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FastR

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R is ...

- A programming language
  - Many built-in statistical functions and data types
  - Very high abstraction for common statistical tasks
  - A DSL for statistics
  - Also, a general-purpose array programming language: ability to implement algorithms, analyses

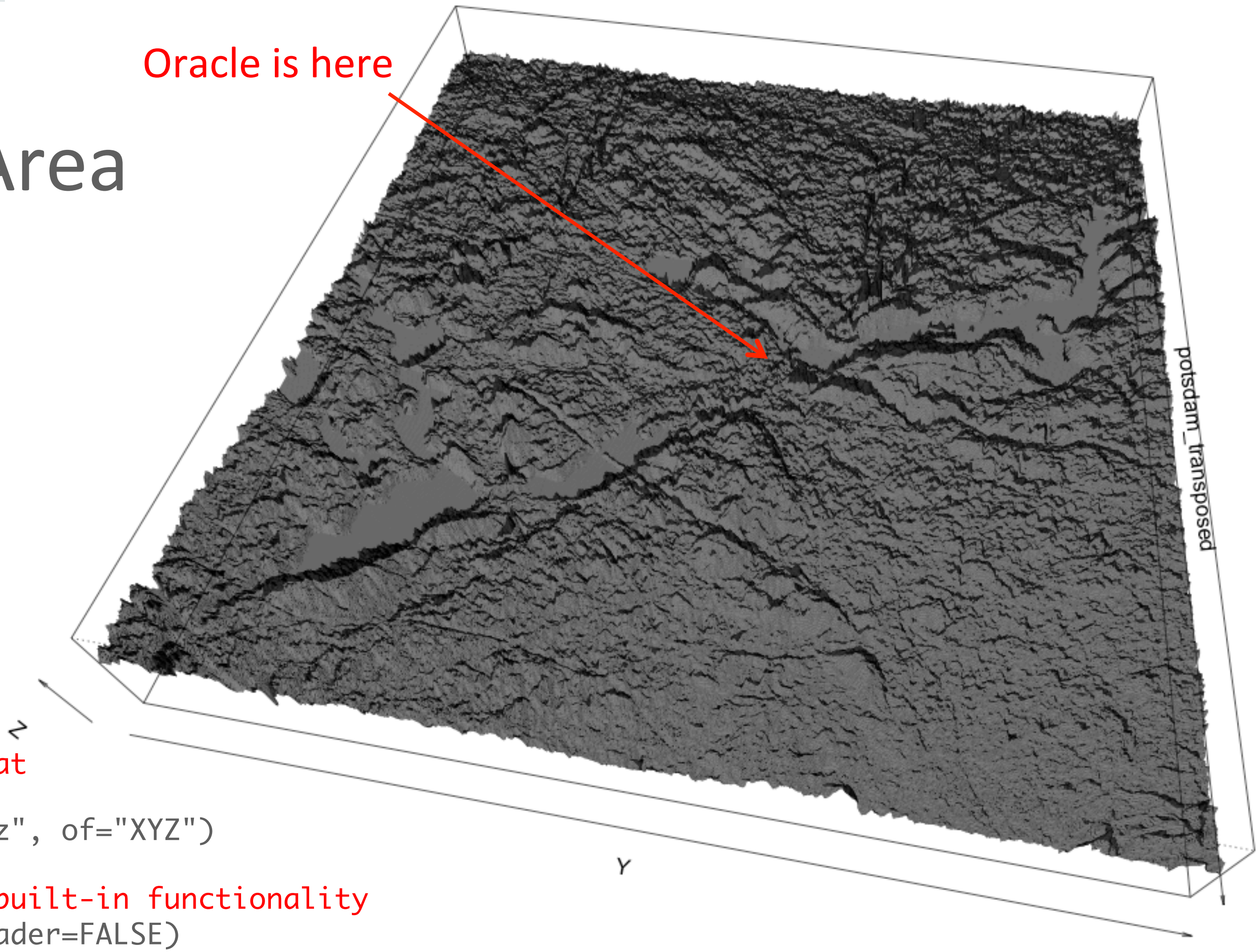
- A statistics workbench
  - Data exploration and manipulation
  - Graphics capabilities for visualizing data
  - Interactions with typesetting systems and web servers for data presentation

