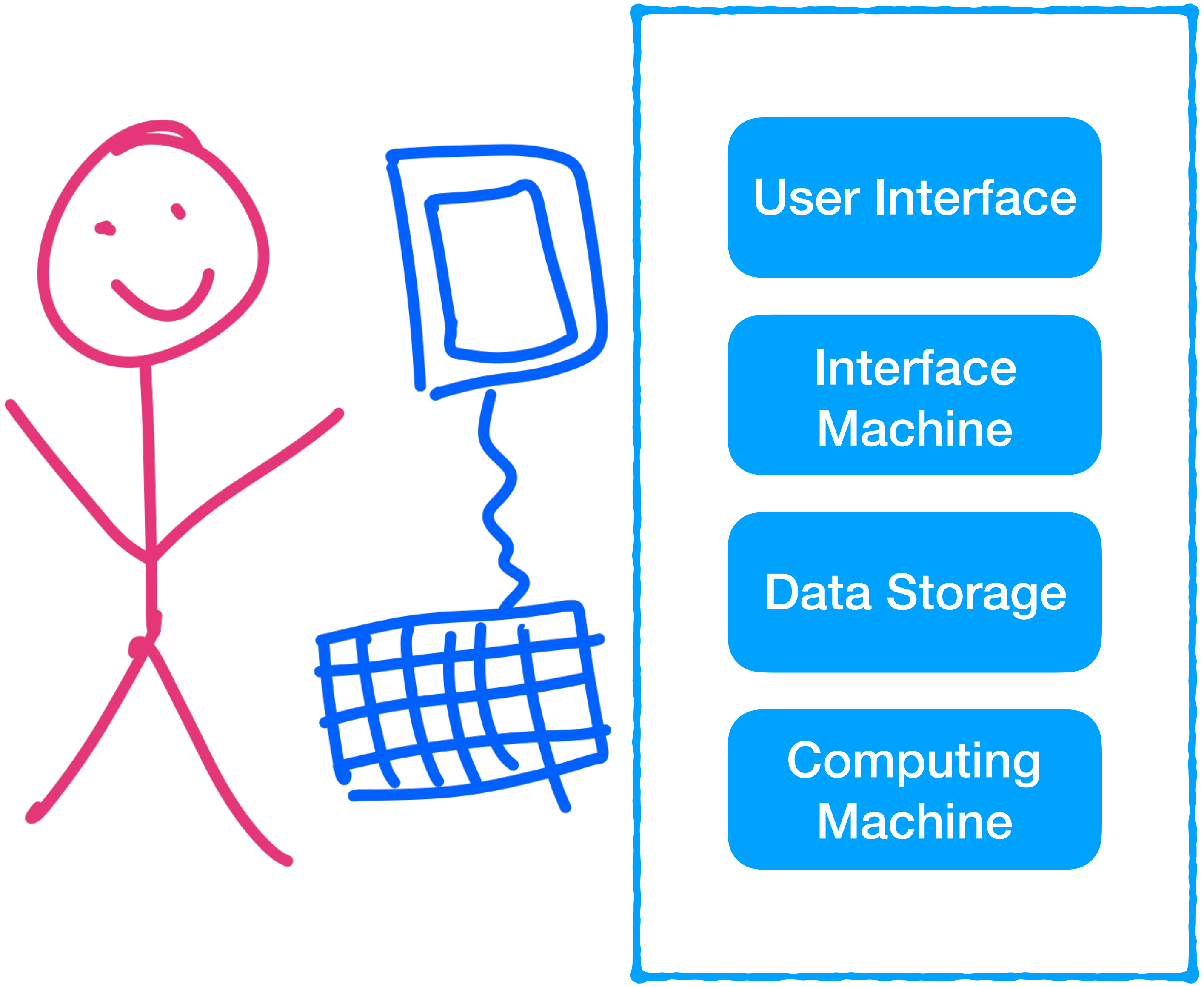
Deploying Algorithms

Biostatistics 140.711

Running Your Algorithm



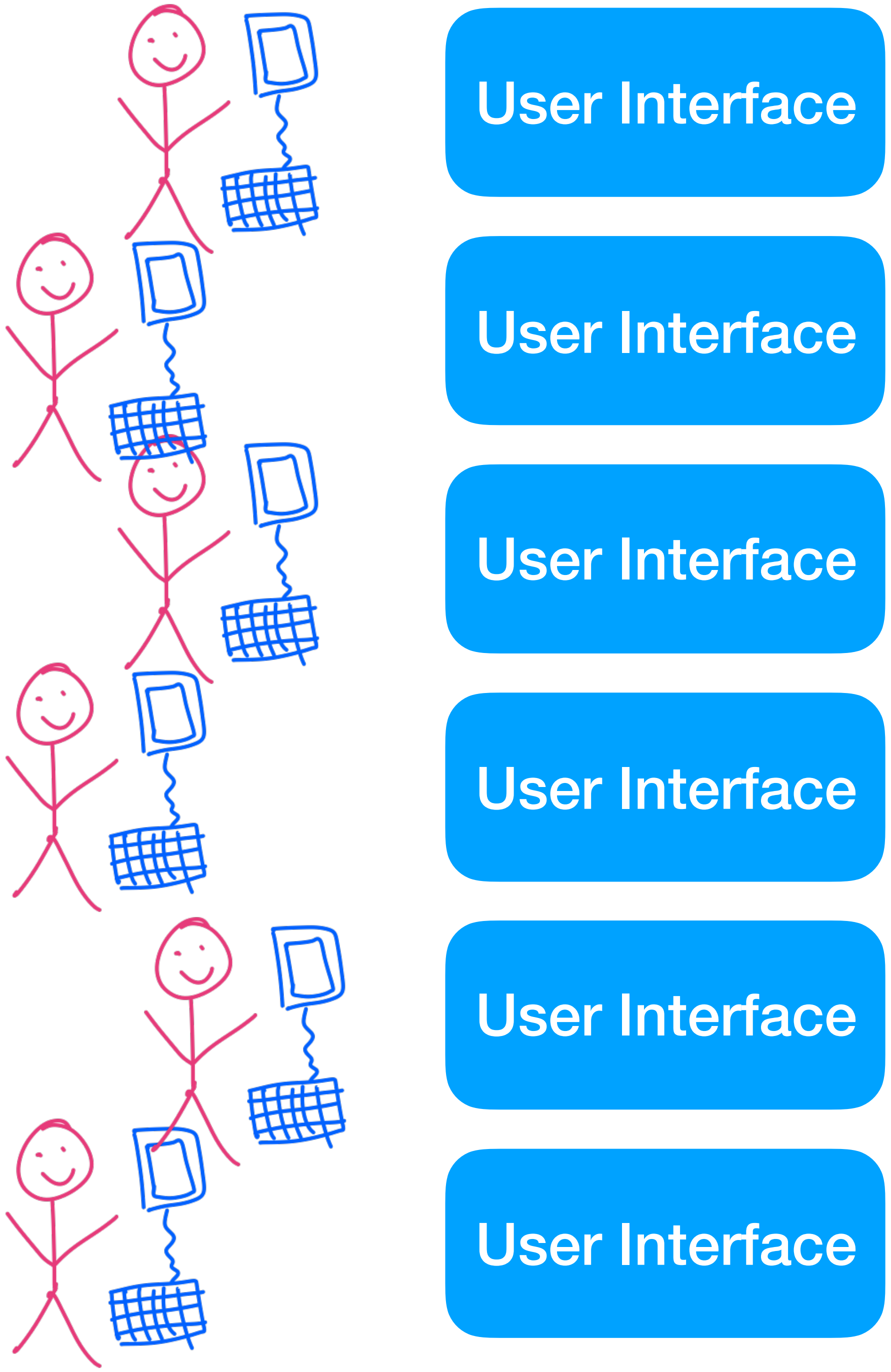
User Interface

Interface Machine

Data Storage

