# Production Networks

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# Chapter 1

# Class Index

## 1.1 Class List

Here are the classes, structs, unions and interfaces with brief descriptions:

# Chapter 2

# File Index

## 2.1 File List

Here is a list of all documented files with brief descriptions:

# Chapter 3

# Class Documentation

## 3.1 Company Class Reference

Model for a company.

`#include <Models.hpp>`

### Public Member Functions

- Company () noexcept
  *Default constructor. Don't use it.*
- Company (const std::string &r) noexcept
  *Constructor with a R.I.F as l-value.*
- Company (std::string &&r) noexcept
  *Constructor with a R.I.F as l-value.*
- Company (const Company &c) noexcept
  *Copy constructor.*
- Company (Company &&c) noexcept
  *Move constructor.*
- void swap (Company &c) noexcept
  *Swap elements.*
- Company & operator= (Company c) noexcept
  *Assignment operator.*
- const std::string & get_rif () const noexcept
  *Gets the R.I.F.*
- const std::string & get_name () const noexcept
  *Gets the name.*
- void set_name (const std::string &n) noexcept
  *Sets name as l-value.*
- void set_name (std::string &&n) noexcept
  *Sets name as r-value.*
- void add_plant (std::shared_ptr< Plant > p) noexcept
  *Adds the plant p.*
- std::vector< std::shared_ptr< Plant > > & get_plants () noexcept
  *Returns the list of plants.*

### 3.1.1 Detailed Description

Model for a company.

The documentation for this class was generated from the following file:

- CC05/lib/include/Models.hpp

## 3.2 Good Class Reference

Model for goods or services.

`#include <Models.hpp>`

### Public Member Functions

- Good () noexcept
  *Default constructor. Don't use it.*
- Good (const std::string &d) noexcept
  *Constructor that receives a description as l-value.*
- Good (std::string &&d) noexcept
  *Constructor that receives a description as r-value.*
- Good (const Good &g) noexcept
  *Copy constructor.*
- Good (Good &&g) noexcept
  *Move contructor.*
- void swap (Good &g) noexcept
  *Swap elements.*
- Good & operator= (Good g) noexcept
  *Assignment operator.*
- const std::string & get_description () const noexcept
  *Gets the description.*
- void add_producer_process (std::shared_ptr< Process > p) noexcept
  *Add a process as a producer of this good.*
- void add_consumer_process (std::shared_ptr< Process > p) noexcept
  *Add a process as a consumer of this good.*
- std::vector< std::shared_ptr< Process > > & get_producer_processes () noexcept
  *Returns the list of producer processes.*
- std::vector< std::shared_ptr< Process > > & get_consumer_processes () noexcept
  *Returns the list of consumer processes.*

### 3.2.1 Detailed Description

Model for goods or services.

The documentation for this class was generated from the following file:

- CC05/lib/include/Models.hpp

## 3.3 ModelBuilder Class Reference

`#include <Models.hpp>`

### Public Member Functions

- std::shared_ptr< Good > create_good (const std::string &description) noexcept

  *Creates a new good.*
- std::shared_ptr< Process > create_process (std::shared_ptr< Good > output, std::vector< std::tuple< std::shared_ptr< Good >, float >> &inputs) noexcept

  *Creates a process.*
- std::shared_ptr< Process > create_process_randomly (std::shared_ptr< Good > output, std::unordered_set< std::shared_ptr< Good >> &possible_inputs) noexcept

  *Creates a process with random inputs.*
- std::shared_ptr< Plant > create_plant (std::shared_ptr< Company > owner, std::vector< std::tuple< std::shared_ptr< Process >, float, float >> &production) noexcept

  *Creates a plant.*
- std::shared_ptr< Plant > create_plant_randomly (std::shared_ptr< Company > owner, size_t num_processes, std::vector< std::shared_ptr< Process >> &process_set) noexcept

  *Creates a plant with random processes.*
- std::shared_ptr< Company > create_company (const std::string &rif) noexcept

  *Creates a company.*

### 3.3.1 Detailed Description

This class is intended to wrap the complex construction of some of the objects by granting that they are constructed with the right references in both directions.