- A data science ecosystem
  - Vast open-source package repositories for multiple purposes
  - Roughly 5,800 packages in CRAN, 850 in Bioconductor
  - Application areas: statistics, geoscience, bioinformatics, health sciences, machine learning, ...

R is the *lingua franca* for data science.

Visualizing the Potsdam Area

geospatial data (potsdam_dem.tif)




```
> # use package to transform data into tabular format
> library(gdalUtils)
> gdal_translate("potsdam_dem.tif", "potsdam_dem.xyz", of="XYZ")
NULL
> # no package support needed from here on – all R built-in functionality
> potsdam_table <- read.table("potsdam_dem.xyz", header=FALSE)
> names(potsdam_table) <- c("longitude", "latitude", "elevation")
> n_rows <- length(levels(as.factor(potsdam_table$longitude)))
> potsdam_matrix <- matrix(potsdam_table$elevation, nrow=n_rows)
> potsdam_transposed <- t(potsdam_matrix)
> persp(potsdam_transposed, r=0.5, col=grey(.25), border=NA, expand=.15, theta=100, phi=50, ltheta=70, lphi=10, shade=3)
```

Common R Workflows

Explorative Data Analysis

1. Load the data
   - From a flat file, database, or other source
   - Possibly store them in R-specific format for later reuse
2. Massage the data
   - Identify the relevant subset: search, filter, "ask questions"
   - Bring the data into the right shape
3. Visualize the data
   - Choose the right kind of visualization and apply it (it's usually directly possible)
4. Interpret the results
   - Possibly go back to step 2 to ask more questions and visualize again

Implementing Analytic Algorithms

1. Implement algorithm in R
   - Performance problems will arise
2. Address critical paths
   - Identify the "expensive inner loops" that are performance bottlenecks
   - Port them to C/C++ and call them through the R FFI
3. Possibly parallelize
   - Identify parts of the code that is parallelizable
   - Adopt existing R libraries for multithreading, GPU usage

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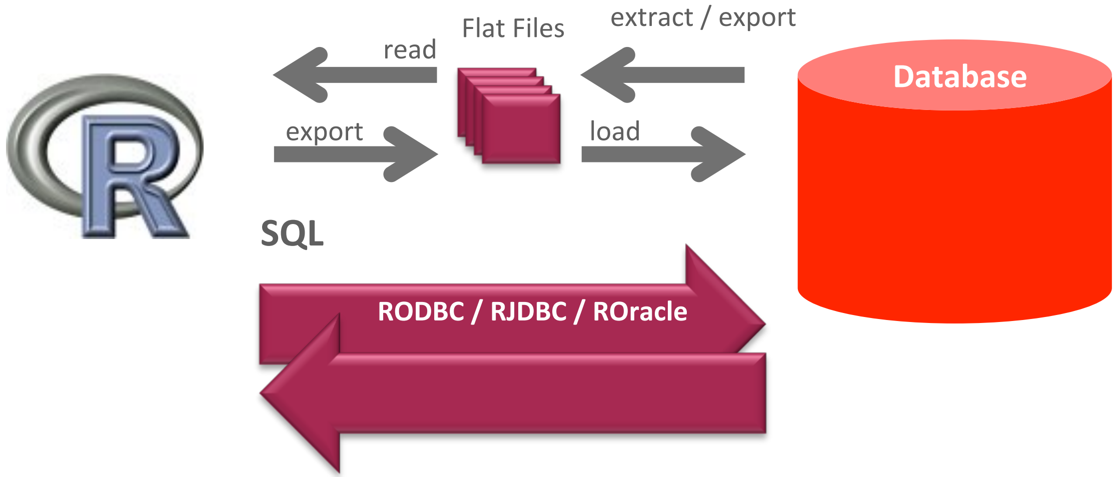
R Roundup

