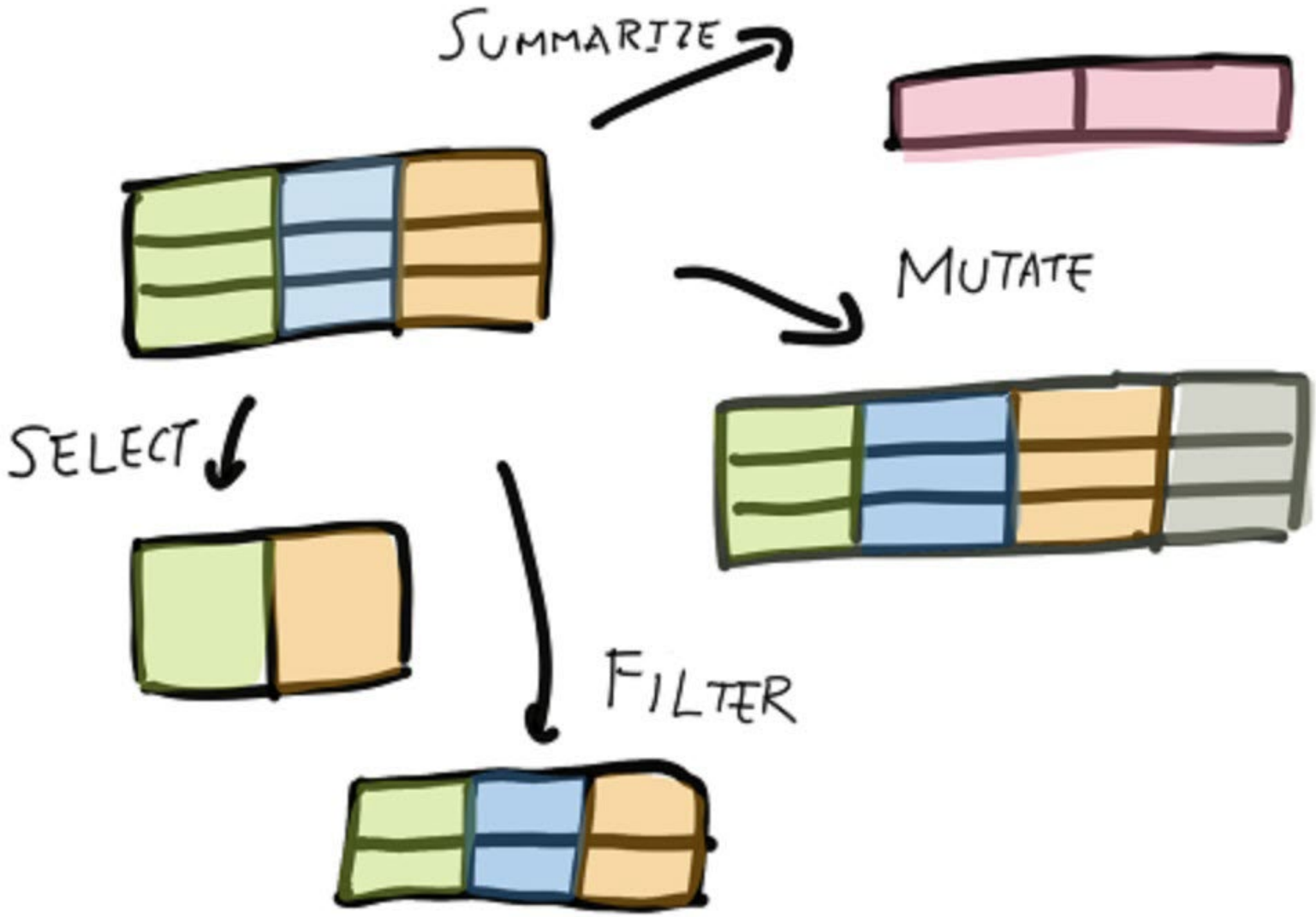
Window Functions

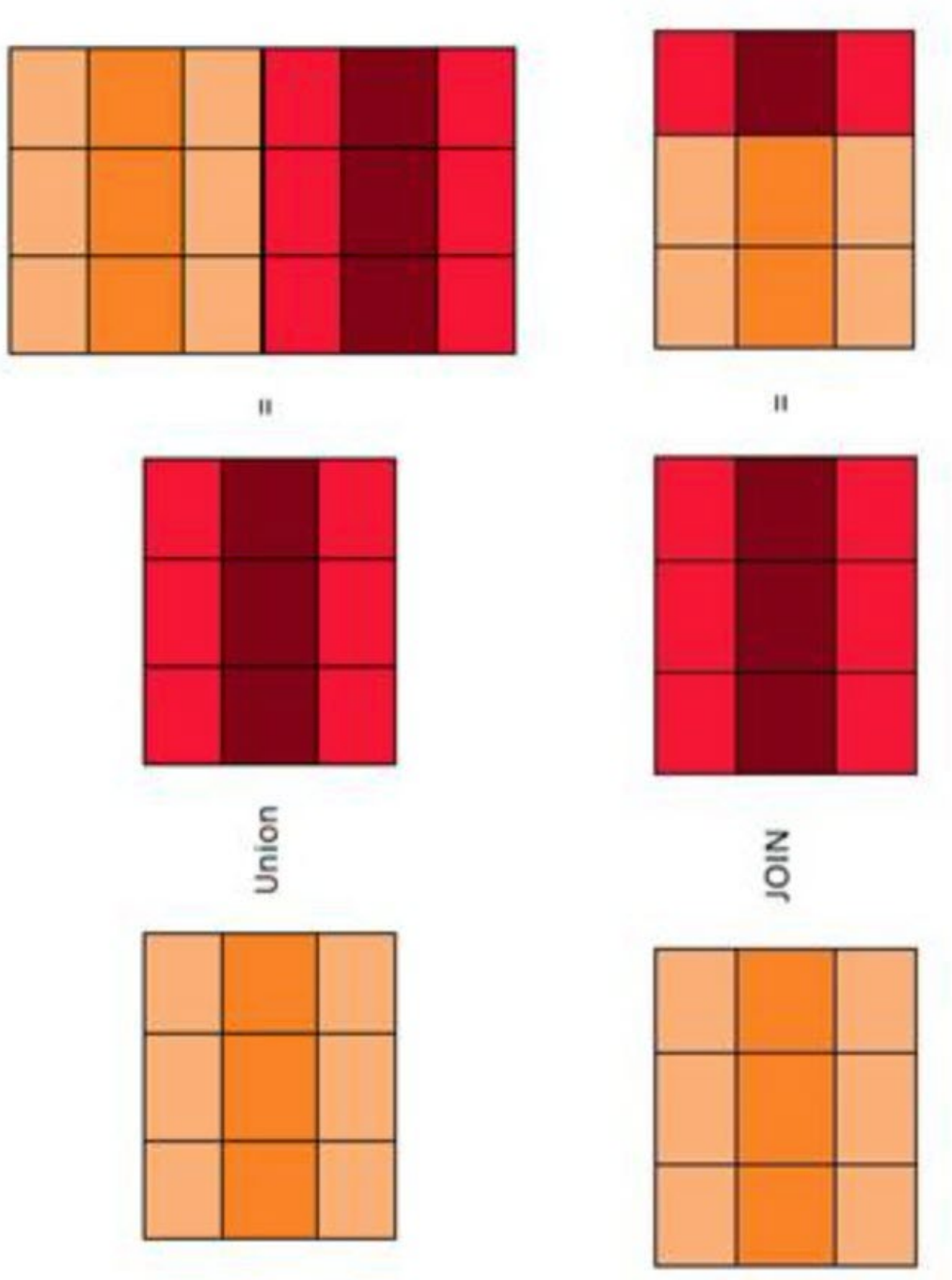
Andy Catlin

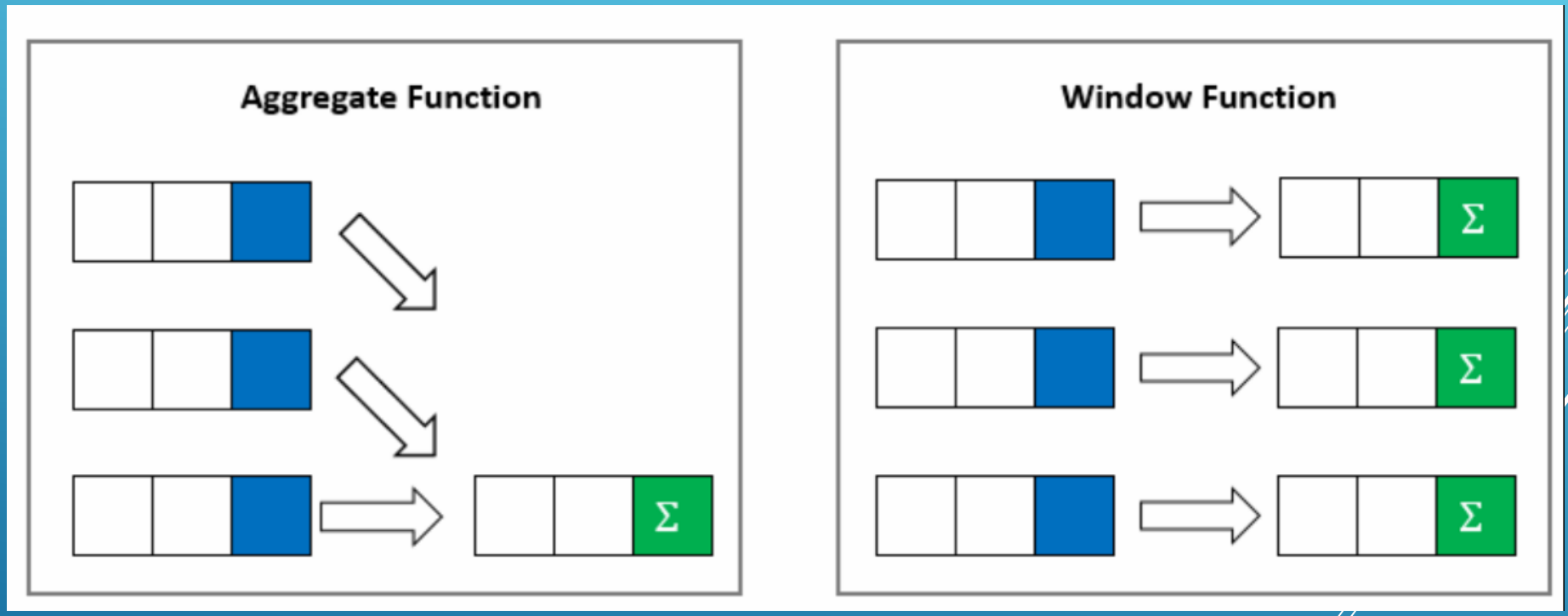
Rectangular Operations



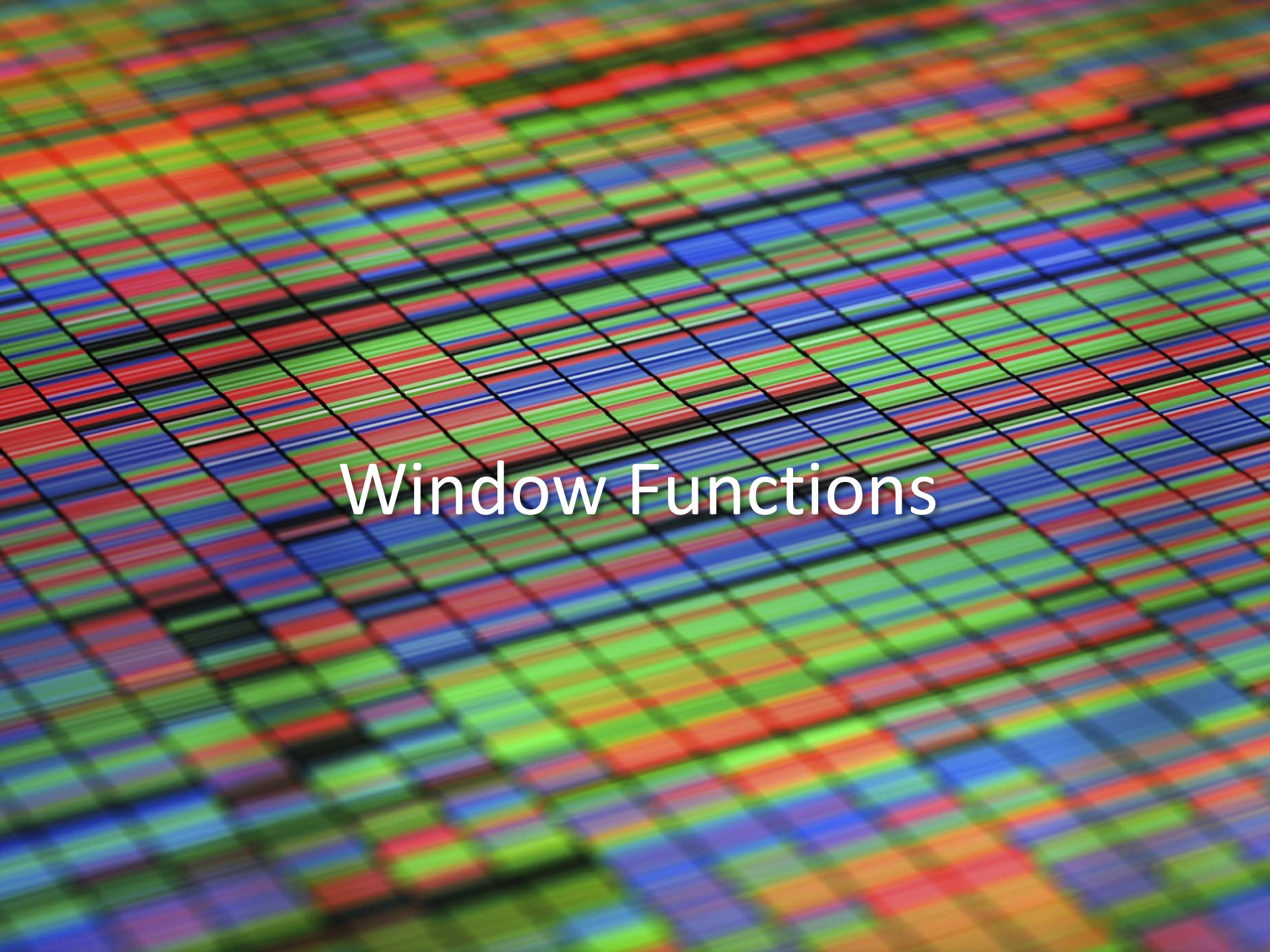
Source: https://changhsinlee.com/pyspark-dataframe-basics/

https://www.c-sharpcorner.com/blogs/union-vs-join-in-





https://www.sqltutorial.org/sql-window-functions/


Window Functions

The Power of Toy Datasets

game_date	home_team	away_team	home_points	away_points
2019-09-29	Bills	Patriots	10	16
2019-10-20	Bills	Dolphins	31	21
2019-12-29	Bills	Jets	6	13
2019-09-15	Dolphins	Patriots	0	43
2019-11-03	Dolphins	Jets	26	18
2019-11-17	Dolphins	Bills	20	37
2019-09-08	Jets	Bills	16	17
2019-10-21	Jets	Patriots	0	33
2019-12-08	Jets	Dolphins	22	21
2019-09-22	Patriots	Jets	30	14
2019-12-21	Patriots	Bills	24	17
2019-12-29	Patriots	Dolphins	24	27

