05','2020-01-01') AS "2020";
```

```
|2017        |2020          |
|------------|--------------|
|1 year 1 day|1 year 4 days|
```

Misinterpreting differences

```
SELECT
AGE('2017-12-31','2017-01-01') AS "2017",
AGE('2018-12-31','2018-01-01') AS "2018",
AGE('2019-12-31','2019-01-01') AS "2019",
AGE('2020-12-31','2020-01-01') AS "2020";
```

```
|2017           |2018           |2019           |2020           |
|---------------|---------------|---------------|---------------|
|11 mons 30 days|11 mons 30 days|11 mons 30 days|11 mons 30 days|
```

The subtract operator

```
SELECT
'2018-01-01'::DATE - '2017-01-01'::DATE AS "2017",
'2019-01-01'::DATE - '2018-01-01'::DATE AS "2018",
'2020-01-01'::DATE - '2019-01-01'::DATE AS "2019",
'2021-01-01'::DATE - '2020-01-01'::DATE AS "2020";
```

```
|2017|2018|2019|2020|
|----|----|----|----|
| 365| 365| 365| 366|
```

Using the subtract operator

- `-` : subtract operator
- Provides an `INTERVAL` data type
- `INTERVAL` allows us to store and manipulate a period of time

```
SELECT
    '2021-01-01 00:03:00'::TIMESTAMP - '2021-01-01 00:01:30'::TIMESTAMP
    AS interval;
```

```
|interval|
|--------|
|00:01:30|
```

Time intervals

```
WITH line_324 AS (
    SELECT station, arrival_time
    FROM train_schedule
    WHERE train_id=324 )
SELECT hillsdale.arrival_time - millbrae.arrival_time AS diff
FROM line_324 AS millbrae, line_324 AS hillsdale
WHERE millbrae.station='Millbrae'
AND hillsdale.station='Hillsdale';
```

- CTE : Common Table Expression, defines a temporary table for one query

[1] https://www.caltrain.com/schedules/weekdaytimetable.html

Time intervals

```
WITH line_324 AS (
    SELECT station, arrival_time
    FROM train_schedule
    WHERE train_id=324 )
SELECT hillsdale.arrival_time - millbrae.arrival_time AS diff
FROM line_324 AS millbrae, line_324 AS hillsdale
WHERE millbrae.station='Millbrae'
AND hillsdale.station='Hillsdale';
```

```
|diff    |
|--------|
|00:08:00|
```

[1] https://www.caltrain.com/schedules/weekdaytimetable.html

Subtracting an interval

```
SELECT
    '2020-02-01'::DATE - INTERVAL '1 month' AS "1 month sooner";
```

```
|1 month sooner     |
|-------------------|
|2020-01-01 00:00:00|
```

Converting an interval to a specified unit of time

- `EXTRACT(epoch FROM start_time - end_time)`

```
SELECT EXTRACT(epoch FROM
    ('2021-01-01 00:03:00'::TIMESTAMP - '2021-01-01 00:01:30'::TIMESTAMP))
    AS seconds;
```

```
|seconds|
|-------|
|   90.0|
```

Converting an interval to a specified unit of time

```
SELECT (EXTRACT(epoch FROM
    ('2021-01-01 00:01:00'::TIMESTAMP - '2020-12-31 23:59:30'::TIMESTAMP)))
    / 60 AS minutes;
```

```
|minutes|
|-------|
|    1.5|
```

Adding time

```
SELECT '2019-02-01'::DATE + INTERVAL '28 days' AS "28 days later";
```

```
|28 days later      |
|-------------------|
|2019-03-01 00:00:00|
```

```
SELECT '2020-02-01'::DATE + INTERVAL '28 days' AS "28 days later";
```

```
|28 days later      |
|-------------------|
|2020-02-29 00:00:00|
```

Adding a month to a date

```
SELECT '2019-02-01'::DATE + INTERVAL '1 month' AS "1 month later";
```

```
|1 month later       |
|--------------------|
|2019-03-01 00:00:00|
```

```
SELECT '2020-02-01'::DATE + INTERVAL '1 month' AS "1 month later";
```

```
|1 month later       |
|--------------------|
|2020-03-01 00:00:00|
```

Let's practice!

TIME SERIES ANALYSIS IN POSTGRESQL

Aggregating time series data

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Measuring the length of time series

- `dc_news_fact` : table with time series data for news articles
- `dc_news_dim` : table with the title of the articles

```
SELECT
    COUNT(*) AS length,
    title
FROM dc_news_fact
JOIN dc_news_dim USING(id)
GROUP BY title
ORDER BY length DESC;
```

Measuring the length of time series