- Things cool about R
  - Open-source code and libraries
  - Ease of use, DSL for statistics
- Bottlenecks
  - Performance out of the box
  - Database interaction
- Challenges and possibilities
  - "Big data" contexts
  - Heterogeneous computing resources



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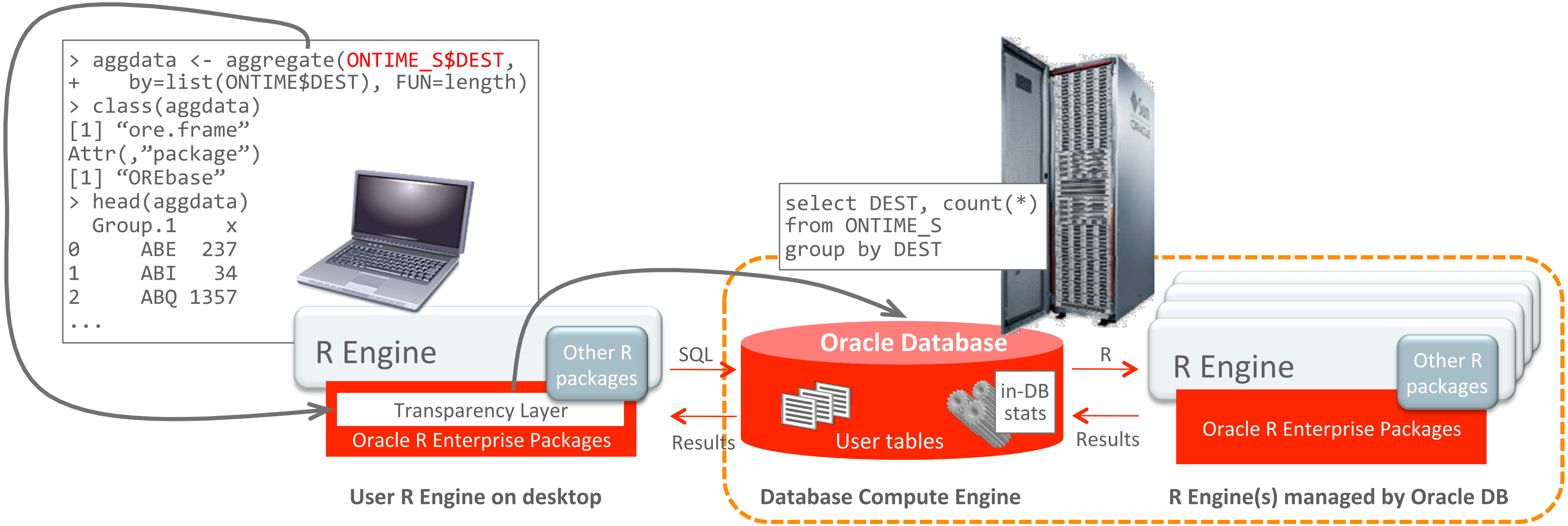
Oracle R Enterprise (ORE)