Computing Machine

Deploying Your Algorithm



User Interface

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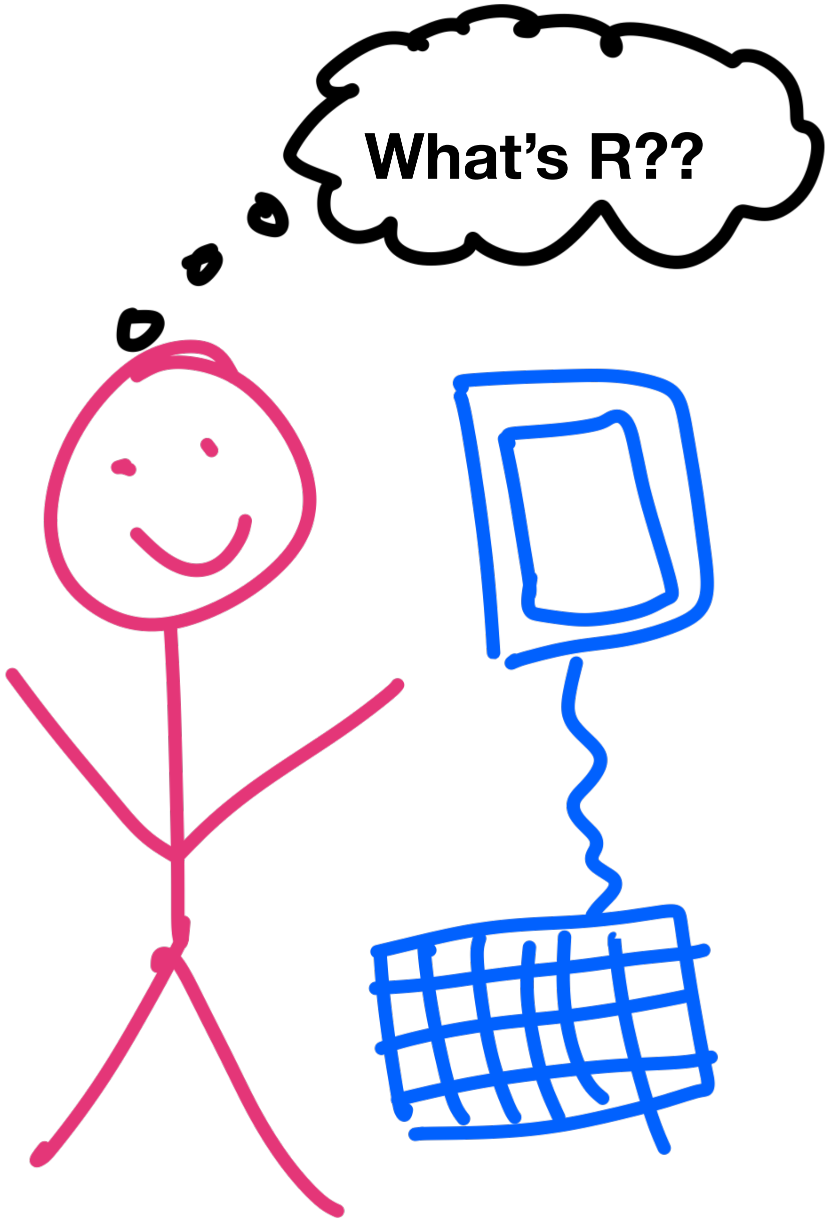
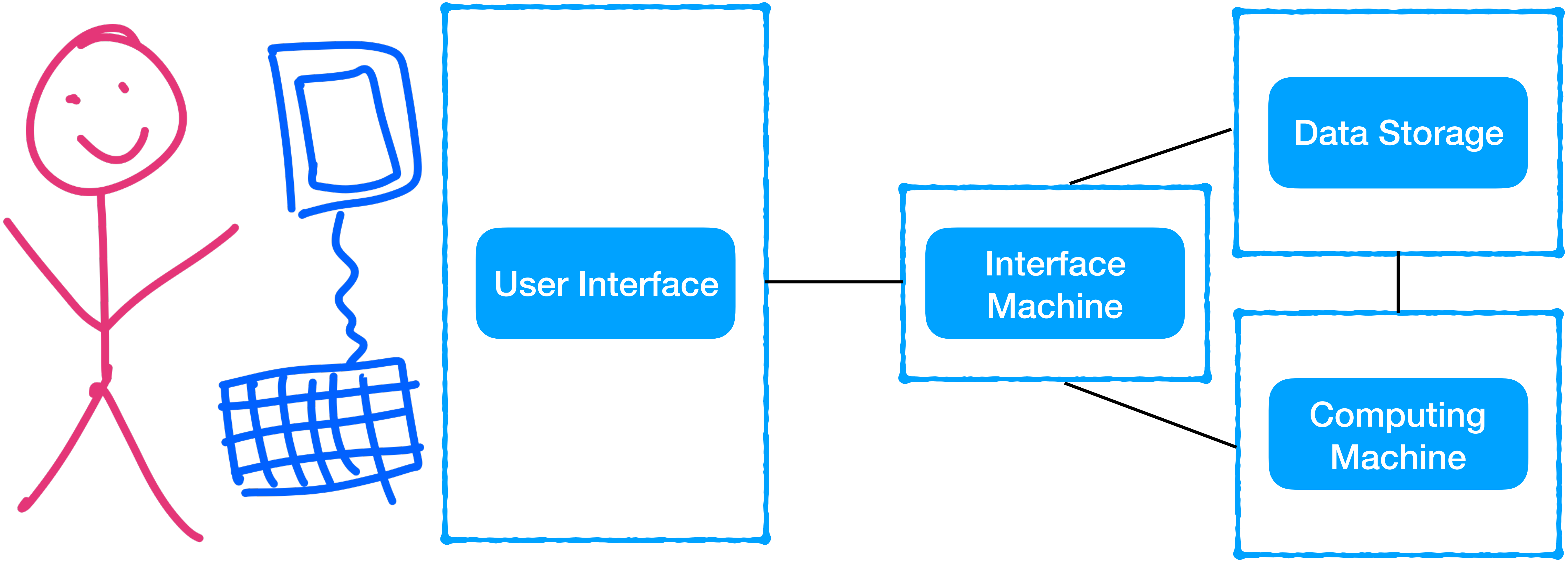