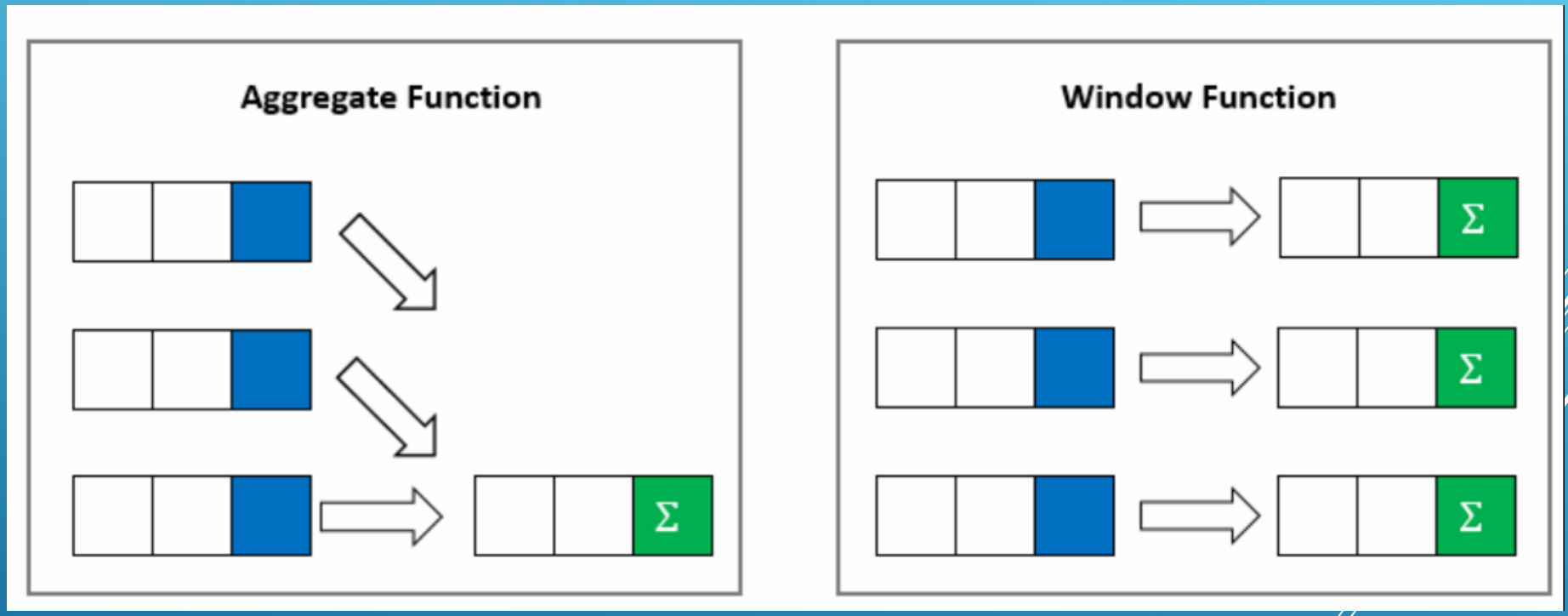
I won’t (at least happily) write the code before I figure out how to test the code

game_date	home_team	away_team	home_points	away_points
2019-09-29	Bills	Patriots	10	16
2019-10-20	Bills	Dolphins	31	21
2019-12-29	Bills	Jets	6	13
2019-09-15	Dolphins	Patriots	0	43
2019-11-03	Dolphins	Jets	26	18
2019-11-17	Dolphins	Bills	20	37
2019-09-08	Jets	Bills	16	17
2019-10-21	Jets	Patriots	0	33
2019-12-08	Jets	Dolphins	22	21
2019-09-22	Patriots	Jets	30	14
2019-12-21	Patriots	Bills	24	17
2019-12-29	Patriots	Dolphins	24	27

TASK: WRITE SQL TO DISPLAY INFORMATION ABOVE, AND TO CALCULATE NEW COLUMNS TO DISPLAY THE OVERALL AVERAGE HOME POINTS ACROSS ALL TEAMS(17.4), AND THE DIFFERENTIAL FROM EACH GAME'S SCORE TO THE OVERALL SCORE (FOR THE FIRST GAME ABOVE, -7.4)

