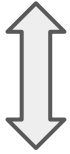# Memory models

V.MM.5 + V.MM.6

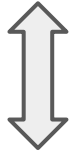**Processor**
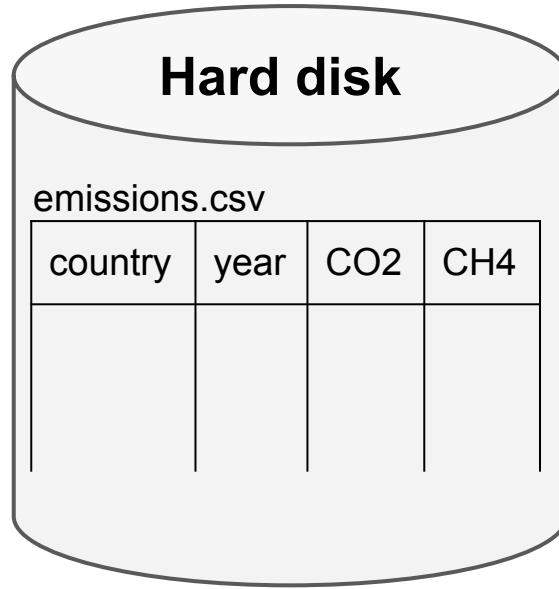
Memory
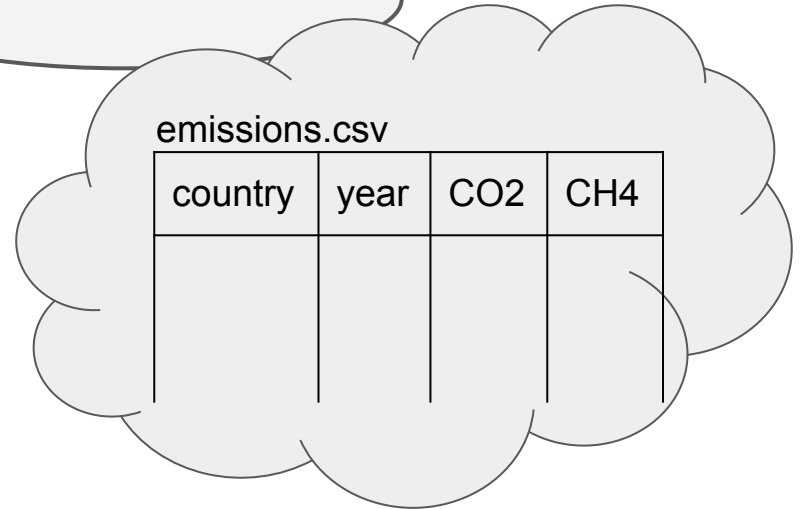
program   data

Processor

Memory

program   data

Hard disk

emissions.csv

country	year	CO2	CH4

Processor

Memory

program   data

Hard disk

emissions.csv

country	year	CO2	CH4

emissions.csv

country	year	CO2	CH4

Processor

Memory

program   data

Hard disk

emissions.csv

country	year	CO2	CH4

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
```

Processor

Memory

Hard disk

emissions.csv

country	year	CO2	CH4

symbol table

names	values
filename	"emissions.csv"

program   data

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
```

Processor

Hard disk

emissions.csv

country	year	CO2	CH4

Memory

program   data

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
```
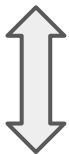
symbol table

names	values
filename	"emissions.csv"
emissions_data	??

Processor
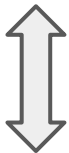
Hard disk

emissions.csv

country	year	CO2	CH4

symbol table

names	values
filename	"emissions.csv"
emissions_data	

Memory

program   data

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
```

country	year	CO2	CH4
USA ⋮	2000 ⋮	301000 ⋮	5950000 ⋮

Program:

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
```
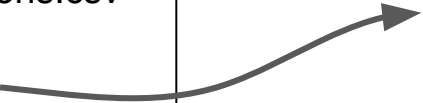
In memory:

symbol table

names	values
filename	"emissions.csv"
emissions_data	

dataframe

country	year	CO2	CH4
USA ⋮	2000 ⋮	301000 ⋮	5950000 ⋮

Memory models

V.MM.7

Program:

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
```
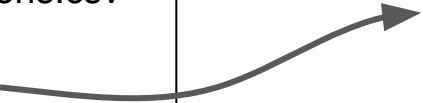
In memory:

symbol table

names	values
filename	"emissions.csv"
emissions_data	

dataframe

country	year	CO2	CH4
USA ⋮	2000 ⋮	301000 ⋮	5950000 ⋮

Program 1: accessing columns by name

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
countries <- get_column(emissions_data, "country")
```

In memory:

dataframe

symbol table

names	values
filename	"emissions.csv"
emissions_data	
countries	

country	year	CO2	CH4
USA ⋮	2000 ⋮	301000 ⋮	5950000 ⋮

USA	USA	Canada	...

Program 2: accessing columns by column number

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
years <- get_column_by_number(emissions_data, 2)
```
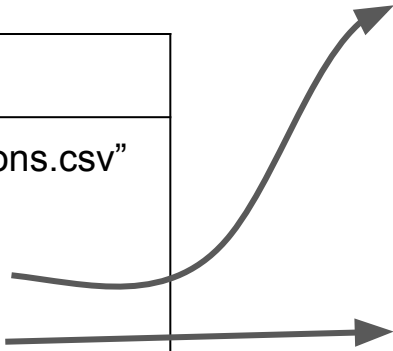
In memory:

dataframe

country	year	CO2	CH4
USA ⋮	2000 ⋮	301000 ⋮	5950000 ⋮

symbol table

names	values
filename	"emissions.csv"
emissions_data	
years	

2000	2001	1990	...