Deploying Your Algorithm



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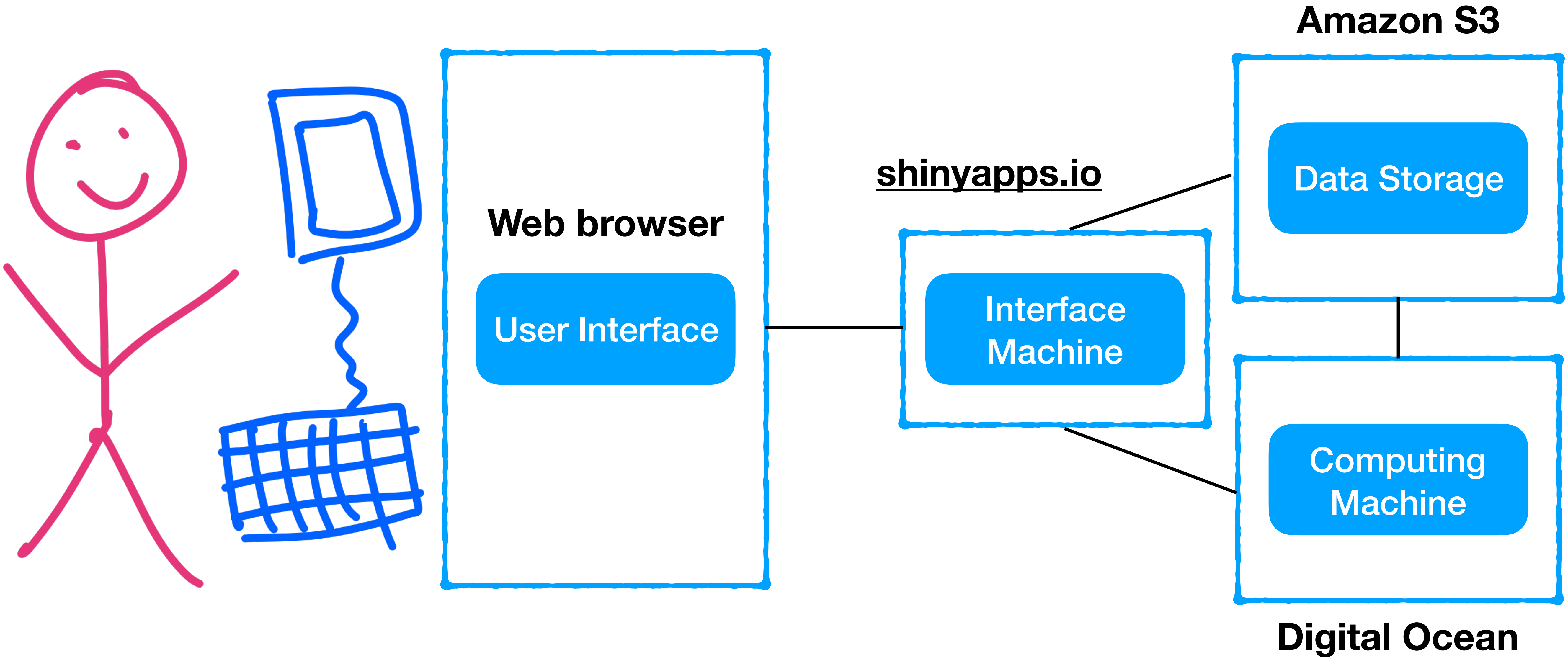