### 3.3.2 Member Function Documentation

#### 3.3.2.1 create_company()

```
std::shared_ptr<Company> ModelBuilder::create_company (
            const std::string & rif )  [noexcept]
```

Creates a company.

**Parameters**

| | |
|---|---|
| *rif* | The R.I.F. |

**Returns**

A shared pointer to the company.

#### 3.3.2.2 create_good()

```
std::shared_ptr<Good> ModelBuilder::create_good (
            const std::string & description )  [noexcept]
```

Creates a new good.

**Parameters**

| | |
|---|---|
| *description* | The description (name) of the good. |

**Returns**

a shared pointer to the good.

#### 3.3.2.3 create_plant()

```
std::shared_ptr<Plant> ModelBuilder::create_plant (
            std::shared_ptr< Company > owner,
            std::vector< std::tuple< std::shared_ptr< Process >, float, float >> & production
)  [noexcept]
```

Creates a plant.

**Parameters**

| | |
|---|---|
| *owner* | The company to which the plant belongs. |
| *production* | A list of tuples (process, produced amount, used capacity) with all of the production processes. |

**Returns**

a shared pointer to the plant.

#### 3.3.2.4 create_plant_randomly()

```
std::shared_ptr<Plant> ModelBuilder::create_plant_randomly (
            std::shared_ptr< Company > owner,
            size_t num_processes,
            std::vector< std::shared_ptr< Process >> & process_set )  [noexcept]
```

Creates a plant with random processes.

**Parameters**

| | |
|---|---|
| *owner* | The company to which the plant belongs. |
| *num_processes* | The maximum amount of processes that the plant will have. |
| *process_set* | A set of available processes. |

**Returns**

a shared pointer to the plant.

#### 3.3.2.5 create_process()

```
std::shared_ptr<Process> ModelBuilder::create_process (
            std::shared_ptr< Good > output,
            std::vector< std::tuple< std::shared_ptr< Good >, float >> & inputs )  [noexcept]
```

Creates a process.

**Parameters**

| | |
|---|---|
| *output* | The produced good. |
| *inputs* | A list of tuples (good, amount) with the inputs. |

**Returns**

a shared pointer to the process.

#### 3.3.2.6 create_process_randomly()

```
std::shared_ptr<Process> ModelBuilder::create_process_randomly (
            std::shared_ptr< Good > output,
            std::unordered_set< std::shared_ptr< Good >> & possible_inputs )  [noexcept]
```

Creates a process with random inputs.

This method creates a process by selecting inputs and their required amounts randomly.

**Parameters**

| | |
|---|---|
| *output* | The good that the process produces. |
| *possible_inputs* | A set with the possible inputs of the process. |

**Returns**

a shared pointer to the process.

The documentation for this class was generated from the following file:

- CC05/lib/include/Models.hpp

## 3.4 NetworkGenerator Class Reference

### Static Public Member Functions

- static ProductionData generate_random_production_data (unsigned int num_levels, unsigned int num_plants_per_level, unsigned int num_goods_per_plant, unsigned int num_inputs_per_process, float probability_to_repeat_good, float probability_to_repeat_company)

  *Generates a random production network.*

### 3.4.1 Member Function Documentation

#### 3.4.1.1 generate_random_production_data()

```
static ProductionData NetworkGenerator::generate_random_production_data (
            unsigned int num_levels,
            unsigned int num_plants_per_level,
            unsigned int num_goods_per_plant,
            unsigned int num_inputs_per_process,
            float probability_to_repeat_good,
            float probability_to_repeat_company )  [static]
```

Generates a random production network.

This function generates a very idealist-random-production network. The features that this function provides are:

- It is structured by production levels.
- Each plant is only in one of the levels (although many plants might belong to the same company).
- Each good is produced in an only level too.
- Each good has a unique producer process.
- The inputs of each process are produced in any of the previous levels.
- The processes in the first level do not have inputs.
- The production amounts in the last level were generated randomly.
- The production amounts of the non-last-level-goods are computed to satisfy the required production.
- The production prices in the first level were generated randomly.
- The production prices of the non-first-level-goods are computed according to the input prices.

