

Advanced topics in Databases

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Agenda

- Informal discussion of a csv dataset to anchor
 - The issues raised
 - The challenges in working with such data
 - The concept of functional dependencies
 - Initial insights into the value of normalizing relational schemas (using functional dependencies)

Dataset

- Kaggle F1 dataset
 - Formula 1 World Championship (1950 - 2024)
 - <https://www.kaggle.com/datasets/rohanrao/formula-1-world-championship-1950-2020>
- One file contains data about races

races.csv (164.34 kB)

Detail Compact Column 10 of 18 columns

About this file Suggest Edits

Races in F1

racelid Id of race	# year Year	# round Race number	circuitid Id of circuit	A name Name of circuit	date Date
				British Grand Prix 7%	
1	2009	1	1	Australian Grand Prix	2009-03-
2	2009	2	2	Malaysian Grand Prix	2009-04-
3	2009	3	17	Chinese Grand Prix	2009-04-

Data Explorer
Version 24 (21.99 MB)

- circuits.csv
- constructor_results.csv
- constructor_standings.csv
- constructors.csv
- driver_standings.csv
- drivers.csv
- lap_times.csv
- pit_stops.csv
- qualifying.csv
- races.csv** (164.34 kB)
- seasons.csv
- sprint_results.csv
- status.csv


Summary

- 14 files
- 120 columns

Insight the data

- Once loaded with excel or Power BI

racelid	year	round	circuitid	name	date	time	url	fp1_date	fp1_time	fp2_date	fp2_time	fp3_date	fp3_time	quali_date	quali_time	sprint_date	sprint_time
1	2009	1	1	Australian Grand Prix	29/3/2009	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_P...	\N	\N	\N	\N	\N	\N	\N	\N	\N	\N
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4	2009	4	3	Bahrain Grand Prix	26/4/2009	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix	\N	\N	\N	\N	\N	\N	\N	\N	\N	\N
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20	2008	3	3	Bahrain Grand Prix	6/4/2008	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix	\N	\N	\N	\N	\N	\N	\N	\N	\N	\N

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Insight the data

- Once loaded with excel or Power BI
 - Details of each race


racelid	year	round	circuitId	name	date	time	url	fp1_date	fp1_time	fp2_date	fp2_time	fp3_date	fp3_time	quali_date	quali_time	sprint_date	sprint_time
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The data in the preview has been truncated due to size limits.

Insight the data (cont.)

- As presented to you in excel or Power BI
 - Three free practice sessions per race


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Insight the data (cont.)

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 - Qualifying session per race


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Insight the data (cont.)

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 - Sprint race

racelid	year	round	circuitid	name	date	time	url	fp1_date	fp1_time	fp2_date	fp2_time	fp3_date	fp3_time	quali_date	quali_time	sprint_date	sprint_time
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14	2009	14	15	Singapore Grand Prix	27/9/2009	12:00:00	http://en.wikipedia.org/wiki/2009_Singapore_Grand_P...	\N	\N	\N	\N	\N	\N	\N	\N	\N	\N
15	2009	15	22	Japanese Grand Prix	4/10/2009	05:00:00	http://en.wikipedia.org/wiki/2009_Japanese_Grand_Prix	\N	\N	\N	\N	\N	\N	\N	\N	\N	\N
16	2009	16	18	Brazilian Grand Prix	18/10/2009	16:00:00	http://en.wikipedia.org/wiki/2009_Brazilian_Grand_Prix	\N	\N	\N	\N	\N	\N	\N	\N	\N	\N
17	2009	17	24	Abu Dhabi Grand Prix	1/11/2009	11:00:00	http://en.wikipedia.org/wiki/2009_Abu_Dhabi_Grand_...	\N	\N	\N	\N	\N	\N	\N	\N	\N	\N
18	2008	1	1	Australian Grand Prix	16/3/2008	04:30:00	http://en.wikipedia.org/wiki/2008_Australian_Grand_P...	\N	\N	\N	\N	\N	\N	\N	\N	\N	\N
19	2008	2	2	Malaysian Grand Prix	23/3/2008	07:00:00	http://en.wikipedia.org/wiki/2008_Malaysian_Grand_P...	\N	\N	\N	\N	\N	\N	\N	\N	\N	\N
20	2008	3	3	Bahrain Grand Prix	6/4/2008	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix	\N	\N	\N	\N	\N	\N	\N	\N	\N	\N

 The data in the preview has been truncated due to size limits.

Clearing the data

- Keeping only the tuples of interest
 - Need to be careful !

raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
2	2009	2	2	Malaysian Grand Prix	2009-04-05	09:00:00	http://en.wikipedia.org/wiki/2009_Malaysian_Grand_Prix
3	2009	3	17	Chinese Grand Prix	2009-04-19	07:00:00	http://en.wikipedia.org/wiki/2009_Chinese_Grand_Prix
4	2009	4	3	Bahrain Grand Prix	2009-04-26	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix
5	2009	5	4	Spanish Grand Prix	2009-05-10	12:00:00	http://en.wikipedia.org/wiki/2009_Spanish_Grand_Prix
6	2009	6	6	Monaco Grand Prix	2009-05-24	12:00:00	http://en.wikipedia.org/wiki/2009_Monaco_Grand_Prix
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8	2009	8	9	British Grand Prix	2009-06-21	12:00:00	http://en.wikipedia.org/wiki/2009_British_Grand_Prix
9	2009	9	20	German Grand Prix	2009-07-12	12:00:00	http://en.wikipedia.org/wiki/2009_German_Grand_Prix
10	2009	10	11	Hungarian Grand Prix	2009-07-26	12:00:00	http://en.wikipedia.org/wiki/2009_Hungarian_Grand_Prix
11	2009	11	12	European Grand Prix	2009-08-23	12:00:00	http://en.wikipedia.org/wiki/2009_European_Grand_Prix
12	2009	12	13	Belgian Grand Prix	2009-08-30	12:00:00	http://en.wikipedia.org/wiki/2009_Belgian_Grand_Prix
13	2009	13	14	Italian Grand Prix	2009-09-13	12:00:00	http://en.wikipedia.org/wiki/2009_Italian_Grand_Prix
14	2009	14	15	Singapore Grand Prix	2009-09-27	12:00:00	http://en.wikipedia.org/wiki/2009_Singapore_Grand_Prix
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18	2008	1	1	Australian Grand Prix	2008-03-16	04:30:00	http://en.wikipedia.org/wiki/2008_Australian_Grand_Prix
19	2008	2	2	Malaysian Grand Prix	2008-03-23	07:00:00	http://en.wikipedia.org/wiki/2008_Malaysian_Grand_Prix
20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Data elements

- The unique id of each race



raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
2	2009	2	2	Malaysian Grand Prix	2009-04-05	09:00:00	http://en.wikipedia.org/wiki/2009_Malaysian_Grand_Prix
3	2009	3	17	Chinese Grand Prix	2009-04-19	07:00:00	http://en.wikipedia.org/wiki/2009_Chinese_Grand_Prix
4	2009	4	3	Bahrain Grand Prix	2009-04-26	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix
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12	2009	12	13	Belgian Grand Prix	2009-08-30	12:00:00	http://en.wikipedia.org/wiki/2009_Belgian_Grand_Prix
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Data elements

- The year in which a specific race took place



raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
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4	2009	4	3	Bahrain Grand Prix	2009-04-26	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix
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20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Data elements

- The round (ή αγωνιστική της σεζόν) in which a specific race took place



raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
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20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Data elements

- The id of the circuit (πίστα) in which a specific race took place



raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
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4	2009	4	3	Bahrain Grand Prix	2009-04-26	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix
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7	2009	7	5	Turkish Grand Prix	2009-06-07	12:00:00	http://en.wikipedia.org/wiki/2009_Turkish_Grand_Prix
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20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Data elements

- The name of the circuit (πίστα) in which a specific race took place



raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
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Data elements

- The date in which the race took place



raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
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Data elements

- The local time in which the race took place



raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
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14	2009	14	15	Singapore Grand Prix	2009-09-27	12:00:00	http://en.wikipedia.org/wiki/2009_Singapore_Grand_Prix
15	2009	15	22	Japanese Grand Prix	2009-10-04	05:00:00	http://en.wikipedia.org/wiki/2009_Japanese_Grand_Prix
16	2009	16	18	Brazilian Grand Prix	2009-10-18	16:00:00	http://en.wikipedia.org/wiki/2009_Brazilian_Grand_Prix
17	2009	17	24	Abu Dhabi Grand Prix	2009-11-01	11:00:00	http://en.wikipedia.org/wiki/2009_Abu_Dhabi_Grand_Prix
18	2008	1	1	Australian Grand Prix	2008-03-16	04:30:00	http://en.wikipedia.org/wiki/2008_Australian_Grand_Prix
19	2008	2	2	Malaysian Grand Prix	2008-03-23	07:00:00	http://en.wikipedia.org/wiki/2008_Malaysian_Grand_Prix
20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Data elements

- The url of the race



raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
2	2009	2	2	Malaysian Grand Prix	2009-04-05	09:00:00	http://en.wikipedia.org/wiki/2009_Malaysian_Grand_Prix
3	2009	3	17	Chinese Grand Prix	2009-04-19	07:00:00	http://en.wikipedia.org/wiki/2009_Chinese_Grand_Prix
4	2009	4	3	Bahrain Grand Prix	2009-04-26	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix
5	2009	5	4	Spanish Grand Prix	2009-05-10	12:00:00	http://en.wikipedia.org/wiki/2009_Spanish_Grand_Prix
6	2009	6	6	Monaco Grand Prix	2009-05-24	12:00:00	http://en.wikipedia.org/wiki/2009_Monaco_Grand_Prix
7	2009	7	5	Turkish Grand Prix	2009-06-07	12:00:00	http://en.wikipedia.org/wiki/2009_Turkish_Grand_Prix
8	2009	8	9	British Grand Prix	2009-06-21	12:00:00	http://en.wikipedia.org/wiki/2009_British_Grand_Prix
9	2009	9	20	German Grand Prix	2009-07-12	12:00:00	http://en.wikipedia.org/wiki/2009_German_Grand_Prix
10	2009	10	11	Hungarian Grand Prix	2009-07-26	12:00:00	http://en.wikipedia.org/wiki/2009_Hungarian_Grand_Prix
11	2009	11	12	European Grand Prix	2009-08-23	12:00:00	http://en.wikipedia.org/wiki/2009_European_Grand_Prix
12	2009	12	13	Belgian Grand Prix	2009-08-30	12:00:00	http://en.wikipedia.org/wiki/2009_Belgian_Grand_Prix
13	2009	13	14	Italian Grand Prix	2009-09-13	12:00:00	http://en.wikipedia.org/wiki/2009_Italian_Grand_Prix
14	2009	14	15	Singapore Grand Prix	2009-09-27	12:00:00	http://en.wikipedia.org/wiki/2009_Singapore_Grand_Prix
15	2009	15	22	Japanese Grand Prix	2009-10-04	05:00:00	http://en.wikipedia.org/wiki/2009_Japanese_Grand_Prix
16	2009	16	18	Brazilian Grand Prix	2009-10-18	16:00:00	http://en.wikipedia.org/wiki/2009_Brazilian_Grand_Prix
17	2009	17	24	Abu Dhabi Grand Prix	2009-11-01	11:00:00	http://en.wikipedia.org/wiki/2009_Abu_Dhabi_Grand_Prix
18	2008	1	1	Australian Grand Prix	2008-03-16	04:30:00	http://en.wikipedia.org/wiki/2008_Australian_Grand_Prix
19	2008	2	2	Malaysian Grand Prix	2008-03-23	07:00:00	http://en.wikipedia.org/wiki/2008_Malaysian_Grand_Prix
20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Data (in the relational view)