Amazon S3

Web browser

User Interface

shinyapps.io

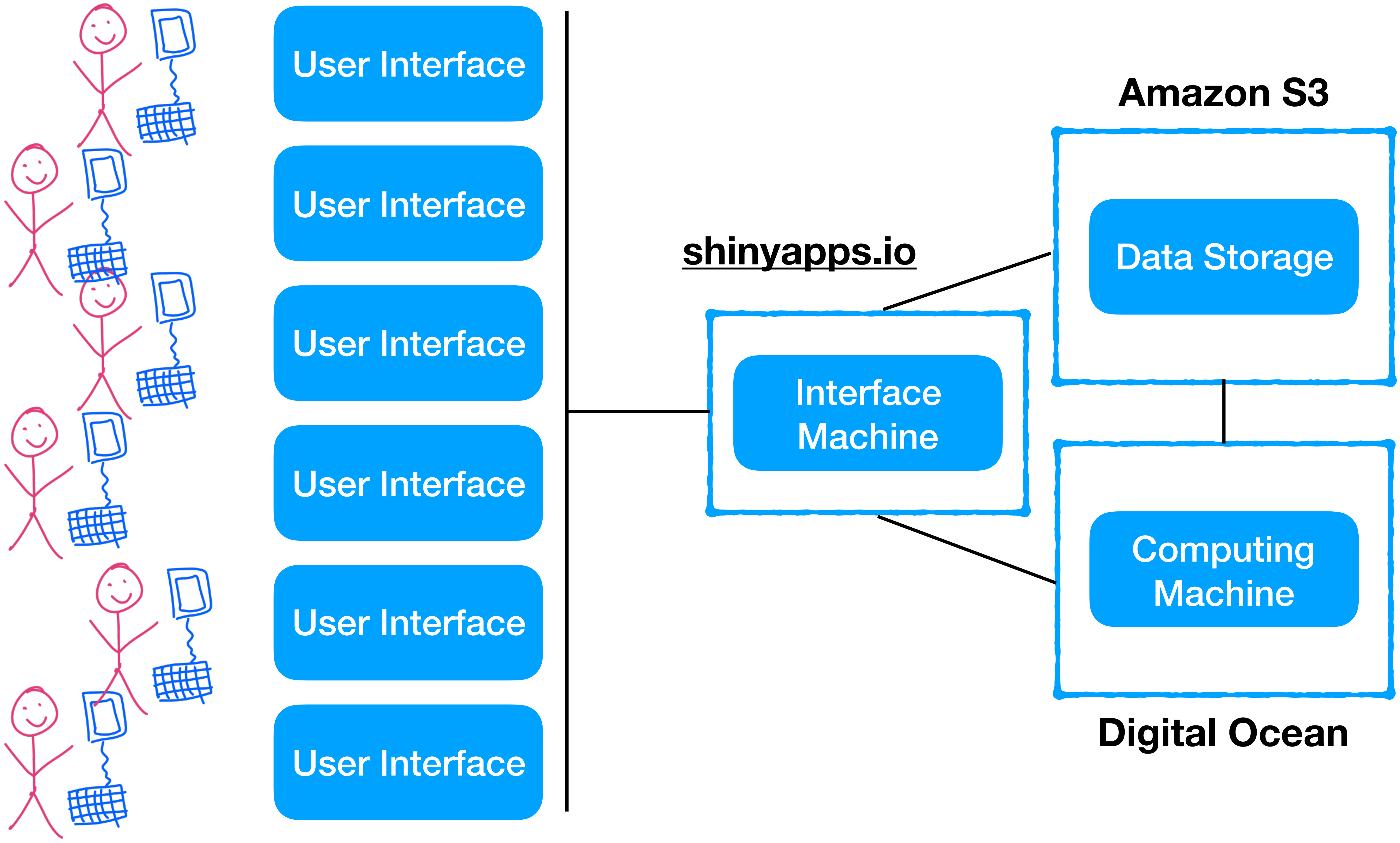
Interface Machine

Data Storage

Computing Machine

Digital Ocean

Deploying Your Algorithm



User Interface

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shinyapps.io

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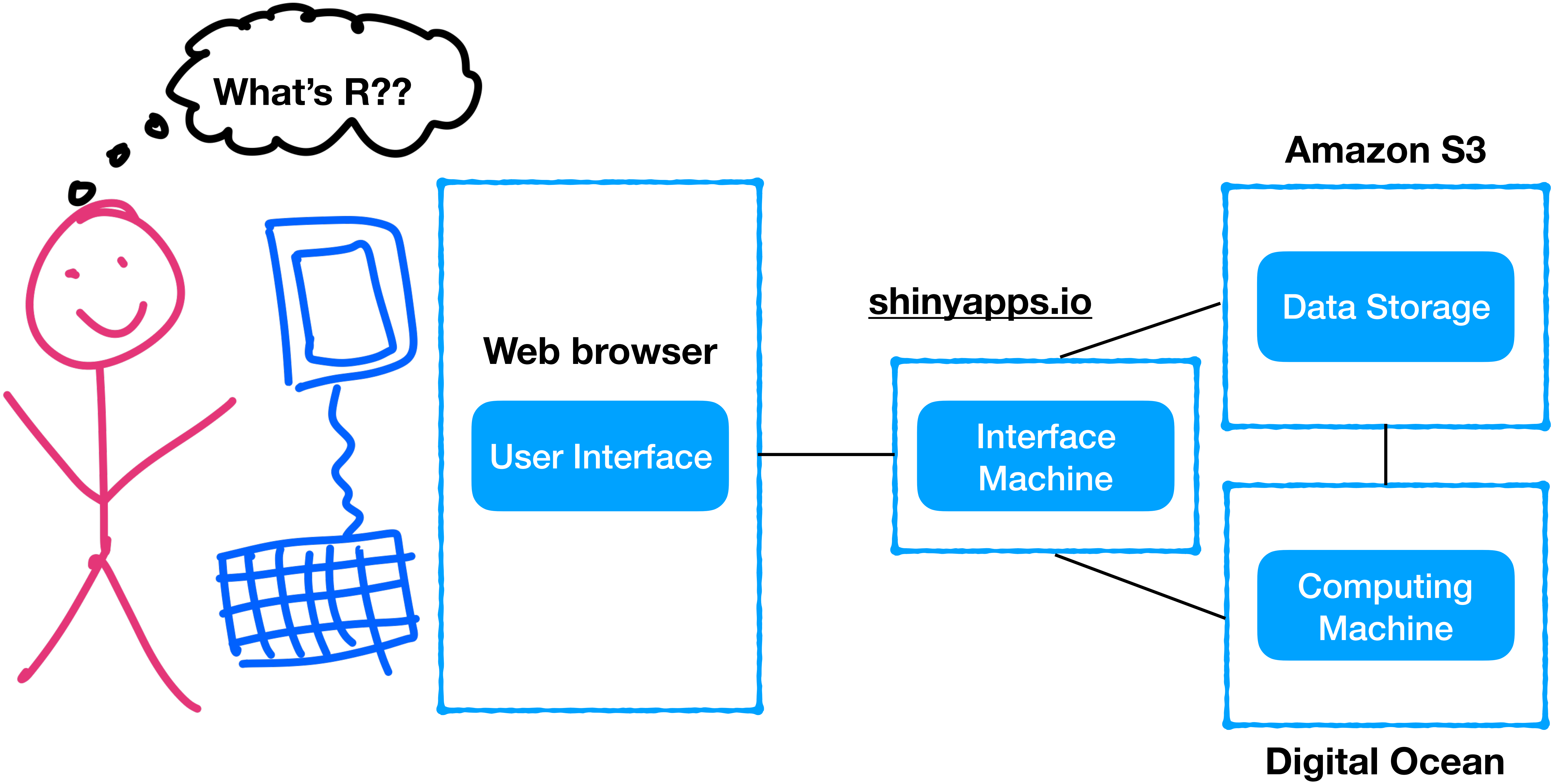

What's R??