```
|length|title                                                    |
|------|---------------------------------------------------------|
|   144|For the Wealthiest, a Private Tax System That Saves Them Billions|
|   144|These 5 charts prove that the economy does better under ...      |
|   144|Pet surrenders on rise as Fort McMurray's economy falls          |
|   144|How Is the Economy Doing? Politics May Decide Your Answer        |
|   144|Argentina's New President Moves Swiftly to Shake Up the Economy  |
```

Counting number of non-null entries in a time series

```
SELECT COUNT(views) AS nonnull, title
FROM dc_news_fact
JOIN dc_news_dim USING(id)
GROUP BY title
ORDER BY nonnull DESC;
```

```
|nonnull |title                          |
|--------|-------------------------------|
|     143|For the Wealthiest, a Pri...|
|     143|These 5 charts prove that...|
|     143|Pet surrenders on rise as...|
|     143|How Is the Economy Doing?...|
|     143|Argentina's New President...|
```

Counting number of non-zero entries in a time series

```
SELECT COUNT(views) AS nonzeros, title
FROM dc_news_fact
JOIN dc_news_dim USING(id)
WHERE views > 0
GROUP BY title
ORDER BY nonzeros DESC;
```

```
|nonzeros|title                        |
|--------|-----------------------------|
|      84|Pet surrenders on rise as...|
|      82|These 5 charts prove that...|
|      79|How Is the Economy Doing?...|
|      78|Argentina's New President...|
|      64|For the Wealthiest, a Pri...|
```

Calculating min and max over time series data

```
SELECT
    MIN(views) as min,
    MAX(views) as max,
    title
FROM dc_news_fact
JOIN dc_news_dim USING(id)
GROUP BY title
ORDER BY max DESC;
```

min	max	title
0	4161	For the Wealthiest, a Pri...
0	289	Argentina's New President...
0	141	Pet surrenders on rise as...
0	73	How Is the Economy Doing?...
0	53	These 5 charts prove that...

Summing time series data

```
SELECT SUM(views) as views, title
FROM dc_news_fact
JOIN dc_news_dim USING(id)
GROUP BY title
ORDER BY views DESC;
```

```
|views|title                              |
|-----|-----------------------------------|
|29565|For the Wealthiest, a Privat...|
| 1737|Pet surrenders on rise as Fo...|
| 1722|Argentina's New President Mo...|
| 1055|How Is the Economy Doing? Po...|
| 1043|These 5 charts prove that th...|
```

Adjusting time granularity

```
SELECT SUM(views) as views, DATE_TRUNC('day', ts) as date, title
FROM dc_news_fact
JOIN dc_news_dim USING(id)
GROUP BY title, date
ORDER BY title, date;
```

```
|views|date                 |title                                                |
|-----|---------------------|-----------------------------------------------------|
|   62|2015-12-27 00:00:00|Argentina's New President Moves Swiftly to Shake Up the ...|
|  414|2015-12-28 00:00:00|Argentina's New President Moves Swiftly to Shake Up the ...|
| 1246|2015-12-29 00:00:00|Argentina's New President Moves Swiftly to Shake Up the ...|
|15265|2015-12-29 00:00:00|For the Wealthiest, a Private Tax System That Saves Them...|
...
```

Adjusting time granularity

```
SELECT SUM(views) as views, ts::date as date, title
FROM dc_news_fact
JOIN dc_news_dim USING(id)
GROUP BY title, date
ORDER BY title, date;
```

```
|views|date      |title                                                    |
|-----|----------|---------------------------------------------------------|
|   62|2015-12-27|Argentina's New President Moves Swiftly to Shake Up the Economy |
|  414|2015-12-28|Argentina's New President Moves Swiftly to Shake Up the Economy |
| 1246|2015-12-29|Argentina's New President Moves Swiftly to Shake Up the Economy |
|15265|2015-12-29|For the Wealthiest, a Private Tax System That Saves Them Bill...|
...
```

Measuring the days

```
SELECT COUNT(DISTINCT ts::DATE) AS days, title
FROM dc_news_fact
JOIN dc_news_dim USING(id)
WHERE views > 0
GROUP BY title
ORDER BY days DESC, title;
```

```
|days|title                                                          |
|----|---------------------------------------------------------------|
|   3|Argentina's New President Moves Swiftly to Shake Up the Economy  |
|   3|For the Wealthiest, a Private Tax System That Saves Them Billions|
|   3|How Is the Economy Doing? Politics May Decide Your Answer        |
...
```

Let's practice!

TIME SERIES ANALYSIS IN POSTGRESQL

Applying statistical aggregates to time series data

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Statistical aggregates

- Aggregate functions: `MIN()`, `MAX()`, `SUM()`, `AVG()`, `COUNT()`
- Statistical aggregates: means and medians

Calculating the average

