UNIVERSITÀ DEGLI STUDI DI PADOVA

DIPARTIMENTO DI INGEGNERIA DELL'INFORMAZIONE

FASTLan™

Developed by:

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Introduction

This project aims to create a graph database representing the world of Formula 1.

Formula 1 (a.k.a. F1 or Formula One) is the highest category of single-seat auto racing sanctioned by the Fédération Internationale de l'Automobile (FIA) and owned by the Formula One Group.

The datasets used to create this database contain information regarding races, drivers, driver ratings, constructors, qualifying, circuits, lap times, pit stops, and championships from 1950 until the latest 2023 season.

The project also consists on some SPARQL queries to show how the database works.

Datasets

Formula 1 data:

https://ergast.com/mrd/ or

https://www.kaggle.com/datasets/rohanrao/formula-1-world-championship-1950-2020

The dataset consists of all information on the Formula 1 races, drivers, constructors, qualifying, circuits, lap times, pit stops, championships from 1950 till the latest 2023 season.

Ratings data:

- 2023: https://ratings-api.ea.com/v2/entities/f1-23-drivers-ratings
- Older: https://github.com/toUpperCase78/formula1-datasets

Driver Ratings from EA & Codemasters F1 2021 / F1 22 / F1 23 Official Video Game

Country to Nationality csv:

https://github.com/Imagin-io/country-nationality-list/tree/master

Csv file that maps nationalities to countries.

Università degli Studi di Padova

Dipartimento di Ingegneria dell'Informazione

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Development process

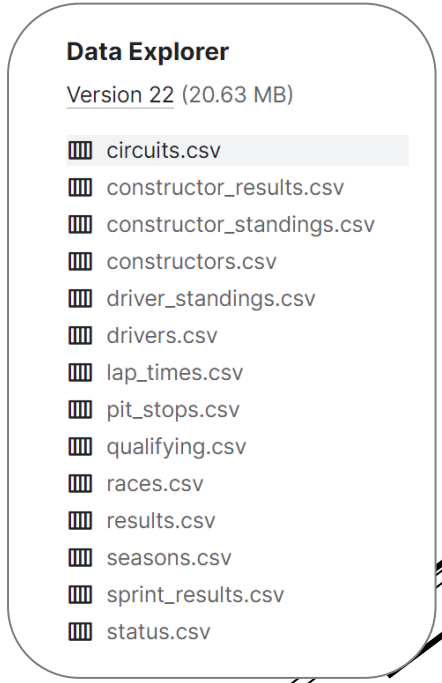
Graph schema → Ontology → Serialization → Queries

Graph schema	Ontology	Serialization	Queries
Graph model designed to fit the F1 data	Ontology according to the Graph model	Serialization process to produce turtle files	Queries writing to test the database
Developed with **arrows.app**	Developed with **Protégé**	Developed with **Jupyter Notebook**	Developed with **SPARQL**

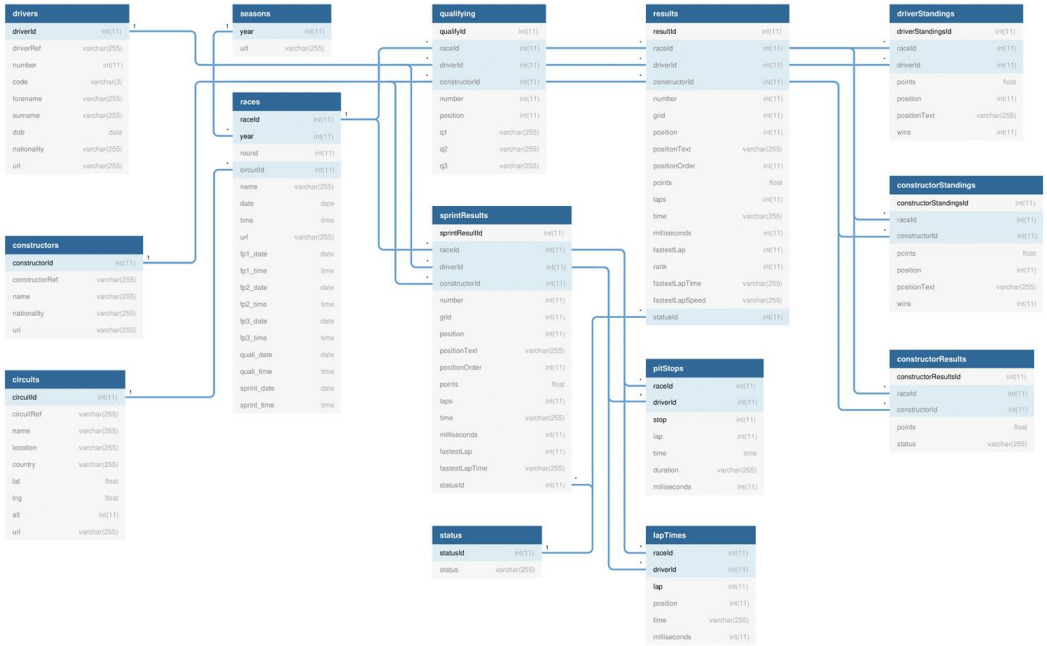
Dataset

CSV files list

circuits.csv	Circuits where F1 races are held
constructor_results.csv	Race results of the constructors' championship
constructor_standings.csv	Final standings of the constructors' championship
constructors.csv	Constructor teams in F1
driver_standings.csv	Final standings of the driver's championship
drivers.csv	Drivers in F1
lap_times.csv	Lap times in F1
nationalities.csv	Map nationalities to countries
pit_stops.csv	Pit stops in F1
qualifying.csv	Qualifying in F1
races.csv	Races in F1
ratings.csv	Ratings of F1 drivers
results.csv	Results of F1 races for each driver
seasons.csv	Seasons of F1
sprint_results.csv	Results of F1 sprint races for each driver
status.csv	Various status related to drivers' results



E-R Schema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dob date
nationality varchar(255)
url varchar(255)
seasons
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qualifying
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position int(11)
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driverId int(11)
constructorId int(11)
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position int(11)
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positionOrder int(11)
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laps int(11)
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races
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time time
url varchar(255)
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fp1_time time
fp2_date date
fp2_time time
fp3_date date
fp3_time time
quali_date date
quali_time time
sprint_date date
sprint_time time
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laps int(11)
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status varchar(255)
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E-R Schema


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surname varchar(255)
dob date
nationality varchar(255)
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time time
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fp1_time time
fp2_date date
fp2_time time
fp3_date date
fp3_time time
quali_date date
quali_time time
sprint_date date
sprint_time time
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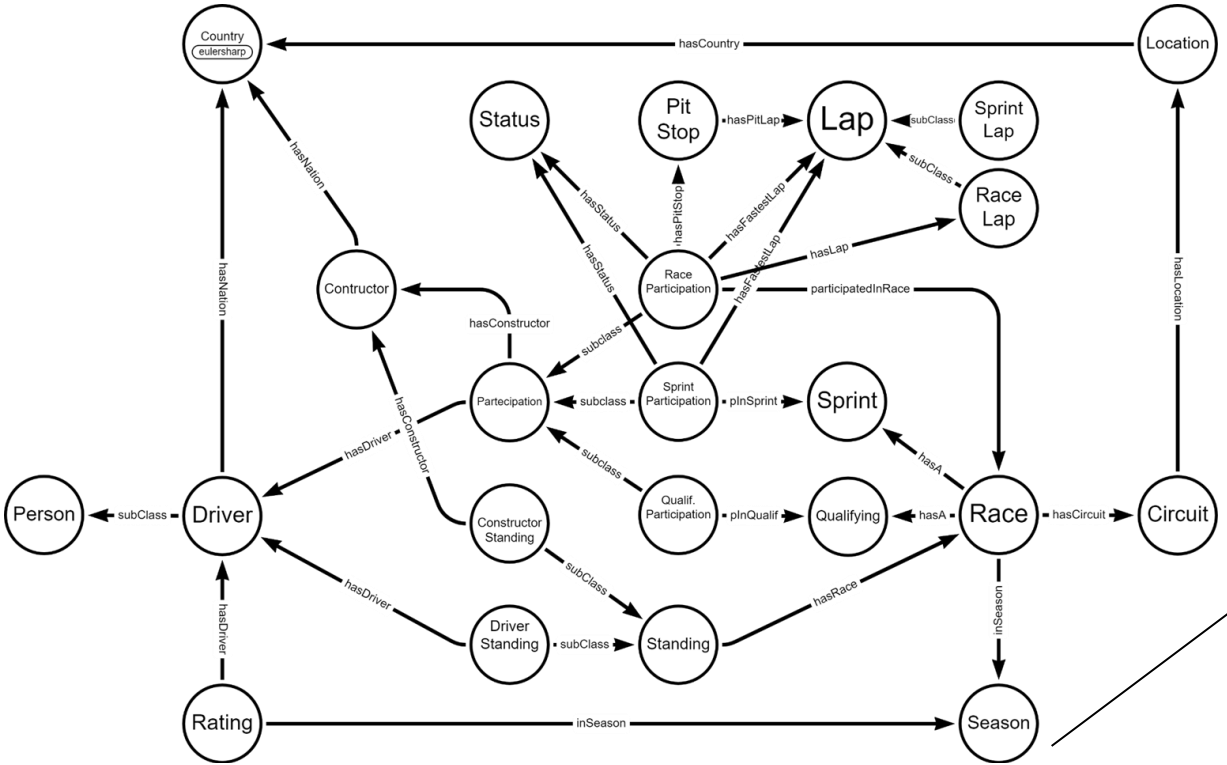
Graph Schema