Web browser

User Interface

shinyapps.io

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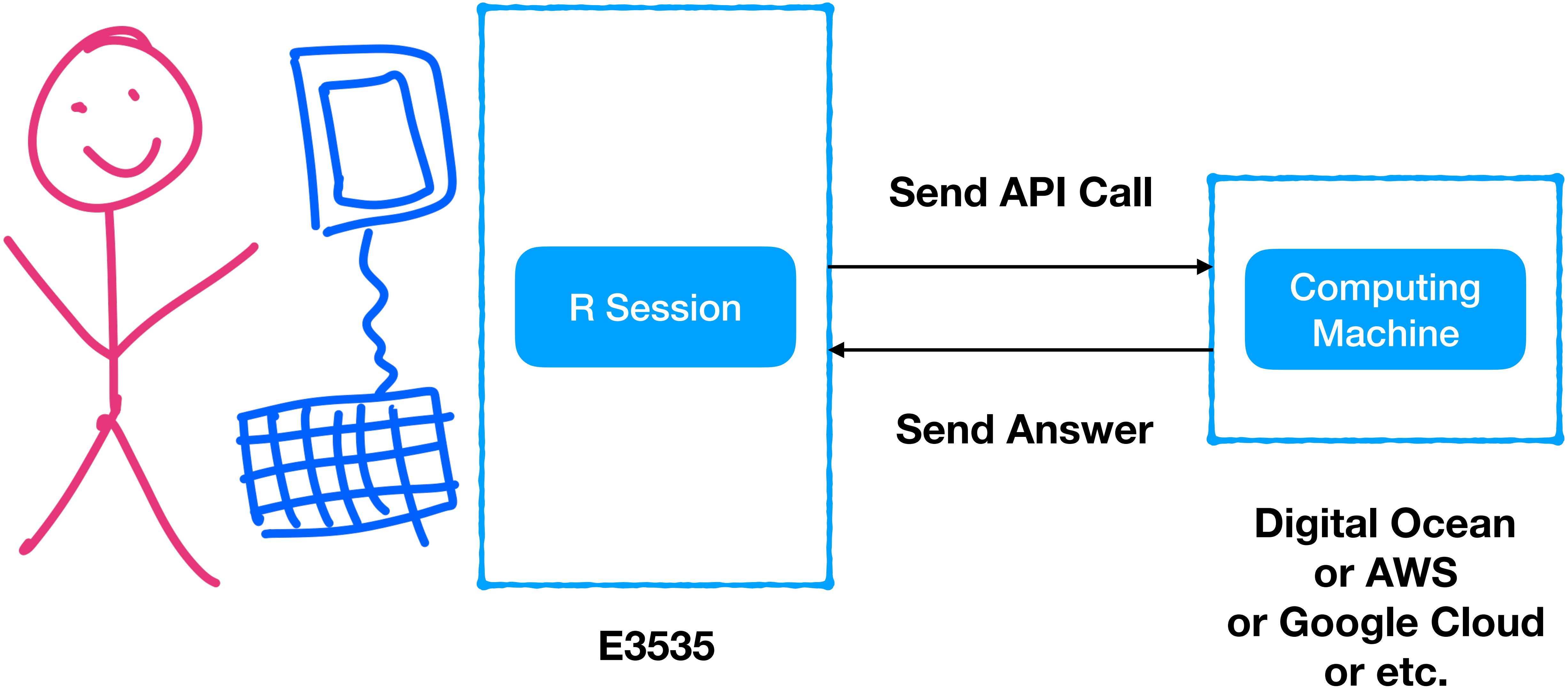
Deploying Your Algorithm



Deployment Strategy

- The **plumber** package converts an R function into a REST API

- Part of the “RStudio Universe” but does not require RStudio

- Can run on a server running R and provide a web interface

- Requires writing R code with a few extra markups (a little bit like roxygen2)

Ozone Prediction

- Given a temperature value, what level of ozone should we expect?
- This is a “hard problem” in general but is easily solved with regression
- We can provide a web interface that can take temperature as input and provide predicted ozone as output

Server: Ozone Prediction

```
## Predict Ozone Levels Given Temperature
library(splines)
library(datasets)
fit <- lm(Ozone ~ ns(Temp, 2), data = airquality)

#* Predict Ozone from Temperature
#* @param temp The temperature input
#* @get /ozone
ozone_predict <- function(temp) {
        ## Check input type
        temp <- as.numeric(temp)

        ## Make prediction from fitted model
        p <- predict(fit, data.frame(Temp = temp))

        ## Return predicted value
        as.numeric(p)
}
```

Client: Ozone Prediction

```r
library(jsonlite); library(curl); library(glue)

ozone_predict_remote <- function(temp) {
        ## Construct API URL
        cmd <- glue("http://67.205.166.80:8000/ozone?",
                    "temp={temp}")

        ## Open connection to the web server
        con <- curl(cmd)

        ## Read the answer from the server
        ans <- readLines(con, 1, warn = FALSE)

        ## Close server connection
        close(con)

        ## Convert answer from JSON and return
        fromJSON(ans)
}
```

Run Function

Sending More Data

- Typical web APIs are expecting lightweight inputs
- Not realistic to pass large data objects via URL strings
- For larger input data we need a different strategy where data can be stored/retrieved elsewhere
- The **aws.s3** package can be used to store/retrieve data from S3 (installed from GitHub)
    - remotes::install_github("cloudyr/aws.s3")

Confidence Intervals for the Median

- No closed-form solution
- Use the bootstrap to compute!
- Write a function called `confint_median(x, N)` that takes a vector of observations and a number of bootstrap iterations
- Return a vector containing the lower 2.5% and upper 97.5% of the median via the bootstrap

