Introducing a New Client/Server Framework for Big Data Analytics with the R Language

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  - Just got an allocation on Comet! Thank you XSEDE!

- Disclaimer
  - The findings and conclusions in this presentation have not been formally disseminated by the U.S. Department of Health & Human Services nor by the U.S. Department of Energy, and should not be construed to represent any determination or policy of University, Agency, Administration and National Laboratory.

1 Background and Motivation

2 pbdR Compute Backend

3 The Client/Server

4 Challenges and Future Work

Problems with "Big Data" Software

- *Many* frameworks; what do they all do?
- Don't always play nice with HPC systems.
- Often not as "high level" as advertised.
- Almost exclusively batch!

Data Analysis Is An Interactive Activity

Data analysis is an interactive activity[a]

[a] Data analysis is an interactive activity

Why am I here?

- XSEDE: a conference for users and service providers.
- I want to talk to you!

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pbdR

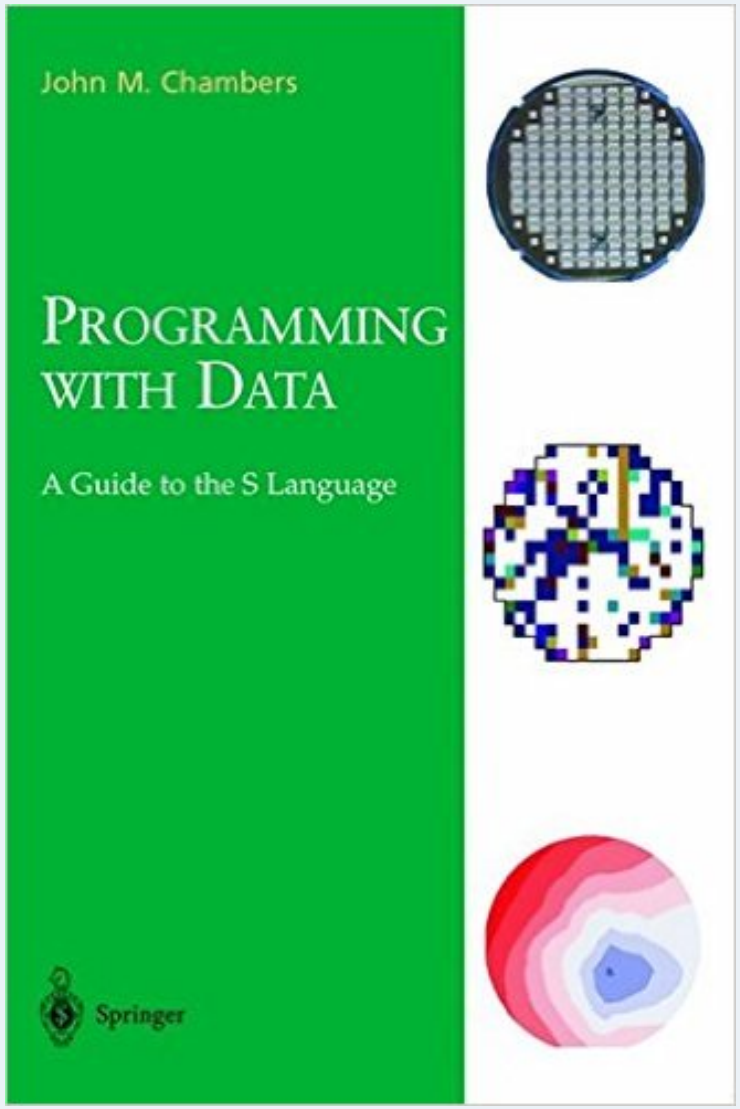
Client/Server + **pbdR** = interactive big data analysis

- This talk is not about the old stuff...
- But we have to talk about it!

