

Parallel Computing in R using NetWorkSpaces

N Carriero, J Lai, M Schultz, S Weston
and G Warnes

Supported by:

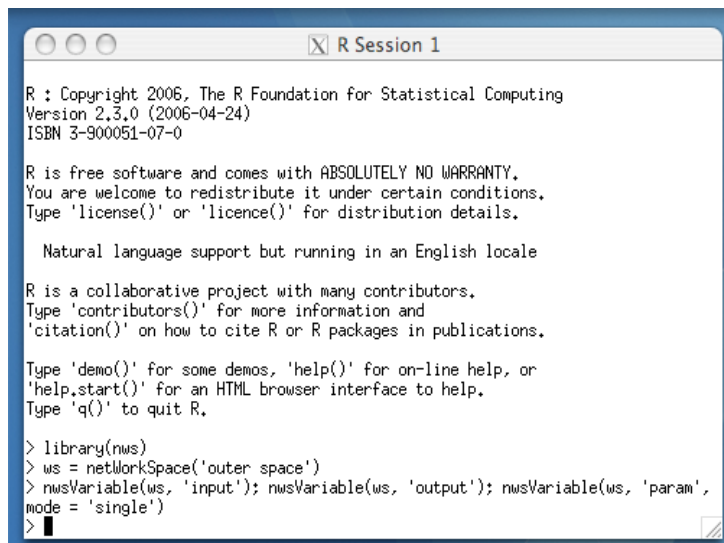
Yale Center for High Performance Computation in
Biology and Biomedicine and NIH grant: RR19895-02

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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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ISBN 3-900051-07-0

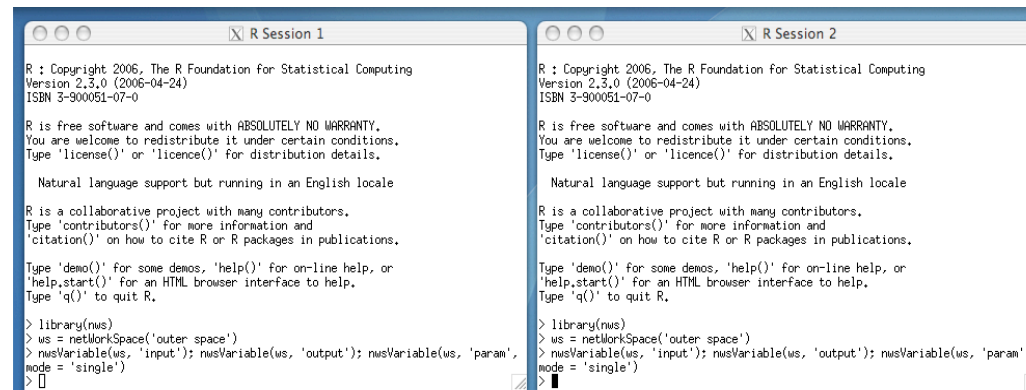
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> library(nws)
> ws = netWorkspace('outer space')
> nwsVariable(ws, 'input'); nwsVariable(ws, 'output'); nwsVariable(ws, 'param',
mode = 'single')
>
```



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> input
[1] 123
>

```

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>

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> input
[1] 123
> input

```

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> nusVariable(us, 'input'); nusVariable(us, 'output'); nusVariable(us, 'param',
mode = 'single')
> input = 123
> input
[1] 123
> input = 456
>

```

```

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> input
[1] 123
> input
[1] 456
>

```

```
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> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> █

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> input
[1] 123
> input
[1] 456
> █
```

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> nusVariable(us, 'input'); nusVariable(us, 'output'); nusVariable(us, 'param',
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> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> █
```

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> nusVariable(us, 'input'); nusVariable(us, 'output'); nusVariable(us, 'param',
mode = 'single')
> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
> █

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> nusVariable(us, 'input'); nusVariable(us, 'output'); nusVariable(us, 'param',
mode = 'single')
> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> output
[1] 1003
> █
```

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> us = netWorkspace('outer space')
> nusVariable(us, 'input'); nusVariable(us, 'output'); nusVariable(us, 'param',
mode = 'single')
> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
> █

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> us = netWorkspace('outer space')
> nusVariable(us, 'input'); nusVariable(us, 'output'); nusVariable(us, 'param',
mode = 'single')
> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> output = input * 7
> █
```

```

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

```

```

R Session 2
Type 'q()' to quit R.

> library(nus)
> us = netWorkSpace('outer space')
> nusVariable(us, 'input'); nusVariable(us, 'output'); nusVariable(us, 'param',
mode = 'single')
> input
[1] 123
> input
[1] 456
> input = 1001
> input
[1] 1002
> input
[1] 1003
> output = input * 7
> param
[1] 8
> param
[1] 8
> param
[1] 8
> param
[1] 8

```

```

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> input = 123
> input = 456
> input = 1001
> input = 1002
> input = 1003
> input = 111
> output
[1] 777
> param = 8
>

```

```

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

```

```

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Type 'q()' to quit R.