Transparency Layer



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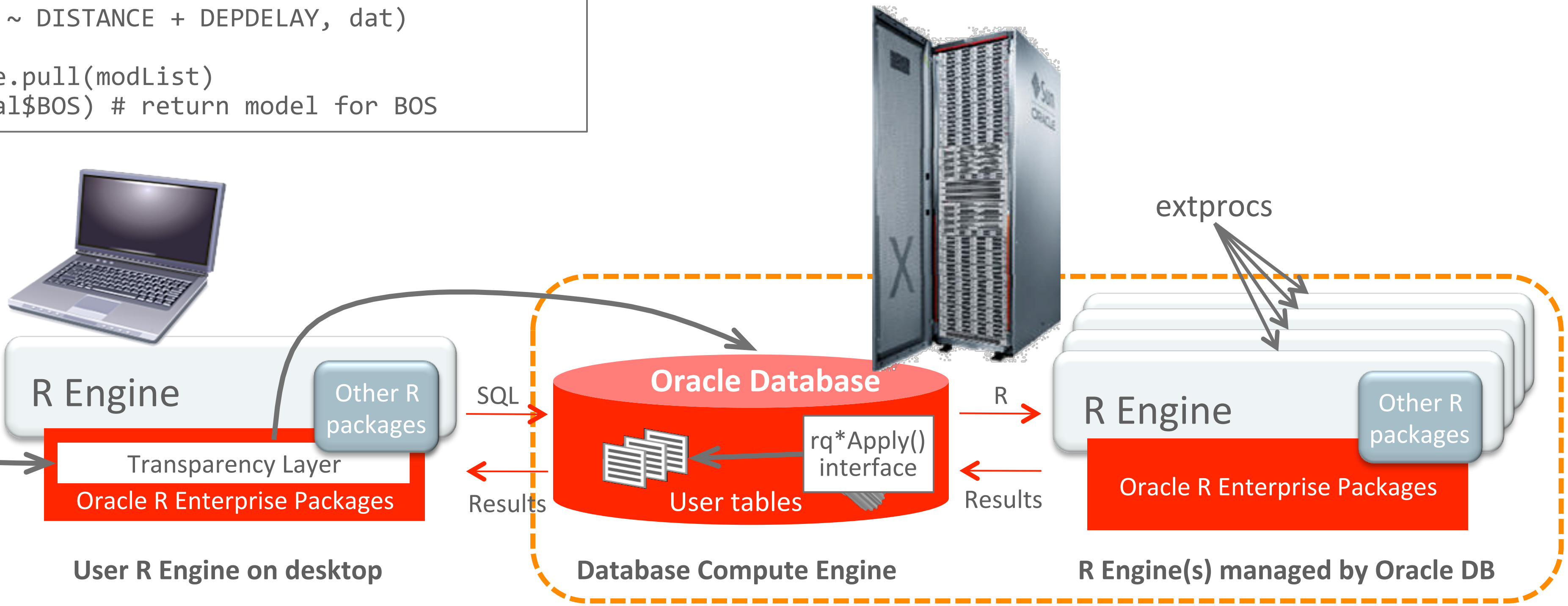
Oracle R Enterprise (ORE)