**Parameters**

| | |
|---|---|
| *num_levels* | The number of production levels in the network. |
| *num_plants_per_level* | Expected number of plants by level. |
| *num_goods_per_plant* | Expected number of goods produced by a plant. |
| *num_inputs_per_process* | Expected number of inputs for a process. |
| *probability_to_repeat_good* | Probability of many plants producing the same good. |
| *probability_to_repeat_company* | Probability of many plants belonging to the same company. |

**Returns**

ProductionData

The documentation for this class was generated from the following file:

- CC05/lib/include/Generator.hpp

## 3.5 Plant Class Reference

`#include <Models.hpp>`

### Public Member Functions

- Plant () noexcept

  *Default constructor. Don't use it.*
- Plant (std::shared_ptr< Company > ow) noexcept

  *Constructor with the owner company.*
- Plant (const Plant &p) noexcept

  *Copy constructor.*
- Plant (Plant &&p) noexcept

  *Move constructor.*
- void swap (Plant &p) noexcept

  *Swap elements.*
- Plant & operator= (Plant p) noexcept

  *Assignment operator.*
- std::shared_ptr< Company > get_owner () const noexcept

  *Gets the owner company.*
- void add_production_process (std::shared_ptr< Process > p, float q, float cap)
- void set_production_quantity (std::shared_ptr< Process > p, float q)
- void inc_production_quantity (std::shared_ptr< Process > p, float q)
- void set_production_capacity (std::shared_ptr< Process > p, float c)
- void inc_production_capacity (std::shared_ptr< Process > p, float c)
- std::tuple< float, float > get_production (std::shared_ptr< Process > p) const
- std::unordered_map< std::shared_ptr< Process >, std::pair< float, float > > & get_production_table () noexcept

  *Gets the table of production.*
- std::vector< std::tuple< std::shared_ptr< Process >, float, float > > get_production () const noexcept

  *Gets a list of tuples (process, quantity, capacity) de los procesos.*

### 3.5.1 Detailed Description

Represents a plant or a company branch office that produces goods.

The goods that produces are defined by each process that the plant owns.

In this model, the production of the goods is represented by a table of processes, each of them associated with the actual production and its capacity of production represented as a percentage.

For instance: Lets P1 be a process owned by a plant. Suppose that P1 has a capacity of production of 100 units by time unit and in a time point it is producing 80 units, then P1 will be associated with the pair (80, 80). That means that P1 is producing 80 units of its output and it is using the 80% of its capacity of production.

### 3.5.2 Member Function Documentation

#### 3.5.2.1 add_production_process()

```
void Plant::add_production_process (
            std::shared_ptr< Process > p,
            float q,
            float cap )
```

Adds a process with its actual production and its capacity of production.

If the process already exists, then the production and the capacity will be updated.

**Exceptions**

| | |
|---|---|
| *std::invalid_argument* | if the quantity or the capacity are less than zero or the capacity is greater than 100. |

#### 3.5.2.2 get_production()

```
std::tuple<float, float> Plant::get_production (
            std::shared_ptr< Process > p ) const
```

Gets a tuple (q, c) with the quantity and capacity of production of a given process.

**Exceptions**

| | |
|---|---|
| *std::domain_error* | if the process does not exist. |

#### 3.5.2.3 inc_production_capacity()

```
void Plant::inc_production_capacity (
            std::shared_ptr< Process > p,
            float c )
```

Increments the capacity of production of a given process. A negative value will decrement the capacity of production. The value will be truncated to be in [0, 100].

**Exceptions**

| | |
|---|---|
| *std::domain_error* | if the process does not exist. |

#### 3.5.2.4 inc_production_quantity()

```
void Plant::inc_production_quantity (
            std::shared_ptr< Process > p,
            float q )
```

Increments the quantity of production of a given process. A negative value will decrement the quantity of production. The value will be truncated to zero.