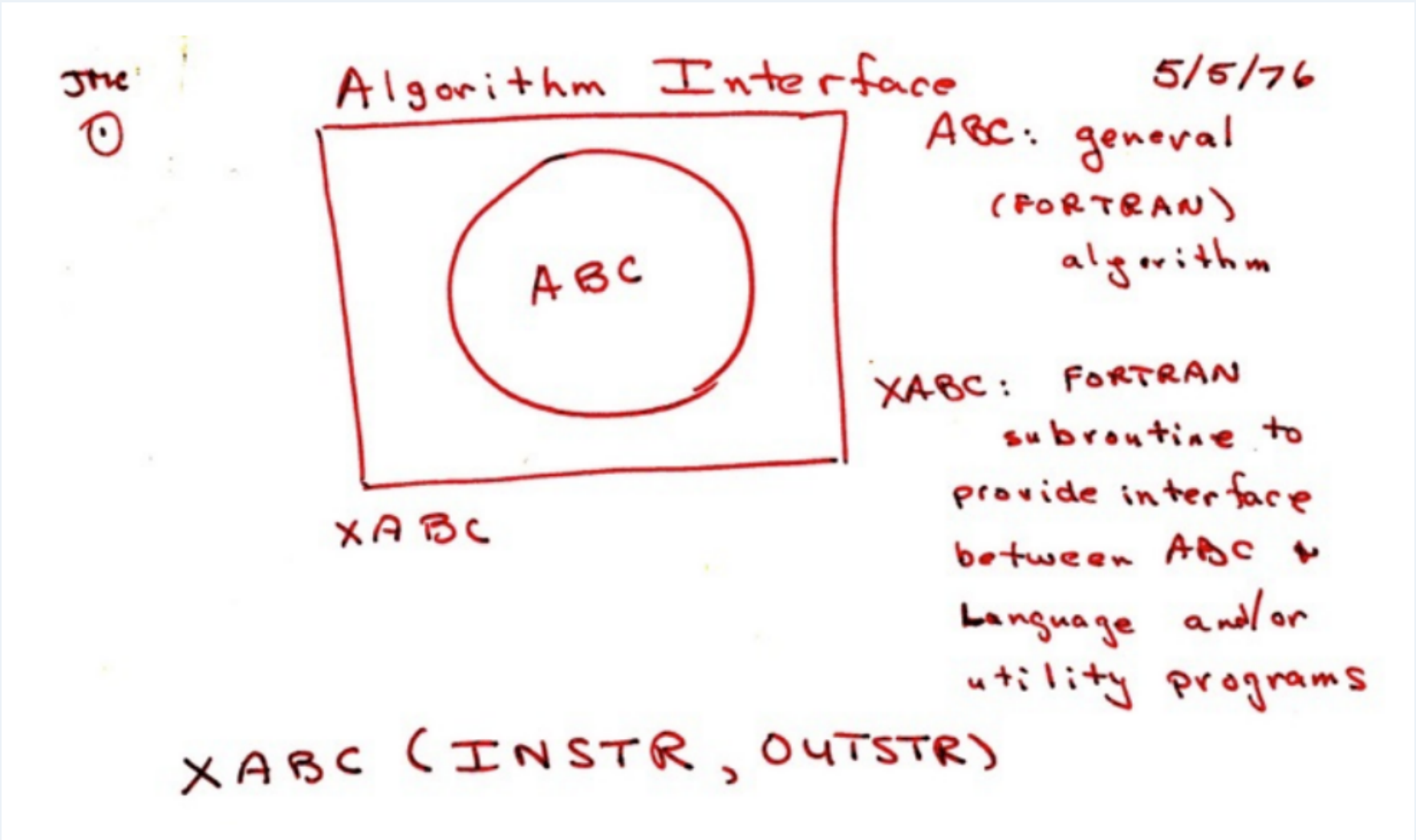
Programming with Big Data in R (pbdR)

- Free/Open Source R packages.
- Actively maintained, available on CRAN and Github.
- Packages: Library interfaces, high-level frameworks, profiling and vis, ...
- For today: MPI+ScaLAPACK stuff.
- Syntax *identical* to R.

