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Parallel-PSM
Parallelizing the Population Stochastic Modeling R Package with UNICORE

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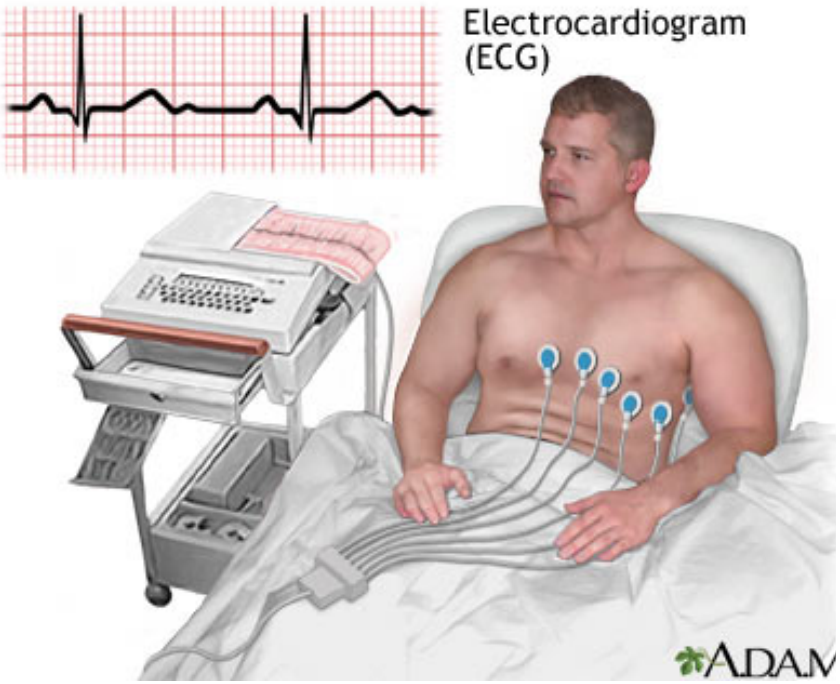
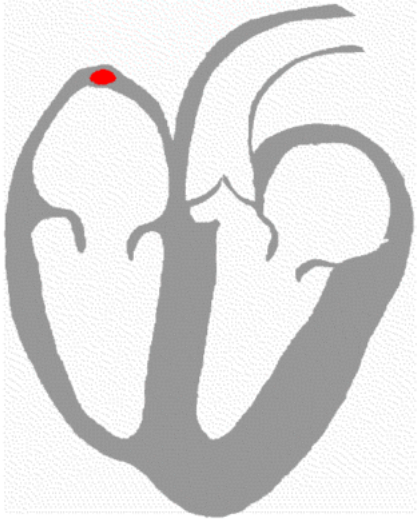
ECG - Electrocardiogram





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CPR - cardiopulmonary resuscitation

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Start of the story…

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Modelling the relationship between ECG characteristics and CPR quality during cardiac arrest

Kenneth Gundersen

Jan Terje Kvaløy

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Introduction

- Measurements easily available during out-of-hospital resuscitation include:
  - Electrocardiogram (ECG)
  - End-Tidal CO_2 (ETCO2)
  - **Compression depth** and **force**
  - Thoracic impedance

  } Response

  } Intervention

- Overall aim: a mathematical model for the interaction between intervention and response during VF/VT.
- This work: develop minimal model for CPR quality variables and ECG coarseness (response).

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Introduction

- This type of model can possibly be used to:
  - Identify the CPR quality variables that indicate its effectiveness.
  - Test different compression techniques against each other.
  - Predict the patiens' response to further CPR and thereby to **chose between immediate defibrillation or further CPR.**
  - General framework for testing different hypothesis.

ECG coarseness – median slope

- The ROSC-predictor median-slope (MS) has high prediction accuracy and is easily computed:

$$MS = \text{median}\left(\left|ecg(n) - ecg(n-1)\right|\right), n = 1, \ldots, N$$

- MS combines amplitude and frequency information -> high ECG amplitude and frequency (coarse ECG) indicates a good state of patient.

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ECG coarseness – median slope

Normal

Heart block

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Data

- Observational data from out-of hospital cardiac arrest episodes.
- 85 patients in baseline data, 27 patients contributed with a total of 118 VF/VT sequences.

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Challenges

- Model fitting extremely computationally intensive.
- Hetereogenous patients -> random effects on many parameters -> many model parameters to fit.
- Limited size of available dataset.
- Noise in ECG recordings (must be manually identified and censored).

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Future research

- **Speed up model fitting (modify software to enable parallell processing).**
- **Obtain (larger) dataset where ECG noise is minimized.**
- Include $ETCO_2$ in an extended model.
- Consider excluding ”hopeless” patients from analysis.
- Take a step back and develop (idealized) model from animal data?