- Data definition

```
CREATE TABLE races (  
    raceId integer not null,  
    year varchar(255),  
    round integer,  
    circuitId integer,  
    name varchar(255),  
    date date,  
    time TEXT,  
    url varchar(255),  
    primary key (raceId));  
COPY races  
FROM 'C:\Demos\races.csv' DELIMITER ',' CSV HEADER;
```

Questions (in the relational view)

- Data definition

```
CREATE TABLE races (  
    raceId integer not null,  
    year varchar(255),  
    round integer,  
    circuitId integer,  
    name varchar(255),  
    date date,  
    time TEXT,  
    url varchar(255),  
    primary key (raceId));
```

- What if the data contain an invalid circuitId?

Answer (in the relational view)

- Data definition

```
CREATE TABLE races (  
    raceId integer not null,  
    year varchar(255),  
    round integer,  
    circuitId integer,  
    name varchar(255),  
    date date,  
    time TEXT,  
    url varchar(255),  
    primary key (raceId));
```

- Introduce foreign key constraint !

Questions (cont.)

- Data definition

```
CREATE TABLE races (  
    raceId integer not null,  
    year varchar(255),  
    round integer,  
    circuitId integer,  
    name varchar(255),  
    date date,  
    time TEXT,  
    url varchar(255),  
    foreign key (circuitId) references circuits (circuitId),  
    primary key (raceId));
```

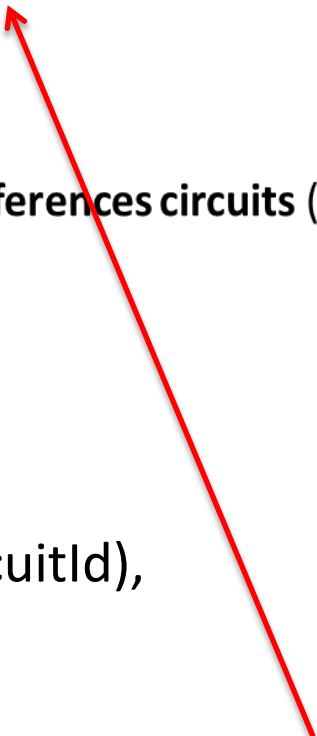
- What if for the same circuitId correspond two different names?

Answer

- Data definition

```
CREATE TABLE races (  
    raceId integer not null,  
    year varchar(255),  
    round integer,  
    circuitId integer,  
    name varchar(255),  
    date date,  
    time TEXT,  
    url varchar(255),  
    foreign key (circuitId) references circuits (circuitId),  
    primary key (raceId));
```

```
CREATE TABLE races (  
    raceId integer not null,  
    year varchar(255),  
    round integer,  
    circuitId integer UNIQUE,  
    name varchar(255) UNIQUE,  
    date date,  
    time TEXT,  
    url varchar(255),  
    foreign key (circuitId) references circuits (circuitId),  
    primary key (raceId));
```



- No obvious method (other than use of UNIQUE) to represent this semantic constraint !

The source of the problem ...

- The data is not normalized !

raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
2	2009	2	2	Malaysian Grand Prix	2009-04-05	09:00:00	http://en.wikipedia.org/wiki/2009_Malaysian_Grand_Prix
3	2009	3	17	Chinese Grand Prix	2009-04-19	07:00:00	http://en.wikipedia.org/wiki/2009_Chinese_Grand_Prix
4	2009	4	3	Bahrain Grand Prix	2009-04-26	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix
5	2009	5	4	Spanish Grand Prix	2009-05-10	12:00:00	http://en.wikipedia.org/wiki/2009_Spanish_Grand_Prix
6	2009	6	6	Monaco Grand Prix	2009-05-24	12:00:00	http://en.wikipedia.org/wiki/2009_Monaco_Grand_Prix
7	2009	7	5	Turkish Grand Prix	2009-06-07	12:00:00	http://en.wikipedia.org/wiki/2009_Turkish_Grand_Prix
8	2009	8	9	British Grand Prix	2009-06-21	12:00:00	http://en.wikipedia.org/wiki/2009_British_Grand_Prix
9	2009	9	20	German Grand Prix	2009-07-12	12:00:00	http://en.wikipedia.org/wiki/2009_German_Grand_Prix
10	2009	10	11	Hungarian Grand Prix	2009-07-26	12:00:00	http://en.wikipedia.org/wiki/2009_Hungarian_Grand_Prix
11	2009	11	12	European Grand Prix	2009-08-23	12:00:00	http://en.wikipedia.org/wiki/2009_European_Grand_Prix
12	2009	12	13	Belgian Grand Prix	2009-08-30	12:00:00	http://en.wikipedia.org/wiki/2009_Belgian_Grand_Prix
13	2009	13	14	Italian Grand Prix	2009-09-13	12:00:00	http://en.wikipedia.org/wiki/2009_Italian_Grand_Prix
14	2009	14	15	Singapore Grand Prix	2009-09-27	12:00:00	http://en.wikipedia.org/wiki/2009_Singapore_Grand_Prix
15	2009	15	22	Japanese Grand Prix	2009-10-04	05:00:00	http://en.wikipedia.org/wiki/2009_Japanese_Grand_Prix
16	2009	16	18	Brazilian Grand Prix	2009-10-18	16:00:00	http://en.wikipedia.org/wiki/2009_Brazilian_Grand_Prix
17	2009	17	24	Abu Dhabi Grand Prix	2009-11-01	11:00:00	http://en.wikipedia.org/wiki/2009_Abu_Dhabi_Grand_Prix
18	2008	1	1	Australian Grand Prix	2008-03-16	04:30:00	http://en.wikipedia.org/wiki/2008_Australian_Grand_Prix
19	2008	2	2	Malaysian Grand Prix	2008-03-23	07:00:00	http://en.wikipedia.org/wiki/2008_Malaysian_Grand_Prix
20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Unnormalized tables have problems ...

- Repetition of data

raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
2	2009	2	2	Malaysian Grand Prix	2009-04-05	09:00:00	http://en.wikipedia.org/wiki/2009_Malaysian_Grand_Prix
3	2009	3	17	Chinese Grand Prix	2009-04-19	07:00:00	http://en.wikipedia.org/wiki/2009_Chinese_Grand_Prix
4	2009	4	3	Bahrain Grand Prix	2009-04-26	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix
5	2009	5	4	Spanish Grand Prix	2009-05-10	12:00:00	http://en.wikipedia.org/wiki/2009_Spanish_Grand_Prix
6	2009	6	6	Monaco Grand Prix	2009-05-24	12:00:00	http://en.wikipedia.org/wiki/2009_Monaco_Grand_Prix
7	2009	7	5	Turkish Grand Prix	2009-06-07	12:00:00	http://en.wikipedia.org/wiki/2009_Turkish_Grand_Prix
8	2009	8	9	British Grand Prix	2009-06-21	12:00:00	http://en.wikipedia.org/wiki/2009_British_Grand_Prix
9	2009	9	20	German Grand Prix	2009-07-12	12:00:00	http://en.wikipedia.org/wiki/2009_German_Grand_Prix
10	2009	10	11	Hungarian Grand Prix	2009-07-26	12:00:00	http://en.wikipedia.org/wiki/2009_Hungarian_Grand_Prix
11	2009	11	12	European Grand Prix	2009-08-23	12:00:00	http://en.wikipedia.org/wiki/2009_European_Grand_Prix
12	2009	12	13	Belgian Grand Prix	2009-08-30	12:00:00	http://en.wikipedia.org/wiki/2009_Belgian_Grand_Prix
13	2009	13	14	Italian Grand Prix	2009-09-13	12:00:00	http://en.wikipedia.org/wiki/2009_Italian_Grand_Prix
14	2009	14	15	Singapore Grand Prix	2009-09-27	12:00:00	http://en.wikipedia.org/wiki/2009_Singapore_Grand_Prix
15	2009	15	22	Japanese Grand Prix	2009-10-04	05:00:00	http://en.wikipedia.org/wiki/2009_Japanese_Grand_Prix
16	2009	16	18	Brazilian Grand Prix	2009-10-18	16:00:00	http://en.wikipedia.org/wiki/2009_Brazilian_Grand_Prix
17	2009	17	24	Abu Dhabi Grand Prix	2009-11-01	11:00:00	http://en.wikipedia.org/wiki/2009_Abu_Dhabi_Grand_Prix
18	2008	1	1	Australian Grand Prix	2008-03-16	04:30:00	http://en.wikipedia.org/wiki/2008_Australian_Grand_Prix
19	2008	2	2	Malaysian Grand Prix	2008-03-23	07:00:00	http://en.wikipedia.org/wiki/2008_Malaysian_Grand_Prix
20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Unnormalized tables have problems ...