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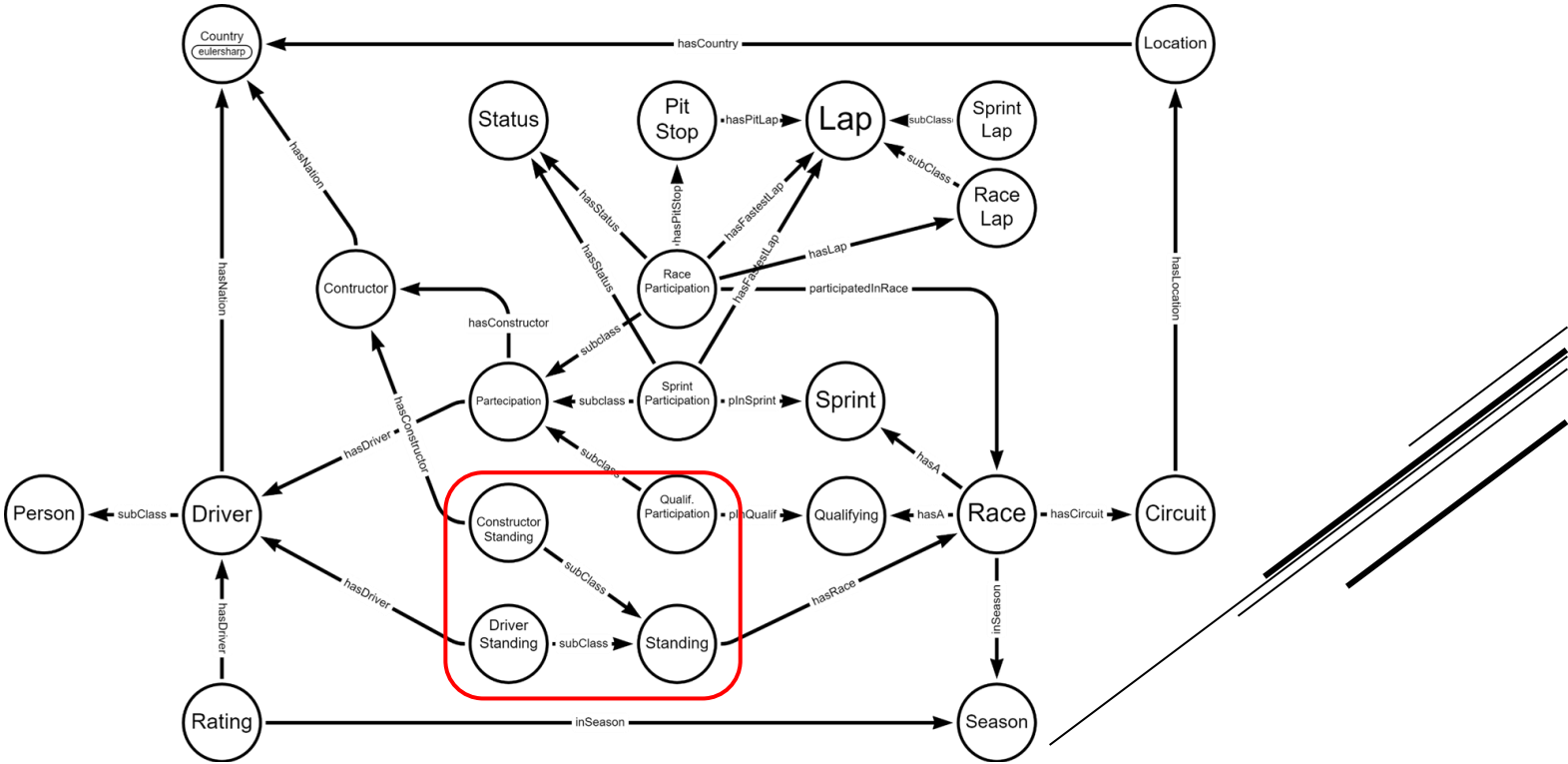
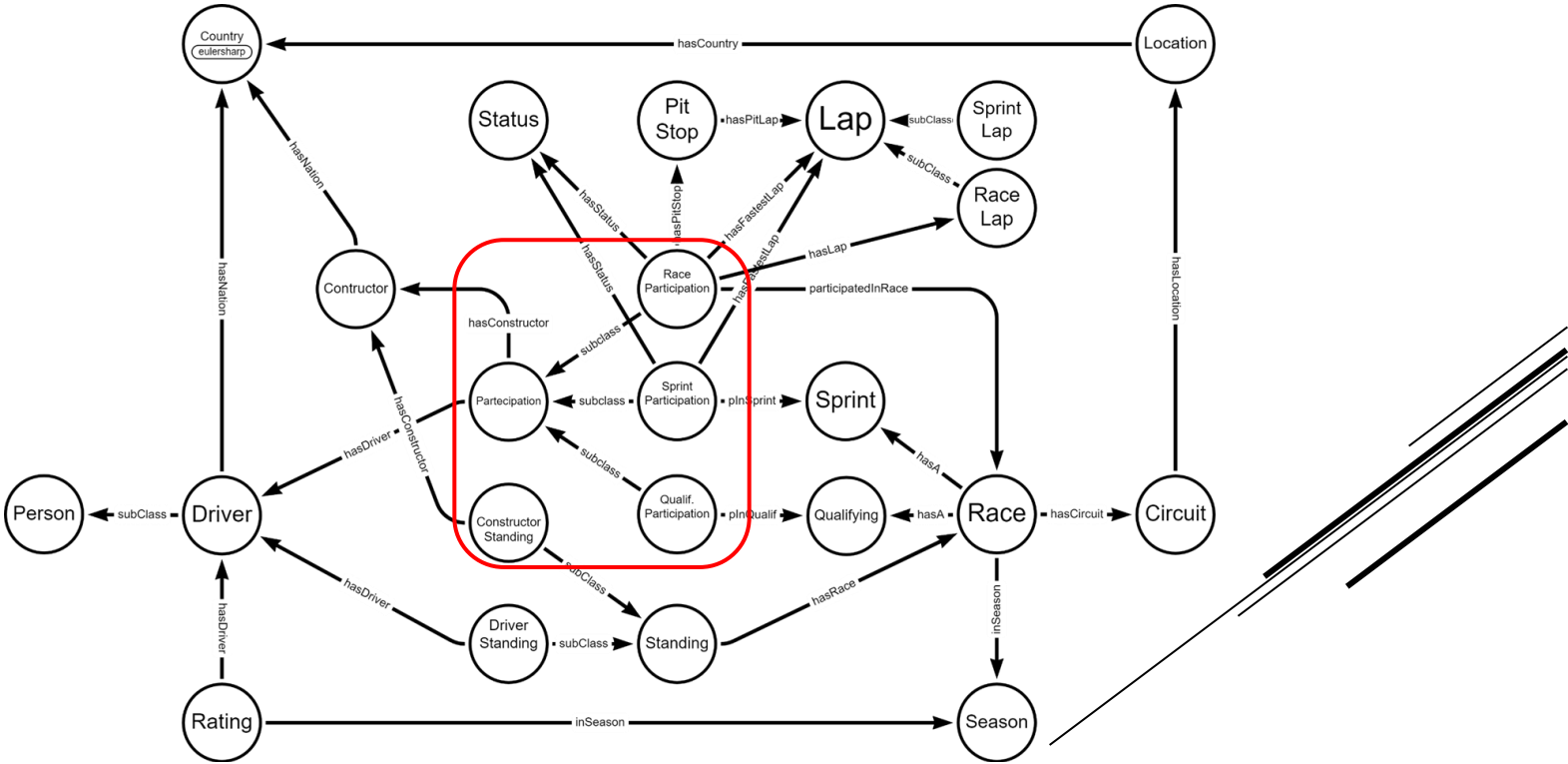
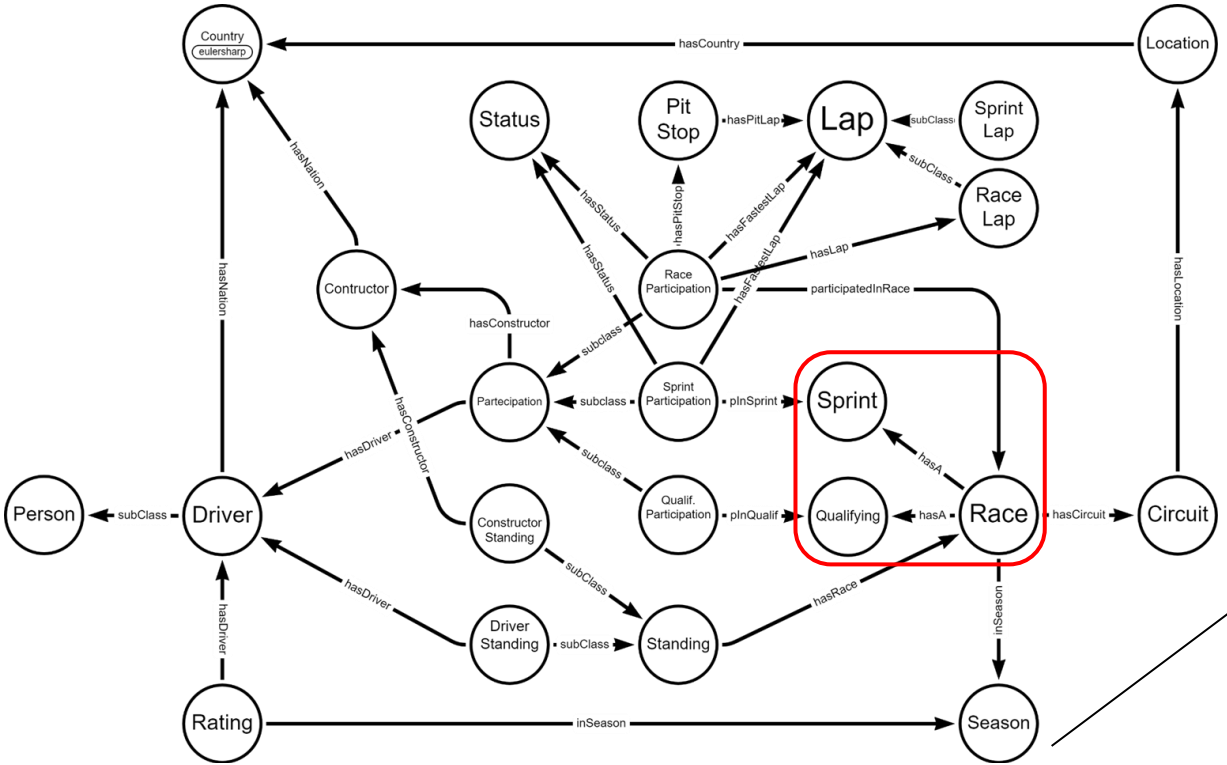