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In brief…

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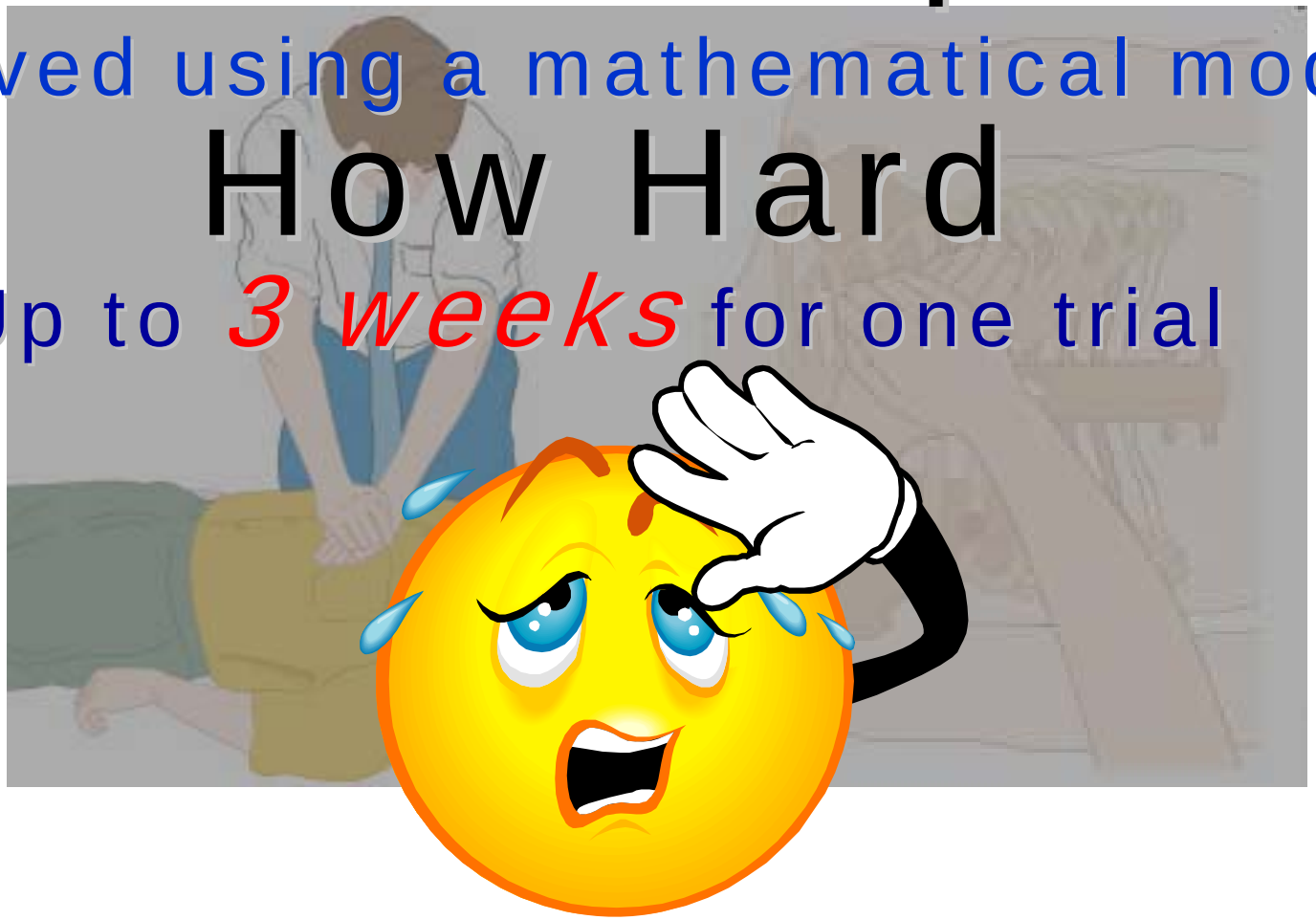
In brief…

How Deep

Solved using a mathematical model

How Hard

Up to *3 weeks* for one trial



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And then…

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Scenario…

Hein,
can you try to do it?

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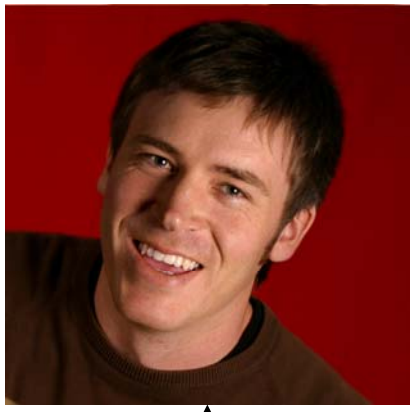
Scenario…



Hein,
can you try to do it?

CC:

Azab,
See what you can do?

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Scenario…

bla bla bla…

Hmmmm…

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Team

Kenneth Gundersen
Post Doc
UiS

Hein Meling
Asc. Professor
UiS

Abdulrahman Azab
Research Fellow
UiS

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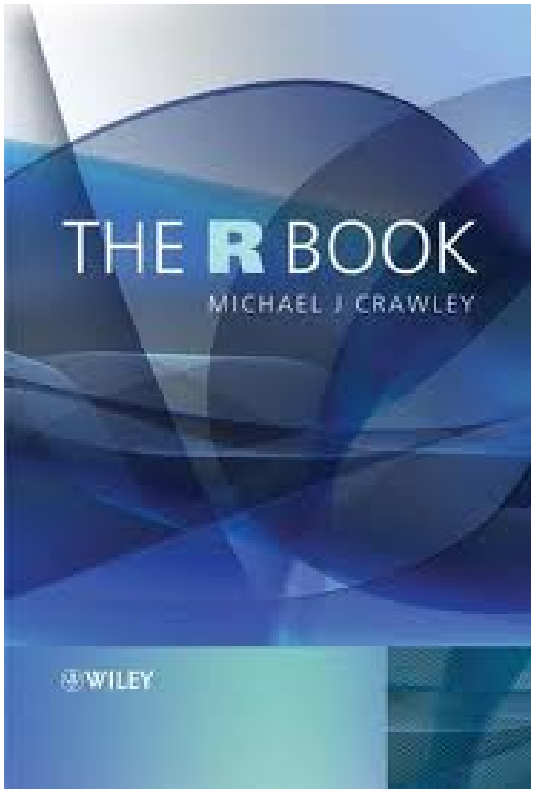
Scenario…

Learning R



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The *R* language

What is R?