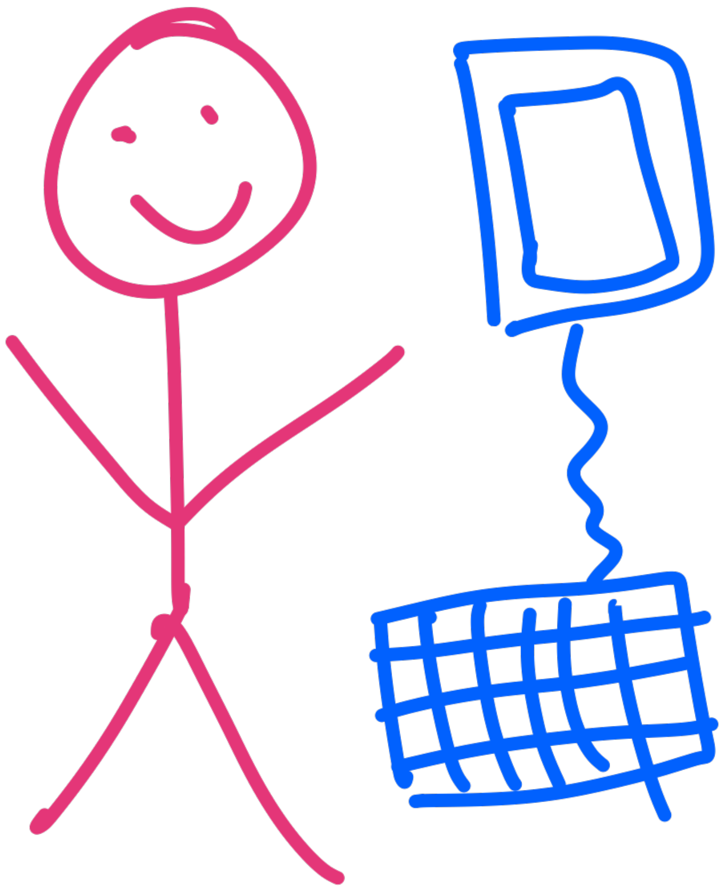
Confidence Intervals for the Median

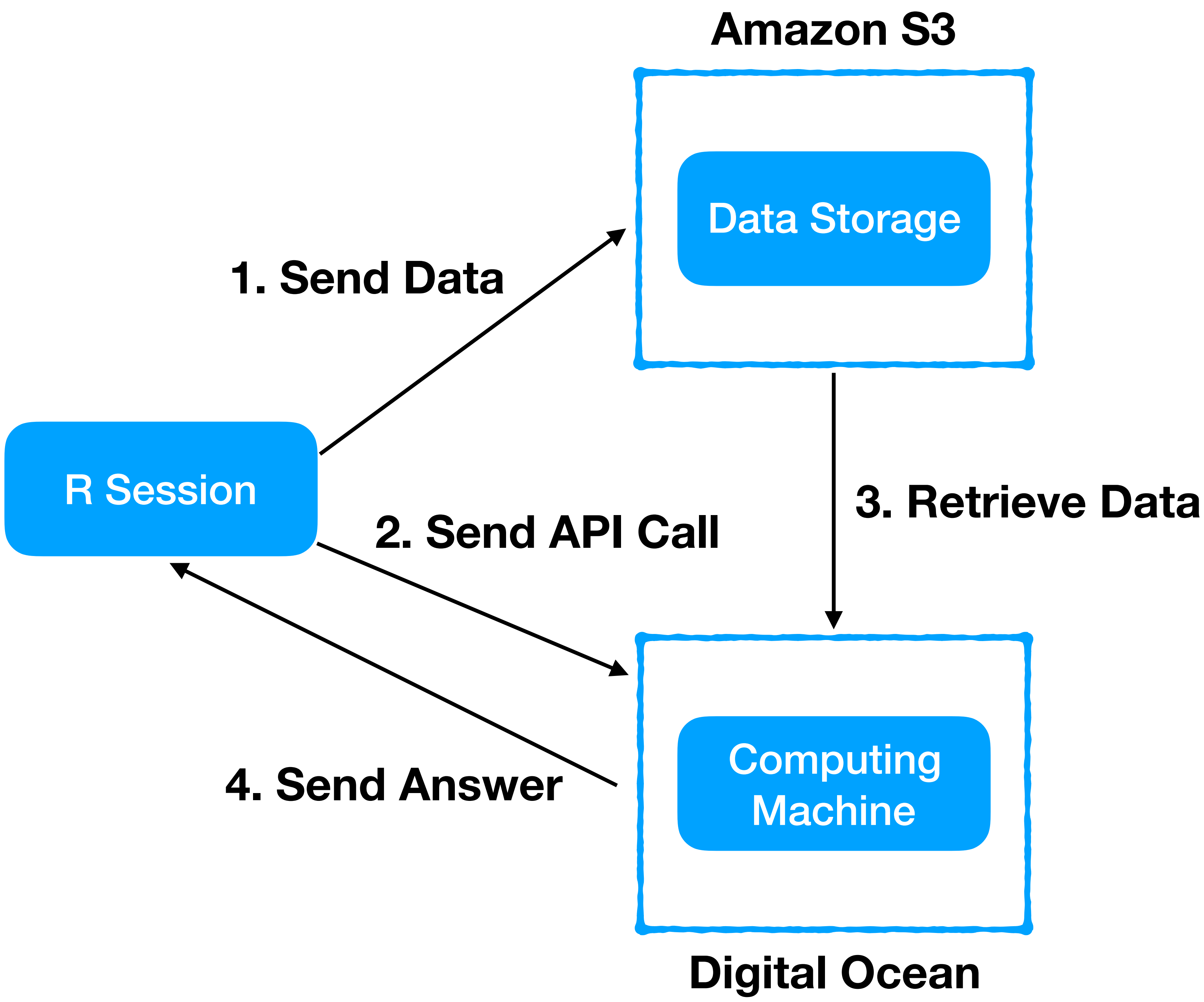
```
confint_median <- function(x, N = 1000) {
        ## Coerce to numeric
        x <- as.numeric(x)

        ## Remove missing values
        x <- x[!is.na(x)]

        if(length(x) == 0L)
                stop("no non-missing data values")
        nobs <- length(x)
        med <- replicate(N, {
                x.new <- sample(x, nobs, replace = TRUE)
                median(x.new)
        })
        quantile(med, c(0.025, 0.975))
}
```

Deploying This Function

- Storage
  - Copy input data from user to a the storage server
- Compute
  - Deploy the CI algorithm to the compute server
  - Read data from the storage server
  - Compute answer and return to the user