Graph Schema



Graph Schema



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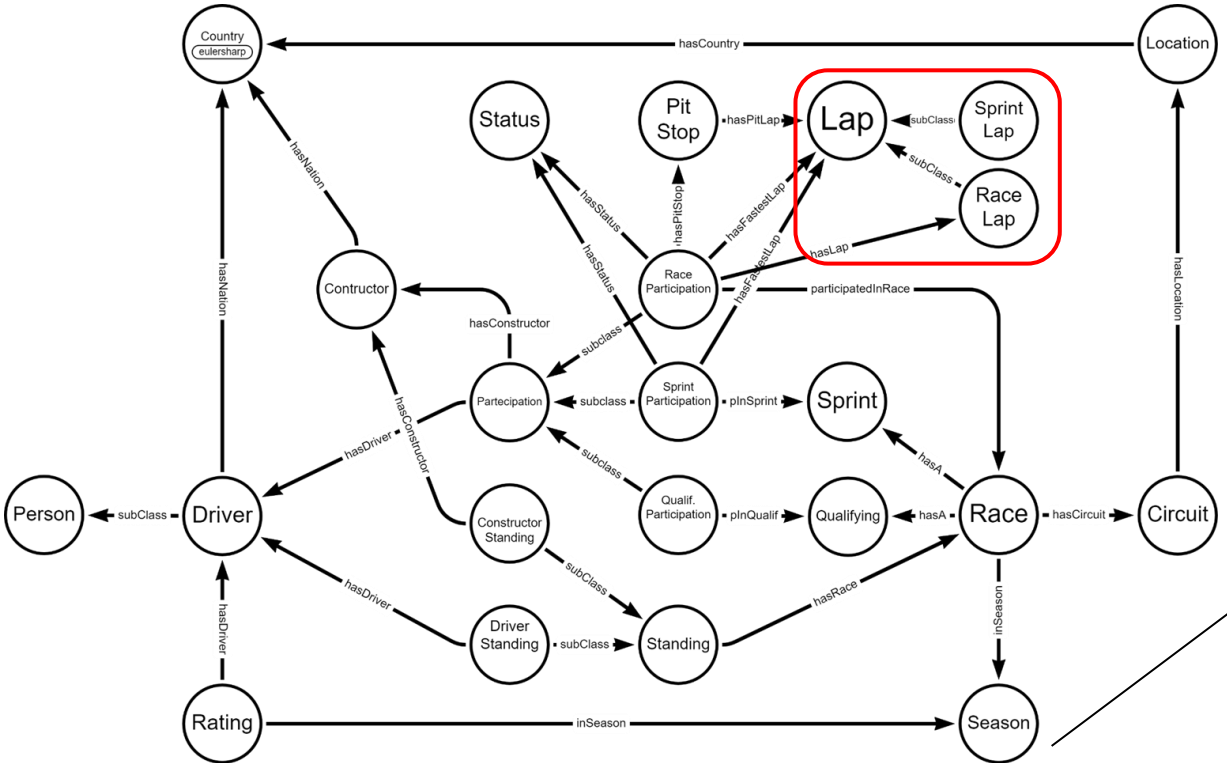
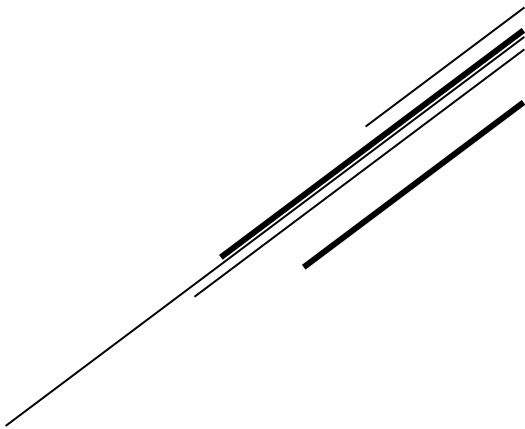


Ontology



Ontology

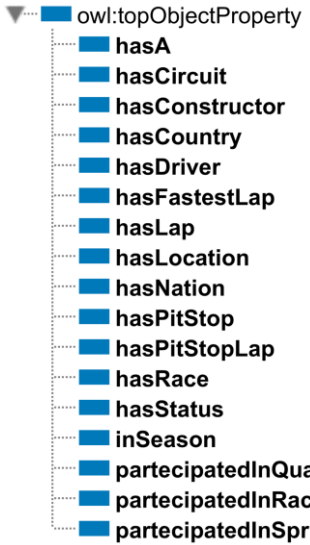
Class hierarchy

- **Standing** — Represents championship standings
  - → **DriverStanding** — ...related to drivers
  - → **ConstructorStanding** — ...related to constructors
- **Sprint** — Represents a sprint race related to a specific race
- **Race** — Represents a specific F1 race
- **Person** — Represents a person in general
  - → **Driver** — Represents a F1 driver
- **Lap** — Represents a single lap in a generic race
  - → **SprintLap** — Represents a single lap in a sprint
  - → **RaceLap** — Represents a single lap in a race
- **Participation** — Represents the participation of a driver and his related constructor team
  - → **QualifParticipation** — ...to a qualifying
  - → **SprintParticipation** — ...to a sprint
  - → **RaceParticipation** — ...to a race
- **Season** — Represents a F1 season
- **Rating** — Represents a rating tab for a driver
- **Circuit** — Represents the circuits on which F1 races are done
- **Constructor** — Represents F1 teams
- **Qualifying** — Represents a qualifying related to a particular race
- **Location** — Represents the location/city of a circuit
- **PitStop** — Represents a single pitstop in a F1 race
- **Country** — Represents world countries
- **Status** — Represents a status of a driver or a car in a race/sprint