- A 'language and environment for statistical computing and graphics' (implements a dialect of the language 'S')
- Syntax is C-like, but philosophy is functional
- Focus on matrices and vectors
- Free, open-source (GPL)
- Well documented
- Command line based, but there are GUIs
- Latest version: 2.13.0 (April 2011)
- URL: `http://www.r-project.org/`

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The *R* language

R Features

- Very many analysis methods available
- Scriptable and extensible
- Can be used interactively, process batch jobs or run as a script
- Bindings to many other systems/languages, e.g., Python, Perl, Matlab, *SQL, Excel
- Active user community with thousands of contributed packages

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The *R* language

Elementary Data Types

Basic elements: *numbers*, *strings*, *logicals*

```
> 42
[1] 42
> "a string"
[1] "a string"
> TRUE
[1] TRUE

> 42 + 13.5
[1] 55.5
> 42 > 13.5
[1] TRUE
> substr("a string", 3, 5)
[1] "str"
> ! TRUE
[1] FALSE
```

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The *R* language

Compound Data Types: Vectors

- Basic elements collected in *vectors*, *lists*, *matrices* and *data frames*
- Collection of *equal* types of elements: *vector*:

```
> 1:5
[1] 1 2 3 4 5
> c(42, 1:5)   # "c" for "concatenate"
[1] 42  1  2  3  4  5
> c("three", "small", "things")
[1] "three"  "small"  "things"
```

- Indexing:

```
> nums <- c(42, 33, 58, 1, 3.2)
> nums[2]
[1] 33
> nums[2:3]
[1] 33 58
> nums[c(1,3)]
[1] 42 58
```

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The *R* language

Compound Data Types: Lists

- Collection of *different* types of elements: *list*:

```
> c(42, "Mary")       # Probably not what you want
[1] "42"   "Mary"
> list(42, "Mary")    # That's more like it!
[[1]]
[1] 42

[[2]]
[1] "Mary"
```

- Indexing: [] and [[]]:

```
> lag <- list(c(3,5), "string", rep(TRUE, 5))
> lag
> lag[2:3]    # sub list
> lag[3]      # still sub list
> lag[[3]]    # element
```

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The *R* language

Compound Data Types: Matrices

- Two-dimensional collections: *matrices* and *data frames*
- Same element type (usually number): *matrix*:

```
> A <- matrix(1:9, ncol = 3, nrow = 3)
> A
     [,1] [,2] [,3]
[1,]    1    4    7
[2,]    2    5    8
[3,]    3    6    9
> B <- matrix(6:1, ncol = 2, nrow = 3)
> A %*% B
     [,1] [,2]
[1,]   54   18
[2,]   69   24
[3,]   84   30
```

- Indexing: `A[2,1]`

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The *R* language

Variables

- Values can be stored in *variables*:

```
> mynum <- 42
> mynum + 13.5
[1] 55.5
> adj <- "interesting"
> sentence <- paste("Very", adj)
> sentence
[1] "Very interesting"
```

- Tip: use descriptive names; avoid single-character names.
- List all variables: `ls()`
- Show value of variable: `mynum` or `print(mynum)`
- Remove a variable: `rm()`, e.g., `rm(adj)`

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The *R* language

Help!

This is probably the most important slide!

- `?mean` - help for a function
- `help.search("regression")` or simply `??regression` - search in your installed R
- `RSiteSearch("logistic")` - search the R web site
- `demo()` - list/run demos
- `vignette()` - list package vignettes
- `help.start()` - start help centre

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The *R* language

http://www.notur.no/notur2011/material/R_course_notur2011_slides.pdf

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Back to the problem…

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ECG – CPR modeling code (by Kenneth)

1. Create the model

   NLmod.MS ← ***Model***

2. Generate the simulated heart block reading

   simdatar <- PSM.simulate(NLmod.MS,...)

3. Estimate the optimum compression force and depth

   fit_simmod <-
   PSM.estimate(NLmod.MS,simdatar,...,maxit=1000,...)

30 minutes per iteration on a single machine

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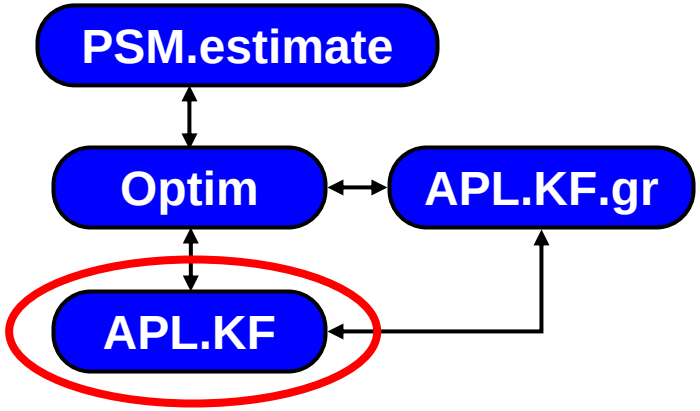
ECG – CPR modeling code (by Kenneth)