Running Your Algorithm





Amazon S3

Data Storage

1. Send Data

R Session

2. Send API Call

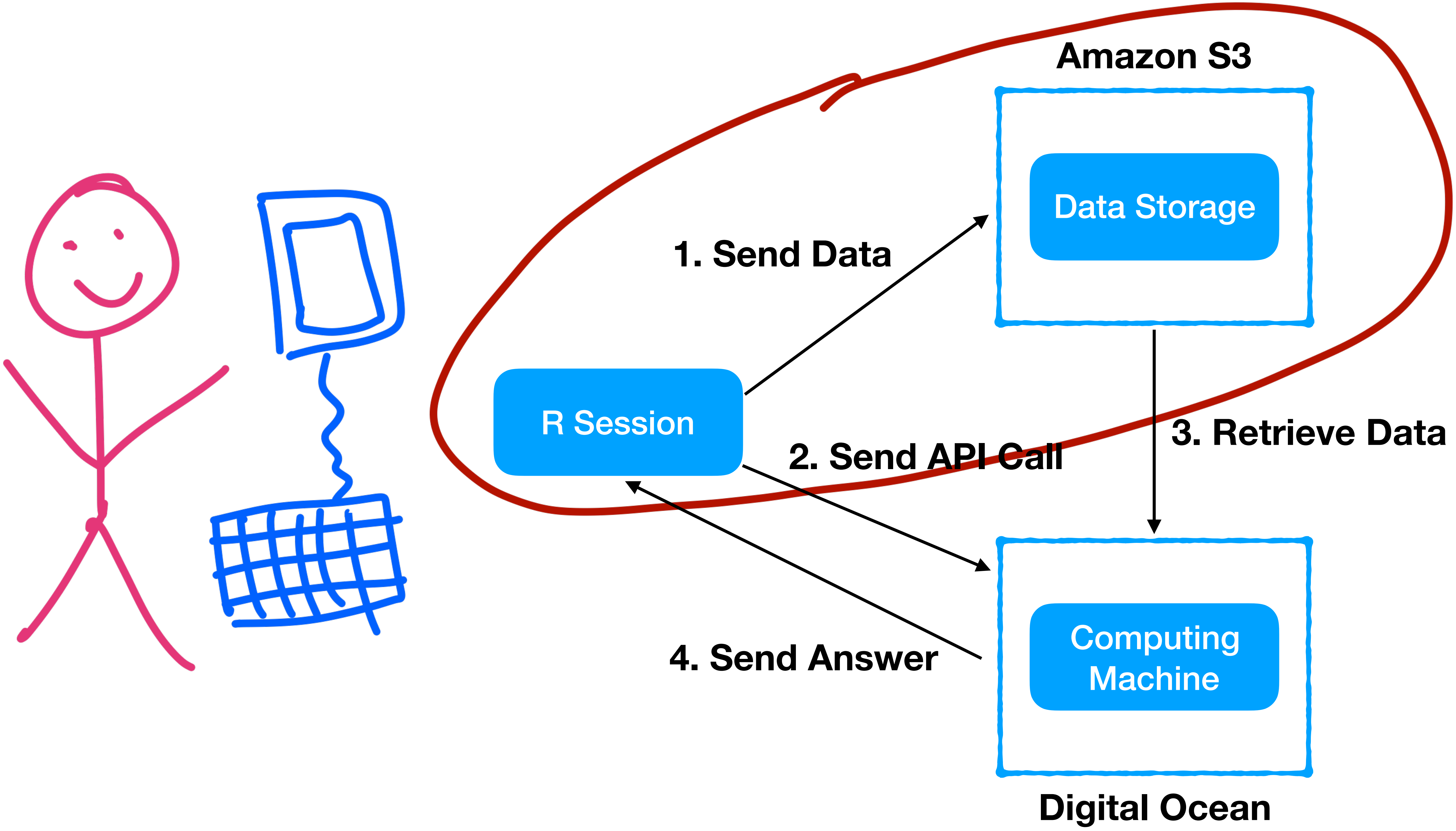
3. Retrieve Data

4. Send Answer

Computing Machine

Digital Ocean

Running Your Algorithm



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Save to AWS S3

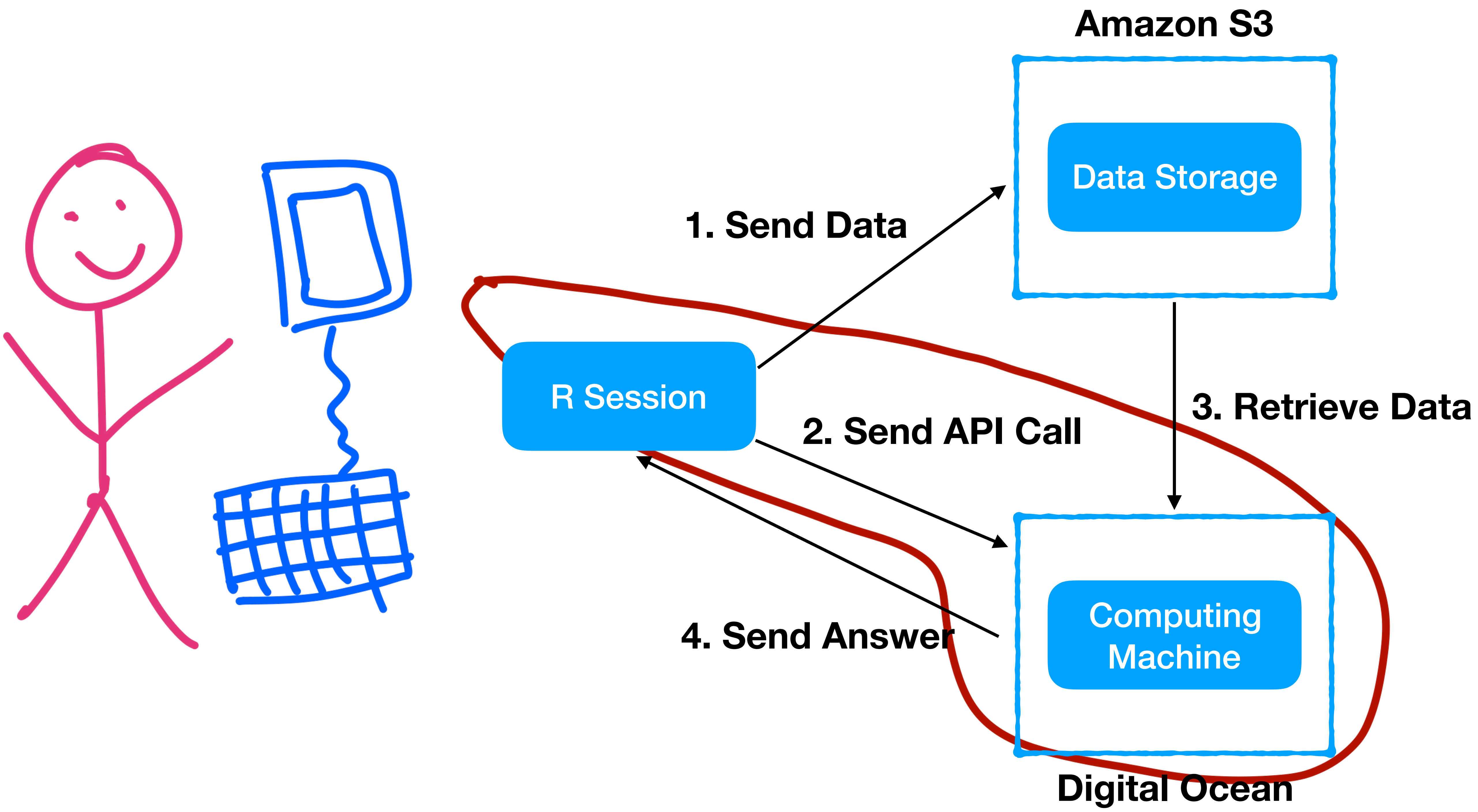
```r
median_CI <- function(x, N = 1000) {
        bucket <- "confint"
        key <- "xdata"
        val <- s3saveRDS(x, key, bucket)

        cmd <- glue("http://67.205.166.80:8000/confint?",
                    "key={key}&bucket={bucket}&N={N}")