- Anomalies

- inconsistencies or errors that can arise when inserting, deleting or modifying data

raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
2	2009	2	2	Malaysian Grand Prix	2009-04-05	09:00:00	http://en.wikipedia.org/wiki/2009_Malaysian_Grand_Prix
3	2009	3	17	Chinese Grand Prix	2009-04-19	07:00:00	http://en.wikipedia.org/wiki/2009_Chinese_Grand_Prix
4	2009	4	3	Bahrain Grand Prix	2009-04-26	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix
5	2009	5	4	Spanish Grand Prix	2009-05-10	12:00:00	http://en.wikipedia.org/wiki/2009_Spanish_Grand_Prix
6	2009	6	6	Monaco Grand Prix	2009-05-24	12:00:00	http://en.wikipedia.org/wiki/2009_Monaco_Grand_Prix
7	2009	7	5	Turkish Grand Prix	2009-06-07	12:00:00	http://en.wikipedia.org/wiki/2009_Turkish_Grand_Prix
8	2009	8	9	British Grand Prix	2009-06-21	12:00:00	http://en.wikipedia.org/wiki/2009_British_Grand_Prix
9	2009	9	20	German Grand Prix	2009-07-12	12:00:00	http://en.wikipedia.org/wiki/2009_German_Grand_Prix
10	2009	10	11	Hungarian Grand Prix	2009-07-26	12:00:00	http://en.wikipedia.org/wiki/2009_Hungarian_Grand_Prix
11	2009	11	12	European Grand Prix	2009-08-23	12:00:00	http://en.wikipedia.org/wiki/2009_European_Grand_Prix
12	2009	12	13	Belgian Grand Prix	2009-08-30	12:00:00	http://en.wikipedia.org/wiki/2009_Belgian_Grand_Prix
13	2009	13	14	Italian Grand Prix	2009-09-13	12:00:00	http://en.wikipedia.org/wiki/2009_Italian_Grand_Prix
14	2009	14	15	Singapore Grand Prix	2009-09-27	12:00:00	http://en.wikipedia.org/wiki/2009_Singapore_Grand_Prix
15	2009	15	22	Japanese Grand Prix	2009-10-04	05:00:00	http://en.wikipedia.org/wiki/2009_Japanese_Grand_Prix
16	2009	16	18	Brazilian Grand Prix	2009-10-18	16:00:00	http://en.wikipedia.org/wiki/2009_Brazilian_Grand_Prix
17	2009	17	24	Abu Dhabi Grand Prix	2009-11-01	11:00:00	http://en.wikipedia.org/wiki/2009_Abu_Dhabi_Grand_Prix
18	2008	1	1	Australian Grand Prix	2008-03-16	04:30:00	http://en.wikipedia.org/wiki/2008_Australian_Grand_Prix
19	2008	2	2	Malaysian Grand Prix	2008-03-23	07:00:00	http://en.wikipedia.org/wiki/2008_Malaysian_Grand_Prix
20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Observations

- For a given value of *circuitId* we have exactly one (and only one) value for *name*

raceId [PK] integer	year character varying (255)	round integer	circuitId integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
2	2009	2	2	Malaysian Grand Prix	2009-04-05	09:00:00	http://en.wikipedia.org/wiki/2009_Malaysian_Grand_Prix
3	2009	3	17	Chinese Grand Prix	2009-04-19	07:00:00	http://en.wikipedia.org/wiki/2009_Chinese_Grand_Prix
4	2009	4	3	Bahrain Grand Prix	2009-04-26	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix
5	2009	5	4	Spanish Grand Prix	2009-05-10	12:00:00	http://en.wikipedia.org/wiki/2009_Spanish_Grand_Prix
6	2009	6	6	Monaco Grand Prix	2009-05-24	12:00:00	http://en.wikipedia.org/wiki/2009_Monaco_Grand_Prix
7	2009	7	5	Turkish Grand Prix	2009-06-07	12:00:00	http://en.wikipedia.org/wiki/2009_Turkish_Grand_Prix
8	2009	8	9	British Grand Prix	2009-06-21	12:00:00	http://en.wikipedia.org/wiki/2009_British_Grand_Prix
9	2009	9	20	German Grand Prix	2009-07-12	12:00:00	http://en.wikipedia.org/wiki/2009_German_Grand_Prix
10	2009	10	11	Hungarian Grand Prix	2009-07-26	12:00:00	http://en.wikipedia.org/wiki/2009_Hungarian_Grand_Prix
11	2009	11	12	European Grand Prix	2009-08-23	12:00:00	http://en.wikipedia.org/wiki/2009_European_Grand_Prix
12	2009	12	13	Belgian Grand Prix	2009-08-30	12:00:00	http://en.wikipedia.org/wiki/2009_Belgian_Grand_Prix
13	2009	13	14	Italian Grand Prix	2009-09-13	12:00:00	http://en.wikipedia.org/wiki/2009_Italian_Grand_Prix
14	2009	14	15	Singapore Grand Prix	2009-09-27	12:00:00	http://en.wikipedia.org/wiki/2009_Singapore_Grand_Prix
15	2009	15	22	Japanese Grand Prix	2009-10-04	05:00:00	http://en.wikipedia.org/wiki/2009_Japanese_Grand_Prix
16	2009	16	18	Brazilian Grand Prix	2009-10-18	16:00:00	http://en.wikipedia.org/wiki/2009_Brazilian_Grand_Prix
17	2009	17	24	Abu Dhabi Grand Prix	2009-11-01	11:00:00	http://en.wikipedia.org/wiki/2009_Abu_Dhabi_Grand_Prix
18	2008	1	1	Australian Grand Prix	2008-03-16	04:30:00	http://en.wikipedia.org/wiki/2008_Australian_Grand_Prix
19	2008	2	2	Malaysian Grand Prix	2008-03-23	07:00:00	http://en.wikipedia.org/wiki/2008_Malaysian_Grand_Prix
20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Functional dependency

