CU25_MODEL_DEVELOPMENT_02_DES

June 13, 2023

\#

CU25_Modelo de gestión de Lista de Espera Quirúrgica

1   IV. Model development

En este anexo se incluye el código utilizado durante el desarrollo de los modelos incluidos en el caso de uso.

1.1   Modelo DES

```
[4]: Sys.setlocale(category = "LC_ALL", locale = "es_ES.UTF-8")
```

'es_ES.UTF-8/es_ES.UTF-8/es_ES.UTF-8/C/es_ES.UTF-8/C'

1.1.1   Paquetes

```
[1]: #https://r-simmer.org/articles/simmer-06-queueing.html

library(tidyverse)
library(tidymodels)
library(lubridate)
library(modeltime)
library(simmer)
library(simmer.plot)
```

```
-- Attaching packages -------------------------------------- tidyverse
1.3.2 --
v ggplot2 3.4.2      v purrr   1.0.1
v tibble  3.2.1      v dplyr   1.1.0
v tidyr   1.3.0      v stringr 1.5.0
v readr   2.1.3      v forcats 0.5.2
-- Conflicts -----------------------------------------
tidyverse_conflicts() --
x dplyr::filter() masks stats::filter()
x dplyr::lag()    masks stats::lag()
-- Attaching packages -------------------------------------- tidymodels
1.0.0 --
```

```
v broom        1.0.3      v rsample      1.1.1
v dials        1.1.0      v tune         1.0.1
v infer        1.0.4      v workflows    1.1.3
v modeldata    1.1.0      v workflowsets 1.0.0
v parsnip      1.0.4      v yardstick    1.1.0
v recipes      1.0.4

-- Conflicts ---------------------------------------- tidymodels_conflicts() --
x scales::discard() masks purrr::discard()
x dplyr::filter()   masks stats::filter()
x recipes::fixed()  masks stringr::fixed()
x dplyr::lag()      masks stats::lag()
x yardstick::spec() masks readr::spec()
x recipes::step()   masks stats::step()
* Use tidymodels_prefer() to resolve common conflicts.


Attaching package: 'lubridate'


The following objects are masked from 'package:base':

    date, intersect, setdiff, union



Attaching package: 'simmer'


The following objects are masked from 'package:lubridate':

    now, rollback


The following object is masked from 'package:dplyr':

    select
```

```
The following object is masked from 'package:tidyr':

    separate


Attaching package: 'simmer.plot'


The following objects are masked from 'package:simmer':

    get_mon_arrivals, get_mon_attributes, get_mon_resources
```

1.1.2 Datos

```
[2]: modelo_pacientes <- read_rds("modelos_pacientes_xgboost.rds")
     modelo_tiempo <- read_rds("modelos_tiempo_xgboost.rds")



     capacidad <- read_csv("CU_25_05_07_01_capacidad.csv")
```

```
Rows: 160 Columns: 4
-- Column specification
--------------------------------------------------------
Delimiter: ","
chr (3): id_area, nombre_area, Especialidad
dbl (1): capacidad

i Use `spec()` to retrieve the full column specification for this
data.
i Specify the column types or set `show_col_types = FALSE` to quiet
this message.
```