Ontology

Object properties

- **hasA** (Race ↦ Qualifying or Sprint)
- **hasCircuit** (Race ↦ Circuit) ***F***
- **hasConstructor** (ConstructorStanding or Participation ↦ Constructor) ***F***
- **hasCountry** (Location ↦ Country) ***F***
- **hasDriver** (DriverStanding or Participation or Rating ↦ Driver) ***F***
- **hasFastestLap** (RaceParticipation or SprintParticipation ↦ Lap) ***F***
- **hasLap** (RaceParticipation ↦ Lap)
- **hasLocation** (Circuit ↦ Location) ***F***
- **hasNation** (Constructor or Driver ↦ Country)
- **hasPitStop** (RaceParticipation ↦ PitStop)
- **hasPitStopLap** (PitStop ↦ Lap)***F***
- **hasRace** (Standing ↦ Race) ***F***
- **hasStatus** (RaceParticipation or SprintParticipation ↦ Status) ***F***
- **inSeason** (Race or Rating ↦ Season) ***F***
- **participatedInQualif** (QualifParticipation ↦ Qualifying) ***F***
- **participatedInRace** (RaceParticipation ↦ Race) ***F***
- **participatedInSprint** (SprintParticipation ↦ Sprint) ***F***



Ontology

Data properties

Ontology

Data properties

RACE PARTECIPATION:

Property	Datatype
hasConstructorPoints	xsd:integer
hasFastestLapRank	xsd:integer
hasFastestLapSpeed	xsd:decimal
hasFastestLapTime	xsd:time
hasLaps	xsd:integer
hasMillisecondsResultTime	xsd:integer
hasPoints	xsd:integer
hasPositionOrder	xsd:integer
hasPositionText	xsd:string
hasResultGap	xsd:time
hasResultTime	xsd:time
hasStartingGridPosition	xsd:integer

PARTECIPATION:

Property	Datatype
hasCarNumber	xsd:integer
hasPosition	xsd:integer

SPRINT PARTECIPATION:

Property	Datatype
hasFastestLap	xsd:integer
hasFastestLapTime	xsd:time
hasLaps	xsd:integer
hasMillisecondsResultTime	xsd:integer
hasPoints	xsd:integer
hasPositionOrder	xsd:integer
hasPositionText	xsd:string
hasResultGap	xsd:time
hasResultTime	xsd:time
hasStartingGridPosition	xsd:integer

STANDING:

Property	Datatype
hasTotalPoints	xsd:integer
hasTotalPositionOrder	xsd:integer
hasTotalPositionText	xsd:string
hasWins	xsd:integer

QUALIFYING PARTECIPATION:

Property	Datatype
hasQ1Time	xsd:time
hasQ2Time	xsd:time
hasQ3Time	xsd:time

STATUS:

Property	Datatype
hasName	xsd:string

QUALIFYING and SPRINT:

Property	Datatype
hasDate	xsd:date
hasTime	xsd:time

SEASON:

Property	Datatype
hasURL	xsd:string
hasYear	xsd:gYear

CIRCUIT:

Property	Datatype
hasAlt	xsd:float
hasCircuitRef	xsd:string
hasLat	xsd:float
hasLng	xsd:float
hasName	xsd:string
hasUrl	xsd:string

DRIVER:

Property	Datatype
hasCode	xsd:integer
hasDateOfBirth	xsd:string
hasDriverNumber	xsd:integer
hasDriverRef	xsd:string
hasForename	xsd:string
hasSurname	xsd:string
hasURL	xsd:string

LAP:

Property	Datatype
hasLapNumber	xsd:integer
hasLapTime	xsd:time

CONSTRUCTOR:

Property	Datatype
hasConstructorRef	xsd:string
hasName	xsd:string
hasUrl	xsd:string

RACE:

Property	Datatype
hasDate	xsd:date
hasTime	xsd:time
hasFp1Date	xsd:date
hasFp2Date	xsd:date
hasFp3Date	xsd:date
hasFp1Time	xsd:time
hasFp2Time	xsd:time
hasFp3Time	xsd:time
hasName	xsd:string
hasRound	xsd:integer
hasURL	xsd:string

RACE LAP:

Property	Datatype
hasLapPosition	xsd:integer
hasMillisecondsTime	xsd:integer

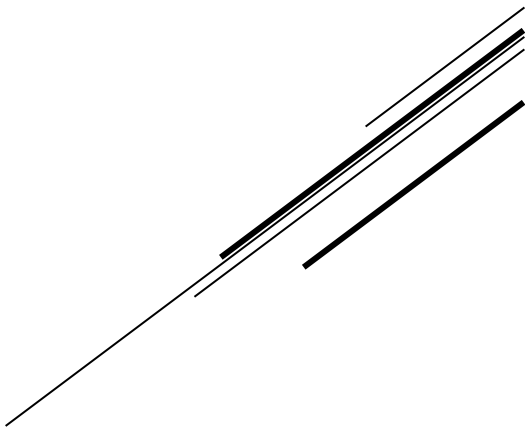
RATING:

Property	Datatype
hasAwarness	xsd:integer
hasBuyout	xsd:long
hasContractCost	xsd:long
hasExperience	xsd:integer
hasPace	xsd:integer
hasPeriod	xsd:date
hasRaceCraft	xsd:integer
hasRating	xsd:integer
hasSalary	xsd:long

PIT STOP:

Property	Datatype
hasDuration	xsd:time
hasMillisecondsTime	xsd:integer
hasPitStopTimeOfDay	xsd:time
hasStopNumber	xsd:integer

Serialization



Serialization

Introduction

Turtle files produced by the serialization process:

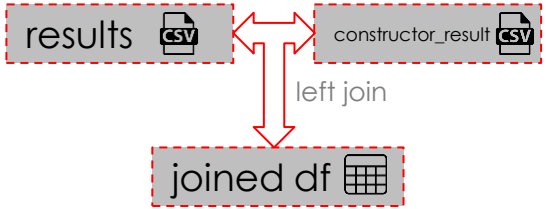
Turtle files	Csv files from which we extracted the data for the turtle files
circuits.ttl	circuits.csv, countries.csv
constructors.ttl	constructors.csv, nationalities.csv
drivers.ttl	drivers.csv, nationalities.csv
laps1.ttl and laps2.ttl	lap_times.csv, results.csv, constructor_results.csv
qualifying.ttl	qualifying.csv, races.csv
race.ttl	races.csv
race_participation.ttl	results.csv, constructor_results.csv, lap_times.csv
ratings.ttl	ratings.csv, drivers.csv
sprint.ttl	sprint_results.csv, races.csv
standings.ttl	driver_standings.csv, constructor_standings.csv
status_season.ttl	status.csv, seasons.csv
stops.ttl	pit_stops.csv, results.csv, constructor_results.csv, lap_times.csv

Serialization

Matching columns

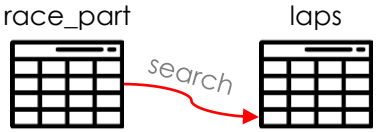
1. Join

We joined *results.csv* and *constructor_results.csv* in a single Pandas data frame. Then, all the results concerning the constructor team were matched with the driver results before managing the data frame.



2. Search

For each current row evaluated, we searched for a matching row in the second table in order to match some constraints, such as some keys.



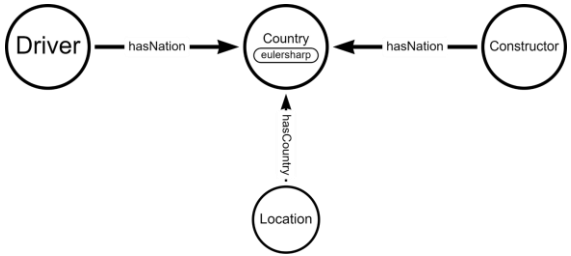
Serialization

Nationality to country mapping

We used this approach in *drivers.ttl* and *constructors.ttl* to maintain a single class country taken by an external source.

In this way, we avoided creating an additional nationality class and it was not necessary to link each individual in the nationality class to the country class via an object property.

