

Just tired of endless loops!
or parallel: Stata module for parallel computing

George G. Vega

`gvega@spensiones.cl`

Chilean Pension Supervisor

Stata Conference New Orleans
July 18-19, 2013

Thanks to Damian C. Clarke, Félix Villatoro and Eduardo Fajnzylber, Tomás Rau, Eric Melse, Valentina Moscoso, the Research team of the Chilean Pension Supervisor and several Stata users worldwide for their valuable contributions. The usual disclaimers applies.

Agenda

Motivation

What is and how does it work

Benchmarks

Syntax and Usage

Concluding Remarks

Motivation

- ▶ Despite the availability of administrative data, its exploitation is still a novel issue.

Motivation

- ▶ Despite the availability of administrative data, its exploitation is still a novel issue.
- ▶ At the same time, currently home computers are arriving with extremely high computational capabilities.

Motivation

- ▶ Despite the availability of administrative data, its exploitation is still a novel issue.
- ▶ At the same time, currently home computers are arriving with extremely high computational capabilities.
- ▶ Given its nature, matching both (big data problems and HPA) sounds straightforward.

Motivation

- ▶ Despite the availability of administrative data, its exploitation is still a novel issue.
- ▶ At the same time, currently home computers are arriving with extremely high computational capabilities.
- ▶ Given its nature, matching both (big data problems and HPA) sounds straightforward.
- ▶ But, implementing parallel computing for the social scientist is not easy,

Motivation

- ▶ Despite the availability of administrative data, its exploitation is still a novel issue.
- ▶ At the same time, currently home computers are arriving with extremely high computational capabilities.
- ▶ Given its nature, matching both (big data problems and HPA) sounds straightforward.
- ▶ But, implementing parallel computing for the social scientist is not easy, most of this due to lack of (user-friendly) statistical computing tools.

Motivation

- ▶ Despite the availability of administrative data, its exploitation is still a novel issue.
- ▶ At the same time, currently home computers are arriving with extremely high computational capabilities.
- ▶ Given its nature, matching both (big data problems and HPA) sounds straightforward.
- ▶ But, implementing parallel computing for the social scientist is not easy, most of this due to lack of (user-friendly) statistical computing tools.
- ▶ parallel aims to make a contribution to these issues.

Motivation

What is and how does it work

Benchmarks

Syntax and Usage

Concluding Remarks

What is and how does it work

What is?

- ▶ Inspired in the R package “snow”

What is and how does it work

What is?

- ▶ Inspired in the R package “snow” (several other examples exists: StataMP, Condor HTC, C’s Ox library, Matlab’s Parallel Toolbox, etc.)

What is and how does it work

What is?

- ▶ Inspired in the R package “snow” (several other examples exists: StataMP, Condor HTC, C’s Ox library, Matlab’s Parallel Toolbox, etc.)
- ▶ Is designed to be used in multicore CPUs (dualcore, quadcore, etc.).

What is and how does it work

What is?

- ▶ Inspired in the R package “snow” (several other examples exists: StataMP, Condor HTC, C’s Ox library, Matlab’s Parallel Toolbox, etc.)
- ▶ Is designed to be used in multicore CPUs (dualcore, quadcore, etc.).
- ▶ It implements parallel computing methods through an OS’s shell scripting (using Stata in batch mode) to accelerate computations.

What is and how does it work

What is?

- ▶ Inspired in the R package “snow” (several other examples exists: StataMP, Condor HTC, C’s Ox library, Matlab’s Parallel Toolbox, etc.)
- ▶ Is designed to be used in multicore CPUs (dualcore, quadcore, etc.).
- ▶ It implements parallel computing methods through an OS’s shell scripting (using Stata in batch mode) to accelerate computations.
- ▶ Depending on the task, can reach near to (or over) linear speedups proportional to the number of physical cores of the computer.