1.2 Spot checking

```
[5]: ## Ejemplo base

     # h <- "HOSPITAL UNIVERSITARIO LA PAZ"
     # a <- "05"
     e <- "Angiología y Cirugía Vascular"
     z <- "Centro-Norte"

     s <- paste(z, e, sep = ".")
     h <- 2
     cap <- capacidad |>
```

```r
    filter(nombre_area == z,
           Especialidad == e) |>
    pull(capacidad)

NPER <- 365

## Si se elige último
pacientes_en_cola <- modelo_pacientes |>
  pluck(s, ".calibration_data", 1) |>
  slice_max(fecha) |>
  pull(.actual)

tiempo_medio_en_cola <- modelo_tiempo |>
  pluck(s, ".calibration_data", 1) |>
  slice_max(fecha) |>
  pull(.actual)

## Si se elige predicción

pacientes_en_cola <- modelo_pacientes |>
  pluck(s) |>
  modeltime_forecast(h = h) |>
  slice_tail(n = 1) |> pull(.value)

tiempo_medio_en_cola <- modelo_tiempo |>
  pluck(s) |>
  modeltime_forecast(h = h) |>
  slice_tail(n = 1) |> pull(.value)


## Parámetros
## Llegadas

lambda <- pacientes_en_cola / tiempo_medio_en_cola

## Tiempo de servicio
mu <- lambda/pacientes_en_cola

## Capacidad es cap



library(simmer)
#set.seed(1) no usar en la app para que salgan cosas distintas al cambiar

env <- simmer("listasSim")
# env
```

```r
paciente <- trajectory("Trayectoria del paciente") %>%
  ## Operación
  seize("quirofano", 1) %>%
  timeout(function() rexp(1, mu)) %>%
  release("quirofano", 1)

env %>%
  add_resource("quirofano", cap) %>%
  add_generator("inicial", paciente, at(rep(0, pacientes_en_cola))) |>
  add_generator("paciente", paciente, function() rpois(1, lambda))


env %>%
  run(NPER)

# env %>% peek(3)

#Esto de momento no
# library(parallel)
# envs <- mclapply(1:100, function(i) {
#   simmer("listassim100") %>%
#     add_resource("quirofano", cap) %>%
#     add_generator("inicial", paciente, at(rep(0, pacientes_en_cola))) |>
#     add_generator("paciente", paciente, function() rpois(1, lambda)) |>
#     run(NPER) %>%
#     wrap()
# })
#
# resources <- get_mon_resources(envs)
# plot(resources, metric = "utilization")
# plot(resources, metric = "usage", c("quirofano"))


## Mostrar con datatable
recursos <- get_mon_resources(env)
recursos

llegadas <- get_mon_arrivals(env, ongoing = TRUE)
llegadas

## Mostrar estos gráficos

plot(recursos, metric = "utilization")
plot(recursos, metric = "usage", c("quirofano"))

plot(llegadas)
```

```
simmer environment: listasSim | now: 0 | next: 0
{ Monitor: in memory }
{ Resource: quirofano | monitored: TRUE | server status: 0(6) | queue status: 0(Inf) }
{ Source: inicial | monitored: 1 | n_generated: 0 }
{ Source: paciente | monitored: 1 | n_generated: 0 }


simmer environment: listasSim | now: 365 | next: 370.546641111228
{ Monitor: in memory }
{ Resource: quirofano | monitored: TRUE | server status: 6(6) | queue status: 304(Inf) }
{ Source: inicial | monitored: 1 | n_generated: 343 }
{ Source: paciente | monitored: 1 | n_generated: 31 }
```