- circuitId* → *name*

raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
2	2009	2	2	Malaysian Grand Prix	2009-04-05	09:00:00	http://en.wikipedia.org/wiki/2009_Malaysian_Grand_Prix
3	2009	3	17	Chinese Grand Prix	2009-04-19	07:00:00	http://en.wikipedia.org/wiki/2009_Chinese_Grand_Prix
4	2009	4	3	Bahrain Grand Prix	2009-04-26	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix
5	2009	5	4	Spanish Grand Prix	2009-05-10	12:00:00	http://en.wikipedia.org/wiki/2009_Spanish_Grand_Prix
6	2009	6	6	Monaco Grand Prix	2009-05-24	12:00:00	http://en.wikipedia.org/wiki/2009_Monaco_Grand_Prix
7	2009	7	5	Turkish Grand Prix	2009-06-07	12:00:00	http://en.wikipedia.org/wiki/2009_Turkish_Grand_Prix
8	2009	8	9	British Grand Prix	2009-06-21	12:00:00	http://en.wikipedia.org/wiki/2009_British_Grand_Prix
9	2009	9	20	German Grand Prix	2009-07-12	12:00:00	http://en.wikipedia.org/wiki/2009_German_Grand_Prix
10	2009	10	11	Hungarian Grand Prix	2009-07-26	12:00:00	http://en.wikipedia.org/wiki/2009_Hungarian_Grand_Prix
11	2009	11	12	European Grand Prix	2009-08-23	12:00:00	http://en.wikipedia.org/wiki/2009_European_Grand_Prix
12	2009	12	13	Belgian Grand Prix	2009-08-30	12:00:00	http://en.wikipedia.org/wiki/2009_Belgian_Grand_Prix
13	2009	13	14	Italian Grand Prix	2009-09-13	12:00:00	http://en.wikipedia.org/wiki/2009_Italian_Grand_Prix
14	2009	14	15	Singapore Grand Prix	2009-09-27	12:00:00	http://en.wikipedia.org/wiki/2009_Singapore_Grand_Prix
15	2009	15	22	Japanese Grand Prix	2009-10-04	05:00:00	http://en.wikipedia.org/wiki/2009_Japanese_Grand_Prix
16	2009	16	18	Brazilian Grand Prix	2009-10-18	16:00:00	http://en.wikipedia.org/wiki/2009_Brazilian_Grand_Prix
17	2009	17	24	Abu Dhabi Grand Prix	2009-11-01	11:00:00	http://en.wikipedia.org/wiki/2009_Abu_Dhabi_Grand_Prix
18	2008	1	1	Australian Grand Prix	2008-03-16	04:30:00	http://en.wikipedia.org/wiki/2008_Australian_Grand_Prix
19	2008	2	2	Malaysian Grand Prix	2008-03-23	07:00:00	http://en.wikipedia.org/wiki/2008_Malaysian_Grand_Prix
20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Observations (cont.)

- For a given value of *circuitId* we have different values for *date*

raceId [PK] integer	year character varying (255)	round integer	circuitId integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
2	2009	2	2	Malaysian Grand Prix	2009-04-05	09:00:00	http://en.wikipedia.org/wiki/2009_Malaysian_Grand_Prix
3	2009	3	17	Chinese Grand Prix	2009-04-19	07:00:00	http://en.wikipedia.org/wiki/2009_Chinese_Grand_Prix
4	2009	4	3	Bahrain Grand Prix	2009-04-26	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix
5	2009	5	4	Spanish Grand Prix	2009-05-10	12:00:00	http://en.wikipedia.org/wiki/2009_Spanish_Grand_Prix
6	2009	6	6	Monaco Grand Prix	2009-05-24	12:00:00	http://en.wikipedia.org/wiki/2009_Monaco_Grand_Prix
7	2009	7	5	Turkish Grand Prix	2009-06-07	12:00:00	http://en.wikipedia.org/wiki/2009_Turkish_Grand_Prix
8	2009	8	9	British Grand Prix	2009-06-21	12:00:00	http://en.wikipedia.org/wiki/2009_British_Grand_Prix
9	2009	9	20	German Grand Prix	2009-07-12	12:00:00	http://en.wikipedia.org/wiki/2009_German_Grand_Prix
10	2009	10	11	Hungarian Grand Prix	2009-07-26	12:00:00	http://en.wikipedia.org/wiki/2009_Hungarian_Grand_Prix
11	2009	11	12	European Grand Prix	2009-08-23	12:00:00	http://en.wikipedia.org/wiki/2009_European_Grand_Prix
12	2009	12	13	Belgian Grand Prix	2009-08-30	12:00:00	http://en.wikipedia.org/wiki/2009_Belgian_Grand_Prix
13	2009	13	14	Italian Grand Prix	2009-09-13	12:00:00	http://en.wikipedia.org/wiki/2009_Italian_Grand_Prix
14	2009	14	15	Singapore Grand Prix	2009-09-27	12:00:00	http://en.wikipedia.org/wiki/2009_Singapore_Grand_Prix
15	2009	15	22	Japanese Grand Prix	2009-10-04	05:00:00	http://en.wikipedia.org/wiki/2009_Japanese_Grand_Prix
16	2009	16	18	Brazilian Grand Prix	2009-10-18	16:00:00	http://en.wikipedia.org/wiki/2009_Brazilian_Grand_Prix
17	2009	17	24	Abu Dhabi Grand Prix	2009-11-01	11:00:00	http://en.wikipedia.org/wiki/2009_Abu_Dhabi_Grand_Prix
18	2008	1	1	Australian Grand Prix	2008-03-16	04:30:00	http://en.wikipedia.org/wiki/2008_Australian_Grand_Prix
19	2008	2	2	Malaysian Grand Prix	2008-03-23	07:00:00	http://en.wikipedia.org/wiki/2008_Malaysian_Grand_Prix
20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Observations (cont.)