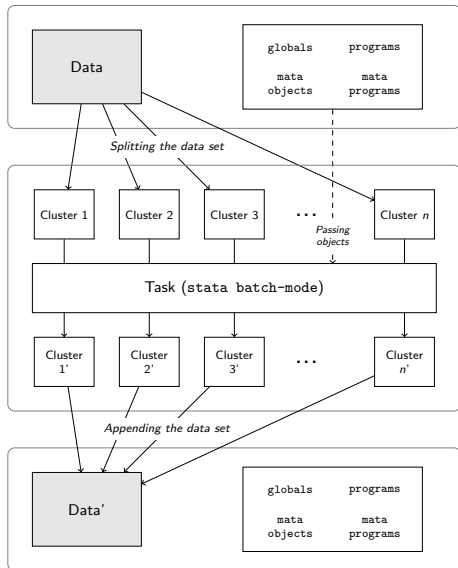
What is and how does it work

What is?

- ▶ Inspired in the R package “snow” (several other examples exists: StataMP, Condor HTC, C’s Ox library, Matlab’s Parallel Toolbox, etc.)
- ▶ Is designed to be used in multicore CPUs (dualcore, quadcore, etc.).
- ▶ It implements parallel computing methods through an OS’s shell scripting (using Stata in batch mode) to accelerate computations.
- ▶ Depending on the task, can reach near to (or over) linear speedups proportional to the number of physical cores of the computer.
- ▶ Thus having a quad-core computer can lead to a 400% speedup.

What is and how does it work

How does it work?



Starting (current) stata instance loaded with data plus user defined globals, programs, mata objects and mata programs

A new stata instance (batch-mode) for every data-clusters. Programs, globals and mata objects/programs are passed to them.

The same algorithm (task) is simultaneously applied over the data-clusters.

After every instance stops, the data-clusters are appended into one.

Ending (resulting) stata instance loaded with the new data.

User defined globals, programs, mata objects and mata programs remain unchanged.

What is and how does it work

Sounds “pretty” but...

What is and how does it work

Sounds “pretty” but...is this for real!?

What is and how does it work

Parallel's backend

When the user enters

```
parallel: gen n = _N
```

`parallel` takes the command and writes something like this

What is and how does it work

Parallel's backend

When the user enters

```
parallel: gen n = _N
```

`parallel` takes the command and writes something like this

```
cap clear all
cd ~
1 set seed 34815
  set memory 16777216b
  cap set maxvar 5000
  cap set matsize 400
2 local pll_instance 1
  local pll_id efcql2tspr
  capture {
    noisily {
3 use __pllefcql2tsprdataset if _efcql2tsprcut == 1
    gen n = _N
    }
  }
4 save __pllefcql2tsprdata1, replace
  local result = _rc
  cd ~
5 mata: write_diagnosis(st_local("result"),
  >"__pllefcql2tsprfinito1")
```

What is and how does it work

Parallel's backend

When the user enters

```
parallel: gen n = _N
```

parallel takes the command and writes something like this

```
cap clear all
cd ~
1 set seed 34815
  set memory 16777216b
  cap set maxvar 5000
  cap set matsize 400
2 local pll_instance 1
  local pll_id efcql2tspr
  capture {
  noisily {
3 use __pllefcql2tsprdataset if _efcql2tsprcut == 1
  gen n = _N
  }
  }
4 save __pllefcql2tsprdata1, replace
  local result = _rc
  cd ~
5 mata: write_diagnosis(st_local("result"),
  >"__pllefcql2tsprfinito1")
```

```
cap clear all
cd ~
1 set seed 98327
  set memory 16777216b
  cap set maxvar 5000
  cap set matsize 400
2 local pll_instance 2
  local pll_id efcql2tspr
  capture {
  noisily {
3 use __pllefcql2tsprdataset if _efcql2tsprcut == 2
  gen n = _N
  }
  }
4 save __pllefcql2tsprdata2, replace
  local result = _rc
  cd ~
5 mata: write_diagnosis(st_local("result"),
  >"__pllefcql2tsprfinito2")
```

What is and how does it work

Ok, it works but...

What is and how does it work

Ok, it works but...

it must be really hard to use!