The mapping was done directly in the serialization step.



num_code	alpha_2_code	alpha_3_code	en_short_name	nationality
4	AF	AFG	Afghanistan	Afghan
248	AX	ALA	Åland Islands	Åland Island
8	AL	ALB	Albania	Albanian
12	DZ	DZA	Algeria	Algerian
16	AS	ASM	American Samoa	American Samoan
20	AD	AND	Andorra	Andorran
24	AO	AGO	Angola	Angolan
660	AI	AIA	Anguilla	Anguillan
10	AQ	ATA	Antarctica	Antarctic
28	AG	ATG	Antigua and Barbuda	Antiguan or Barbudan
32	AR	ARG	Argentina	Argentine

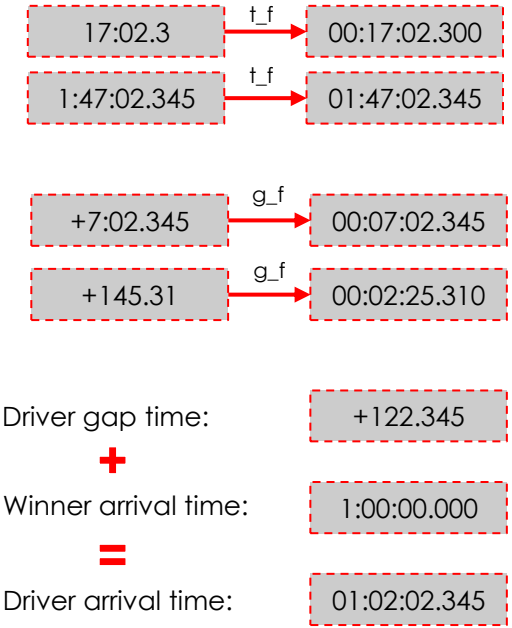
⋮

Serialization

Time format

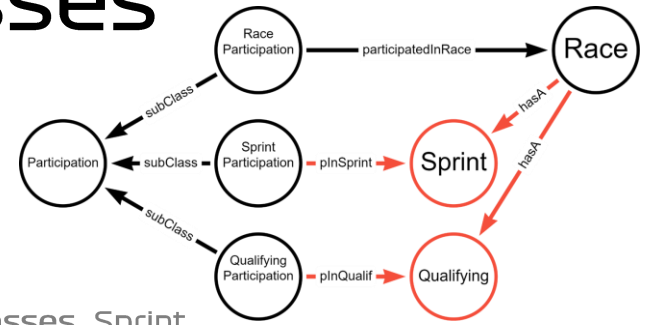
We used 3 functions to manage time:

1. time_formatter
   Function that transforms a time value to the standard %H:%M:%S.%f format, adds the zeros and the missing colon to the beginning and end of the string.
2. gap_formatter
   Function that transforms a gap time value to the standard %H:%M:%S.%f format, adds the zeros and the missing colon to the beginning and end of the string.
3. time_converter
   Function that calculates a driver's actual arrival time using the winner's arrival time and the time distance from it.



Serialization

Qualifying and Sprint classes



In the source dataset, we have two csv files concerning the races:

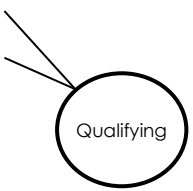
- the one for the generic race (races.csv) and
- the one for each driver's participation in the race (results.csv).

For qualifying and sprints this does not happen and we only have files representing the participations (qualifying.csv, sprint_results.csv).

To make the database more consistent, we decided to add two classes, Sprint and Qualifying, to represent the generic sprints and qualifications, not related to the driver.

...	quali_date	quali_time	...	...
	2020/01/05	17:00:00		
	2021/06/20	18:00:00		
	2023/07/01	19:00:00		

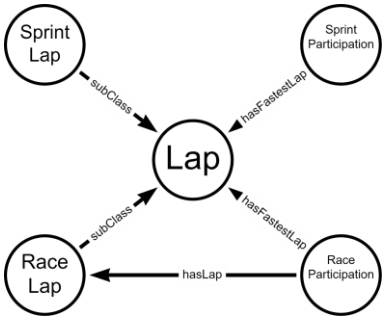
races.csv



Serialization

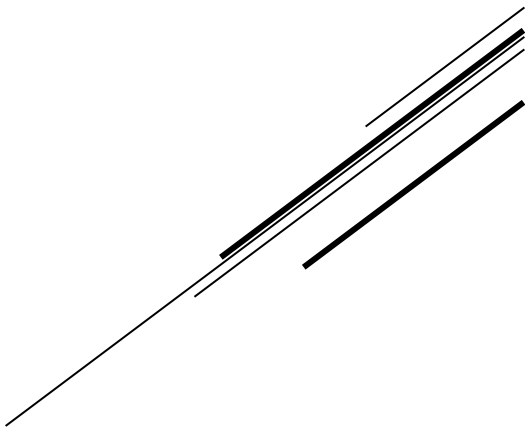
Race and sprint laps

In the source dataset, we have the *lap_times.csv* file that contains all the laps of each driver in each race, with their positions and times.



Consequently, we decided to create a subclass of Lap, called SprintLap, to include the fastest laps related to sprints, with related time.
We also chose to keep this information in SprintParticipation so that it would be faster to extract it in SPARQL.

Queries



Query 8.1

The 5 most winning drivers in F1 history, ordered by number of grand prix wins

```
PREFIX : <https://www.dei.unipd.it/db2/groupProject/FASTianF1#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT ?name (COUNT(?name) as ?numOfWins) WHERE {
    ?race :hasCircuit ?circuit;
          a :Race.
    ?racePart :partecipatedInRace ?race;
              :hasPositionOrder "1"^^xsd:integer;
              :hasDriver ?driver.
    ?driver a :Driver;
            :hasForename ?fname;
            :hasSurname ?sname.
    BIND(CONCAT(?fname, " ", ?sname) AS ?name).
} GROUP BY ?name
ORDER BY DESC (?numOfWins)
LIMIT 5
```

SPARQL RESULT

	name	numOfWins
1	"Lewis Hamilton"	"103"^^xsd:integer
2	"Michael Schumacher"	"91"^^xsd:integer
3	"Max Verstappen"	"54"^^xsd:integer
4	"Sebastian Vettel"	"53"^^xsd:integer
5	"Alain Prost"	"51"^^xsd:integer

WIKIPEDIA

Rank	Country	Driver	Wins	Seasons active	First win	Last win
1	United Kingdom	Lewis Hamilton†	103	2007–	2007 Canadian Grand Prix	2021 Saudi Arabian Grand Prix
2	Germany	Michael Schumacher‡	91	1991–2006, 2010–2012	1992 Belgian Grand Prix	2006 Chinese Grand Prix
3	Netherlands	Max Verstappen†	54	2015–	2016 Spanish Grand Prix	2023 Abu Dhabi Grand Prix
4	Germany	Sebastian Vettel‡	53	2007–2022	2008 Italian Grand Prix	2019 Singapore Grand Prix
5	France	Alain Prost‡	51	1980–1991, 1993	1981 French Grand Prix	1993 German Grand Prix

Query 11.3

Data about fastest qualifying laps in F1 history (both q1, q2 and q3)

```
PREFIX : <https://www.dei.unipd.it/db2/groupProject/FASTianF1#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT ?driversName ?qTime ?circuitName ?raceName WHERE {
    {
        ?qualPart :hasQ3Time ?qTime.
    }
    UNION
    {
        ?qualPart :hasQ2Time ?qTime.
    }
    UNION
    {
        ?qualPart :hasQ1Time ?qTime.
    }
    ?qualPart :hasDriver ?driver;
              :partecipatedInQualif ?quali;
              a :QualifPartecipation.
    ?quali a :Qualifying.
    ?race a :Race;
          :hasA ?quali;
          :hasName ?raceName;
          :hasCircuit ?circ.
    ?circ a :Circuit;
          :hasName ?circuitName.
    ?driver a :Driver;
            :hasForename ?fname;
            :hasSurname ?sname.
    BIND(CONCAT(?fname, " ", ?sname) AS ?driversName).
    FILTER(?qTime != "00:00:00"^^xsd:time)
}
ORDER BY (?qTime)
LIMIT 100
```