Very computational intensive, but parallelizable

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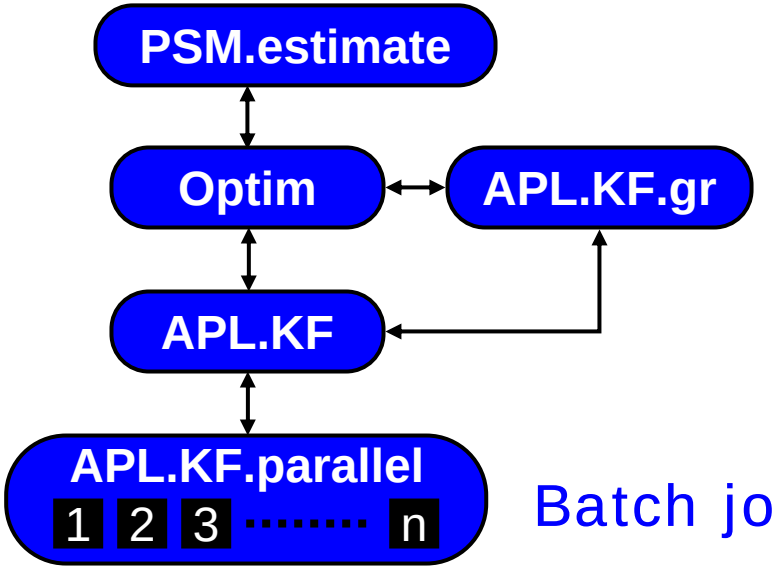
ECG – CPR modeling code (by Kenneth)



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Challenges

- Parallel packages for R, e.g. snow and GridR, are either not dependable or faulty.
- R doesn't directly support java. Cannot use HiLA.
- The computation is iterative, cannot be shaped as a workflow.
- It is time consuming to create a new parallel R package, *and I want to finish my PhD*.

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Thinking…

Azab,
Why don't you implement a file-system interface

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Thinking…

Azab,
Why don't you implement a file-system interface

Let's try and see..

Do you think it is a good solution?

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Stroll: Job submission by file-system **write()**

```
#Create the job directory
taskDir<-dir.create("./Parallel.APL.KF")

# Set the job configuration
write("exec=job.R;in=in$(i).RData;target=unicore", file
    = "./config")
```

...Generate input files...

```
# Submit the job
write("SUBMIT -W", file = "./control")
```

...Collect output files...

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It works

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Stroll: Job submission by file-system **write("SUBMIT")** using Condor

```
> source("simmod_Grid.R")
* Non-linear model (Grid)*
Using logit transformation of parameters
Grid: Starting switch statement
Using Optimizer:        optim
optim: Start
optim: functions defined
optim: 1
APL.KF: Start  dimS =  40 , Time: 0.19
Grid: input copied to 40 Workers: elapsed time =  0.91
1 ,2 ,3 ,4 ,5 ,6 ,7 ,8 ,9 ,10 ,11 ,12 ,13 ,14 ,15 ,16 ,17 ,18 ,19 ,20 ,21 ,22 ,23 ,24 ,25 ,26 ,27 ,28 ,29 ,30
     ,31 ,32 ,33 ,34 ,35 ,36 ,37 ,38 ,39 ,40 ,
Submitting job(s).....................................
Logging submit event(s).....................................
40 job(s) submitted to cluster 624.
Waiting for results from workers....
3 ,9 ,5 ,7 ,6 ,11 ,12 ,4 ,8 ,13 ,17 ,10 ,14 ,15 ,2 ,16 ,18 ,19 ,20 ,21 ,22 ,23 ,24 ,25 ,1 ,26 ,27 ,28 ,29 ,30
     ,31 ,32 ,33 ,34 ,36 ,37 ,38 ,39 ,40 ,35 ,
APL.KF: Ends  , Time: 150.5
                a
  -logL  = -45.2597115   (2:30.31)
optim: 2
Grid: switch statement ended
[1] Runtime:  2:30.56
Collecting average data colums..
```

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Stroll: Job submission by file-system **write("SUBMIT -W")** using UNICORE

```
> source("simmod_Grid.R")
* Non-linear model (Grid)*
Using logit transformation of parameters
Grid: Starting switch statement
Using Optimizer:        optim
optim: Start
optim: functions defined
optim: 1
APL.KF: Start  dimS =  40 , Time: 0.07
Grid: input copied to 40 Workers: elapsed time =  4.21
1 ,2 ,3 ,4 ,5 ,6 ,7 ,8 ,9 ,10 ,11 ,12 ,13 ,14 ,15 ,16 ,17 ,18 ,19 ,20 ,21 ,22 ,23 ,24 ,25 ,26 ,27 ,28 ,29 ,30
     ,31 ,32 ,33 ,34 ,35 ,36 ,37 ,38 ,39 ,40 ,
Waiting for results from workers....
1 ,2 ,3 ,4 ,5 ,6 ,7 ,8 ,9 ,10 ,11 ,12 ,13 ,14 ,15 ,16 ,17 ,18 ,19 ,20 ,21 ,22 ,23 ,24 ,25 ,26 ,27 ,28 ,29 ,30
     ,31 ,32 ,33 ,34 ,35 ,36 ,37 ,38 ,39 ,40 ,
APL.KF: Ends  , Time: 294.01
                a
  -logL  = -45.2597115   (4:53.97)
optim: 2
Grid: switch statement ended
[1] Runtime:  4:54.04
Collecting average data colums..
```