Motivation

What is and how does it work

Benchmarks

Syntax and Usage

Concluding Remarks

Benchmarks

Simple example: Serial replace

Serial fashion

```
do mydofile.do
```

Parallel fashion

```
parallel do mydofile.do
```

Figure: mydofile.do

```
local size = _N
forval i=1/'size' {
    qui replace x = ///
        1/sqrt(2*'c(pi)')*exp(-(x^2/2)) in 'i'
}
```

Table: Serial replacing using a loop on a Linux Server (16 clusters)

	100.000	1.000.000	10.000.000
CPU	1.43	16.94	144.68
Total	0.34	3.20	12.49
Setup	0.00	0.00	0.00
Compute	0.32	3.07	11.54
Finish	0.02	0.12	0.95
Ratio (compute)	4.50	5.51	12.53
Ratio (total)	4.22 (26%)	5.30 (30%)	11.58 (72%)

Tested on a Intel Xeon X470 (hexadeca-core) machine

Benchmarks

Monte Carlo simulation (Windows Machine)

Serial fashion

do myexperiment.do

Parallel fashion

parallel do myexperiment.do, nodata

Figure: myexperiment.do

```
local num_of_intervals = 50
if length("`pl1,id'") == 0 {
    local start = 1
    local end = "num_of_intervals"
}
else {
    local stot = floor("num_of_intervals"/$PL1_CLUSTERS)
    local start = ("pl1_instance" - 1)*stot + 1
    local end = ("pl1_instance")*stot
    if "pl1_instance" == $PL1_CLUSTERS local end = 10
}

local reps 10000
forval i="start"/"end" {
    qui use cnumm2, clear
    gen true_y = age
    gen x_factor = region
    sum x_factor, meanonly
    scalar xmu = r(mean)
    qui {
        gen y1 = .
        gen y2 = .
        local c = '1'
        set seed `c'
        simulate c=r(c) mul=r(mul) ss_mu1 = r(ss_mu1) ///
            mul=r(mu2) ss_mu2 = r(ss_mu2), ///
            saving(cc1, replace) nodata reps(`reps'): ///
            mcsimul1, c(`c')
    }
}
```

Table: Monte Carlo Experiment on a Windows Machine (4 clusters)

	2	4
CPU	111.49	114.13
Total	58.02	37.48
Setup	0.00	0.00
Compute	58.02	37.48
Finish	0.00	0.00
Ratio (compute)	1.92	3.04
Ratio (total)	1.92 (96%)	3.04 (76%)

Tested on a Intel i3 2120 (dual-core) machine

Benchmarks

Monte Carlo simulation (Unix Machine)

Serial fashion

```
do myexperiment.do
```

Parallel fashion

```
parallel do myexperiment.do, nodata
```

Table: Monte Carlo Experiment on a Linux Server (16 clusters)

	2	4	8	16
CPU	164.79	164.04	162.84	163.89
Total	69.85	34.28	19.00	10.78
Setup	0.00	0.00	0.00	0.00
Compute	69.85	34.28	19.00	10.78
Finish	0.00	0.00	0.00	0.00
Ratio (compute)	2.36	4.78	8.57	15.21
Ratio (total)	2.36 (118%)	4.78 (120%)	8.57 (107%)	15.21 (95%)

Tested on a Intel Xeon X470 (hexadeca-core) machine

Benchmarks

Reshaping Administrative Data

Serial fashion

```
reshape wide tipsolic rutemp opta derecho ngiros, ///  
  i(id) j(time)
```

Parallel fashion

```
parallel, by(id) :reshape wide tipsolic rutemp opta derecho ngiros, ///  
  i(id) j(time)
```

Table: Reshaping wide a large database on a Linux Server (8 clusters)

	100.000	1.000.000	5.000.000
CPU	5.51	72.70	392.97
Total	2.33	17.46	86.44
Setup	0.00	0.00	0.00
Compute	1.83	12.42	57.93
Finish	0.50	5.04	28.51
Ratio (compute)	3.01	5.85	6.78
Ratio (total)	2.37 (29%)	4.16 (52%)	4.55 (57%)