resource	time	server	queue	capacity	queue_size	system	limit	replicati
<chr>	<dbl>	<int>	<int>	<dbl>	<dbl>	<int>	<dbl>	<int>
quirofano	0	1	0	6	Inf	1	Inf	1
quirofano	0	2	0	6	Inf	2	Inf	1
quirofano	0	3	0	6	Inf	3	Inf	1
quirofano	0	4	0	6	Inf	4	Inf	1
quirofano	0	5	0	6	Inf	5	Inf	1
quirofano	0	6	0	6	Inf	6	Inf	1
quirofano	0	6	1	6	Inf	7	Inf	1
quirofano	0	6	2	6	Inf	8	Inf	1
quirofano	0	6	3	6	Inf	9	Inf	1
quirofano	0	6	4	6	Inf	10	Inf	1
quirofano	0	6	5	6	Inf	11	Inf	1
quirofano	0	6	6	6	Inf	12	Inf	1
quirofano	0	6	7	6	Inf	13	Inf	1
quirofano	0	6	8	6	Inf	14	Inf	1
quirofano	0	6	9	6	Inf	15	Inf	1
quirofano	0	6	10	6	Inf	16	Inf	1
quirofano	0	6	11	6	Inf	17	Inf	1
quirofano	0	6	12	6	Inf	18	Inf	1
quirofano	0	6	13	6	Inf	19	Inf	1
quirofano	0	6	14	6	Inf	20	Inf	1
quirofano	0	6	15	6	Inf	21	Inf	1
quirofano	0	6	16	6	Inf	22	Inf	1
quirofano	0	6	17	6	Inf	23	Inf	1
quirofano	0	6	18	6	Inf	24	Inf	1
quirofano	0	6	19	6	Inf	25	Inf	1
quirofano	0	6	20	6	Inf	26	Inf	1
quirofano	0	6	21	6	Inf	27	Inf	1
quirofano	0	6	22	6	Inf	28	Inf	1
quirofano	0	6	23	6	Inf	29	Inf	1
quirofano	0	6	24	6	Inf	30	Inf	1
...	...	...	...	...	...	...	...	...
quirofano	275.8182	6	315	6	Inf	321	Inf	1
quirofano	282.0000	6	316	6	Inf	322	Inf	1
quirofano	285.8024	6	315	6	Inf	321	Inf	1
quirofano	286.8380	6	314	6	Inf	320	Inf	1
quirofano	292.0000	6	315	6	Inf	321	Inf	1
quirofano	297.7804	6	314	6	Inf	320	Inf	1
quirofano	297.8699	6	313	6	Inf	319	Inf	1
quirofano	300.6548	6	312	6	Inf	318	Inf	1
quirofano	303.1420	6	311	6	Inf	317	Inf	1
quirofano	307.0000	6	312	6	Inf	318	Inf	1
quirofano	308.9614	6	311	6	Inf	317	Inf	1
quirofano	313.0000	6	312	6	Inf	318	Inf	1
quirofano	314.6020	6	311	6	Inf	317	Inf	1
quirofano	322.0696	6	310	6	Inf	316	Inf	1
quirofano	327.0000	6	311	6	Inf	317	Inf	1
quirofano	332.3649	6	310	6	Inf	316	Inf	1
quirofano	333.6867	6	309	6	Inf	315	Inf	1
quirofano	337.0000	6	310	6	Inf	316	Inf	1
quirofano	343.9157	6	309	6	Inf	315	Inf	1
quirofano	345.0000	6	310	6	Inf	316	Inf	1