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Execution Scenario

Me

Start

End

Stroll

My machine

Lab E-462 UiS

Grid

20 PCs

From 3 weeks
to
60 hours
Speedup = 8.5

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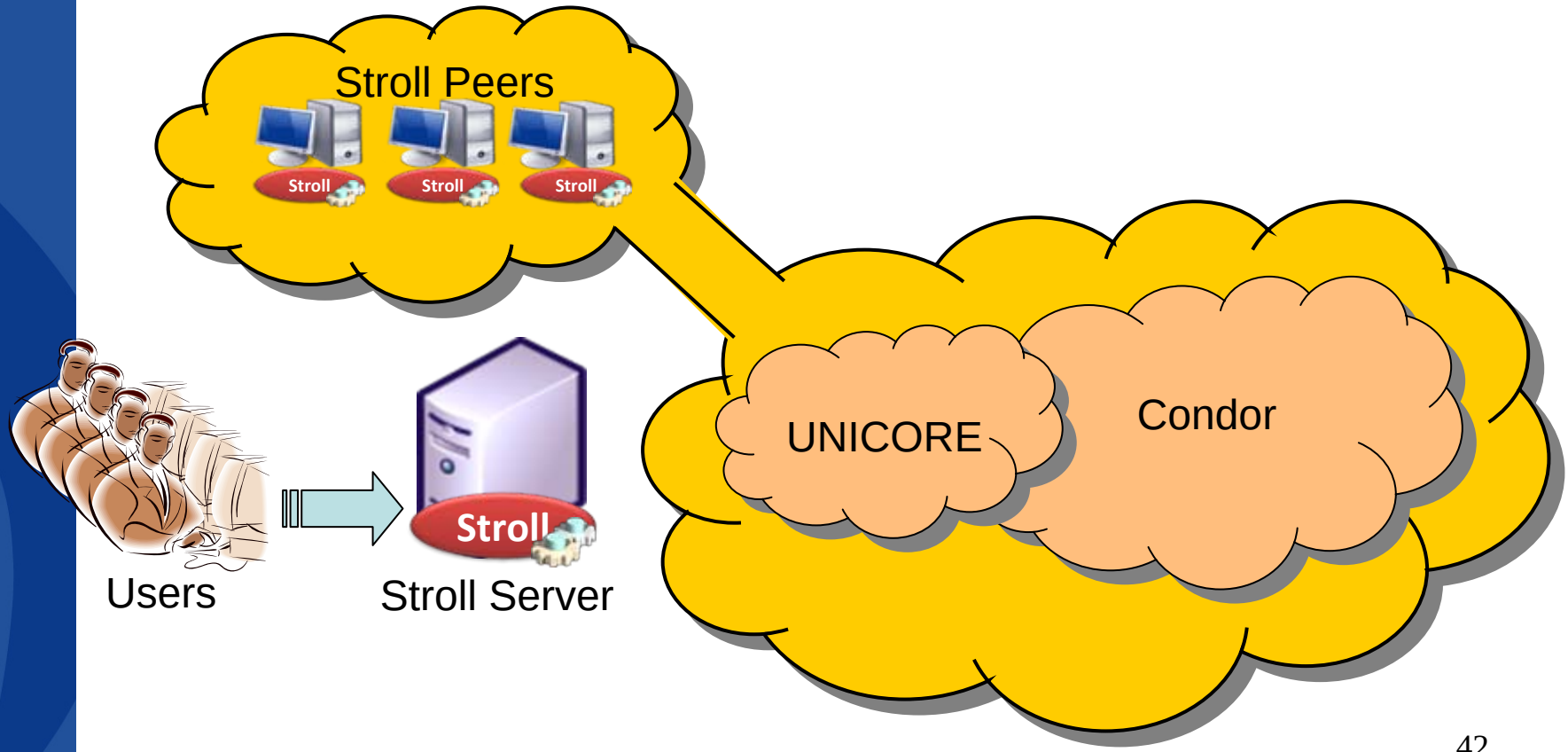
Setup

- 20 single node UNICORE target systems.
- 40 Condor workers, in 3 labs.



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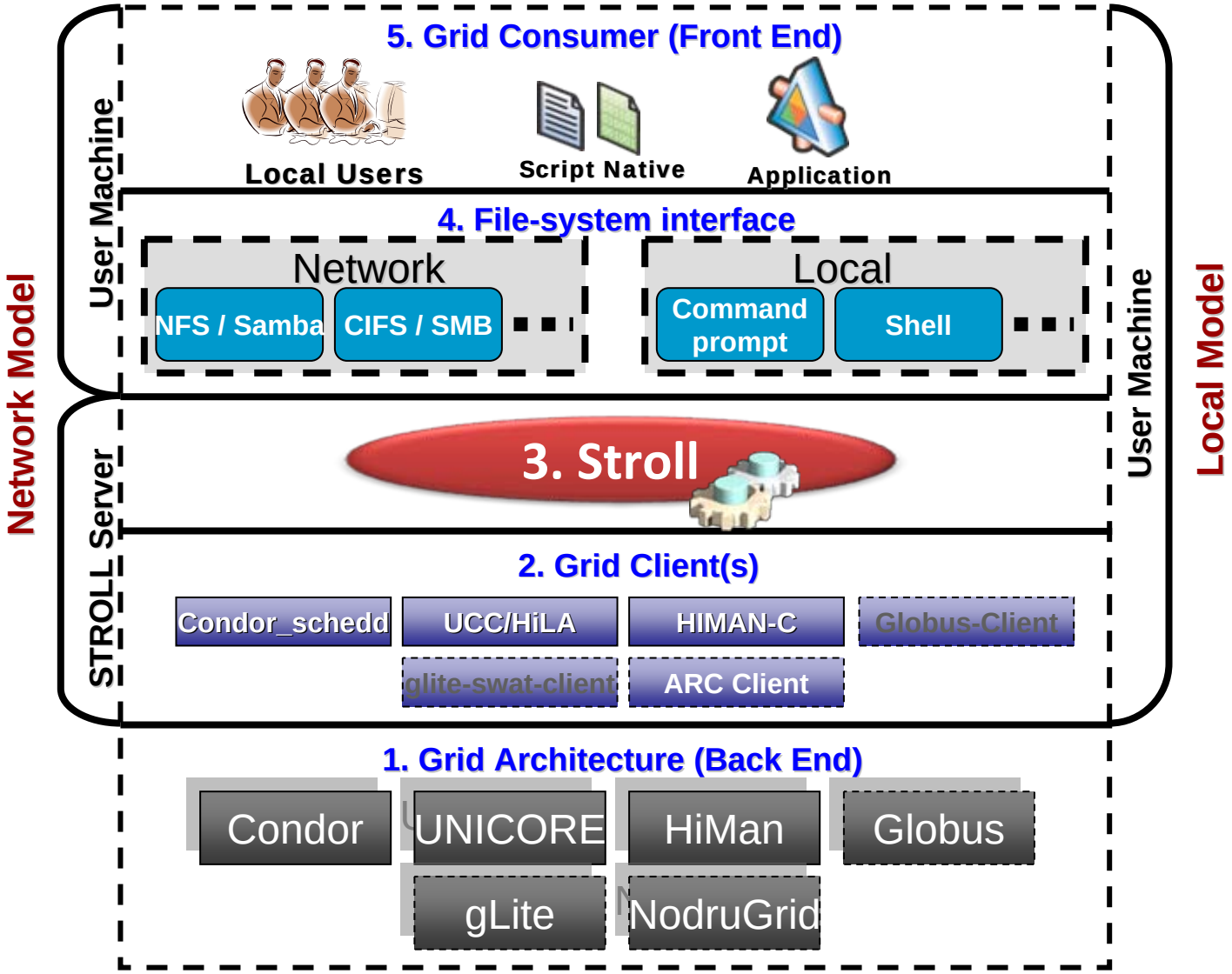
Stroll Architecture