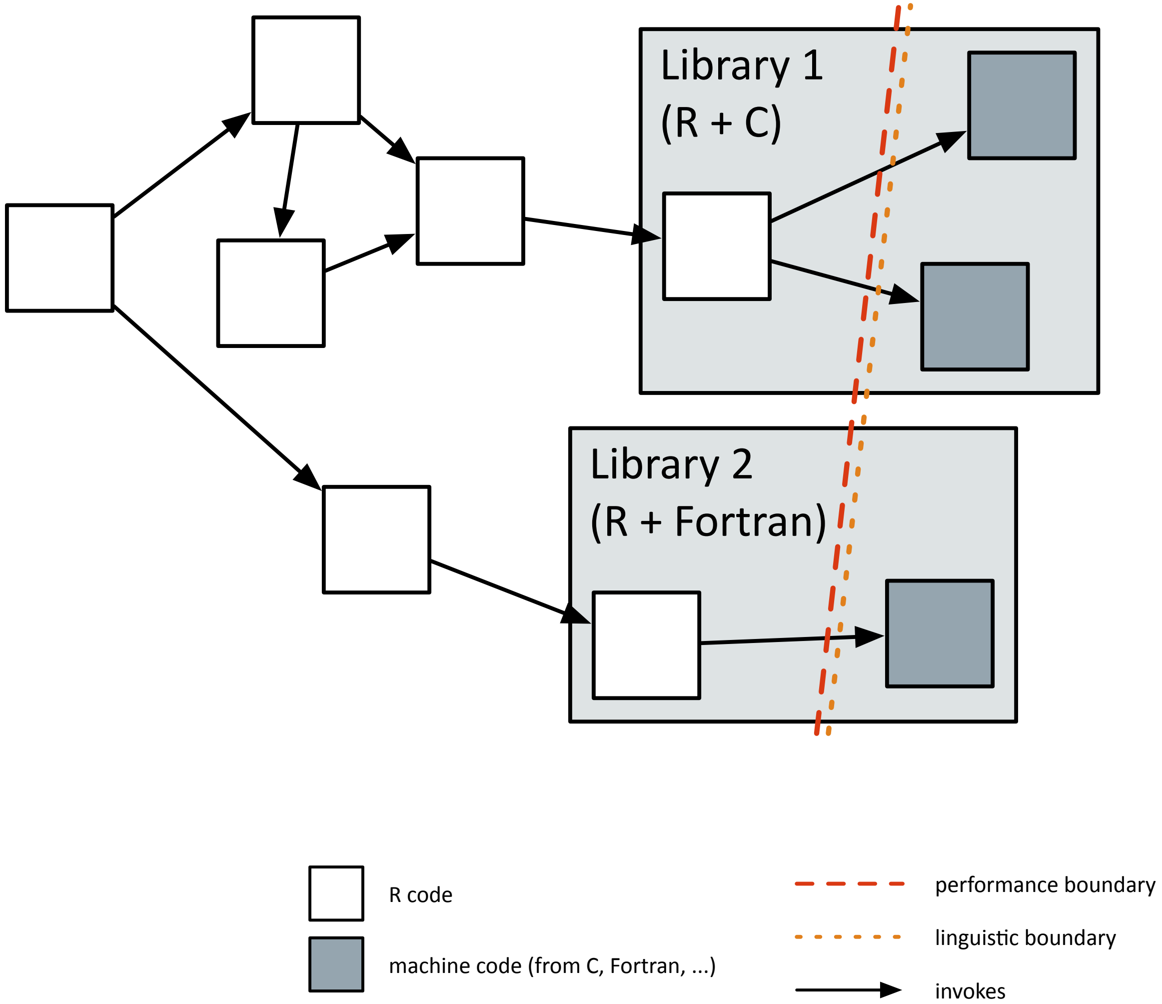
Parallel Execution

```
modList <- ore.groupApply(X=ONTIME_S, INDEX=ONTIME_S$DEST,
    function(dat) {
        lm(ARRDELAY ~ DISTANCE + DEPDELAY, dat)
    })
modList_local <- ore.pull(modList)
summary(modList_local$BOS) # return model for BOS
```



Considerations

- R is a great language for statistics.
  Why resort to C and Fortran?
- R features inherent parallelism.
  Why implement it on top?



FastR

- Open-source R implementation
  - GPL 2
  - https://bitbucket.org/allr/fastr
  - Research prototype
  - Linux, Mac
- Characteristics
  - Implemented in “100 % Java”
  - With *Truffle* (interpreter)
    and *Graal* (dynamic compiler)
- Collaborations
  - Purdue U (Jan Vitek, Tiark Rompf)
  - JKU Linz (Hanspeter Mössenböck)
  - TU Dortmund (Peter Marwedel)
  - UC Davis (Duncan Temple Lang)