About the Name

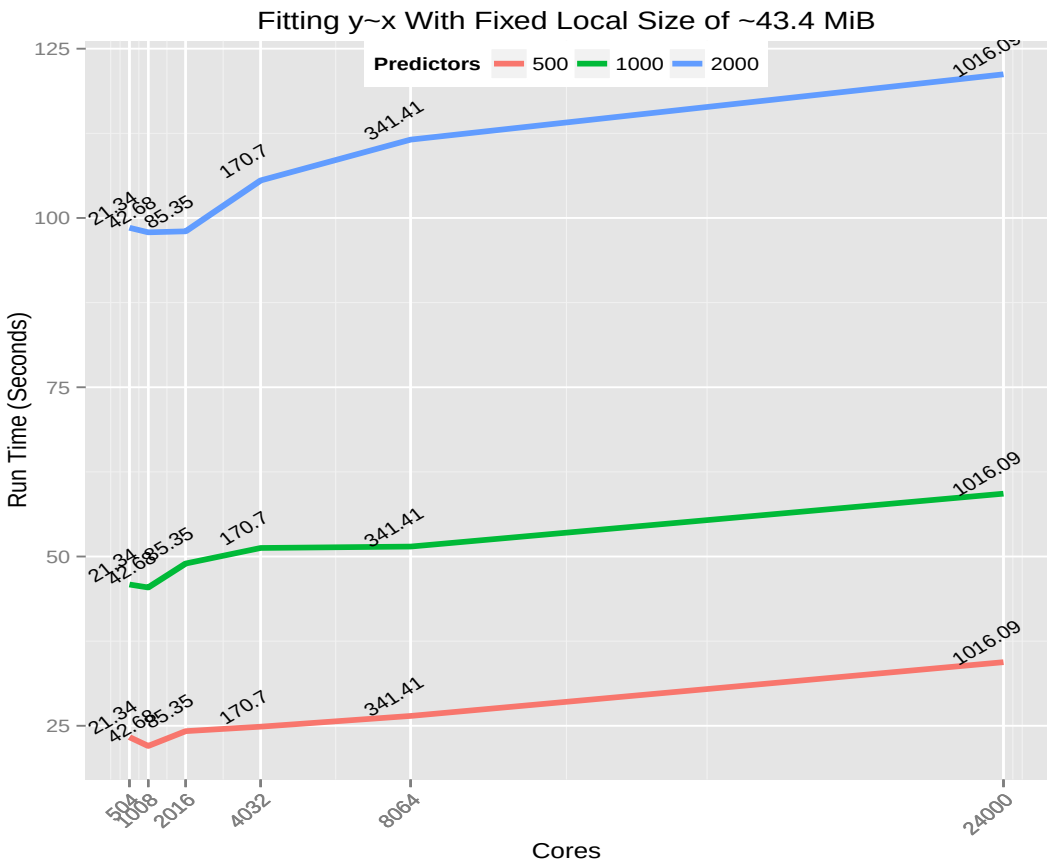


R as an Interface Language



http://datascience.la/john-chambers-user-2014-keynote/

Distributed Matrices and Statistics with **pbdDMAT**




```
library(pbdDMAT)
init.grid()

x <- ddmatrix("rnorm",
    nrow=m, ncol=n)
y <- ddmatrix("rnorm",
    nrow=m, ncol=1)

mdl <- lm.fit(x=x, y=y)

finalize()
```

pbdR Paradigms/"Opinions"

- In core.
- Focus on dense data.
- Integrates well with traditional HPC.
- C and Fortran for performance; R for the interface.
- Exclusively batch.
- (Mostly) Very different from Hadoop/Spark!

"OLCF Researchers Scale R to Tackle Big Science Data Sets"

HPC wire

- A problem that takes several hours on Apache Spark [was analyzed] in less than a minute using R on OLCF high-performance hardware.
- "...for situations where one needs interactive near-real-time analysis, **the pbdR approach is much better**."

https://www.hpcwire.com/2016/07/06/olcf-researchers-scale-r-tackle-big-science-data-sets/

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- Design and Architecture of the Client Server
- Examples
- Overhead