- ... but for a given pair of *year, circuitId* we have one (and only one) value for *date*

raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
2	2009	2	2	Malaysian Grand Prix	2009-04-05	09:00:00	http://en.wikipedia.org/wiki/2009_Malaysian_Grand_Prix
3	2009	3	17	Chinese Grand Prix	2009-04-19	07:00:00	http://en.wikipedia.org/wiki/2009_Chinese_Grand_Prix
4	2009	4	3	Bahrain Grand Prix	2009-04-26	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix
5	2009	5	4	Spanish Grand Prix	2009-05-10	12:00:00	http://en.wikipedia.org/wiki/2009_Spanish_Grand_Prix
6	2009	6	6	Monaco Grand Prix	2009-05-24	12:00:00	http://en.wikipedia.org/wiki/2009_Monaco_Grand_Prix
7	2009	7	5	Turkish Grand Prix	2009-06-07	12:00:00	http://en.wikipedia.org/wiki/2009_Turkish_Grand_Prix
8	2009	8	9	British Grand Prix	2009-06-21	12:00:00	http://en.wikipedia.org/wiki/2009_British_Grand_Prix
9	2009	9	20	German Grand Prix	2009-07-12	12:00:00	http://en.wikipedia.org/wiki/2009_German_Grand_Prix
10	2009	10	11	Hungarian Grand Prix	2009-07-26	12:00:00	http://en.wikipedia.org/wiki/2009_Hungarian_Grand_Prix
11	2009	11	12	European Grand Prix	2009-08-23	12:00:00	http://en.wikipedia.org/wiki/2009_European_Grand_Prix
12	2009	12	13	Belgian Grand Prix	2009-08-30	12:00:00	http://en.wikipedia.org/wiki/2009_Belgian_Grand_Prix
13	2009	13	14	Italian Grand Prix	2009-09-13	12:00:00	http://en.wikipedia.org/wiki/2009_Italian_Grand_Prix
14	2009	14	15	Singapore Grand Prix	2009-09-27	12:00:00	http://en.wikipedia.org/wiki/2009_Singapore_Grand_Prix
15	2009	15	22	Japanese Grand Prix	2009-10-04	05:00:00	http://en.wikipedia.org/wiki/2009_Japanese_Grand_Prix
16	2009	16	18	Brazilian Grand Prix	2009-10-18	16:00:00	http://en.wikipedia.org/wiki/2009_Brazilian_Grand_Prix
17	2009	17	24	Abu Dhabi Grand Prix	2009-11-01	11:00:00	http://en.wikipedia.org/wiki/2009_Abu_Dhabi_Grand_Prix
18	2008	1	1	Australian Grand Prix	2008-03-16	04:30:00	http://en.wikipedia.org/wiki/2008_Australian_Grand_Prix
19	2008	2	2	Malaysian Grand Prix	2008-03-23	07:00:00	http://en.wikipedia.org/wiki/2008_Malaysian_Grand_Prix
20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Functional dependency

- year, circuitId* → *date*

raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
2	2009	2	2	Malaysian Grand Prix	2009-04-05	09:00:00	http://en.wikipedia.org/wiki/2009_Malaysian_Grand_Prix
3	2009	3	17	Chinese Grand Prix	2009-04-19	07:00:00	http://en.wikipedia.org/wiki/2009_Chinese_Grand_Prix
4	2009	4	3	Bahrain Grand Prix	2009-04-26	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix
5	2009	5	4	Spanish Grand Prix	2009-05-10	12:00:00	http://en.wikipedia.org/wiki/2009_Spanish_Grand_Prix
6	2009	6	6	Monaco Grand Prix	2009-05-24	12:00:00	http://en.wikipedia.org/wiki/2009_Monaco_Grand_Prix
7	2009	7	5	Turkish Grand Prix	2009-06-07	12:00:00	http://en.wikipedia.org/wiki/2009_Turkish_Grand_Prix
8	2009	8	9	British Grand Prix	2009-06-21	12:00:00	http://en.wikipedia.org/wiki/2009_British_Grand_Prix
9	2009	9	20	German Grand Prix	2009-07-12	12:00:00	http://en.wikipedia.org/wiki/2009_German_Grand_Prix
10	2009	10	11	Hungarian Grand Prix	2009-07-26	12:00:00	http://en.wikipedia.org/wiki/2009_Hungarian_Grand_Prix
11	2009	11	12	European Grand Prix	2009-08-23	12:00:00	http://en.wikipedia.org/wiki/2009_European_Grand_Prix
12	2009	12	13	Belgian Grand Prix	2009-08-30	12:00:00	http://en.wikipedia.org/wiki/2009_Belgian_Grand_Prix
13	2009	13	14	Italian Grand Prix	2009-09-13	12:00:00	http://en.wikipedia.org/wiki/2009_Italian_Grand_Prix
14	2009	14	15	Singapore Grand Prix	2009-09-27	12:00:00	http://en.wikipedia.org/wiki/2009_Singapore_Grand_Prix
15	2009	15	22	Japanese Grand Prix	2009-10-04	05:00:00	http://en.wikipedia.org/wiki/2009_Japanese_Grand_Prix
16	2009	16	18	Brazilian Grand Prix	2009-10-18	16:00:00	http://en.wikipedia.org/wiki/2009_Brazilian_Grand_Prix
17	2009	17	24	Abu Dhabi Grand Prix	2009-11-01	11:00:00	http://en.wikipedia.org/wiki/2009_Abu_Dhabi_Grand_Prix
18	2008	1	1	Australian Grand Prix	2008-03-16	04:30:00	http://en.wikipedia.org/wiki/2008_Australian_Grand_Prix
19	2008	2	2	Malaysian Grand Prix	2008-03-23	07:00:00	http://en.wikipedia.org/wiki/2008_Malaysian_Grand_Prix
20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Observations (cont.)