```
SELECT
  AVG(views)::INTEGER as avg_views
  title
FROM dc_news_fact
JOIN dc_news_dim USING(id)
GROUP BY title
ORDER BY avg_views DESC;
```

```
|avg_views|title                          |
|---------|-------------------------------|
|      207|For the Wealthiest, a Pr...|
|       12|Pet surrenders on rise a...|
|       12|Argentina's New Presiden...|
|        7|These 5 charts prove tha...|
|        7|How Is the Economy Doing...|
```

Average number of views per day

```
WITH day_views AS (
  SELECT id, ts::DATE AS date, SUM(views) AS views
  FROM dc_news_fact
  GROUP BY id, date
)
SELECT
  AVG(views)::INTEGER AS avg
  title
FROM day_views JOIN dc_news_dim USING(id)
GROUP BY title
ORDER BY avg DESC;
```

Average number of views per day

```
| avg|title                                                    |
|----|---------------------------------------------------------|
|9855|For the Wealthiest, a Private Tax System That Saves Them Billions|
| 579|Pet surrenders on rise as Fort McMurray's economy falls  |
| 574|Argentina's New President Moves Swiftly to Shake Up the Economy  |
| 352|How Is the Economy Doing? Politics May Decide Your Answer  |
| 348|These 5 charts prove that the economy does better under ...  |
```

Average number of views per day

```
SELECT
  (SUM(views)/COUNT(DISTINCT ts::DATE))::INTEGER as avg,
  title
FROM dc_news_fact JOIN dc_news_dim USING(id)
GROUP BY title
ORDER BY avg DESC;
```

```
|avg |title                                                    |
|----|---------------------------------------------------------|
|9855|For the Wealthiest, a Private Tax System That Saves Them Billions|
| 579|Pet surrenders on rise as Fort McMurray's economy falls  |
| 574|Argentina's New President Moves Swiftly to Shake Up the Economy  |
...
```

Discrete and continuous medians

- **Discrete median:** the first value closest to the middle value
- **Continuous median:** a value that cuts the dataset in half

Odd number of elements

- Series = (1, 2, 3, 4, 5)
- Discrete median = 3
- Continuous median = 3

Even number of elements

- Series = (1, 2, 3, 4)
- Discrete median = 2
- Continuous median = 2.5

Ordered-set aggregate functions

- `PERCENTILE_DISC()`
- `PERCENTILE_CONT()`
- Ordered-set aggregate functions :

```
PERCENTILE_DISC(fraction) WITHIN GROUP
(ORDER BY field)
```

```
SELECT
  PERCENTILE_CONT(0.5) WITHIN GROUP
  (ORDER BY value) AS median_cont,
  PERCENTILE_DISC(0.5) WITHIN GROUP
  (ORDER BY value) AS median_disc
FROM
(
  VALUES
  (1,1), (1,2), (1,3), (1,4), (1,5),
  (2,1), (2,5), (2,7), (2,11), (2,11)
) AS t (id, value)
GROUP BY id;
```

Ordered-set aggregate functions

```
|median_cont|median_disc|
|-----------|-----------|
|        3.0|          3|
|        7.0|          7|
```

Median, quantile, percentile, quartile

- Median is a type of percentile
- Percentile is a type of quantile

- **Quantile** : divides a sample into almost equal subsets
  - quartiles (four subsets)
  - deciles (ten subsets)

Calculating quartiles

```
SELECT
  PERCENTILE_DISC(0.25) WITHIN GROUP (ORDER BY value) AS ptile_25,
  PERCENTILE_DISC(0.5) WITHIN GROUP (ORDER BY value) AS ptile_50,
  PERCENTILE_DISC(0.75) WITHIN GROUP (ORDER BY value) AS ptile_75
FROM
(
  VALUES
  (1,1), (1,2), (1,3), (1,4), (1,5)
) AS t (id, value)
GROUP BY id;
```

```
|ptile_25|ptile_50|ptile_75|
|--------|--------|--------|
|       2|       3|       4|
```

Calculating an array of discrete quartiles

```
SELECT
  PERCENTILE_DISC(ARRAY[0.25, 0.5, 0.75])
  WITHIN GROUP (ORDER BY value) AS median_disc
FROM (
  VALUES
  (1,1), (1,2), (1,3), (1,4), (1,5) )
  AS t (id, value)
GROUP BY id;
```

```
|median_disc|
|-----------|
|{2,3,4}    |
```

Let's practice!

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