SPARQL RESULT

	driversName	qTime	circuitName	raceName
1	"Valtteri Bottas"	"00:00:53.377000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
2	"George Russell"	"00:00:53.403000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
3	"Max Verstappen"	"00:00:53.433000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
4	"Charles Leclerc"	"00:00:53.613000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
5	"Max Verstappen"	"00:00:53.647000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
6	"Sergio Pérez"	"00:00:53.787000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
7	"Sergio Pérez"	"00:00:53.790000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
8	"Valtteri Bottas"	"00:00:53.803000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
9	"Carlos Sainz"	"00:00:53.818000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
10	"George Russell"	"00:00:53.819000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
11	"Charles Leclerc"	"00:00:53.825000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
12	"Lance Stroll"	"00:00:53.840000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
13	"Daniil Kvyat"	"00:00:53.856000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
14	"Daniel Ricciardo"	"00:00:53.871000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
15	"Valtteri Bottas"	"00:00:53.904000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
16	"Daniil Kvyat"	"00:00:53.906000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
17	"Pierre Gasly"	"00:00:53.941000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
18	"Daniel Ricciardo"	"00:00:53.957000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"
19	"Esteban Ocon"	"00:00:53.995000"^^xsd:time	"Bahrain International Circuit"	"Sakhir Grand Prix"

Query 12

Data about 10 fastest pit stops in F1 history

```
PREFIX : <https://www.dei.unipd.it/db2/groupProject/FASTianF1#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT ?driversName ?pitDuration ?circuitName ?raceName ?raceDate WHERE {
    ?racePart :hasPitStop ?pit;
              :hasDriver ?driver;
              :partecipatedInRace ?race;
              a :RacePartecipation.
    ?race a :Race;
          :hasName ?raceName;
          :hasDate ?raceDate;
          :hasCircuit ?circ.
    ?circ a :Circuit;
            :hasName ?circuitName.
    ?pit a :PitStop;
         :hasDuration ?pitDuration.
    ?driver a :Driver;
            :hasForename ?fname;
            :hasSurname ?sname.
    BIND(CONCAT(?fname, " ", ?sname) AS ?driversName).
}
ORDER BY (?pitDuration)
LIMIT 10
```

SPARQL RESULT

	driversName	pitDuration	circuitName	raceName	raceDate
1	"Pastor Maldonado"	"00:00:12.897000"^^xsd:time	"Yas Marina Circuit"	"Abu Dhabi Grand Prix"	"2011-11-13"^^xsd:date
2	"Bruno Senna"	"00:00:12.959000"^^xsd:time	"Yas Marina Circuit"	"Abu Dhabi Grand Prix"	"2011-11-13"^^xsd:date
3	"Lewis Hamilton"	"00:00:13.173000"^^xsd:time	"Hungaroring"	"Hungarian Grand Prix"	"2011-07-31"^^xsd:date
4	"Pastor Maldonado"	"00:00:13.186000"^^xsd:time	"Hungaroring"	"Hungarian Grand Prix"	"2011-07-31"^^xsd:date
5	"Michael Schumacher"	"00:00:13.199000"^^xsd:time	"Hungaroring"	"Hungarian Grand Prix"	"2012-07-29"^^xsd:date
6	"Sergio Pérez"	"00:00:13.201000"^^xsd:time	"Hungaroring"	"Hungarian Grand Prix"	"2011-07-31"^^xsd:date
7	"Pastor Maldonado"	"00:00:13.206000"^^xsd:time	"Hungaroring"	"Hungarian Grand Prix"	"2012-07-29"^^xsd:date
8	"Felipe Massa"	"00:00:13.259000"^^xsd:time	"Circuit de Barcelona-Catalunya"	"Spanish Grand Prix"	"2012-05-13"^^xsd:date
9	"Pastor Maldonado"	"00:00:13.266000"^^xsd:time	"Circuit de Barcelona-Catalunya"	"Spanish Grand Prix"	"2013-05-12"^^xsd:date
10	"Sebastian Vettel"	"00:00:13.335000"^^xsd:time	"Circuit de Barcelona-Catalunya"	"Spanish Grand Prix"	"2012-05-13"^^xsd:date

Query 14

Constructors with most wins in the constructors' championship

```
PREFIX : <https://www.dei.unipd.it/db2/groupProject/FASTianF1#>
SELECT ?name (COUNT(?name) AS ?totalWins) (GROUP_CONCAT(DISTINCT ?outerYear ; separator=",") AS ?years) WHERE{
    {
        SELECT ?name ?race (AVG(?pos) AS ?finalPosition) ?outerYear WHERE{
            ?stand :hasRace ?race ;
                   :hasConstructor ?cons ;
                   :hasTotalPosition ?pos .
            ?race :hasRound ?outerRound ;
                  :inSeason ?outerSeason .
            ?outerSeason :hasYear ?outerYear .
            ?cons :hasName ?name .
            FILTER(?outerRound = ?maxRound && ?outerYear = ?year && ?pos = 1)
            {
                SELECT ?year (MAX(?round) AS ?maxRound) WHERE {
                    ?race :inSeason ?season ;
                          :hasRound ?round .
                    ?season :hasYear ?year .
                }
                GROUP BY ?year
            }
        }
        GROUP BY ?name ?race ?outerYear
        ORDER BY (?outerYear)
    }
}
GROUP BY ?name
ORDER BY DESC (?totalWins)
```

SPARQL RESULT

	name	totalWins	years
1	"Ferrari"	"16"^^xsd:integer	"1961,1964,1975,1976,1977,1979,1982,1983,1999,2000,2001,2002,2003,2004,2007,2008"
2	"Williams"	"9"^^xsd:integer	"1980,1981,1986,1987,1992,1993,1994,1996,1997"
3	"McLaren"	"8"^^xsd:integer	"1974,1984,1985,1988,1989,1990,1991,1998"
4	"Mercedes"	"8"^^xsd:integer	"2014,2015,2016,2017,2018,2019,2020,2021"
5	"Red Bull"	"6"^^xsd:integer	"2010,2011,2012,2013,2022,2023"
6	"Team Lotus"	"4"^^xsd:integer	"1970,1972,1973,1978"
7	"Cooper-Climax"	"2"^^xsd:integer	"1959,1960"
8	"Lotus-Climax"	"2"^^xsd:integer	"1963,1965"
9	"Brabham-Repco"	"2"^^xsd:integer	"1966,1967"
10	"Renault"	"2"^^xsd:integer	"2005,2006"
11	"Vanwall"	"1"^^xsd:integer	"1958"
12	"BRM"	"1"^^xsd:integer	"1962"
13	"Lotus-Ford"	"1"^^xsd:integer	"1968"
14	"Matra-Ford"	"1"^^xsd:integer	"1969"
15	"Tyrrell"	"1"^^xsd:integer	"1971"
16	"Benetton"	"1"^^xsd:integer	"1995"
17	"Brawn"	"1"^^xsd:integer	"2009"

WIKIPEDIA

Constructor	Titles	Seasons
Ferrari	16	1961, 1964, 1975, 1976, 1977, 1979, 1982, 1983, 1999, 2000, 2001, 2002, 2003, 2004, 2007, 2008
Williams	9	1980, 1981, 1986, 1987, 1992, 1993, 1994, 1996, 1997
McLaren	8	1974, 1984, 1985, 1988, 1989, 1990, 1991, 1998
Mercedes		2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021
Lotus	7	1963, 1965, 1968, 1970, 1972, 1973, 1978
Red Bull	6	2010, 2011, 2012, 2013, 2022, 2023
Cooper	2	1959, 1960
Brabham		1966, 1967
Renault		2005, 2006
Vanwall	1	1958
BRM		1962
Matra		1969
Tyrrell		1971
Benetton		1995
Brawn		2009

Query 16

Are drivers who won the championship after 2000 older than those who won it before 2000, on average?

```
PREFIX : <https://www.dei.unipd.it/db2/groupProject/FASTianF1#>
ASK WHERE{
    {
        SELECT (AVG(?age) as ?avgOldAge) WHERE{
            ?stand :hasRace ?race ;
                   :hasDriver ?driv ;
                   :hasTotalPosition ?pos .
            ?driv :hasDateOfBirth ?dob .
            ?race :hasDate ?raceDate ;
                  :inSeason ?outerSeason ;
                  :hasRound ?outerRound .
            ?outerSeason :hasYear ?outerYear .
            BIND((YEAR(?raceDate) - YEAR(?dob)) AS ?age)
            FILTER(?outerRound = ?maxRound && ?outerYear = ?year && ?pos = 1)
            {
                SELECT ?year (MAX(?round) AS ?maxRound) WHERE {
                    ?race :inSeason ?season ;
                          :hasRound ?round .
                    ?season :hasYear ?year .
                    FILTER(?year < 2000)
                }
                GROUP BY ?year
            }
        }
    }
    {
        SELECT (AVG(?age) as ?avgRecentAge) WHERE{
            ?stand :hasRace ?race ;
                   :hasDriver ?driv ;
                   :hasTotalPosition ?pos .
            ?driv :hasDateOfBirth ?dob .
            ?race :hasDate ?raceDate ;
                  :inSeason ?outerSeason ;
                  :hasRound ?outerRound .
            ?outerSeason :hasYear ?outerYear .
            BIND((YEAR(?raceDate) - YEAR(?dob)) AS ?age)
            FILTER(?outerRound = ?maxRound && ?outerYear = ?year && ?pos = 1)
            {
                SELECT ?year (MAX(?round) AS ?maxRound) WHERE {
                    ?race :inSeason ?season ;
                          :hasRound ?round .
                    ?season :hasYear ?year .
                    FILTER(?year >= 2000)
                }
                GROUP BY ?year
            }
        }
    }
    FILTER(?avgRecentAge > ?avgOldAge)
}
```