**Exceptions**

| | |
|---|---|
| *std::domain_error* | if the process does not exist. |

#### 3.5.2.5 set_production_capacity()

```
void Plant::set_production_capacity (
            std::shared_ptr< Process > p,
            float c )
```

Sets a new capacity of production to a process.

**Exceptions**

| | |
|---|---|
| *std::domain_error* | if the process does not exist. |
| *std::invalid_argument* | if the quantity is not in [0, 100]. |

#### 3.5.2.6 set_production_quantity()

```
void Plant::set_production_quantity (
```

```
std::shared_ptr< Process > p,
float q )
```

Sets a new quantity of production to a process.

**Exceptions**

| | |
|---|---|
| *std::domain_error* | if the process does not exist. |
| *std::invalid_argument* | if the quantity is less than zero. |

The documentation for this class was generated from the following file:

- CC05/lib/include/Models.hpp

## 3.6 Process Class Reference

Represents a formula to generate a good.

```
#include <Models.hpp>
```

### Public Member Functions

- Process () noexcept
  *Default constructor, Don't use it.*
- Process (std::shared_ptr< Good > out) noexcept
  *Constructor that receives the produced good.*
- Process (const Process &p) noexcept
  *Copy constructor.*
- Process (Process &&p) noexcept
  *Move constructor.*
- void swap (Process &p) noexcept
  *Swap elements.*
- Process & operator= (Process p) noexcept
  *Assignment operator.*
- float get_quantity (std::shared_ptr< Good > input) const
- void add_input (std::shared_ptr< Good > input, float quantity)
- void add_plant (std::shared_ptr< Plant > plant) noexcept
  *Add a new plant that owns this process.*
- std::shared_ptr< Good > get_output () const noexcept
  *Gets the produced good.*
- std::unordered_map< std::shared_ptr< Good >, float > & get_inputs_table () noexcept
  *Gets the input table.*
- std::vector< std::tuple< std::shared_ptr< Good >, float > > get_inputs () const noexcept
  *Returns a list of tuples (good, quantity) of the inputs.*
- std::vector< std::shared_ptr< Plant > > & get_plants () noexcept
  *Returns the list of plants that own this process.*

### 3.6.1 Detailed Description

Represents a formula to generate a good.

### 3.6.2 Member Function Documentation

#### 3.6.2.1 add_input()

```
void Process::add_input (
            std::shared_ptr< Good > input,
            float quantity )
```

Add a new input associated with the required amount. If the input already exists, then the required amount is updated.

**Exceptions**

| | |
|---|---|
| *std::invalid_argument* | if quantity less or equal to zero. |

#### 3.6.2.2 get_quantity()

```
float Process::get_quantity (
            std::shared_ptr< Good > input ) const
```

Returns the required amount of an input to produce one unit of the output.

**Exceptions**

| | |
|---|---|
| *std::domain_error* | if the input does not belong to the process. |

The documentation for this class was generated from the following file:

- CC05/lib/include/Models.hpp

## 3.7 ProductionData Class Reference

```
#include <Models.hpp>
```

### Public Types

- using RelationShip = std::tuple< std::shared_ptr< Plant >, std::shared_ptr< Plant >, std::shared_ptr< Good >, float, float >

  *Represents a relationship (sale - purchase) between two plants.*

### Public Member Functions

- ProductionData ()=default

  *Default constructor.*
- ProductionData (const ProductionData &)=delete

  *Deleted copy constructor.*
- ProductionData (ProductionData &&pd) noexcept

  *Move constructor.*
- ProductionData & operator= (ProductionData pd) noexcept

  *Assignment operator.*
- void swap (ProductionData &pd) noexcept

  *Swap elements.*

### Public Attributes

- std::unordered_set< std::shared_ptr< Good > > **goods**
- std::unordered_set< std::shared_ptr< Process > > **processes**
- std::unordered_set< std::shared_ptr< Plant > > **plants**
- std::unordered_set< std::shared_ptr< Company > > **companies**
- std::vector< RelationShip > relationships

  *List of relationships.*

#### 3.7.1 Detailed Description

This class contains all of the goods, processes, plants, and companies of a production network.