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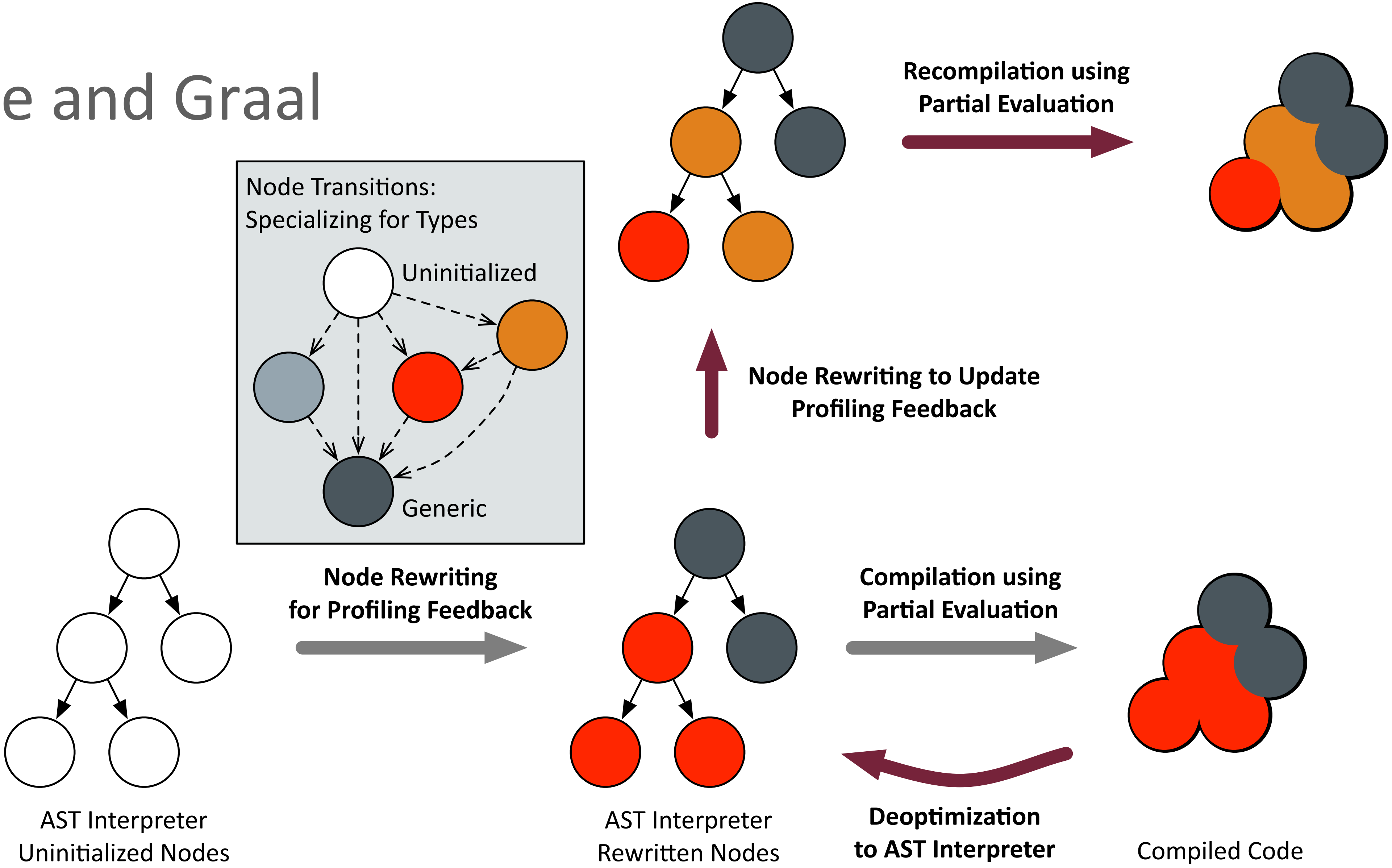