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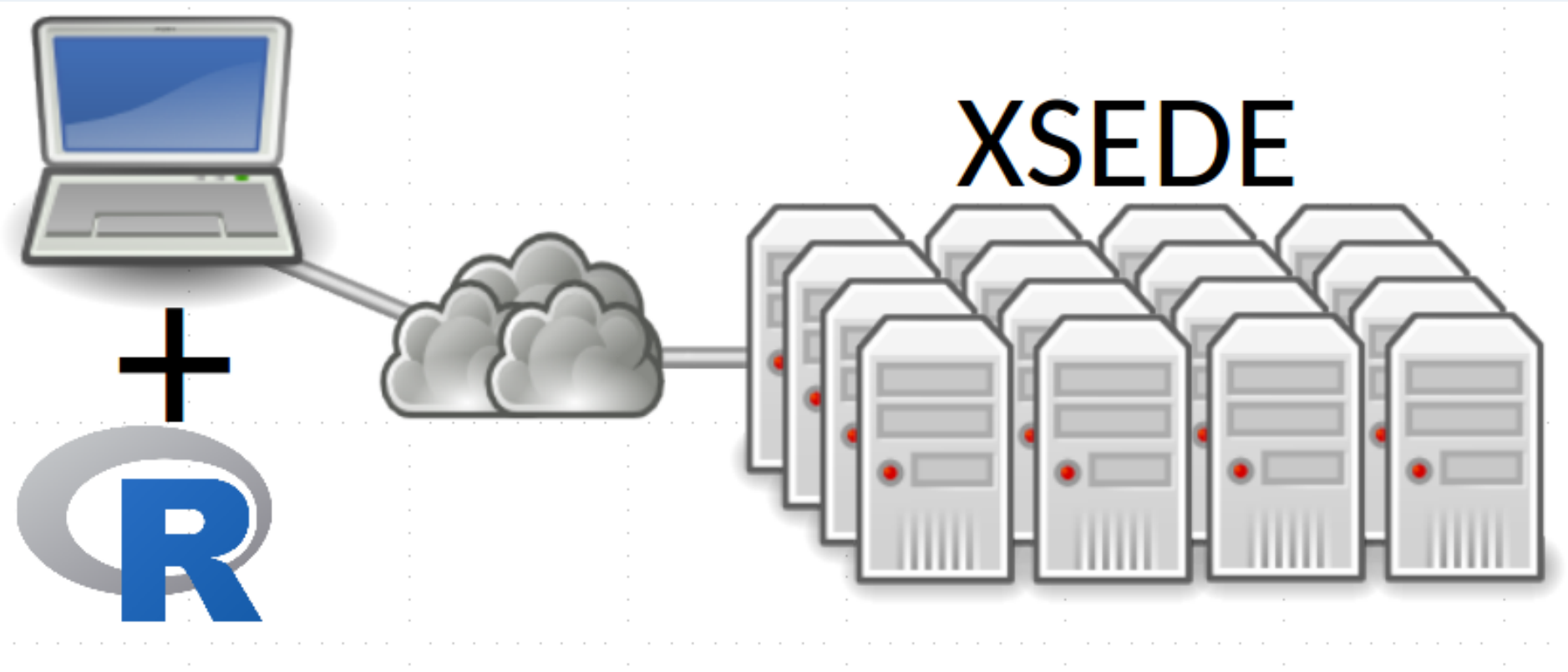
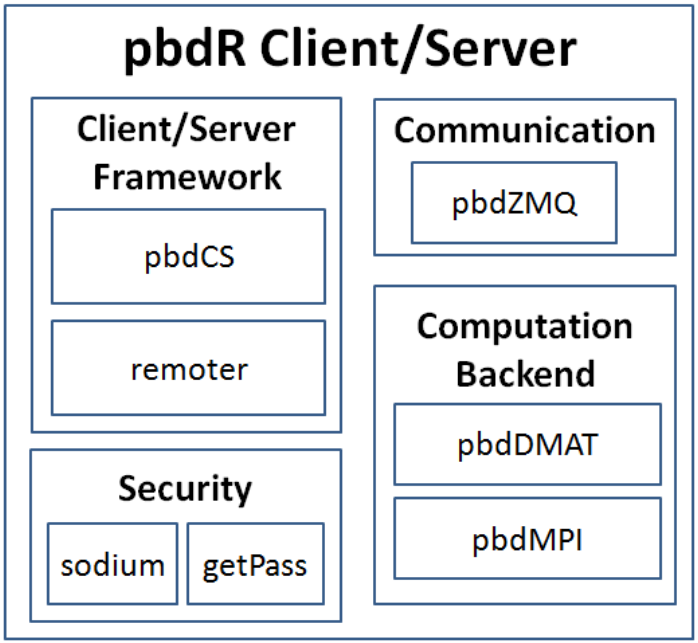
Motivation