SPARQL RESULT

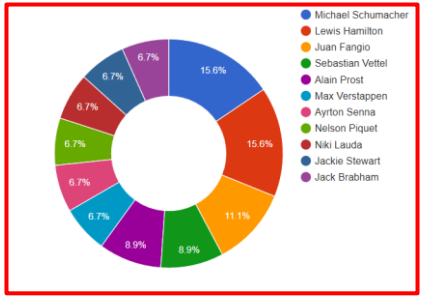
NO

Before 2000 avg age:	33.0
After 2000 avg age:	28.8

Query 19

Championship winning drivers who won more than 2 championships, ordered by number of championships won

```
PREFIX : <https://www.dei.unipd.it/db2/groupProject/FASTianF1#>
SELECT ?name (COUNT(?name) AS ?numOfWins)(GROUP_CONCAT(DISTINCT ?outerYear ; separator=",") AS ?years) WHERE{
    ?stand :hasRace ?race ;
           :hasDriver ?driv ;
           :hasTotalPosition ?pos .
    ?driv a :Driver;
          :hasForename ?fname;
          :hasSurname ?sname.
    BIND(CONCAT(?fname, " ", ?sname) AS ?name).
    ?race :hasDate ?raceDate ;
          :inSeason ?outerSeason ;
          :hasRound ?outerRound .
    ?outerSeason :hasYear ?outerYear .
    FILTER(?outerRound = ?maxRound && ?outerYear = ?year && ?pos = 1)
    {
        SELECT ?year (MAX(?round) AS ?maxRound) WHERE {
            ?race :inSeason ?season ;
                  :hasRound ?round .
            ?season :hasYear ?year .
        }
        GROUP BY ?year
        ORDER BY ?year
    }
}
GROUP BY ?name
HAVING (?numOfWins > 2)
ORDER BY DESC (?numOfWins)
```



SPARQL RESULT

	name	numOfWins	years
1	"Michael Schumacher"	"7"^^xsd:integer	"1994,1995,2000,2001,2002,2003,2004"
2	"Lewis Hamilton"	"7"^^xsd:integer	"2008,2014,2015,2017,2018,2019,2020"
3	"Juan Fangio"	"5"^^xsd:integer	"1951,1954,1955,1956,1957"
4	"Alain Prost"	"4"^^xsd:integer	"1985,1986,1989,1993"
5	"Sebastian Vettel"	"4"^^xsd:integer	"2010,2011,2012,2013"
6	"Jack Brabham"	"3"^^xsd:integer	"1959,1960,1966"
7	"Jackie Stewart"	"3"^^xsd:integer	"1969,1971,1973"
8	"Niki Lauda"	"3"^^xsd:integer	"1975,1977,1984"
9	"Nelson Piquet"	"3"^^xsd:integer	"1981,1983,1987"
10	"Ayrton Senna"	"3"^^xsd:integer	"1988,1990,1991"
11	"Max Verstappen"	"3"^^xsd:integer	"2021,2022,2023"

WIKIPEDIA

Driver	Titles	Season(s)
Michael Schumacher	7	1994, 1995, 2000, 2001, 2002, 2003, 2004
Lewis Hamilton		2008, 2014, 2015, 2017, 2018, 2019, 2020
Juan Manuel Fangio	5	1951, 1954, 1955, 1956, 1957
Alain Prost	4	1985, 1986, 1989, 1993
Sebastian Vettel		2010, 2011, 2012, 2013
Jack Brabham	3	1959, 1960, 1966
Jackie Stewart		1969, 1971, 1973
Niki Lauda		1975, 1977, 1984
Nelson Piquet		1981, 1983, 1987
Ayrton Senna		1988, 1990, 1991
Max Verstappen		2021, 2022, 2023

Query 22

Winners of drivers' championship and constructors' championship for each season.

```
PREFIX : <https://www.dei.unipd.it/db2/groupProject/FASTianF1#>
SELECT ?outerYear ?driverName ?constructorName WHERE{
    ?driverStand :hasTotalPosition ?pos ;
                 :hasRace ?race ;
                 :hasDriver ?driver .
    ?constStand :hasTotalPosition ?pos ;
                :hasRace ?race ;
                :hasConstructor ?const .
    ?race :hasRound ?outerRound ;
          :inSeason ?season .
    ?season :hasYear ?outerYear .
    ?driver :hasForename ?fname ;
            :hasSurname ?sname .
    ?const :hasName ?constructorName .
    BIND(CONCAT(?fname, " ", ?sname) AS ?driverName).
    FILTER(?outerRound = ?maxRound && ?outerYear = ?year && ?pos = 1)
    {
        SELECT ?year (MAX(?round) AS ?maxRound) WHERE {
            ?race :inSeason ?season ;
                  :hasRound ?round .
            ?season :hasYear ?year .
        }
        GROUP BY ?year
    }
}
ORDER BY DESC (?outerYear)
```

SPARQL RESULT

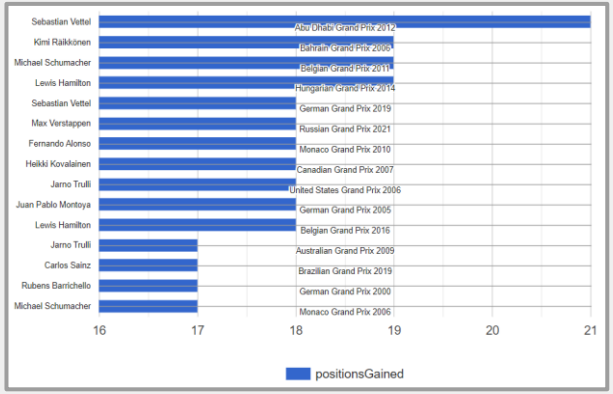
	outerYear	driverName	constructorName
1	"2023"^^xsd:integer	"Max Verstappen"	"Red Bull"
2	"2022"^^xsd:integer	"Max Verstappen"	"Red Bull"
3	"2021"^^xsd:integer	"Max Verstappen"	"Mercedes"
4	"2020"^^xsd:integer	"Lewis Hamilton"	"Mercedes"
5	"2019"^^xsd:integer	"Lewis Hamilton"	"Mercedes"
6	"2018"^^xsd:integer	"Lewis Hamilton"	"Mercedes"
7	"2017"^^xsd:integer	"Lewis Hamilton"	"Mercedes"
8	"2016"^^xsd:integer	"Nico Rosberg"	"Mercedes"
9	"2015"^^xsd:integer	"Lewis Hamilton"	"Mercedes"
10	"2014"^^xsd:integer	"Lewis Hamilton"	"Mercedes"
11	"2013"^^xsd:integer	"Sebastian Vettel"	"Red Bull"

Query 23

Drivers who gained the most positions during a race after 2000

```
PREFIX : <https://www.dei.unipd.it/db2/groupProject/FASTianF1#>
SELECT ?driverName ?raceSeason ?positionsGained WHERE{
    ?part :hasStartingGridPosition ?grid ;
          :partecipatedInRace ?race ;
          :hasDriver ?driver ;
          :hasPosition ?pos .
    ?driver :hasForename ?fname ;
            :hasSurname ?sname .
    ?race :inSeason ?season ;
          :hasName ?raceName .
    ?season :hasYear ?year .
    BIND(CONCAT(?fname, " ", ?sname) AS ?driverName)
    BIND((?grid - ?pos) AS ?positionsGained)
    FILTER(?year >= 2000)
    BIND(CONCAT(?raceName, " ", STR(?year)) AS ?raceSeason)
}
ORDER BY DESC (?positionsGained)
LIMIT 15
```