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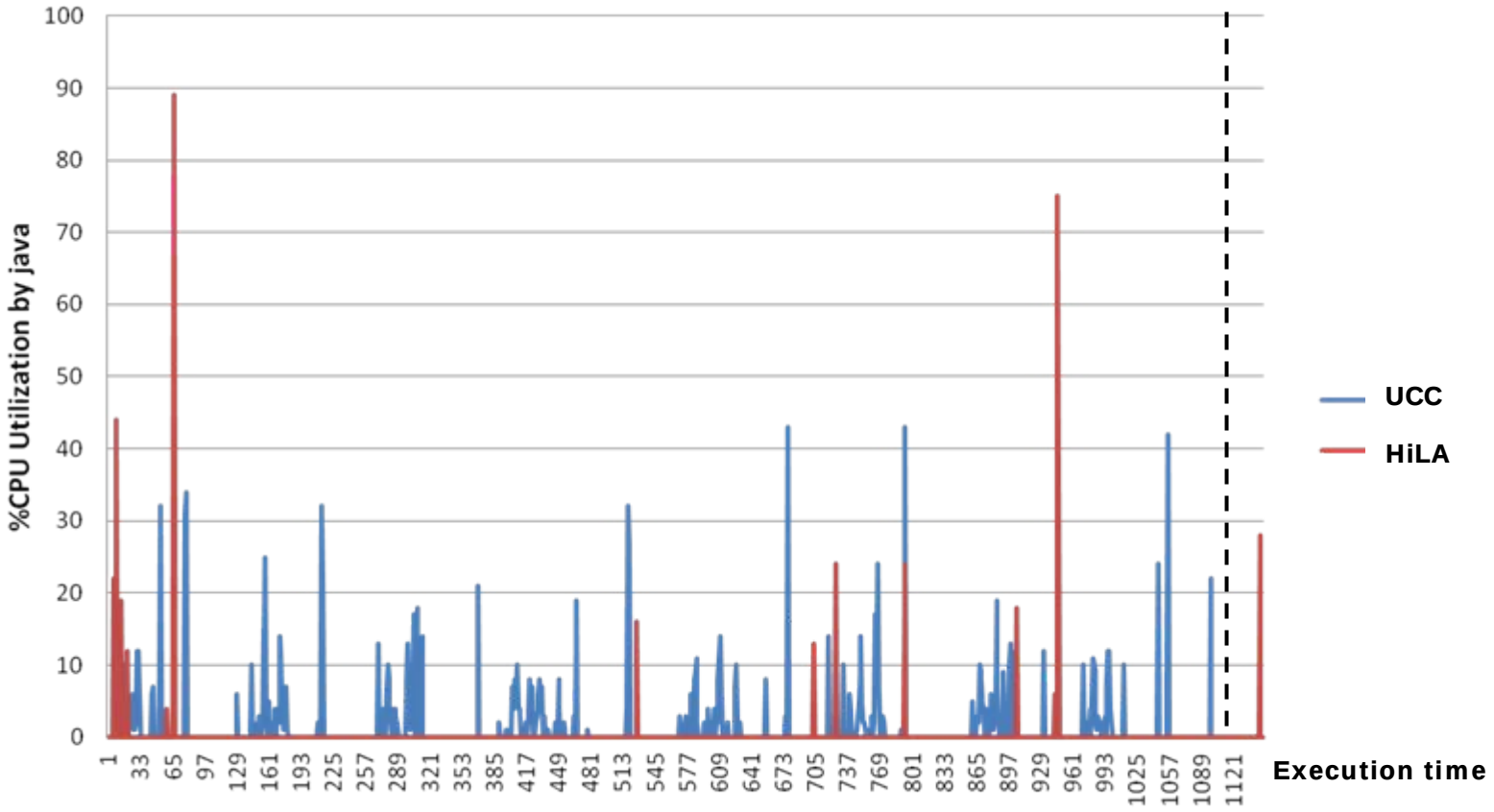
Results – UNICORE

- PSM.estimate(...,maxit=1,...)