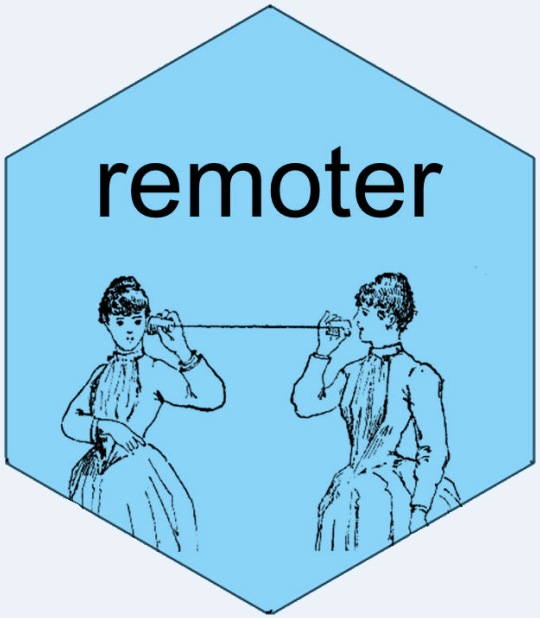
Connect local R session to a remote one.

The C/S Framework



- No specialized software environment; just R packages.
- Designed for the cloud or HPC resources.
- Mostly "un-opinionated"; can use our compute backend, SparkR, whatever.
- Optional security features: passwords and encryption.

A Quick Summary of the Main Components



- **pbdZMQ**: ZeroMQ bindings.
  Use: our C/S packages; IRkernel, ...
- **remoter**: client/server core.
  Use: cloud computing, "reference" big data framework.
- **pbdCS**: Extension of remoter for the MPI backend stuff.
  Use: Bringing interactivity to pbdR "big data" system.

Comparison to Similar Utilities

"Moving computations to a remote machine"

- Web frameworks: **shiny**, **htmlwidgets**, **fiery**, ...
- ~~Revolution~~ Microsoft Analytics: Microsoft R Server and R Client
- Jupyter/notebooks.
- RStudio Server
- **rmote**