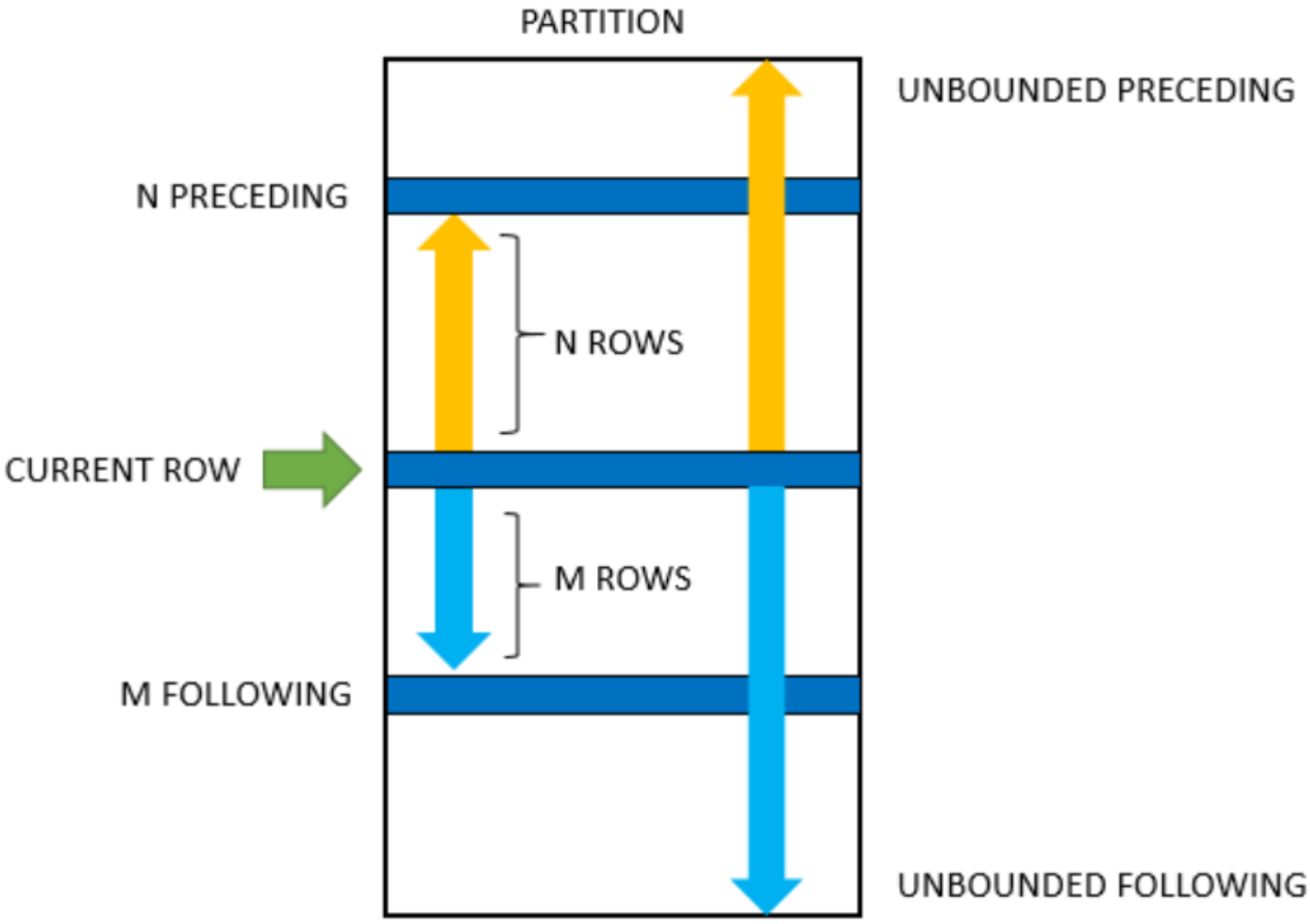
game_date	home_team	away_team	home_points	away_points
2019-09-29	Bills	Patriots	10	16
2019-10-20	Bills	Dolphins	31	21
2019-12-29	Bills	Jets	6	13
2019-09-15	Dolphins	Patriots	0	43
2019-11-03	Dolphins	Jets	26	18
2019-11-17	Dolphins	Bills	20	37
2019-09-08	Jets	Bills	16	17
2019-10-21	Jets	Patriots	0	33
2019-12-08	Jets	Dolphins	22	21
2019-09-22	Patriots	Jets	30	14
2019-12-21	Patriots	Bills	24	17
2019-12-29	Patriots	Dolphins	24	27

game_date	home_team	away_team	home_points	away_points	home_avg	home_differential
2019-09-29	Bills	Patriots	10	16	17.4	-7.4
2019-10-20	Bills	Dolphins	31	21	17.4	13.6
2019-12-29	Bills	Jets	6	13	17.4	-11.4
2019-09-15	Dolphins	Patriots	0	43	17.4	-17.4
2019-11-03	Dolphins	Jets	26	18	17.4	8.6
2019-11-17	Dolphins	Bills	20	37	17.4	2.6
2019-09-08	Jets	Bills	16	17	17.4	-1.4
2019-10-21	Jets	Patriots	0	33	17.4	-17.4
2019-12-08	Jets	Dolphins	22	21	17.4	4.6
2019-09-22	Patriots	Jets	30	14	17.4	12.6
2019-12-21	Patriots	Bills	24	17	17.4	6.6
2019-12-29	Patriots	Dolphins	24	27	17.4	6.6



https://www.sqltutorial.org/sql-window-functions/

```
-- subquery in SELECT list
SELECT *,
  (SELECT round(avg(home_points),1) AS home_avg FROM
afc_east),
  home_points - (SELECT round(avg(home_points),1) FROM
afc_east) AS home_differential
FROM afc_east
  ORDER BY home_team, game_date;
```



https://www.sqltutorial.org/sql-window-functions/

game_date	home_team	away_team	home_points	away_points	cum_home_points
2019-09-29	Bills	Patriots	10	16	10
2019-10-20	Bills	Dolphins	31	21	41
2019-12-29	Bills	Jets	6	13	47
2019-09-15	Dolphins	Patriots	0	43	0
2019-11-03	Dolphins	Jets	26	18	26
2019-11-17	Dolphins	Bills	20	37	46
2019-09-08	Jets	Bills	16	17	16
2019-10-21	Jets	Patriots	0	33	16
2019-12-08	Jets	Dolphins	22	21	38
2019-09-22	Patriots	Jets	30	14	30
2019-12-21	Patriots	Bills	24	17	54
2019-12-29	Patriots	Dolphins	24	27	78

