

Parallel Computing in R using NetWorkSpaces

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and G Warnes

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Pfizer

Shared Workspaces

- Variation on the theme of a workspace.
- The NetWorkSpace object encapsulation uses an Internet-based server to hold the workspace.
- A given NetWorkSpace can be accessed by multiple processes: *Any process capable of instantiating an appropriate NetWorkSpace object may retrieve the value of a variable.* (Or store (name, value) pairs for that matter.)

```
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Type 'demo()' for some demos, 'help()' for on-line help, or
'help.start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> library(nws)
> ws = netWorkSpace('outer space')
> nwsVariable(ws, 'input'); nwsVariable(ws, 'output'); nwsVariable(ws, 'param',
mode = 'single')
> █
```

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R Session 1

R Session 2

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R Session 2

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> nwsVariable(ws, 'input'); nwsVariable(ws, 'output'); nwsVariable(ws, 'param',
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> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 1005
> 
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R Session 2

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> nwsVariable(ws, 'input'); nwsVariable(ws, 'output'); nwsVariable(ws, 'param',
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> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> 
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R Session 1

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[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> 
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R Session 2

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> ws = networkSpace('outer space')
> nwsVariable(ws, 'input'); nwsVariable(ws, 'output'); nwsVariable(ws, 'param',
mode = 'single')
> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> output = input * 7
> 
```

R Session 1

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> ws = networkSpace('outer space')
> nwsVariable(ws, 'input'); nwsVariable(ws, 'output'); nwsVariable(ws, 'param',
mode = 'single')
> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> input
[1] 111
> output
[1] 777
> 
```

R Session 2

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> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> output
[1] 1003
> output = input * 7
> 
```

R Session 1

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'help,start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> library(nus)
> ws = networkSpace('outer space')
> nusVariable(ws, 'input'); nusVariable(ws, 'output'); nusVariable(ws, 'param',
mode = 'single')
> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
> param = 8
> 
```

R Session 2

```
Type 'q()' to quit R.

> library(nus)
> ws = networkSpace('outer space')
> nusVariable(ws, 'input'); nusVariable(ws, 'output'); nusVariable(ws, 'param',
mode = 'single')
> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
> param = 8
> 
```

R Session 1

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> ws = networkSpace('outer space')
> nusVariable(ws, 'input'); nusVariable(ws, 'output'); nusVariable(ws, 'param',
mode = 'single')
> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
> param = 8
> 
```

R Session 2

```
> library(nus)
> ws = networkSpace('outer space')
> nusVariable(ws, 'input'); nusVariable(ws, 'output'); nusVariable(ws, 'param',
mode = 'single')
> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output = input * 7
> param
[1] 8
> param
[1] 8
> param
[1] 8
> while (1) { x = input; cat(x, '\n'); output = x * param }
[1] 8
> 
```

R Session 3

```
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'help,start()' for an HTML browser interface to help.
Type 'q()' to quit R.

> library(nus)
> ws = networkSpace('outer space')
> nusVariable(ws, 'input'); nusVariable(ws, 'output'); nusVariable(ws, 'param',
mode = 'single')
> param
[1] 8
> while (1) { x = input; cat(x, '\n'); output = x * param }
[1] 8
> 
```

R Session 1

```
> library(nus)
> ws = networkSpace('outer space')
> nusVariable(ws, 'input'); nusVariable(ws, 'output'); nusVariable(ws, 'param',
mode = 'single')
> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
> param = 8
> for (i in 1:7) input = i
> for (i in 1:7) cat(output, '\n')
8
16
24
32
40
48
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> 
```

R Session 2

```
mode = 'single'
> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> input
[1] 111
> output = input * 7
> param
[1] 8
> param
[1] 8
> param
[1] 8
> 
```

R Session 3

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> ws = networkSpace('outer space')
> nusVariable(ws, 'input'); nusVariable(ws, 'output'); nusVariable(ws, 'param',
mode = 'single')
> param
[1] 8
> while (1) { x = input; cat(x, '\n'); output = x * param }
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> input
[1] 456
> input
[1] 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
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```

The screenshot shows two windows. The top window is an 'R Session' window with the following R code:

```

> library(nws)
> ws = networkSpace('outer space')
> nwsVariable(ws, 'input'); nwsVariable(ws, 'output'); nwsVariable(ws, 'param',
+ mode = 'single')
> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
> param = 8
> for (i in 1:7) input = i
> for (i in 1:7) cat(output, '\n')
8
16
24
32
40
48
56
> nwsDeleteVar(ws, 'input')
>

```

The bottom window is a 'Variables in outer space' browser window showing the following table:

Variable	# Values	# Fetchers	# Finders	Mode	Delete?
output	0	0	0	fifo	<input type="button" value="x"/>
param	1	0	0	single	<input type="button" value="x"/>

The screenshot shows two windows. The top window is an 'R Session' window with the following R code:

```

> ws = networkSpace('outer space')
> nwsVariable(ws, 'input'); nwsVariable(ws, 'output'); nwsVariable(ws, 'param',
+ mode = 'single')
> input = 123
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> input = 111
> output
[1] 777
> param = 8
> for (i in 1:7) input = i
> for (i in 1:7) cat(output, '\n')
8
16
24
32
40
48
56
> nwsDeleteVar(ws, 'input')
> param = list('e' = 2.71828, v = 1:4)
>

```

The bottom window is a 'Variables in outer space' browser window showing the following table:

Variable	# Values	# Fetchers	# Finders	Mode	Delete?
output	0	0	0	fifo	<input type="button" value="x"/>
param	1	0	0	single	<input type="button" value="x"/>

Coordination via NetWorkSpaces

- Shared Access: Communication.
- Blocking References: Synchronization.
- Coordination provided within the context of the existing, familiar concept of a “workspace”.
- Coordination data has independent existence

Benefits

- Simplifies development:
 - Familiar conceptual foundation
 - Uncoupling in space and time
 - Anonymity
- Promotes flexibility:
 - Dynamic processing ensembles
 - Cross platform
 - Cross environment

Sleigh

- Inspired by snow (Tierney, Rossini, Li, Sevcikova), but snow and sleigh differ in many ways.
- Supports “parallel” apply.
- Implemented on top of NetWorkSpaces.
- Vehicle for launching codes that explicitly use NetWorkSpaces for coordination.

R Session 1

```
> nwsVariable(ws, 'input'); nwsVariable(ws, 'output'); nwsVariable(ws, 'param');
mode = 'single'
> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
> param = 8
> for (i in 1:7) input = i
> for (i in 1:7) cat(output, '\n')
8
16
24
32
40
48
56
> nwsDeleteVar(ws, 'input')
> param = list('e' = 2,71828, v = 1:4)
> s = sleigh()
```

Variables in sleigh_ride_0003_nwssn2t719

Variable	# Values	# Fetchers	# Finders	Mode	Delete?
Sleigh ride over	0	0	3	unknown	<input type="button" value="x"/>
localhost@0	1	0	0	single	<input type="button" value="x"/>
localhost@1	1	0	0	single	<input type="button" value="x"/>
localhost@2	1	0	0	single	<input type="button" value="x"/>
nodeList	1	0	0	single	<input type="button" value="x"/>
rankCount	1	0	0	single	<input type="button" value="x"/>
task	0	3	0	unknown	<input type="button" value="x"/>
totalTasks	1	0	0	single	<input type="button" value="x"/>
worker info	3	0	0	fifo	<input type="button" value="x"/>
workerCount	1	0	0	single	<input type="button" value="x"/>

NetWorkSpaces

Name	Monitor	Owner	Persistent	Variables	Delete?
Python babelfish	[none]	IPv4Address(TCP, '127.0.0.1', 51321)	False	1	<input type="button" value="x"/>
R babelfish	[none]	IPv4Address(TCP, '127.0.0.1', 51328)	False	2	<input type="button" value="x"/>
_default	[none]	[system]	False	0	<input type="button" value="x"/>
outer space	[none]	IPv4Address(TCP, '127.0.0.1', 51322)	False	2	<input type="button" value="x"/>
sleigh_ride_0003_nwssn2t719	Sleigh Monitor	IPv4Address(TCP, '192.168.2.1', 51329)	False	10	<input type="button" value="x"/>

R Session 1

```
> s = sleigh()
> eachElem(s, function(x) { x*x*x }, list(13:19))
[1] 2197
[2] 2744
[3] 3375
[4] 4096
[5] 4913
[6] 5832
[7] 6859
> s
```

Variables in sleigh_ride_0003_nwssn2t719

Variable	# Values	# Fetchers
Sleigh ride over	0	
localhost@0	1	
localhost@1	1	
localhost@2	1	
nodeList	1	
rankCount	1	
task	0	
totalTasks	1	
worker info	3	
workerCount	1	

NetWorkSpaces

Name	Monitor	Owner	Persistent	Variables	Delete?
Python babelfish	[none]	IPv4Address(TCP, '127.0.0.1', 51321)	False	1	<input type="button" value="x"/>
R babelfish	[none]	IPv4Address(TCP, '127.0.0.1', 51328)	False	2	<input type="button" value="x"/>
_default	[none]	[system]	False	0	<input type="button" value="x"/>
outer space	[none]	IPv4Address(TCP, '127.0.0.1', 51322)	False	2	<input type="button" value="x"/>
sleigh_ride_0003_nwssn2t719	Sleigh Monitor	IPv4Address(TCP, '192.168.2.1', 51329)	False	10	<input type="button" value="x"/>

Values in localhost@0

Value
1. 3

Values in localhost@1

Value
1. 2

Values in localhost@2

Value
1. 2

R Session 1

```
[1] 2197
[2] 2744
[3] 3375
[4] 4096
[5] 4913
[6] 5832
[7] 6859
```

Python Session 1

```
Python 2.3.5 (#1, Jan 13 2006, 20:13:11)
[GCC 4.0.1 (Apple Computer, Inc. build 5250)] on darwin
Type "help", "copyright", "credits" or "license" for more information.
>>> from client import NetworkSpace
ws = NetworkSpace('outer space')
sv = ws.variables('input', 'output', ['param','single'])
>>> sv.param = 'greetings from R!'
>>> sv.param
[1] "hssssss"
```

- MATLAB, octave, python, perl, ruby,
...
- Software available from:
<http://nws-r.sourceforge.net>
(open source for open source systems; commercial
for commercial systems: www.lindaspaces.com)
- API used in this talk is a “teaser”.
More serious projects use a richer, but
more verbose, API.