3 The Client/Server
- Design and Architecture of the Client Server
- Examples
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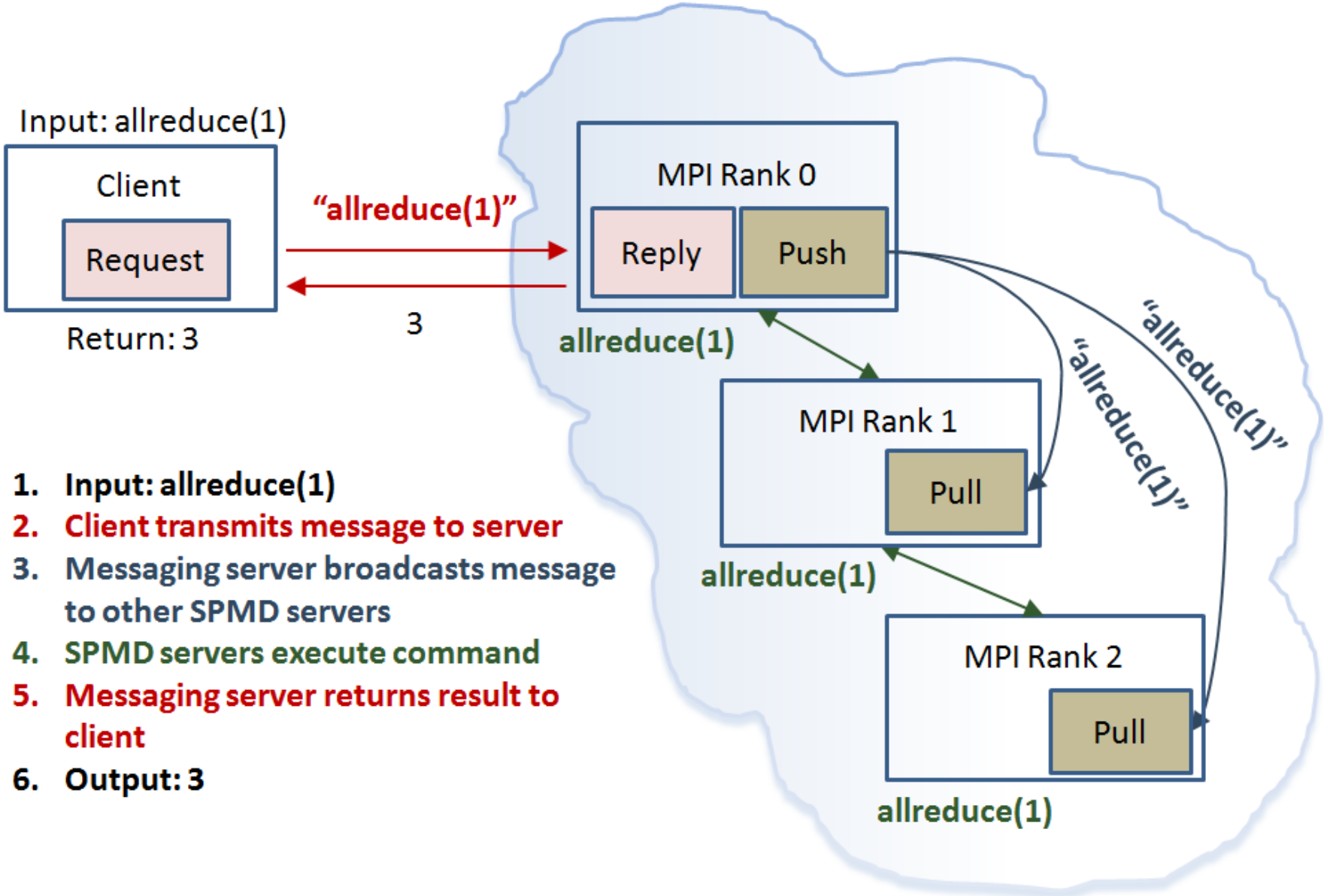
Basics

Elsewhere:

```
R> remoter::server()

## [2016-07-19 12:53:23]: *** Launching secure server ***
```

In your local R session:

```
R> remoter::client()
remoter> x = 1
remoter> x
## [1] 1
remoter> exit()

R> x
## Error: object 'x' not found
R> remoter::client()

remoter> s2c(x)
remoter> exit()
R> x
 [1] 1
```



1. **Input: allreduce(1)**
2. **Client transmits message to server**
3. **Messaging server broadcasts message to other SPMD servers**
4. **SPMD servers execute command**
5. **Messaging server returns result to client**
6. **Output: 3**

A Demo?

- No time for a live demo...
- Any time you see me at XSEDE16, ask and I'll give you one!
- For a non-live demo, see:
  https://github.com/snoweye/user2016.demo
- More information in the **remoter** vignette:
  https://cran.r-project.org/web/packages/remoter/vignettes/remoter.html