Program 3: accessing a cell in a column

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
co2_emissions <- get_column(emissions_data, "CO2")
co2_us_2001 <- get_item(co2_emissions, 2)
```

In memory:

symbol table

dataframe

names	values
filename	"emissions.csv"
emissions_data	
co2_emissions	
co2_us_2001	298000

country	year	CO2	CH4
USA ⋮	2000 ⋮	301000 ⋮	5950000 ⋮

| 301000 | 298000 | ... | ... |

Program 4: accessing rows by row number

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
us_2000 <- get_row_by_number(emissions_data, 1)
```
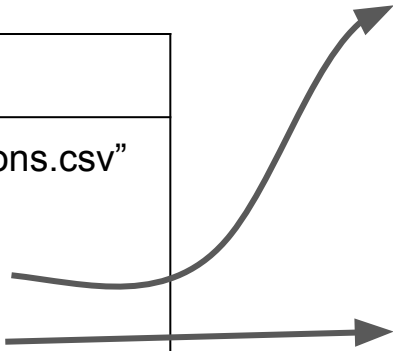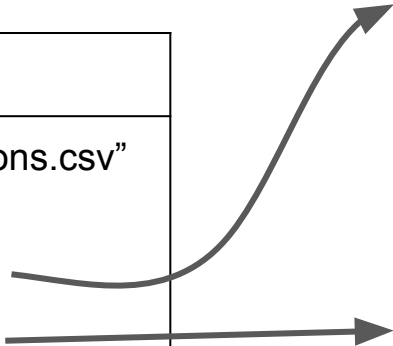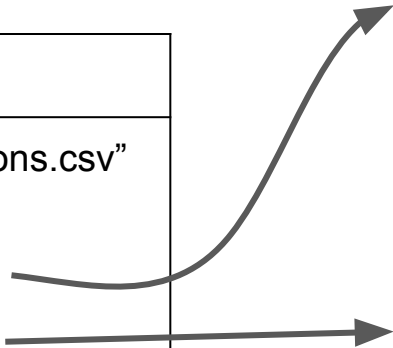
In memory:

dataframe

country	year	CO2	CH4
USA ⋮	2000 ⋮	301000 ⋮	5950000 ⋮

symbol table

names	values
filename	"emissions.csv"
emissions_data	
us_2000	

| USA | 2000 | 301000 | 5950000 |

Program 5: accessing a cell in a row

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
us_2000 <- get_row_by_number(emissions_data, 1)
co2_us_2000 <- get_item(us_2000, 3)
```
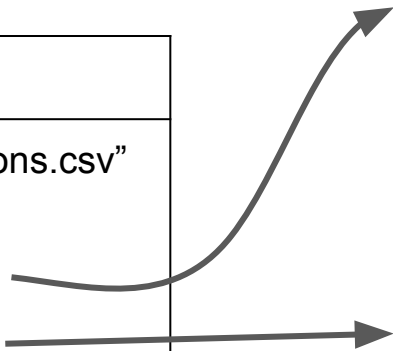
In memory:

dataframe

symbol table

names	values
filename	"emissions.csv"
emissions_data	
us_2000	
co2_us_2000	301000

country	year	CO2	CH4
USA ⋮	2000 ⋮	301000 ⋮	5950000 ⋮

| USA | 2000 | 301000 | 5950000 |

Program 6: accessing a cell by row and column number

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
co2_us_2000 <- get_cell(emissions_data, 1, 3)
```
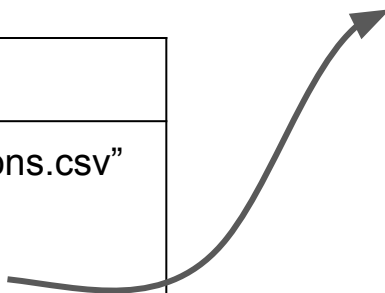
In memory:

symbol table

names	values
filename	"emissions.csv"
emissions_data	
co2_us_2000	301000

dataframe

country	year	CO2	CH4
USA ⋮	2000 ⋮	301000 ⋮	5950000 ⋮

Program 7: changing the value of a cell

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
```

In memory:

dataframe

country	year	CO2	CH4
USA ⋮	2000 ⋮	301000 ⋮	5950000 ⋮

symbol table

names	values
filename	"emissions.csv"
emissions_data	

Program 7: changing the value of a cell

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
set_cell(emissions_data, 1, 3, 303000)
```