A resources: 436 x 9

	name	start_time	end_time	activity_time	finished	replication
	\<chr\>	\<dbl\>	\<dbl\>	\<dbl\>	\<lgl\>	\<int\>
	inicial5	0	12.49577	12.495766	TRUE	1
	inicial0	0	14.61021	14.610211	TRUE	1
	inicial4	0	43.17610	43.176097	TRUE	1
	inicial1	0	49.87241	49.872410	TRUE	1
	inicial8	0	55.18389	12.007793	TRUE	1
	inicial9	0	59.45241	9.579996	TRUE	1
	inicial10	0	73.59897	18.415080	TRUE	1
	inicial6	0	74.16483	61.669062	TRUE	1
	inicial11	0	84.30607	24.853666	TRUE	1
	inicial14	0	86.05369	1.747615	TRUE	1
	inicial13	0	86.53623	12.371398	TRUE	1
	inicial12	0	87.58162	13.982650	TRUE	1
	inicial7	0	90.06163	75.451423	TRUE	1
	inicial15	0	92.11642	6.062738	TRUE	1
	inicial3	0	94.01649	94.016488	TRUE	1
	inicial19	0	98.73756	6.621131	TRUE	1
	inicial21	0	107.40000	8.662440	TRUE	1
	inicial20	0	109.02081	15.004326	TRUE	1
	inicial17	0	111.54987	23.968253	TRUE	1
	inicial16	0	113.14865	26.612421	TRUE	1
	inicial25	0	118.42856	5.279910	TRUE	1
	inicial22	0	124.78362	17.383625	TRUE	1
	inicial26	0	128.29228	9.863725	TRUE	1
	inicial23	0	128.96136	19.940547	TRUE	1
	inicial2	0	160.19551	160.195507	TRUE	1
	inicial29	0	164.53776	35.576404	TRUE	1
	inicial27	0	165.38564	40.602018	TRUE	1
	inicial24	0	165.94578	54.395908	TRUE	1
	inicial31	0	169.70455	5.166786	TRUE	1
A arrivals: 374 x 6	inicial28	0	170.25198	41.959696	TRUE	1
	...	...	...	...	...	...
	inicial180	0	NA	NA	FALSE	1
	inicial173	0	NA	NA	FALSE	1
	inicial165	0	NA	NA	FALSE	1
	inicial126	0	NA	NA	FALSE	1
	inicial232	0	NA	NA	FALSE	1
	inicial149	0	NA	NA	FALSE	1
	inicial144	0	NA	NA	FALSE	1
	inicial325	0	NA	NA	FALSE	1
	inicial290	0	NA	NA	FALSE	1