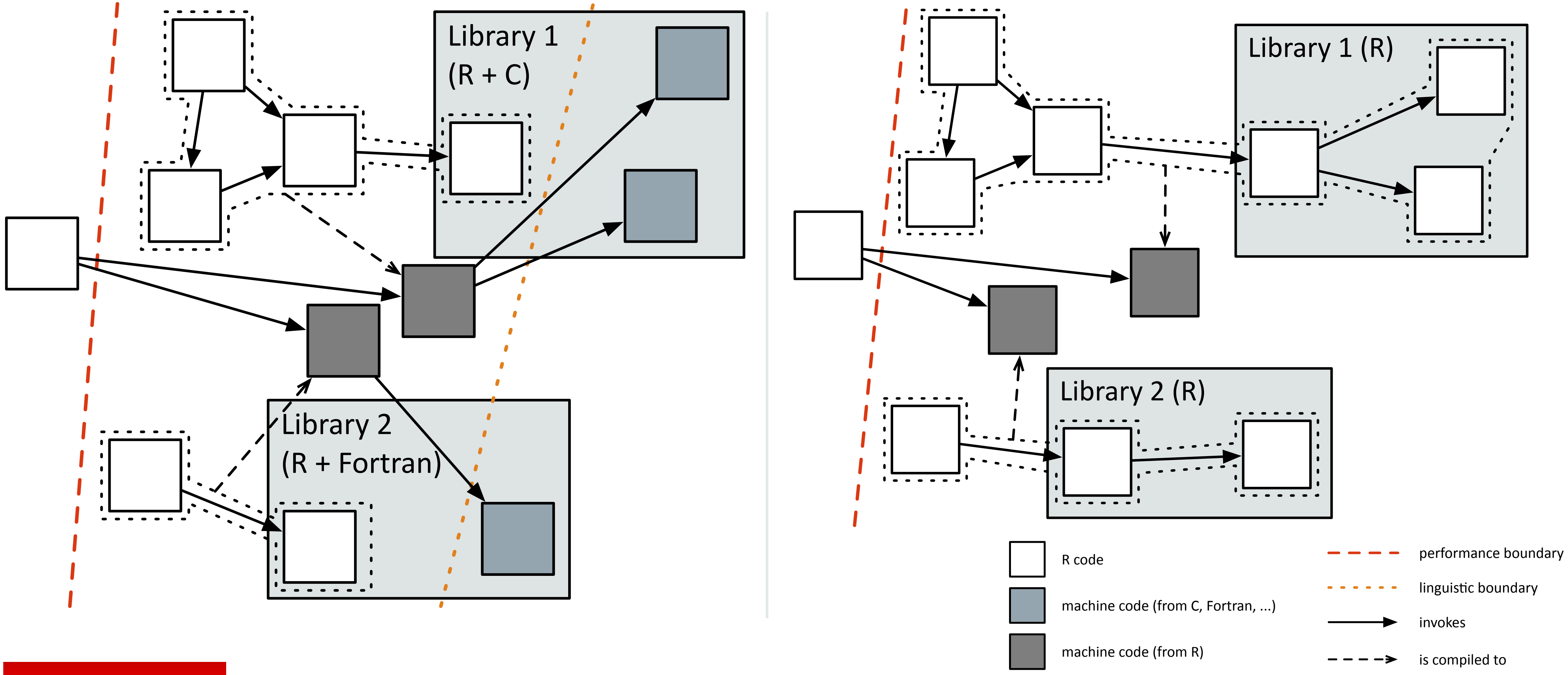
Truffle and Graal