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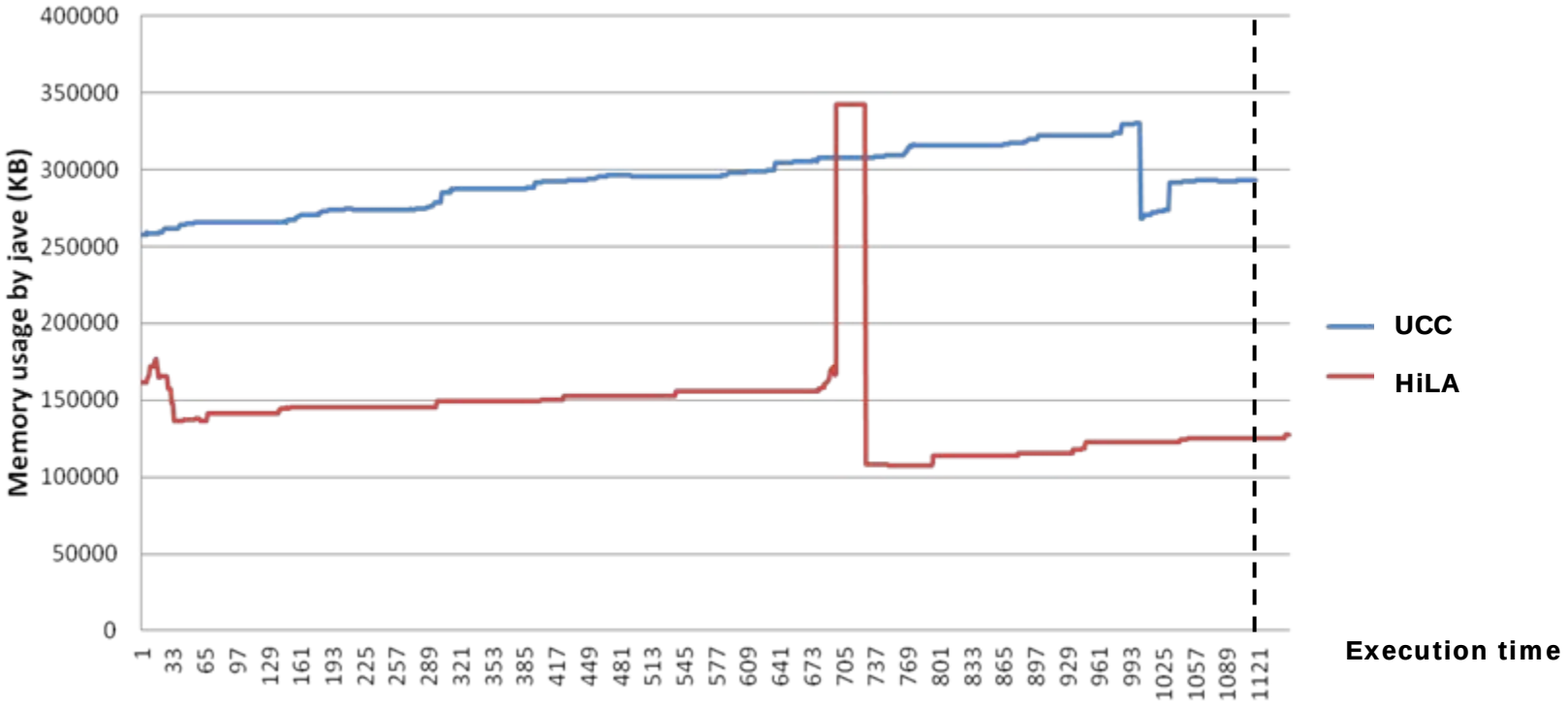
Results – UNICORE

- PSM.estimate(...,maxit=1,...)



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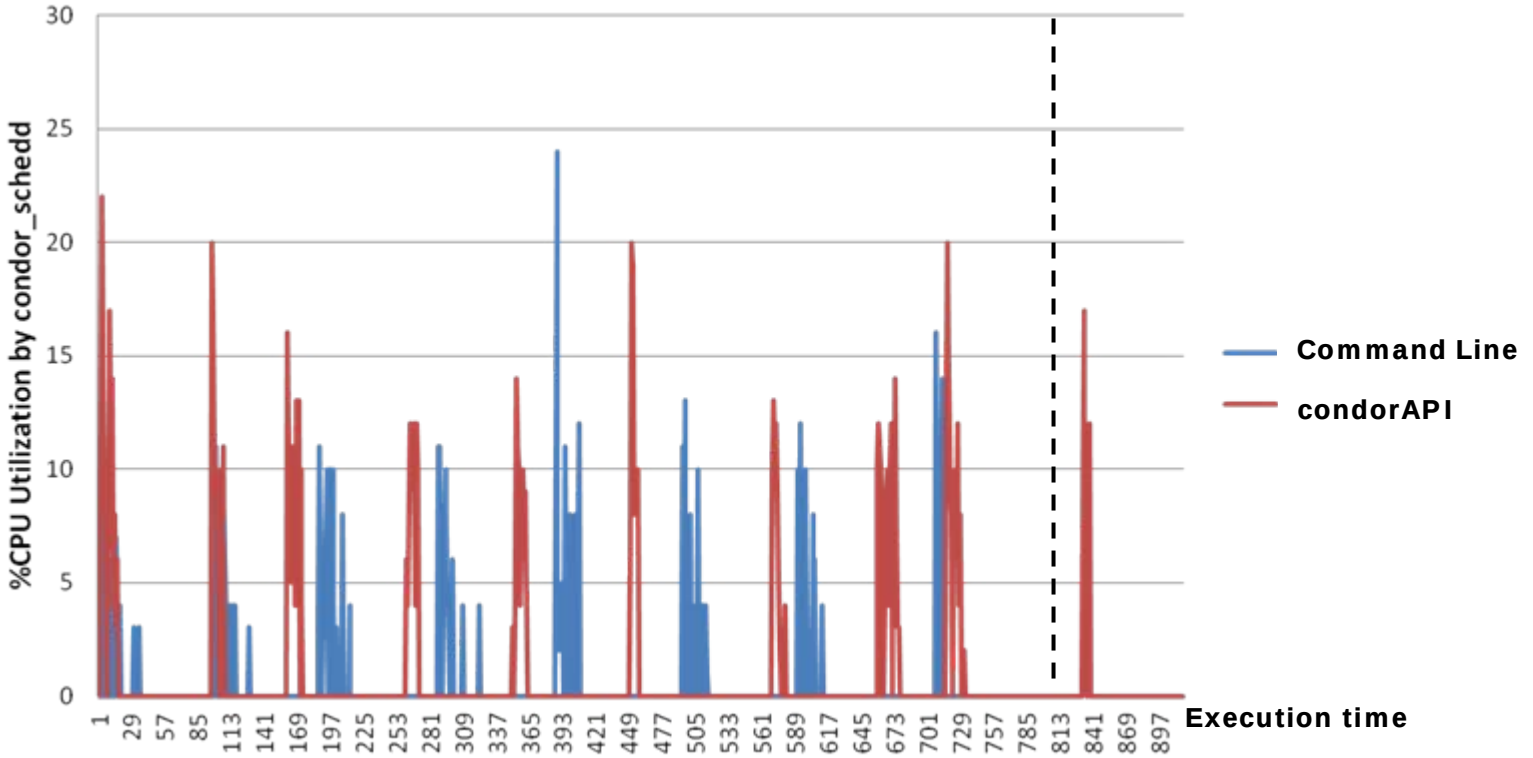
Results – Condor

