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 it and how does it work

Benchmarks

Syntax and Usage

Concluding Remarks
Motivation

- Both computation power and size of data are ever increasing.
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- Stata/MP exists, but only parallelizes a limited set of internal commands, not user commands.
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▶ Often our work is easily broken down into independent chunks
▶ Implementing parallel computing, even for these “embarrassingly parallel” problems, however, is not easy.
▶ Stata/MP exists, but only parallelizes a limited set of internal commands, not user commands.
▶ parallel aims to make this more convenient.
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- Launches “child” batch-mode Stata processes across multiple processors (e.g. simultaneous multi-threading, multiple cores, sockets, cluster nodes).
- Depending on the task, can reach near linear speedups proportional to the number of processors.
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- Launches “child” batch-mode Stata processes across multiple processors (e.g. simultaneous multi-threading, multiple cores, sockets, cluster nodes).
- Depending on the task, can reach near linear speedups proportional to the number of processors.
  - Thus having a quad-core computer can lead to a 400% speedup.
Simple usage

Serial:

- `gen v2 = v*v`
- `do byobs_calc.do`
- `bs, reps(5000): reg price foreign rep`
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Parallel:

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What is it and how does it work

How does it work?

- Method is *split-apply-combine* like MapReduce.
What is it 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.
Method is *split-apply-combine* like MapReduce. Very flexible!
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How does it work?

- Method is *split-apply-combine* like MapReduce. Very flexible!
- Straightforward usage when there is observation- or group-level work
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- If each iteration needs the entire dataset, then use procedure to split the tasks and load the data separately. Examples:
  - Table of seeds for each bootstrap resampling
  - Table of parameter values for simulations
- If the list of tasks is data-dependent then the “nodata” alternative mechanism allows for more flexibility.
Implementation
Some details

- Uses shell on Linux/MacOS. On Windows we have a compiled plugging allowing:
  - Functionality when the parent Stata is in batch-mode
  - Seamless user experience by launching the child programs in a hidden desktop (otherwise GUI for each steals focus)
  - For a Linux/MacOS cluster with a shared filesystem (e.g. NFS) and ssh-like commands, can distribute across nodes.
  - New feature so we'd appreciate help from the community to extend to other cluster settings (e.g. PBS)
  - Make sure that child tempnames or tempvars don't clash with those coming from parent.
  - Passes through programs, macros and mata objects, but NOT Stata matrices or scalars. No state but datasets are returned to parent.
  - Recover gracefully from child failures. Currently no re-try support.
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Benchmarks

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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

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.
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<table>
<thead>
<tr>
<th>Problem size</th>
<th>Serial</th>
<th>2 Clusters</th>
<th>4 Clusters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,000</td>
<td>2.93s</td>
<td>1.62s</td>
<td>1.09s</td>
</tr>
<tr>
<td></td>
<td>×2.69</td>
<td>×1.48</td>
<td>×1.00</td>
</tr>
<tr>
<td>2,000</td>
<td>5.80s</td>
<td>3.13s</td>
<td>2.03s</td>
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<tr>
<td></td>
<td>×2.85</td>
<td>×1.54</td>
<td>×1.00</td>
</tr>
<tr>
<td>4,000</td>
<td>11.59s</td>
<td>6.27s</td>
<td>3.86s</td>
</tr>
<tr>
<td></td>
<td>×3.01</td>
<td>×1.62</td>
<td>×1.00</td>
</tr>
</tbody>
</table>

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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
```
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.

<table>
<thead>
<tr>
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<th>Serial</th>
<th>2 Clusters</th>
<th>4 Clusters</th>
</tr>
</thead>
<tbody>
<tr>
<td>1000</td>
<td>2.19s</td>
<td>1.18s</td>
<td>0.73s</td>
</tr>
<tr>
<td></td>
<td>×3.01</td>
<td>×1.62</td>
<td>×1.00</td>
</tr>
<tr>
<td>2000</td>
<td>4.36s</td>
<td>2.29s</td>
<td>1.33s</td>
</tr>
<tr>
<td></td>
<td>×3.29</td>
<td>×1.73</td>
<td>×1.00</td>
</tr>
<tr>
<td>4000</td>
<td>8.69s</td>
<td>4.53s</td>
<td>2.55s</td>
</tr>
<tr>
<td></td>
<td>×3.40</td>
<td>×1.77</td>
<td>×1.00</td>
</tr>
</tbody>
</table>

Code for replicating this is available at
https://github.com/gvegayon/parallel
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Syntax and Usage

Setup

```plaintext
parallel setclusters # | default [, force hostnames(namelist)]
```
Syntax and Usage

Setup

```plaintext
parallel setclusters #|default [, _force _hostnames(namelist)]
```

Main command types

```plaintext
parallel [, by(varlist) programs(namelist) mata seeds(string) randtype(random.org|datetime) nodata]: stata_cmd
```
Syntax and Usage

Setup

```
parallel setclusters #|default [, force_hostnames(namelist)]
```

Main command types

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

parallel do filename [, by(varlist) programs(namelist) mata seeds(string)
            randtype(random.org|datetime) nodata]
```
Syntax and Usage

Setup

```
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```

Helper commands

```
parallel bs [, expression(exp_list) programs(namelist) mata seeds(string) randtype(random.org|datetime) bs_options]: stata_cmd
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```plaintext
parallel sim [, expression(exp_list) programs(namelist) mata seeds(string) randtype(random.org|datetime) sim_options]]: stata_cmd
```

```plaintext
parallel append [files], do(command|dofile) [in(in) if(if) expression(expand_exp) programs(namelist) mata seeds(string) randtype(random.org|datetime)]
```
Syntax and Usage

Setup

```
parallel setclusters #|default [, force_hostnames(namelist)]
```

Main command types

```
parallel [, by(varlist) programs(namelist) mata_seeds(string) randtype(random.org|datetime) nodata]: stata_cmd
```

```
parallel do filename [, by(varlist) programs(namelist) mata_seeds(string) randtype(random.org|datetime) nodata]
```

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parallel append [files], do(command|dofile) [in(in) if(if) expression(expand_exp) programs(namelist) mata_seeds(string) randtype(random.org|datetime)]
```

Additional Utilities

```
parallel version/clean/printlog/viewlog/numprocessors
```
Use `parallel printlog/viewlog` to view the log of the child process (includes some setup code as well). Can `set trace` in the child do-file or command to see more.
Debugging

- Use **parallel printlog/viewlog** to view the log of the child process (includes some setup code as well). Can **set trace** in the child do-file or command to see more.
- Auxiliary files created during process (harder to use):

  - plId.sh
  - dataset.dta
  - doNUM.do
  - glob.do
  - dtaNUM.dta
  - finitoNUM
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- Can keep these around by specifying the **keep** or **keeplast** options
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Recommendations on its usage

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parallel doesn’t suit ...

- (already) fast commands
- Regressions, ARIMA, etc.
- Linear Algebra
- Whatever Stata/MP does better (on single machine)
Use in other Stata modules

- EVENTSTUDY2: Perform event studies with complex test statistics
- MIPARALLEL: Perform parallel estimation for multiple imputed datasets
- Synth_Runner: Performs multiple Synthetic Control estimations for permutation testing
Concluding Remarks

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- Install, contribute, find help, and report bugs at http://github.com/gvegayon/parallel
Thank you very much!

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