

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

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Thanks to 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

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- ▶ Often our work is easily broken down into independent chunks
- ▶ But, implementing parallel computing even for these “embarrassingly parallel” problems is not easy, most of this due to lack of (user-friendly) statistical computing tools.
- ▶ `parallel` aims to make a contribution to these issues.

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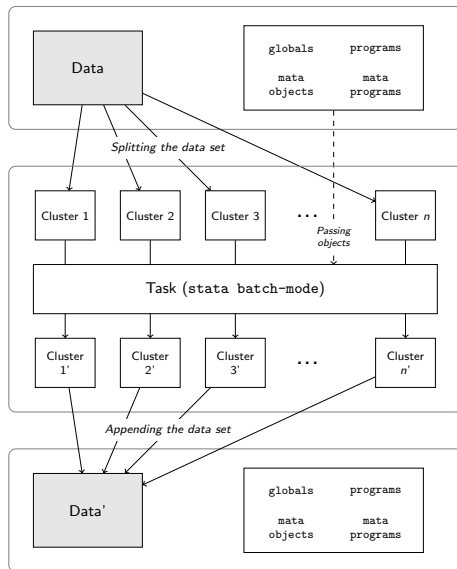
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- ▶ Thus having a quad-core computer can lead to a 400% speedup.

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.

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 - ▶ List of seeds for each bootstrap resampling
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 3. Child process reads its list of tasks, loads the real dataset, and does it's own looping over tasks
- ▶ If the list of tasks is not initially definable then the “nodata” alternative mechanism allows for more flexibility.

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Parallel's backend

When the user enters

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```
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 x2 = x*x
    }
  }
4 save __pllefcql2tsprdata1, replace
  local result = _rc
  cd ~
5 mata: write_diagnosis(st_local("result"),
  >"__pllefcql2tsprfinito1")
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```

```
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 x2 = x*x
  }
  }
4 save __pllefcql2tsprdata2, replace
  local result = _rc
  cd ~
5 mata: write_diagnosis(st_local("result"),
  >"__pllefcql2tsprfinito2")
```

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Benchmarks

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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 ntot = floor("num_of_intervals"/`$PL1_CLUSTERS')
    local start = ("pl1_instances" - 1)*'ntot' + 1
    local end = ("pl1_instances")*'ntot'
    if 'pl1_instance' == '$PL1_CLUSTERS' local end = 10
}
local reps 10000
forval i="`start'/'`end'" {
    qui use census2, clear
    gen trunq = age
    gen x_factor = region
    sum x_factor, semeanly
    scalar sm = r(sean)
    qui {
        gen y1 = .
        gen y2 = .
        local c = '1'
        set seed `c'
        simulate c=r(c) m1=r(sm1) sm_m1 = r(sm_m1) ///
            m2=r(sm2) sm_m2 = r(sm_m2), ///
            saving(cc'1', replace) nodata reps('reps'): ///
            m1sm_m1, 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

Benchmarks

Bootstrap with parallel bs

```
sysuse auto, clear expand 10

// Serial fashion
bs, rep($size) nodots: regress mpg weight gear foreign

// Parallel fashion parallel setclusters $number_of_clusters
parallel bs, rep($size) nodots: regress mpg weight gear foreign
```

| Problem size | Serial | 2 Clusters | 4 Clusters |
|--------------|-----------------|----------------|----------------|
| 1,000 | 2.93s ×2.69 | 1.62s ×1.48 | 1.09s ×1.00 |
| 2,000 | 5.80s ×2.85 | 3.13s ×1.54 | 2.03s ×1.00 |
| 4,000 | 11.59s ×3.01 | 6.27s ×1.62 | 3.86s ×1.00 |

Table: Absolute and relative computing times for each run of a basic bootstrap problem. For each given problem size, the first row shows the time in seconds, and the second row shows the relative time each method took to complete the task relative to using parallel with four clusters. Each cell represents a 1,000 runs.

Benchmarks

Simulations with `parallel sim`

```
prog def mysim, rclass
  // Data generating process
  drop _all
  set obs 1000
  gen eps = rnormal()
  gen X = rnormal()
  gen Y = X*2 + eps

  // Estimation
  reg Y X
  mat def ans = e(b)
  return scalar beta = ans[1,1]
end

// Serial fashion
simulate beta=r(beta), reps($size) nodots: mysim

// Parallel fashion
parallel setclusters $number_of_clusters
parallel sim, reps($size) expr(beta=r(beta)) nodots: mysim
```

Benchmarks

Simulations with `parallel sim` (cont.)

| Problem size | Serial | 2 Clusters | 4 Clusters |
|--------------|----------------|----------------|----------------|
| 1000 | 2.19s ×3.01 | 1.18s ×1.62 | 0.73s ×1.00 |
| 2000 | 4.36s ×3.29 | 2.29s ×1.73 | 1.33s ×1.00 |
| 4000 | 8.69s ×3.40 | 4.53s ×1.77 | 2.55s ×1.00 |

Table: Absolute and relative computing times for each run of a simple Monte Carlo exercise. For each given problem size, the first row shows the time in seconds, and the second row shows the relative time each method took to complete the task relative to using parallel with four clusters. Each cell represents a 1,000 runs.

Code for replicating this is available at
<https://github.com/gvegayon/parallel>

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             processors(integer) nodata]: stata_cmd
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Append syntax

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

Syntax and Usage

Recommendations on its usage

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- ▶ (Currently) Tasks that already take up all of RAM.

Concluding Remarks

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- ▶ Caveat: Has not been tested on Stata 15.
- ▶ Contribute, find help, and report bugs at <http://github.com/gvegayon/parallel>

Concluding Remarks

- ▶ Brings parallel computing to many more commands than StataMP
- ▶ 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 linear scale speedups.
- ▶ `parallel` can be incorporated into other user commands as an optional speedup.
- ▶ Caveat: Has not been tested on Stata 15.
- ▶ Contribute, find help, and report bugs at <http://github.com/gvegayon/parallel>

Thank you very much!

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