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

```

```

R Session 1
> library(nus)
> us = netWorkSpace('outer space')
> nusVariable(us, 'input'); nusVariable(us, 'output'); nusVariable(us, '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
>

```

```

R Session 2
mode = 'single')
> input
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> output = input * 7
> param
[1] 8
> param
[1] 8
> while (1) { x = input; cat(x, '\n'); output = x * param }
1
3
5
7

```

```

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> nusVariable(us, 'input'); nusVariable(us, 'output'); nusVariable(us, 'param',
mode = 'single')
> param
[1] 8
> while (1) { x = input; cat(x, '\n'); output = x * param }
2
4
6

```

```

R Session 1
> library(nus)
> us = netWorkSpace('outer space')
> nusVariable(us, 'input'); nusVariable(us, 'output'); nusVariable(us, 'param',
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> 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
> nusDeleteVar(us, 'input')

```

```

R Session 2
[1] 123
> input
[1] 456
> input
[1] 1001
> input
[1] 1002
> input
[1] 1003
> output = input * 7
> param
[1] 8
> param
[1] 8
> while (1) { x = input; cat(x, '\n'); output = x * param }
1
3
5
7
Error in nusRetrieve(s, us, xName, "fetch") :
retrieval failed

```

```

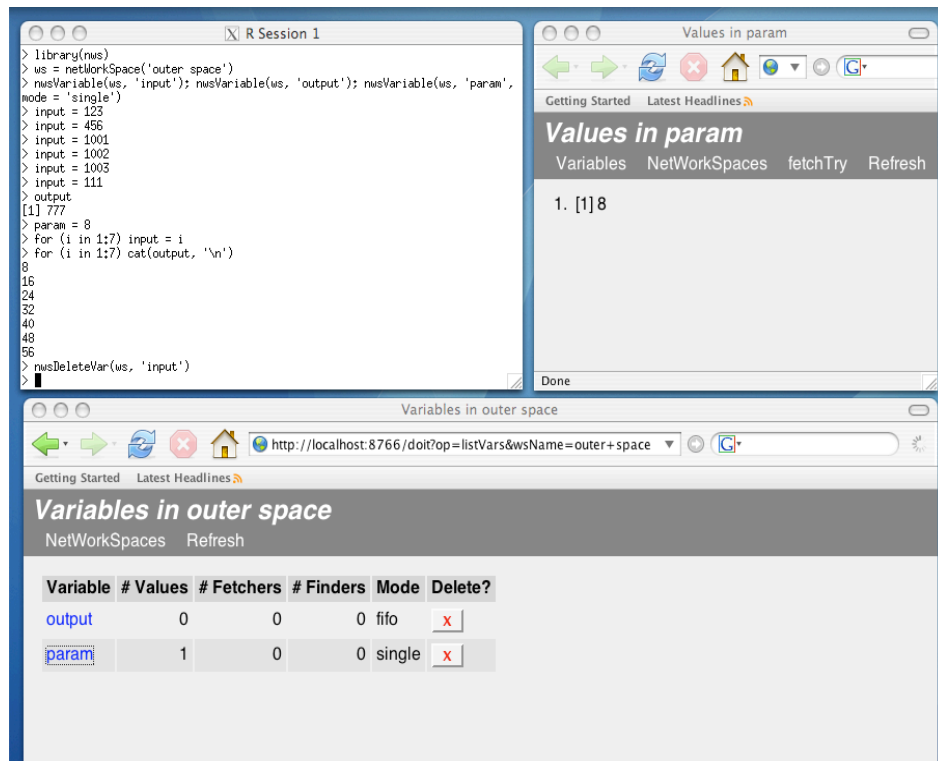
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Type 'q()' to quit R.