In the window function's **OVER()** clause, the window of analysis is defined by the **PARTITION BY** clause; the frame of analysis can be further limited by the **ORDER BY** and **ROWS/RANGE BETWEEN** clauses.

```
SUM(HOME_POINTS)
  OVER(PARTITION BY HOME_TEAM
    ORDER BY GAME_DATE
    ROWS BETWEEN UNBOUNDED PRECEDING
    AND CURRENT ROW)
```

game_date	home_team	away_team	home_points	away_points	cum_home_points
2019-09-29	Bills	Patriots	10	16	10
2019-10-20	Bills	Dolphins	31	21	41
2019-12-29	Bills	Jets	6	13	47
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2019-09-08	Jets	Bills	16	17	16
2019-10-21	Jets	Patriots	0	33	16
2019-12-08	Jets	Dolphins	22	21	38
2019-09-22	Patriots	Jets	30	14	30
2019-12-21	Patriots	Bills	24	17	54
2019-12-29	Patriots	Dolphins	24	27	78

GROUP BY changes the structure of the resultset:
Many -> One

WINDOW FUNCTIONS do not change the structure of the resultset:
One -> One

```
SUM(HOME_POINTS)
  OVER(PARTITION BY HOME_TEAM
    ORDER BY GAME_DATE
    ROWS BETWEEN UNBOUNDED PRECEDING
    AND CURRENT ROW)
```

Aggregation	MIN, MAX, SUM, AVG, COUNT
Ranking	RANK, DENSE_RANK, ROW_NUMBER, NTILE
Offset	LEAD, LAG
Analytic/Distribution	PERCENT_RANK, CUME_DIST

game_date	home_team	away_team	home_points	away_points
2019-09-29	Bills	Patriots	10	16
2019-10-20	Bills	Dolphins	31	21
2019-12-29	Bills	Jets	6	13
2019-09-15	Dolphins	Patriots	0	43
2019-11-03	Dolphins	Jets	26	18
2019-11-17	Dolphins	Bills	20	37
2019-09-08	Jets	Bills	16	17
2019-10-21	Jets	Patriots	0	33
2019-12-08	Jets	Dolphins	22	21
2019-09-22	Patriots	Jets	30	14
2019-12-21	Patriots	Bills	24	17
2019-12-29	Patriots	Dolphins	24	27

game_date	home_team	away_team	home_points	away_points
2019-09-29	Bills	Patriots	10	16
2019-10-20	Bills	Dolphins	31	21
2019-12-29	Bills	Jets	6	13
2019-09-15	Dolphins	Patriots	0	43
2019-11-03	Dolphins	Jets	26	18
2019-11-17	Dolphins	Bills	20	37
2019-09-08	Jets	Bills	16	17
2019-10-21	Jets	Patriots	0	33
2019-12-08	Jets	Dolphins	22	21
2019-09-22	Patriots	Jets	30	14
2019-12-21	Patriots	Bills	24	17
2019-12-29	Patriots	Dolphins	24	27

TASK: USING A WINDOW FUNCTION, WRITE SQL TO DISPLAY INFORMATION ABOVE, AND TO CALCULATE NEW COLUMNS TO DISPLAY THE OVERALL AVERAGE HOME POINTS ACROSS ALL TEAMS(17.4), AND THE DIFFERENTIAL FROM EACH GAME'S SCORE TO THE OVERALL SCORE (FOR THE FIRST GAME ABOVE, -7.4)

game_date	home_team	away_team	home_points	away_points	home_avg	home_differential
2019-09-29	Bills	Patriots	10	16	17.4	-7.4
2019-10-20	Bills	Dolphins	31	21	17.4	13.6
2019-12-29	Bills	Jets	6	13	17.4	-11.4
2019-09-15	Dolphins	Patriots	0	43	17.4	-17.4
2019-11-03	Dolphins	Jets	26	18	17.4	8.6
2019-11-17	Dolphins	Bills	20	37	17.4	2.6
2019-09-08	Jets	Bills	16	17	17.4	-1.4
2019-10-21	Jets	Patriots	0	33	17.4	-17.4
2019-12-08	Jets	Dolphins	22	21	17.4	4.6
2019-09-22	Patriots	Jets	30	14	17.4	12.6
2019-12-21	Patriots	Bills	24	17	17.4	6.6
2019-12-29	Patriots	Dolphins	24	27	17.4	6.6

WHAT IF WE WANT TO CALCULATE (OVERALL *OR FOR EACH TEAM*) THE DIFFERENTIAL IN HOME AVERAGE POINTS SCORED, OR THE RANK OF HOME POINTS SCORED, OR THE CUMULATIVE HOME POINTS SCORED SEASON-TO-DATE, OR…

```
-- SUBQUERY IN SELECT list
SELECT *,
  (SELECT round(avg(home_points),1) AS home_avg FROM
afc_east),
  home_points - (SELECT round(avg(home_points),1) FROM
afc_east) AS home_differential
FROM afc_east
  ORDER BY home_team, game_date;
```

```
-- window function
SELECT *,
  ROUND(AVG(home_points)
      OVER(),1)
      AS home_avg,
  ROUND(home_points -
     AVG(home_points) OVER(),1)
     AS home_differential
FROM afc_east
  ORDER BY home_team, game_date;
```