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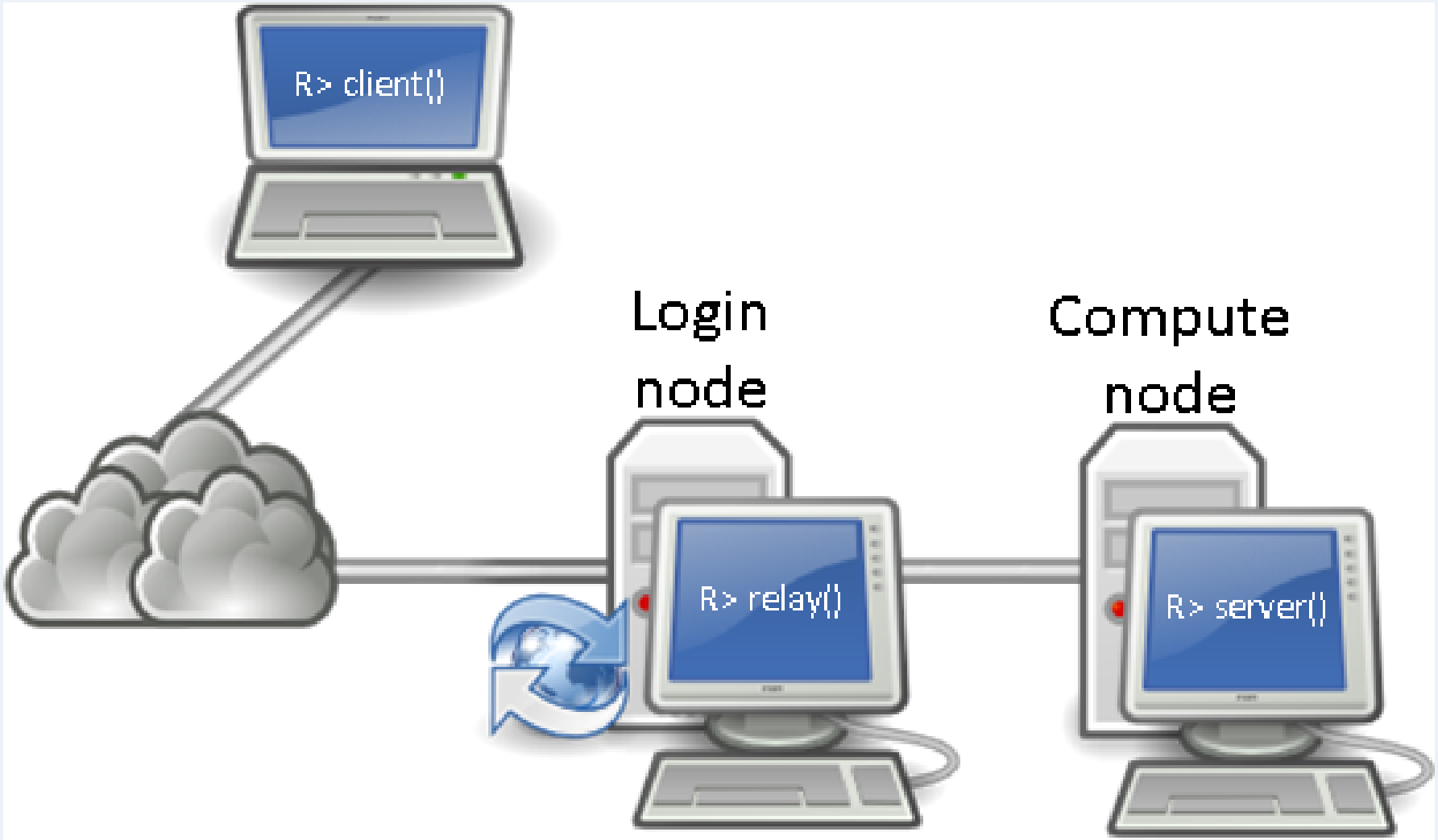
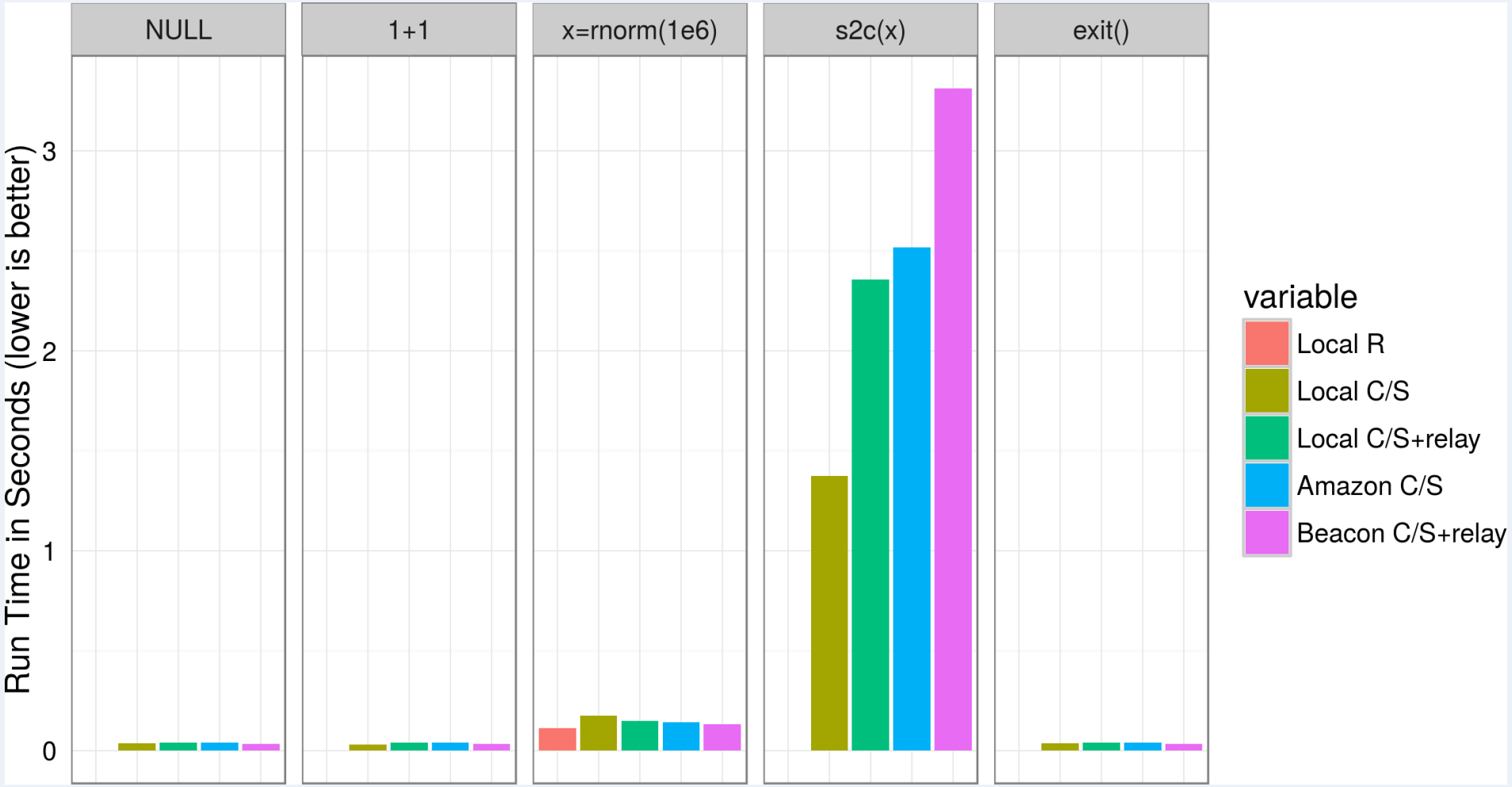
Size Costs