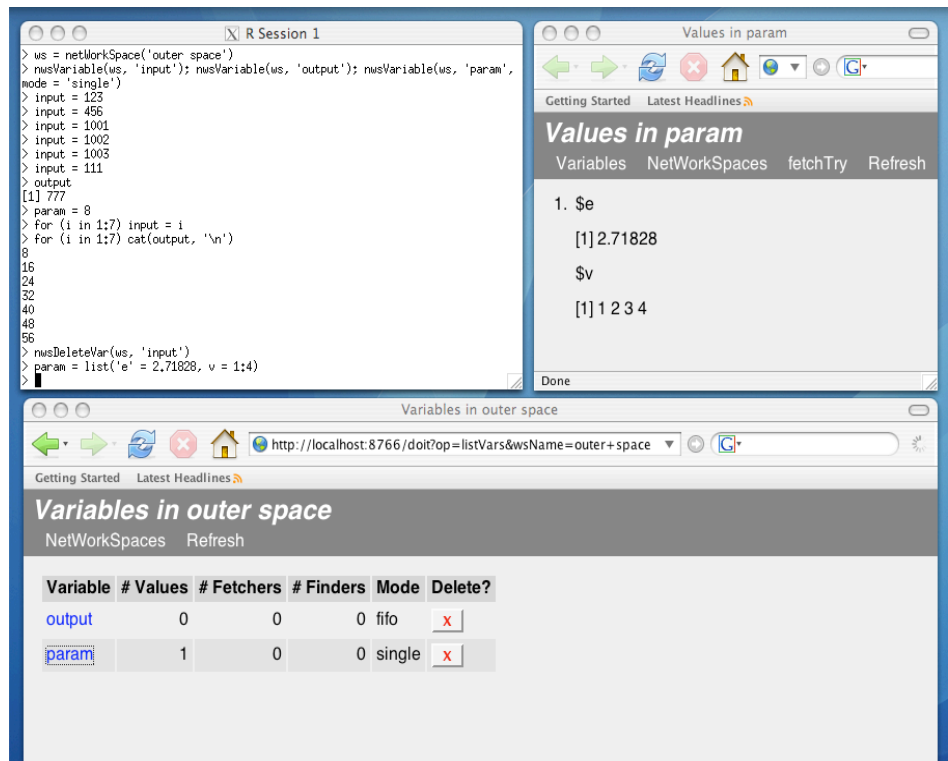
> library(nus)
> us = netWorkSpace('outer space')
> nusVariable(us, 'input'); nusVariable(us, 'output'); nusVariable(us, 'param',
mode = 'single')
> param
[1] 8
> while (1) { x = input; cat(x, '\n'); output = x * param }
2
4
6
Error in nusRetrieve(s, us, xName, "fetch") :
retrieval failed

```



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	X
localhost@0	1	0	0	single	X
localhost@1	1	0	0	single	X
localhost@2	1	0	0	single	X
nodeList	1	0	0	single	X
rankCount	1	0	0	single	X
task	0	3	0	unknown	X
totalTasks	1	0	0	single	X
worker info	3	0	0	fifo	X
workerCount	1	0	0	single	X

NetWorkSpaces

Name	Monitor	Owner	Persistent	Variables	Delete?
Python babelfish	[none]	IPv4Address(TCP, '127.0.0.1', 51321) (4654)	False	1	X
R babelfish	[none]	IPv4Address(TCP, '127.0.0.1', 51328) (4693)	False	2	X
__default	[none]	[system]	False	0	X
outer space	[none]	IPv4Address(TCP, '127.0.0.1', 51322) (4668)	False	2	X
sleigh_ride_0003_nwssn2t719	Sleigh Monitor	IPv4Address(TCP, '192.168.2.1', 51329) (4668)	False	10	X

R Session 1

```

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

Variables in sleigh_ride_0003_nwssn2t719

Variable	# Values	# Fetchers	# Finders	Mode	Delete?
Sleigh ride over	0	0	3	unknown	X
localhost@0	1	0	0	single	X
localhost@1	1	0	0	single	X
localhost@2	1	0	0	single	X
nodeList	1	0	0	single	X
rankCount	1	0	0	single	X
task	0	3	0	unknown	X
totalTasks	1	0	0	single	X
worker info	3	0	0	fifo	X
workerCount	1	0	0	single	X

NetWorkSpaces

Name	Monitor	Owner	Persistent	Variables	Delete?
Python babelfish	[none]	IPv4Address(TCP, '127.0.0.1', 51321) (4654)	False	1	X
R babelfish	[none]	IPv4Address(TCP, '127.0.0.1', 51328) (4693)	False	2	X
__default	[none]	[system]	False	0	X
outer space	[none]	IPv4Address(TCP, '127.0.0.1', 51322) (4668)	False	2	X
sleigh_ride_0003_nwssn2t719	Sleigh Monitor	IPv4Address(TCP, '192.168.2.1', 51329) (4668)	False	10	X

Values in localhost@0

1. 3

Values in localhost@1

1. 2

Values in localhost@2

1. 2

R Session 1

```

[1] 2197
[[2]]
[1] 2744
[[3]]
[1] 3375
[[4]]
[1] 4096
[[5]]
[1] 4913
[[6]]
[1] 5832
[[7]]
[1] 6859
> param = 'greetings from R!'
> param
[1] "hsssssss"
  
```

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 = 'hsssssss'
  
```

- 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.