	inicial202	0	NA	NA	FALSE	1
	inicial168	0	NA	NA	FALSE	1
	inicial239	0	NA	NA	FALSE	1
	inicial341	0	NA	NA	FALSE	1
	inicial76	0	NA	NA	FALSE	1
	inicial73	0	NA	NA	FALSE	1
	inicial159	0	NA	NA	FALSE	1
	inicial200	0	NA	NA	FALSE	1
	inicial81	0	NA	NA	FALSE	1
	inicial230	0	NA	NA	FALSE	1
	inicial192	0	NA	NA	FALSE	1

```
Warning message:
"Removed 1029 rows containing missing values (`geom_line()`)."
```
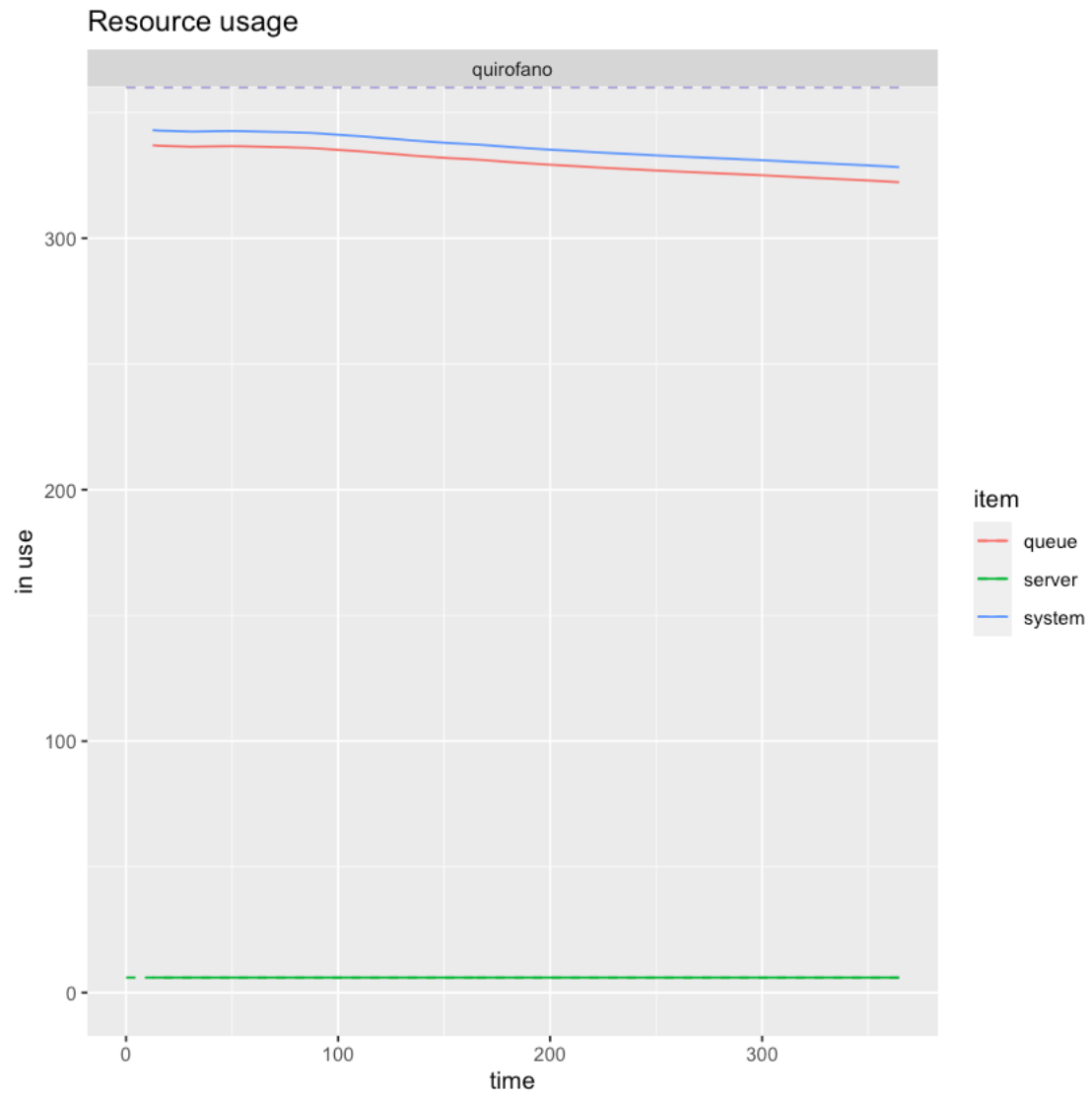
Resource utilization
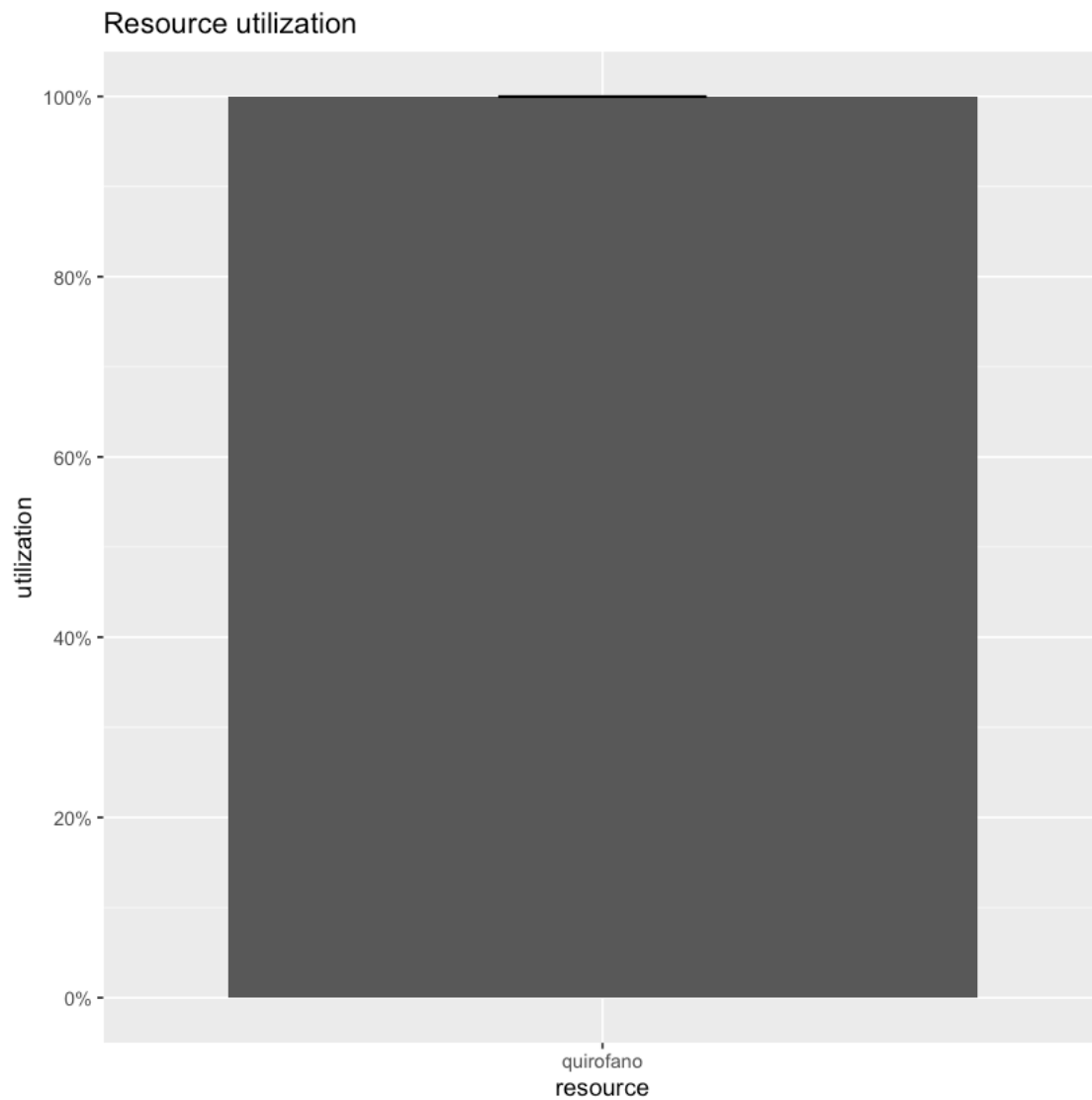

```
`geom_smooth()` using method = 'loess' and formula = 'y ~ x'
Warning message:
"Removed 311 rows containing non-finite values (`stat_smooth()`)."
Warning message:
"Removed 311 rows containing missing values (`geom_line()`)."
```
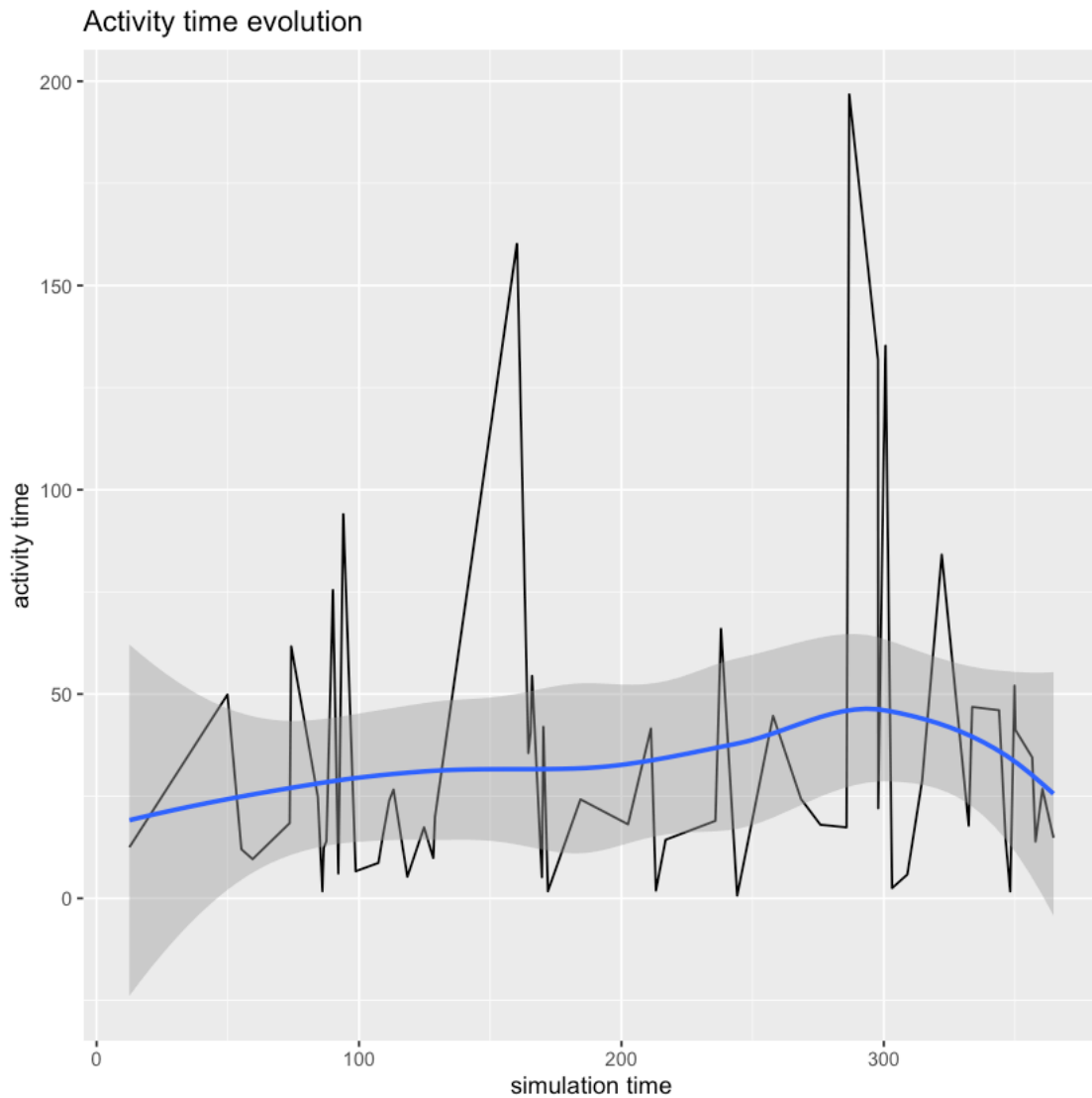
Resource usage