BAR CHART



SPARQL RESULT

	driverName	raceSeason	positionsGained
1	"Sebastian Vettel"	"Abu Dhabi Grand Prix 2012"	"21"^^xsd:integer
2	"Kimi Räikkönen"	"Bahrain Grand Prix 2006"	"19"^^xsd:integer
3	"Michael Schumacher"	"Belgian Grand Prix 2011"	"19"^^xsd:integer
4	"Lewis Hamilton"	"Hungarian Grand Prix 2014"	"19"^^xsd:integer
5	"Sebastian Vettel"	"German Grand Prix 2019"	"18"^^xsd:integer
6	"Max Verstappen"	"Russian Grand Prix 2021"	"18"^^xsd:integer
7	"Fernando Alonso"	"Monaco Grand Prix 2010"	"18"^^xsd:integer
8	"Heikki Kovalainen"	"Canadian Grand Prix 2007"	"18"^^xsd:integer
9	"Jarno Trulli"	"United States Grand Prix 2006"	"18"^^xsd:integer
10	"Juan Pablo Montoya"	"German Grand Prix 2005"	"18"^^xsd:integer
11	"Lewis Hamilton"	"Belgian Grand Prix 2016"	"18"^^xsd:integer
12	"Jarno Trulli"	"Australian Grand Prix 2009"	"17"^^xsd:integer
13	"Carlos Sainz"	"Brazilian Grand Prix 2019"	"17"^^xsd:integer
14	"Rubens Barrichello"	"German Grand Prix 2000"	"17"^^xsd:integer
15	"Michael Schumacher"	"Monaco Grand Prix 2006"	"17"^^xsd:integer

Query 24

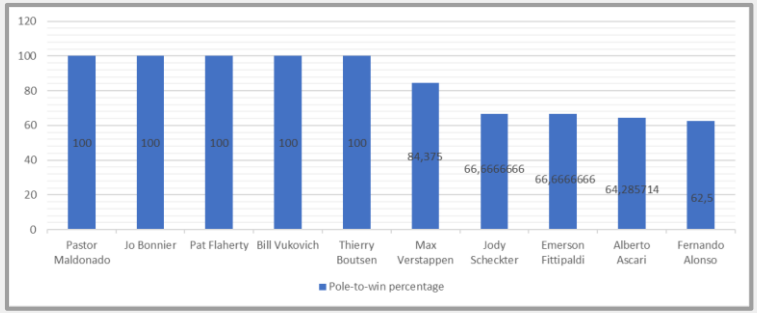
Drivers ordered by pole-to-win percentage (percentage of races won starting from the first position in grid)

```
PREFIX : <https://www.dei.unipd.it/db2/groupProject/FASTianF1#>
SELECT ?name ?numOfPoleWins ?numOfPoles ?winPercentage WHERE{
    {
        SELECT ?name (COUNT(?name) AS ?numOfPoleWins) WHERE{
            ?racePart :partecipatedInRace ?race ;
                      :hasDriver ?driv ;
                      :hasStartingGridPosition ?startPos ;
                      :hasPosition ?pos .
            ?driv a :Driver;
                  :hasForename ?fname;
                  :hasSurname ?sname.
            BIND(CONCAT(?fname, " ", ?sname) AS ?name).
            FILTER(?startPos = 1 && ?pos = 1)
        }
        GROUP BY ?name
    }
    {
        SELECT ?name (COUNT(?name) AS ?numOfPoles) WHERE{
            ?racePart :partecipatedInRace ?race ;
                      :hasDriver ?driv ;
                      :hasStartingGridPosition ?startPos .
            ?driv a :Driver;
                  :hasForename ?fname;
                  :hasSurname ?sname.
            BIND(CONCAT(?fname, " ", ?sname) AS ?name).
            FILTER(?startPos = 1)
        }
        GROUP BY ?name
    }
    BIND((?numOfPoleWins / ?numOfPoles) * 100 AS ?winPercentage)
}
ORDER BY DESC (?winPercentage)
```

SPARQL RESULT

	name	numOfPoleWins	numOfPoles	winPercentage
1	"Pastor Maldonado"	"1"^^xsd:integer	"1"^^xsd:integer	"100"^^xsd:decimal
2	"Jo Bonnier"	"1"^^xsd:integer	"1"^^xsd:integer	"100"^^xsd:decimal
3	"Pat Flaherty"	"1"^^xsd:integer	"1"^^xsd:integer	"100"^^xsd:decimal
4	"Bill Vukovich"	"1"^^xsd:integer	"1"^^xsd:integer	"100"^^xsd:decimal
5	"Thierry Boutsen"	"1"^^xsd:integer	"1"^^xsd:integer	"100"^^xsd:decimal
6	"Max Verstappen"	"27"^^xsd:integer	"32"^^xsd:integer	"84.37500"^^xsd:decimal
7	"Jody Scheckter"	"2"^^xsd:integer	"3"^^xsd:integer	"66.66666666666666666666700"^^xsd:decimal
8	"Emerson Fittipaldi"	"4"^^xsd:integer	"6"^^xsd:integer	"66.66666666666666666666700"^^xsd:decimal
9	"Alberto Ascari"	"9"^^xsd:integer	"14"^^xsd:integer	"64.28571428571428571428570"^^xsd:decimal
10	"Fernando Alonso"	"14"^^xsd:integer	"22"^^xsd:integer	"63.63636363636363636363640"^^xsd:decimal

BAR CHART



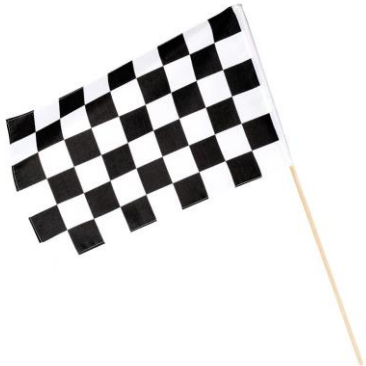
Query 25

Drivers who finished first in a race and were placed in the last quarter in the standing at the previous race

```
PREFIX : <https://www.dei.unipd.it/db2/groupProject/FASTianF1#>
SELECT ?driverName ?raceName ?round ?year WHERE{
    ?race :hasRound ?round ;
          :inSeason ?season ;
          :hasName ?raceName .
    ?part :partecipatedInRace ?race ;
          :hasPosition ?pos ;
          :hasDriver ?driver .
    ?driver :hasForename ?fname ;
            :hasSurname ?lname .
    ?season :hasYear ?year .
    BIND((?round-1) AS ?prevRound)
    BIND(CONCAT(?fname," ",?lname) AS ?driverName)
    FILTER(?pos = 1 && EXISTS{
            ?prevRace :hasRound ?prevRound ;
                      :inSeason ?season .
            ?stand :hasRace ?prevRace ;
                   :hasDriver ?driver ;
                   :hasTotalPosition ?totPos .
            FILTER (?totPos >= ((?maxPos/4)*3) && ?prevRace = ?raceMax)
            {
                SELECT ?raceMax (MAX(?totPos) AS ?maxPos) WHERE {
                    ?standing a :DriverStanding ;
                              :hasRace ?raceMax ;
                              :hasTotalPosition ?totPos .
                }
                GROUP BY ?raceMax
            }
        })
}
ORDER BY (?year)
```

SPARQL RESULT

	driverName	raceName	round	year
1	"Alberto Ascari"	"Belgian Grand Prix"	"3"^^xsd:integer	"1952"^^xsd:integer
2	"Jack Brabham"	"Dutch Grand Prix"	"4"^^xsd:integer	"1960"^^xsd:integer
3	"Dan Gurney"	"French Grand Prix"	"4"^^xsd:integer	"1962"^^xsd:integer
4	"John Surtees"	"Belgian Grand Prix"	"2"^^xsd:integer	"1966"^^xsd:integer
5	"Ludovico Scarfiotti"	"Italian Grand Prix"	"7"^^xsd:integer	"1966"^^xsd:integer
6	"Dan Gurney"	"Belgian Grand Prix"	"4"^^xsd:integer	"1967"^^xsd:integer
7	"Jean-Pierre Beltoise"	"Monaco Grand Prix"	"4"^^xsd:integer	"1972"^^xsd:integer
8	"Jean-Pierre Jabouille"	"French Grand Prix"	"8"^^xsd:integer	"1979"^^xsd:integer
9	"René Arnoux"	"Brazilian Grand Prix"	"2"^^xsd:integer	"1980"^^xsd:integer
10	"Kimi Räikkönen"	"Malaysian Grand Prix"	"2"^^xsd:integer	"2008"^^xsd:integer
11	"Sebastian Vettel"	"Chinese Grand Prix"	"3"^^xsd:integer	"2009"^^xsd:integer
12	"Lewis Hamilton"	"Malaysian Grand Prix"	"2"^^xsd:integer	"2014"^^xsd:integer
13	"Max Verstappen"	"Saudi Arabian Grand Prix"	"2"^^xsd:integer	"2022"^^xsd:integer



Thank you!