The documentation for this class was generated from the following file:

- CC05/lib/include/Models.hpp

## 3.8 ProductionNetwork Class Reference

### Public Types

- using NodeInfoType = std::shared_ptr< Plant >

  *Alias to the data type that should be stored in each node.*
- using ArcInfoType = std::tuple< std::shared_ptr< Plant >, std::shared_ptr< Plant >, std::shared_ptr< Good >, float, float >

  *Alias to the data type that should be stored in each arc.*
- using NetworkType = void

  *Alias for the type of Graph. (optional usage).*
- using NodeData = std::shared_ptr< Plant >

  *Aliases to retrieve data from the graph.*
- using **ArcData** = std::tuple< std::shared_ptr< Plant >, std::shared_ptr< Plant >, std::shared_ptr< Good >, float, float >
- using ChangedPriceData = std::tuple< std::shared_ptr< Company >, std::shared_ptr< Company >, std::shared_ptr< Good >, float, float, float >

  *Alias for changed price data.*

## Public Member Functions

- **ProductionNetwork** (const ProductionData &data) noexcept
- **ProductionNetwork** (const ProductionNetwork &)=delete
- **ProductionNetwork** (const ProductionNetwork &&)=delete
- ProductionNetwork & **operator=** (ProductionNetwork)=delete
- std::vector< NodeData > get_node_info_list () const noexcept

  *Returns the list of the plants stored in nodes.*
- std::vector< ArcData > get_arc_info_list () const noexcept

  *Returns the list of tuples (seller, buyer, good, quantity, price) represented by the arcs.*
- std::vector< ChangedPriceData > change_price (std::shared_ptr< Good > good, float change)

  *changes the sale price of a good.*
- std::ostream & to_dot (std::ostream &output) const noexcept

## 3.8.1 Member Function Documentation

### 3.8.1.1 change_price()

```
std::vector<ChangedPriceData> ProductionNetwork::change_price (
            std::shared_ptr< Good > good,
            float change )
```

changes the sale price of a good.

Changes the sales price of a good and computes the effect of this change, this means that all of the companies that use the good as input should change their products' sales prices. Then, there will be more companies affected by the change in the prices of their inputs.

**Parameters**

| | |
|---|---|
| *good* | The good whose price is changed. |
| *change* | The amount of price change. This could be positive (increment), negative (decrement), or zero (no change). |

**Returns**

a list with the relationship data affected by the change. Each element in the list is a tuple as follows: (seller company, buyer company, good, old_price, new_price, percentage_of_change).

**Exceptions**

| | |
|---|---|
| *std::invalid_argument* | with the message "The good should be not null" if good is nullptr. |
| *std::domain_error* | with the message "Good does not exist" if the good is not in the production network. |
| *std::logic_error* | with the message "The good is not a first-level-good" if the good is not in level 0. |

#### 3.8.1.2 to_dot()

```
std::ostream& ProductionNetwork::to_dot (
            std::ostream & output ) const  [noexcept]
```

Writes on the stream the DOT representation of the production network. See the documentation of Graphviz here: https://graphviz.org/documentation/

The documentation for this class was generated from the following file:

- CC05/lib/include/ProductionNetwork.hpp

## 3.9 Rng Class Reference

Singleton for random number generation.

`#include <Rng.hpp>`

### Static Public Member Functions

- static float random_uniform () noexcept
  *Generates a random real number in [0, 1).*
- template<typename T >
  static T random_uniform_int (T l, T r) noexcept
  *Generates a random integer number in [l, r].*
- template<typename T >
  static T random_uniform_real (T l, T r) noexcept
  *Generates a random real number in [l, r].*
- template<typename T >
  static T random_normal (T mu, T sigma) noexcept
  *Generates a random number normally distributed.*
- template<typename T >
  static T random_exponential (T mu) noexcept
  *Generates a random number exponentially distributed.*
- static bool flip_coin (float p=0.5) noexcept
  *Simulates a coin toss.*
- template<typename It >
  static It random_choice (It begin, It end) noexcept
  *Selects an item randomly between two iterators.*
- static std::string random_rif () noexcept
  *Generates a random string with the R.I.F.-format.*
- static void **set_seed** (std::mt19937::result_type s) noexcept

### 3.9.1 Detailed Description

Singleton for random number generation.