In memory:

symbol table

names	values
filename	"emissions.csv"
emissions_data	

dataframe

country	year	CO2	CH4
USA ⋮	2000 ⋮	**303000** ⋮	5950000 ⋮

Program 7: changing the value of a cell

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
set_cell(emissions_data, 1, 3, 303000)
```
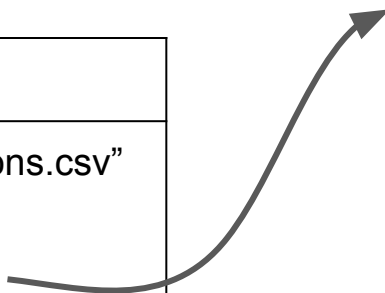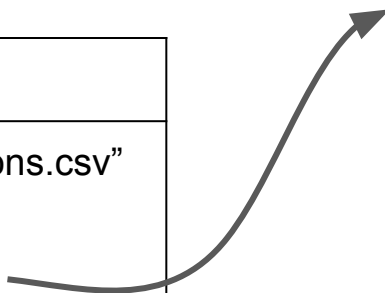
Hard disk

emissions.csv

country	year	CO2	CH4
USA	2000	301000	...
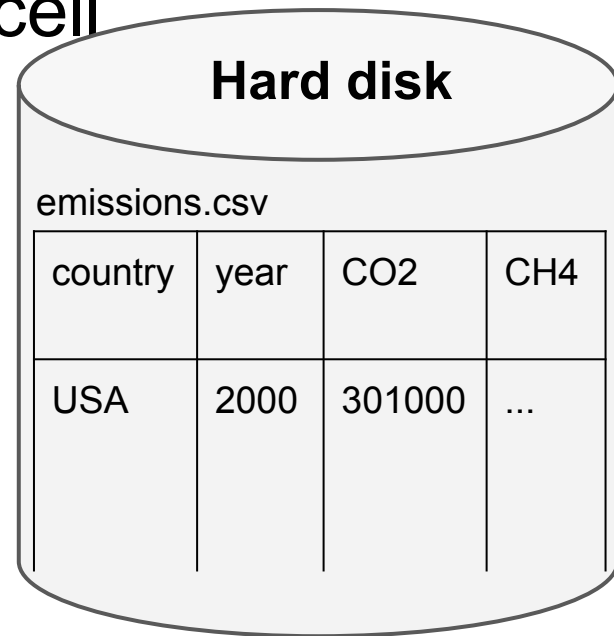
In memory:

symbol table

names	values
filename	"emissions.csv"
emissions_data	

dataframe

country	year	CO2	CH4
USA ⋮	2000 ⋮	**303000** ⋮	5950000 ⋮

Program 8: adding a row

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
us_2012 <- ["USA", 2021, 281000, 5200000]
```
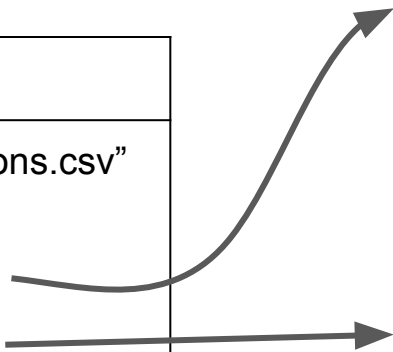
In memory:

symbol table

names	values
filename	"emissions.csv"
emissions_data	
us_2000	

dataframe

country	year	CO2	CH4
USA ⋮	2000 ⋮	301000 ⋮	5950000 ⋮

| USA | 2012 | 281000 | 5200000 |

Program 8: adding a row

```
filename <- "emissions.csv"
emissions_data <- read_spreadsheet(filename)
us_2012 <- ["USA", 2021, 281000, 5200000]
add_row(emissions_data, us_2012)
```
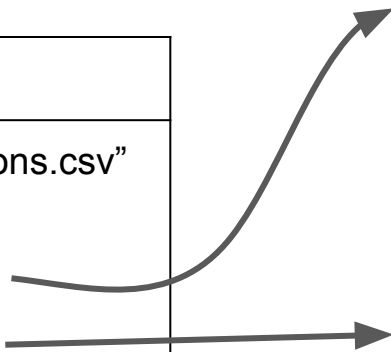
In memory:

symbol table

names	values
filename	"emissions.csv"
emissions_data	
us_2000	

dataframe

country	year	CO2	CH4
USA ⋮ USA	2000 ⋮ 2021	301000 ⋮ 281000	5950000 ⋮ 5200000

| USA | 2012 | 281000 | 5200000 |

Notes

The data are from: https://corgis-edu.github.io/

Supposedly the emissions data originally comes from
https://edgar.jrc.ec.europa.eu

But I don't see how they are derived from the data given on that site. They are also very different from
https://ourworldindata.org/co2/country/united-states?country=~USA