game_date	home_team	away_team	home_points	away_points	home_avg	home_differential
2019-09-29	Bills	Patriots	10	16	15.7	-5.7
2019-10-20	Bills	Dolphins	31	21	15.7	15.3
2019-12-29	Bills	Jets	6	13	15.7	-9.7
2019-09-15	Dolphins	Patriots	0	43	15.3	-15.3
2019-11-03	Dolphins	Jets	26	18	15.3	10.7
2019-11-17	Dolphins	Bills	20	37	15.3	4.7
2019-09-08	Jets	Bills	16	17	12.7	3.3
2019-10-21	Jets	Patriots	0	33	12.7	-12.7
2019-12-08	Jets	Dolphins	22	21	12.7	9.3
2019-09-22	Patriots	Jets	30	14	26.0	4.0
2019-12-21	Patriots	Bills	24	17	26.0	-2.0
2019-12-29	Patriots	Dolphins	24	27	26.0	-2.0

DESCRIBE IN WORDS: WHAT IS HOME_DIFFERENTIAL?

game_date	home_team	away_team	home_points	away_points	home_avg	home_differential
2019-09-29	Bills	Patriots	10	16	15.7	-5.7
2019-10-20	Bills	Dolphins	31	21	15.7	15.3
2019-12-29	Bills	Jets	6	13	15.7	-9.7
2019-09-15	Dolphins	Patriots	0	43	15.3	-15.3
2019-11-03	Dolphins	Jets	26	18	15.3	10.7
2019-11-17	Dolphins	Bills	20	37	15.3	4.7
2019-09-08	Jets	Bills	16	17	12.7	3.3
2019-10-21	Jets	Patriots	0	33	12.7	-12.7
2019-12-08	Jets	Dolphins	22	21	12.7	9.3
2019-09-22	Patriots	Jets	30	14	26.0	4.0
2019-12-21	Patriots	Bills	24	17	26.0	-2.0
2019-12-29	Patriots	Dolphins	24	27	26.0	-2.0

AVG(HOME_POINTS) OVER(PARTITION BY HOME_TEAM)

game_date	home_team	away_team	home_points	away_points	home_rank
2019-09-29	Bills	Patriots	10	16	9
2019-10-20	Bills	Dolphins	31	21	1
2019-12-29	Bills	Jets	6	13	10
2019-09-15	Dolphins	Patriots	0	43	11
2019-11-03	Dolphins	Jets	26	18	3
2019-11-17	Dolphins	Bills	20	37	7
2019-09-08	Jets	Bills	16	17	8
2019-10-21	Jets	Patriots	0	33	11
2019-12-08	Jets	Dolphins	22	21	6
2019-09-22	Patriots	Jets	30	14	2
2019-12-21	Patriots	Bills	24	17	4
2019-12-29	Patriots	Dolphins	24	27	4

DESCRIBE IN WORDS: WHAT IS HOME_RANK?

game_date	home_team	away_team	home_points	away_points	home_rank
2019-09-29	Bills	Patriots	10	16	9
2019-10-20	Bills	Dolphins	31	21	1
2019-12-29	Bills	Jets	6	13	10
2019-09-15	Dolphins	Patriots	0	43	11
2019-11-03	Dolphins	Jets	26	18	3
2019-11-17	Dolphins	Bills	20	37	7
2019-09-08	Jets	Bills	16	17	8
2019-10-21	Jets	Patriots	0	33	11
2019-12-08	Jets	Dolphins	22	21	6
2019-09-22	Patriots	Jets	30	14	2
2019-12-21	Patriots	Bills	24	17	4
2019-12-29	Patriots	Dolphins	24	27	4

RANK()
OVER(ORDER BY HOME_POINTS DESC)

game_date	home_team	away_team	home_points	away_points	home_rank
2019-09-29	Bills	Patriots	10	16	2
2019-10-20	Bills	Dolphins	31	21	1
2019-12-29	Bills	Jets	6	13	3
2019-09-15	Dolphins	Patriots	0	43	3
2019-11-03	Dolphins	Jets	26	18	1
2019-11-17	Dolphins	Bills	20	37	2
2019-09-08	Jets	Bills	16	17	2
2019-10-21	Jets	Patriots	0	33	3
2019-12-08	Jets	Dolphins	22	21	1
2019-09-22	Patriots	Jets	30	14	1
2019-12-21	Patriots	Bills	24	17	2
2019-12-29	Patriots	Dolphins	24	27	2

DESCRIBE IN WORDS: WHAT IS HOME_RANK?

game_date	home_team	away_team	home_points	away_points	home_rank
2019-09-29	Bills	Patriots	10	16	2
2019-10-20	Bills	Dolphins	31	21	1
2019-12-29	Bills	Jets	6	13	3
2019-09-15	Dolphins	Patriots	0	43	3
2019-11-03	Dolphins	Jets	26	18	1
2019-11-17	Dolphins	Bills	20	37	2
2019-09-08	Jets	Bills	16	17	2
2019-10-21	Jets	Patriots	0	33	3
2019-12-08	Jets	Dolphins	22	21	1
2019-09-22	Patriots	Jets	30	14	1
2019-12-21	Patriots	Bills	24	17	2
2019-12-29	Patriots	Dolphins	24	27	2

```
RANK()
  OVER(PARTITION BY HOME_TEAM
  ORDER BY HOME_POINTS DESC)
```

game_date	home_team	away_team	home_points	away_points	cum_home_points
2019-09-29	Bills	Patriots	10	16	10
2019-10-20	Bills	Dolphins	31	21	41
2019-12-29	Bills	Jets	6	13	47
2019-09-15	Dolphins	Patriots	0	43	0
2019-11-03	Dolphins	Jets	26	18	26
2019-11-17	Dolphins	Bills	20	37	46
2019-09-08	Jets	Bills	16	17	16
2019-10-21	Jets	Patriots	0	33	16
2019-12-08	Jets	Dolphins	22	21	38
2019-09-22	Patriots	Jets	30	14	30
2019-12-21	Patriots	Bills	24	17	54
2019-12-29	Patriots	Dolphins	24	27	78