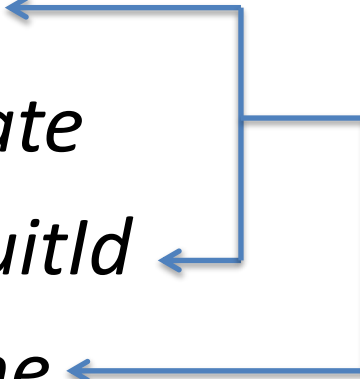
- In a similar fashion
 - *year, round* → *circuitId*

raceid [PK] integer	year character varying (255)	round integer	circuitid integer	name character varying (255)	date date	time text	url character varying (255)
1	2009	1	1	Australian Grand Prix	2009-03-29	06:00:00	http://en.wikipedia.org/wiki/2009_Australian_Grand_Prix
2	2009	2	2	Malaysian Grand Prix	2009-04-05	09:00:00	http://en.wikipedia.org/wiki/2009_Malaysian_Grand_Prix
3	2009	3	17	Chinese Grand Prix	2009-04-19	07:00:00	http://en.wikipedia.org/wiki/2009_Chinese_Grand_Prix
4	2009	4	3	Bahrain Grand Prix	2009-04-26	12:00:00	http://en.wikipedia.org/wiki/2009_Bahrain_Grand_Prix
5	2009	5	4	Spanish Grand Prix	2009-05-10	12:00:00	http://en.wikipedia.org/wiki/2009_Spanish_Grand_Prix
6	2009	6	6	Monaco Grand Prix	2009-05-24	12:00:00	http://en.wikipedia.org/wiki/2009_Monaco_Grand_Prix
7	2009	7	5	Turkish Grand Prix	2009-06-07	12:00:00	http://en.wikipedia.org/wiki/2009_Turkish_Grand_Prix
8	2009	8	9	British Grand Prix	2009-06-21	12:00:00	http://en.wikipedia.org/wiki/2009_British_Grand_Prix
9	2009	9	20	German Grand Prix	2009-07-12	12:00:00	http://en.wikipedia.org/wiki/2009_German_Grand_Prix
10	2009	10	11	Hungarian Grand Prix	2009-07-26	12:00:00	http://en.wikipedia.org/wiki/2009_Hungarian_Grand_Prix
11	2009	11	12	European Grand Prix	2009-08-23	12:00:00	http://en.wikipedia.org/wiki/2009_European_Grand_Prix
12	2009	12	13	Belgian Grand Prix	2009-08-30	12:00:00	http://en.wikipedia.org/wiki/2009_Belgian_Grand_Prix
13	2009	13	14	Italian Grand Prix	2009-09-13	12:00:00	http://en.wikipedia.org/wiki/2009_Italian_Grand_Prix
14	2009	14	15	Singapore Grand Prix	2009-09-27	12:00:00	http://en.wikipedia.org/wiki/2009_Singapore_Grand_Prix
15	2009	15	22	Japanese Grand Prix	2009-10-04	05:00:00	http://en.wikipedia.org/wiki/2009_Japanese_Grand_Prix
16	2009	16	18	Brazilian Grand Prix	2009-10-18	16:00:00	http://en.wikipedia.org/wiki/2009_Brazilian_Grand_Prix
17	2009	17	24	Abu Dhabi Grand Prix	2009-11-01	11:00:00	http://en.wikipedia.org/wiki/2009_Abu_Dhabi_Grand_Prix
18	2008	1	1	Australian Grand Prix	2008-03-16	04:30:00	http://en.wikipedia.org/wiki/2008_Australian_Grand_Prix
19	2008	2	2	Malaysian Grand Prix	2008-03-23	07:00:00	http://en.wikipedia.org/wiki/2008_Malaysian_Grand_Prix
20	2008	3	3	Bahrain Grand Prix	2008-04-06	11:30:00	http://en.wikipedia.org/wiki/2008_Bahrain_Grand_Prix

Dependencies so far

- *circuitId* → *name*
- *year, circuitId* → *date*
- *year, round* → *circuitId*

Look at the transitive relation

- $circuitId \rightarrow name$
 - $year, circuitId \rightarrow date$
 - $year, round \rightarrow circuitId$
 - $year, round \rightarrow name$
- 

Reflection(s)

- Functional dependencies
 - Exist and may be *derived* by looking at the data
 - May be *inferred* as a result of applying certain properties such as transitivity
- Interesting questions
 - How can we identify functional dependencies
 - What are the properties of functional dependencies that allow inference
 - What is the value of the above (if any) in relational database design