- PSM.estimate(...,maxit=1,...)



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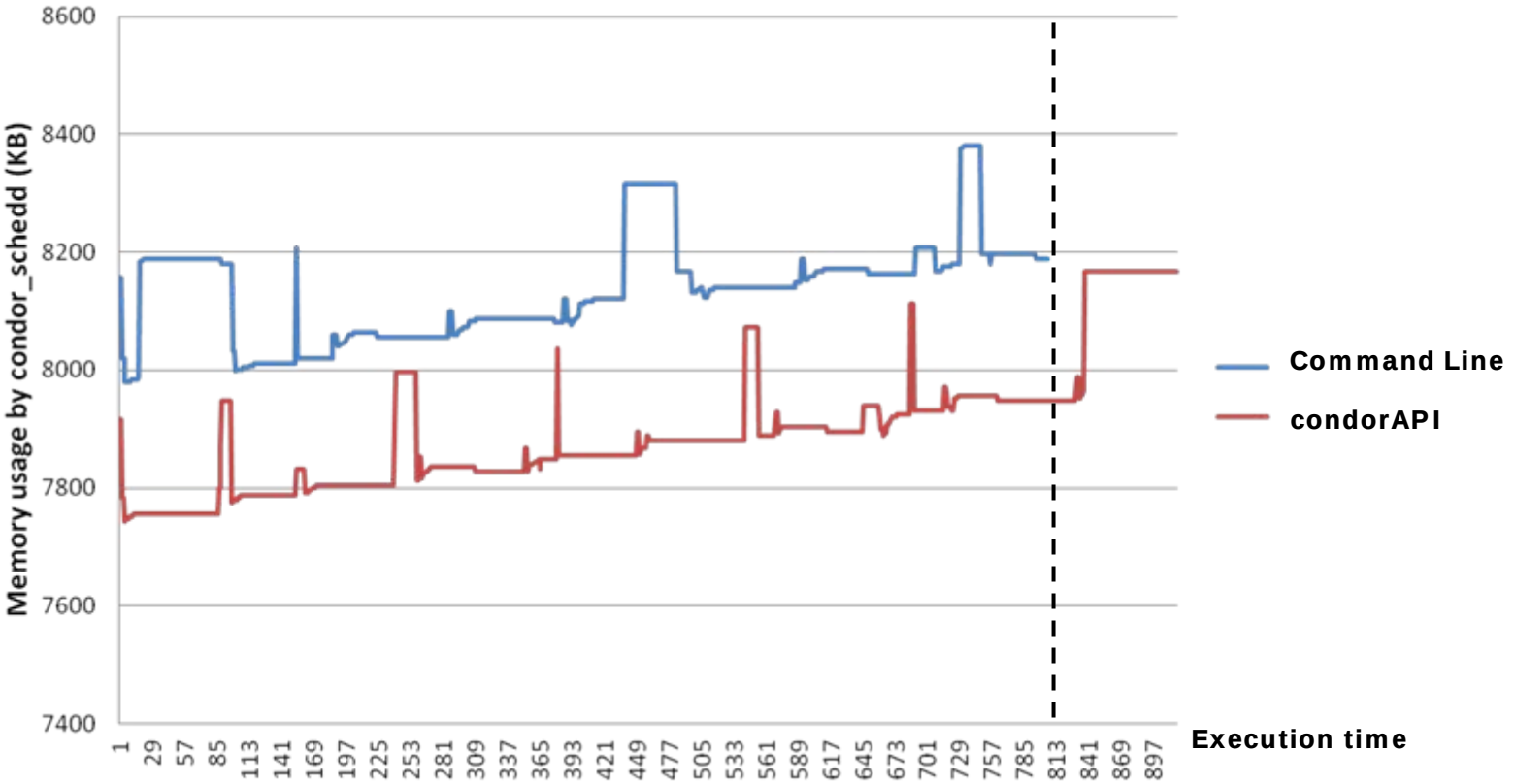
Results – Condor

- PSM.estimate(...,maxit=1,...)



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Questions

?

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