DESCRIBE IN WORDS: WHAT IS CUM_HOME_POINTS?

game_date	home_team	away_team	home_points	away_points	cum_home_points
2019-09-29	Bills	Patriots	10	16	10
2019-10-20	Bills	Dolphins	31	21	41
2019-12-29	Bills	Jets	6	13	47
2019-09-15	Dolphins	Patriots	0	43	0
2019-11-03	Dolphins	Jets	26	18	26
2019-11-17	Dolphins	Bills	20	37	46
2019-09-08	Jets	Bills	16	17	16
2019-10-21	Jets	Patriots	0	33	16
2019-12-08	Jets	Dolphins	22	21	38
2019-09-22	Patriots	Jets	30	14	30
2019-12-21	Patriots	Bills	24	17	54
2019-12-29	Patriots	Dolphins	24	27	78

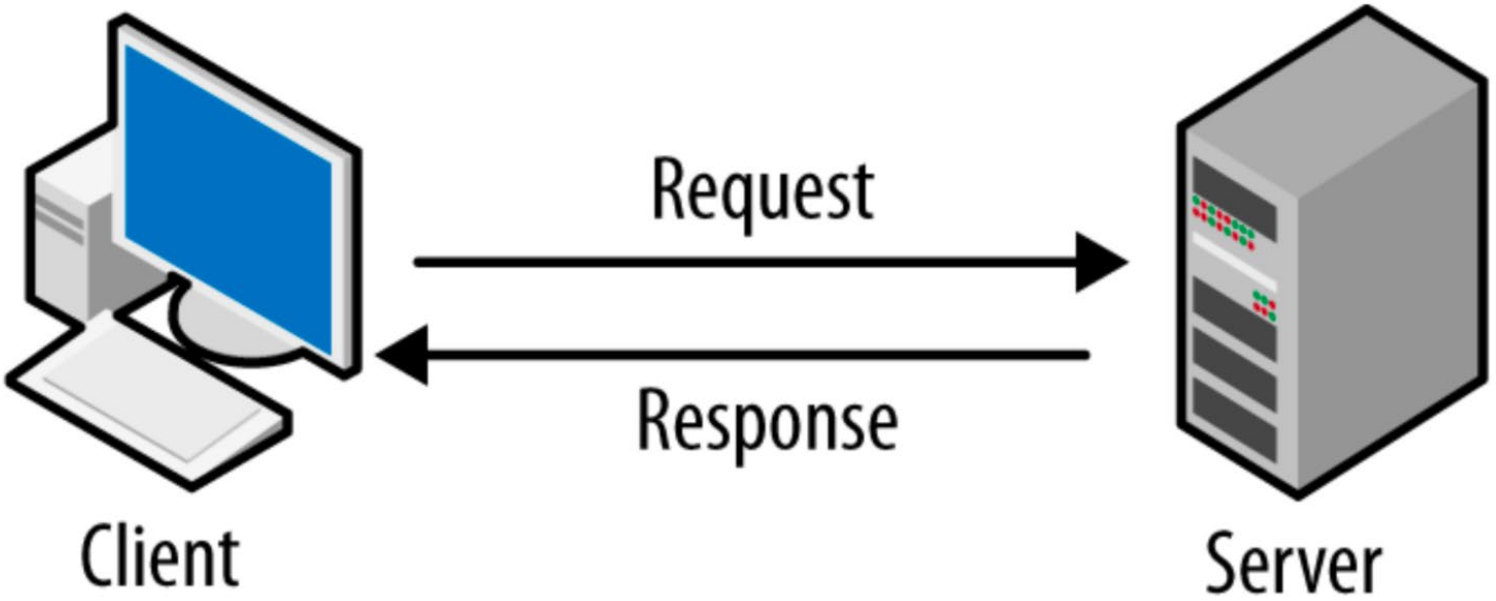
```
SUM(HOME_POINTS)
  OVER(PARTITION BY HOME_TEAM
    ORDER BY GAME_DATE
    ROWS BETWEEN UNBOUNDED PRECEDING
    AND CURRENT ROW)
```

WHAT ARE SOME OTHER INTERESTING USE CASES FOR WINDOW FUNCTIONS?

WINDOW FUNCTIONS IN PANDAS

- https://pandas.pydata.org/docs/user_guide/window.html
- Often, the decision about whether to perform the window functions in SQL or pandas comes down to answering the question, "where should the work be done?"
- (In practice, most data analysts that work in Python don't know about SQL window functions, and most data developer and data engineers that work in SQL are not expert at Python).

What is the work, and where should this work be performed?



Source: https://madooei.github.io/cs421_sp20_homepage/client-server-app/

HTTPS://DBFIDDLE.UK/

The best current SQL implementation for Window Functions is PostgreSQL