Tested on a Intel Xeon X470 (hexadeca-core) machine

Motivation

What is and how does it work

Benchmarks

Syntax and Usage

Concluding Remarks

Syntax and Usage

Setup

parallel setclusters # [, force]

Syntax and Usage

Setup

```
parallel setclusters # [, _force]
```

By syntax

```
parallel [, by(varlist) programs mata seeds(string) randtype(random.org|datetime)  
          processors(integer) nodata]: stata_cmd
```

Syntax and Usage

Setup

```
parallel setclusters # [, _force]
```

By syntax

```
parallel [, by(varlist) programs mata seeds(string) randtype(random.org|datetime)  
          processors(integer) nodata]: stata_cmd
```

Do syntax

```
parallel do filename  
          [, by(varlist) programs mata seeds(string) randtype(random.org|datetime)  
          processors(integer) nodata]
```


Syntax and Usage

Recomendations on its usage

```
parallel suit ...
```

- ▶ Montecarlo simulation.

Syntax and Usage

Recomendations on its usage

```
parallel suit ...
```

- ▶ Montecarlo simulation.
- ▶ Extensive nested control flow (loops, while, ifs, etc.).

Syntax and Usage

Recomendations on its usage

```
parallel suit ...
```

- ▶ Montecarlo simulation.
- ▶ Extensive nested control flow (loops, while, ifs, etc.).
- ▶ Bootstraping/Jackknife.

Syntax and Usage

Recomendations on its usage

```
parallel suit ...
```

- ▶ Montecarlo simulation.
- ▶ Extensive nested control flow (loops, while, ifs, etc.).
- ▶ Bootstraping/Jackknife.
- ▶ Simulations in general.

Syntax and Usage

Recomendations on its usage

`parallel suit ...`

- ▶ Montecarlo simulation.
- ▶ Extensive nested control flow (loops, while, ifs, etc.).
- ▶ Bootstraping/Jackknife.
- ▶ Simulations in general.

`parallel doesn't suit ...`

- ▶ (already) fast commands.

Syntax and Usage

Recomendations on its usage

`parallel suit ...`

- ▶ Montecarlo simulation.
- ▶ Extensive nested control flow (loops, while, ifs, etc.).
- ▶ Bootstraping/Jackknife.
- ▶ Simulations in general.

`parallel doesn't suit ...`

- ▶ (already) fast commands.
- ▶ Regressions, ARIMA, etc.

Syntax and Usage

Recommendations on its usage

parallel suit ...

- ▶ Montecarlo simulation.
- ▶ Extensive nested control flow (loops, while, ifs, etc.).
- ▶ Bootstrapping/Jackknife.
- ▶ Simulations in general.

parallel doesn't suit ...

- ▶ (already) fast commands.
- ▶ Regressions, ARIMA, etc.
- ▶ Linear Algebra.

Syntax and Usage

Recommendations on its usage

`parallel suit ...`

- ▶ Montecarlo simulation.
- ▶ Extensive nested control flow (loops, while, ifs, etc.).
- ▶ Bootstrapping/Jackknife.
- ▶ Simulations in general.

`parallel doesn't suit ...`

- ▶ (already) fast commands.
- ▶ Regressions, ARIMA, etc.
- ▶ Linear Algebra.
- ▶ Whatever StataMP does better.

Concluding Remarks

- ▶ In the case of Stata, `parallel` is, to the authors knowledge, the first public user-contribution to parallel computing

Concluding Remarks

- ▶ In the case of Stata, `parallel` is, to the authors knowledge, the first public user-contribution to parallel computing
- ▶ its major strengths/advantages are in simulation models and non-vectorized operations such as control-flow statements.

Concluding Remarks

- ▶ In the case of Stata, `parallel` is, to the authors knowledge, the first public user-contribution to parallel computing
- ▶ its major strengths/advantages are in simulation models and non-vectorized operations such as control-flow statements.
- ▶ Depending on the proportion of the algorithm that can be de-serialized, it is possible to reach near to constant scale speedups.