## 3.9.2 Member Function Documentation

### 3.9.2.1 flip_coin()

```
static bool Rng::flip_coin (
            float p = 0.5 )  [static], [noexcept]
```

Simulates a coin toss.

This uses the Bernoulli distribution to simulate a coin toss.

**Parameters**

| | |
|---|---|
| *p* | The probability of getting true as the result. By default is 0.5 (fair coin). |

**Returns**

true for p.

false for 1 - p.

### 3.9.2.2 random_choice()

```
template<typename It >
It Rng::random_choice (
            It begin,
            It end )  [static], [noexcept]
```

Selects an item randomly between two iterators.

**Template Parameters**

| | |
|---|---|
| *It* | The iterator type. |

**Parameters**

| | |
|---|---|
| *begin* | The iterator on the start position. |
| *end* | The iterator on the final position. |

**Returns**

The iterator on the selected item.

#### 3.9.2.3 random_exponential()

```
template<typename T >
T Rng::random_exponential (
            T mu )  [static], [noexcept]
```

Generates a random number exponentially distributed.

**Template Parameters**

| | |
|---|---|
| *T* | The floating-point type. |

**Parameters**

| | |
|---|---|
| *mu* | Mean. |

**Returns**

the generated random number.

#### 3.9.2.4 random_normal()

```
template<typename T >
T Rng::random_normal (
            T mu,
            T sigma )  [static], [noexcept]
```

Generates a random number normally distributed.

**Template Parameters**

| | |
|---|---|
| *T* | The floating-point type. |

**Parameters**

| | |
|---|---|
| *mu* | Mean. |
| *sigma* | Standard deviation. |

**Returns**

the generated random number.

#### 3.9.2.5 random_rif()

```
static std::string Rng::random_rif ( )  [static], [noexcept]
```

Generates a random string with the R.I.F.-format.

**Returns**

The generates R.I.F.

#### 3.9.2.6 random_uniform_int()

```
template<typename T >
T Rng::random_uniform_int (
            T l,
            T r )  [static], [noexcept]
```

Generates a random integer number in [l, r].

**Template Parameters**

| | |
|---|---|
| *T* | The integral type. |

**Parameters**

| | |
|---|---|
| *l* | The lowerbound. |
| *r* | The upperbound. |

**Returns**

the generated random number.

#### 3.9.2.7 random_uniform_real()

```
template<typename T >
T Rng::random_uniform_real (
            T l,
            T r )  [static], [noexcept]
```

Generates a random real number in [l, r].

**Template Parameters**

| | |
|---|---|
| *T* | The floating-point type. |

**Parameters**

| | |
|---|---|
| *l* | The lowerbound. |
| *r* | The upperbound. |

**Returns**

the generated random number.

The documentation for this class was generated from the following file:

- CC05/lib/include/Rng.hpp

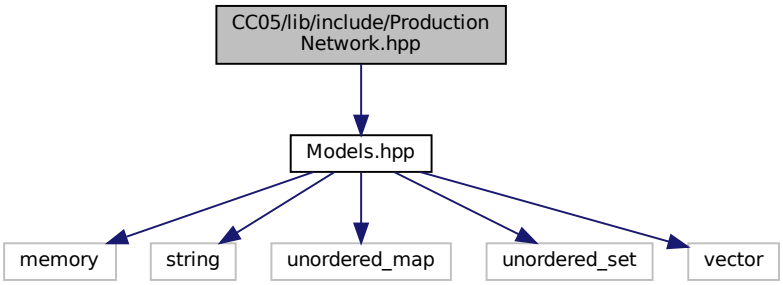
# Chapter 4

# File Documentation

## 4.1 CC05/lib/include/ProductionNetwork.hpp File Reference

```
#include <Models.hpp>
```

Include dependency graph for ProductionNetwork.hpp:




### Classes

- class ProductionNetwork

### 4.1.1 Detailed Description

**Authors**

**Date**