- There is a size overhead in transmitted messages.
- For almost everything you would do, no big deal.
- See paper for full discussion.

Relays



Run Time Costs



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Already done!

- Batch computing with a remote server.
- Graphics and help, integration with **rmote**.
- Many small things we didn't bother to mention.

Object Guarding

Currently possible to send huge amounts of data without realizing it.

```
pbdR> print(huge_thing)
## uh-oh!
```

Relays and Integration with the Scheduler

Some day...

```
R> bigJob(machine="stampede", nodes=10, interactive=TRUE)
```

References

- Schmidt, D., Chen, W.-C. and Ostrouchov, G. (2016), "Introducing a New Client/Server Framework for Big Data Analytics with the R Language, XSEDE2016.
- Chen, W.-C., Ostrouchov, G., Schmidt, D., Patel, P. and Yu, H. (2012), "A Quick Guide for the pbdMPI Package. R Vignette, URL http://cran.r-project.org/package=pbdMPI
- Schmidt, D., Chen, W.-C., Patel, P., and Ostrouchov, G. (2014), "Speaking Serial R with a Parallel Accent. R Vignette, URL http://cran.r-project.org/package=pbdDEMO
- Chen, W.-C., Ostrouchov, G., Pugmire, D., Prahat, and Wehner, M. (2013), "A Parallel EM Algorithm for Model-Based Clustering Applied to the Exploration of Large Spatio-Temporal Data, Technometrics, 55(4), 513-523.

~Thanks!~

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