Concluding Remarks

- ▶ In the case of Stata, `parallel` is, to the authors knowledge, the first public user-contribution to parallel computing
- ▶ its major strengths/advantages are in simulation models and non-vectorized operations such as control-flow statements.
- ▶ Depending on the proportion of the algorithm that can be de-serialized, it is possible to reach near to constant scale speedups.
- ▶ `parallel` establishes a new basis for parallel computing in Stata,

Concluding Remarks

- ▶ In the case of Stata, `parallel` is, to the authors knowledge, the first public user-contribution to parallel computing
- ▶ its major strengths/advantages are in simulation models and non-vectorized operations such as control-flow statements.
- ▶ Depending on the proportion of the algorithm that can be de-serialized, it is possible to reach near to constant scale speedups.
- ▶ `parallel` establishes a new basis for parallel computing in Stata, thus an all new set of algorithms can be implemented:

Concluding Remarks

- ▶ In the case of Stata, `parallel` is, to the authors knowledge, the first public user-contribution to parallel computing
- ▶ its major strengths/advantages are in simulation models and non-vectorized operations such as control-flow statements.
- ▶ Depending on the proportion of the algorithm that can be de-serialized, it is possible to reach near to constant scale speedups.
- ▶ `parallel` establishes a new basis for parallel computing in Stata, thus an all new set of algorithms can be implemented:
 - ▶ `parsimulate`

Concluding Remarks

- ▶ In the case of Stata, `parallel` is, to the authors knowledge, the first public user-contribution to parallel computing
- ▶ its major strengths/advantages are in simulation models and non-vectorized operations such as control-flow statements.
- ▶ Depending on the proportion of the algorithm that can be de-serialized, it is possible to reach near to constant scale speedups.
- ▶ `parallel` establishes a new basis for parallel computing in Stata, thus an all new set of algorithms can be implemented:
 - ▶ `parsimulate`
 - ▶ `parfor`

Concluding Remarks

- ▶ In the case of Stata, `parallel` is, to the authors knowledge, the first public user-contribution to parallel computing
- ▶ its major strengths/advantages are in simulation models and non-vectorized operations such as control-flow statements.
- ▶ Depending on the proportion of the algorithm that can be de-serialized, it is possible to reach near to constant scale speedups.
- ▶ `parallel` establishes a new basis for parallel computing in Stata, thus an all new set of algorithms can be implemented:
 - ▶ `parsimulate`
 - ▶ `parfor`
 - ▶ `parbootstrap`

Concluding Remarks

- ▶ In the case of Stata, `parallel` is, to the authors knowledge, the first public user-contribution to parallel computing
- ▶ its major strengths/advantages are in simulation models and non-vectorized operations such as control-flow statements.
- ▶ Depending on the proportion of the algorithm that can be de-serialized, it is possible to reach near to constant scale speedups.
- ▶ `parallel` establishes a new basis for parallel computing in Stata, thus an all new set of algorithms can be implemented:
 - ▶ `parsimulate`
 - ▶ `parfor`
 - ▶ `parbootstrap`
 - ▶ `parnnmatch`

Concluding Remarks

- ▶ In the case of Stata, `parallel` is, to the authors knowledge, the first public user-contribution to parallel computing
- ▶ its major strengths/advantages are in simulation models and non-vectorized operations such as control-flow statements.
- ▶ Depending on the proportion of the algorithm that can be de-serialized, it is possible to reach near to constant scale speedups.
- ▶ `parallel` establishes a new basis for parallel computing in Stata, thus an all new set of algorithms can be implemented:
 - ▶ `parsimulate`
 - ▶ `parfor`
 - ▶ `parbootstrap`
 - ▶ `parnnmatch`
 - ▶ ... You name it!

Thank you very much!

George G. Vega

`gvega@spensiones.cl`

Chilean Pension Supervisor

Stata Conference New Orleans
July 18-19, 2013