FastR: Shifting Performance and Linguistic Boundaries



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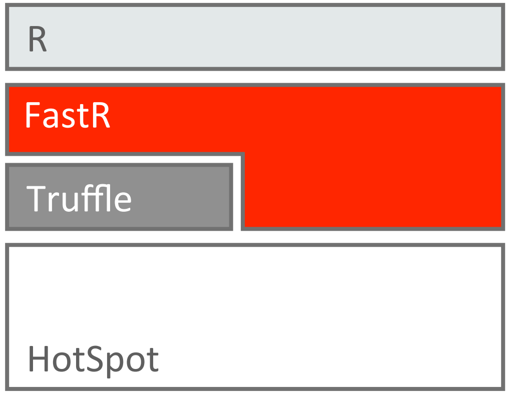
FastR Deployment Models

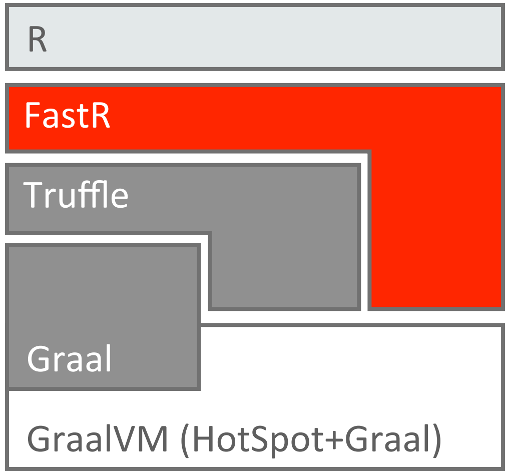
Stock HotSpot™

- Purely interpreted, no compilation
- Performance drawbacks



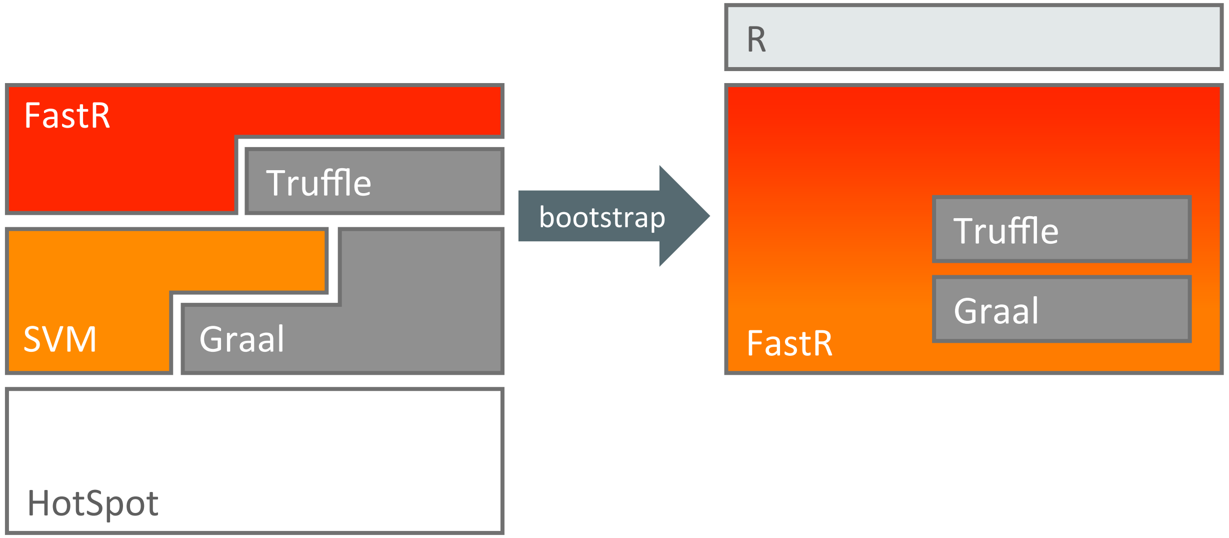
GraalVM

- Interpretation + compilation
- Full performance advantages



Substrate VM

- Bootstrap to get stand-alone binary or shared library
- Interpretation + compilation
- Performance advantages
- Embeddable R execution environment



FastR: Status and Outlook

- Details
  - Ca. 57k LOC (and growing)
  - Ca. 9,000 tests, 66 % pass
  - Plus ca. 7,600 bulk arithmetic tests, all pass
- This year: completeness
  - Load selected CRAN packages
  - Execute “real-world” code
- Next year: transparent scalability
  - Threads, GPUs

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