Activity time evolution

1.3 Lista simmer

```
[6]: library(tidyverse)
     library(xgboost)
     library(simmer)

     modelo_pacientes <- read_rds("modelos_pacientes_xgboost.rds")
     modelo_tiempo <- read_rds("modelos_tiempo_xgboost.rds")

     e <- "Angiología y Cirugía Vascular"
     z <- "Centro-Norte"

     s <- paste(z, e, sep = ".")
```

```r
h <- 2

# ultimo <- modelo_pacientes[[m]]$.calibration_data[[1]]

pacientes_en_cola <- modelo_pacientes |>
  pluck(s, ".calibration_data", 1) |>
  slice_max(fecha) |>
  pull(.actual)

tiempo_medio_en_cola <- modelo_tiempo |>
  pluck(s, ".calibration_data", 1) |>
  slice_max(fecha) |>
  pull(.actual)



lambda <- pacientes_en_cola / tiempo_medio_en_cola

## Tiempo de servicio
mu <- lambda/pacientes_en_cola

## Capacidad
m <- 2


set.seed(1)
env |> reset()
env <- simmer("listasSim")
env


paciente <- trajectory("Trayectoria del paciente") %>%
  ## Operación
  seize("quirofano", 1) %>%
  timeout(function() rexp(1, mu)) %>%
  release("quirofano", 1)

paciente

env %>%
  add_resource("quirofano", m) %>%
  add_generator("inicial", paciente, at(rep(0, pacientes_en_cola))) %>%
  # add_generator("inicial", paciente, at(rep(0, pacientes_en_cola))) |>
  add_generator("paciente", paciente, function() rpois(1, lambda))


env %>%
```

```
  run(10000)

llegadas <- env |> get_mon_arrivals(ongoing = TRUE)
cola <- env |> get_mon_resources()
# env |> get_mon_attributes()
```

Attaching package: 'xgboost'

The following object is masked from 'package:dplyr':

    slice

simmer environment: listasSim | now: 0 | next: 0
{ Monitor: in memory }
{ Resource: quirofano | monitored: TRUE | server status: 0(6) | queue status: 0(Inf) }
{ Source: inicial | monitored: 1 | n_generated: 0 }
{ Source: paciente | monitored: 1 | n_generated: 0 }

simmer environment: listasSim | now: 0 | next:
{ Monitor: in memory }

trajectory: Trayectoria del paciente, 3 activities
{ Activity: Seize | resource: quirofano, amount: 1 }
{ Activity: Timeout | delay: function() }
{ Activity: Release | resource: quirofano, amount: 1 }

simmer environment: listasSim | now: 0 | next: 0
{ Monitor: in memory }
{ Resource: quirofano | monitored: TRUE | server status: 0(2) | queue status: 0(Inf) }
{ Source: inicial | monitored: 1 | n_generated: 0 }
{ Source: paciente | monitored: 1 | n_generated: 0 }

simmer environment: listasSim | now: 10000 | next: 10010
{ Monitor: in memory }
{ Resource: quirofano | monitored: TRUE | server status: 2(2) | queue status: 587(Inf) }
{ Source: inicial | monitored: 1 | n_generated: 364 }
{ Source: paciente | monitored: 1 | n_generated: 882 }
```