        con <- curl(cmd)

        tryCatch({
                ans <- readLines(con, 1, warn = FALSE)
        }, finally = {
                ## Close server connection
                close(con)
        })
        ## Convert answer from JSON and return
        fromJSON(ans)
}
```

Construct API URL

Read from server

Amazon S3

Running Your Algorithm



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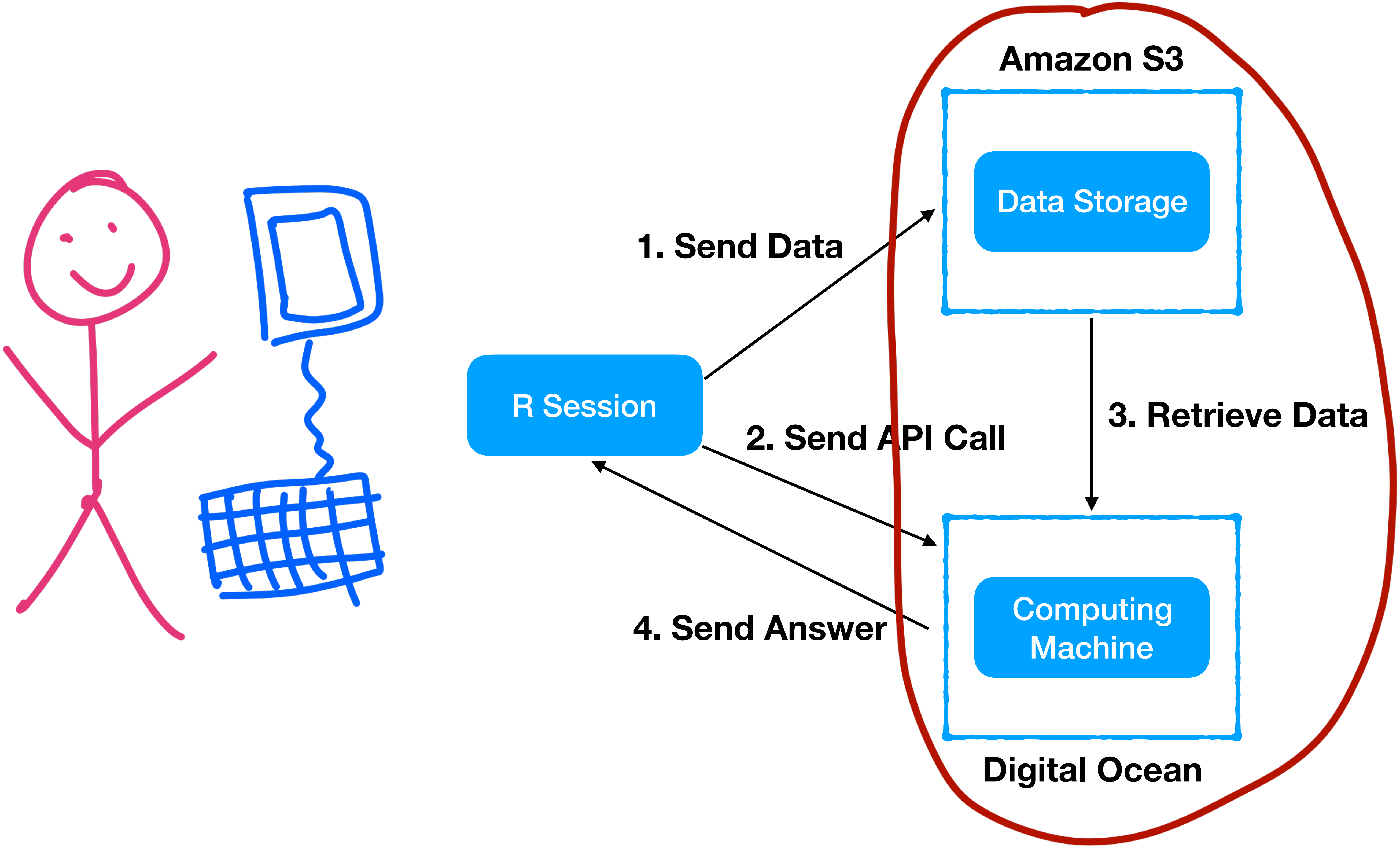
API Demo

Running Your Algorithm



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Digital Ocean

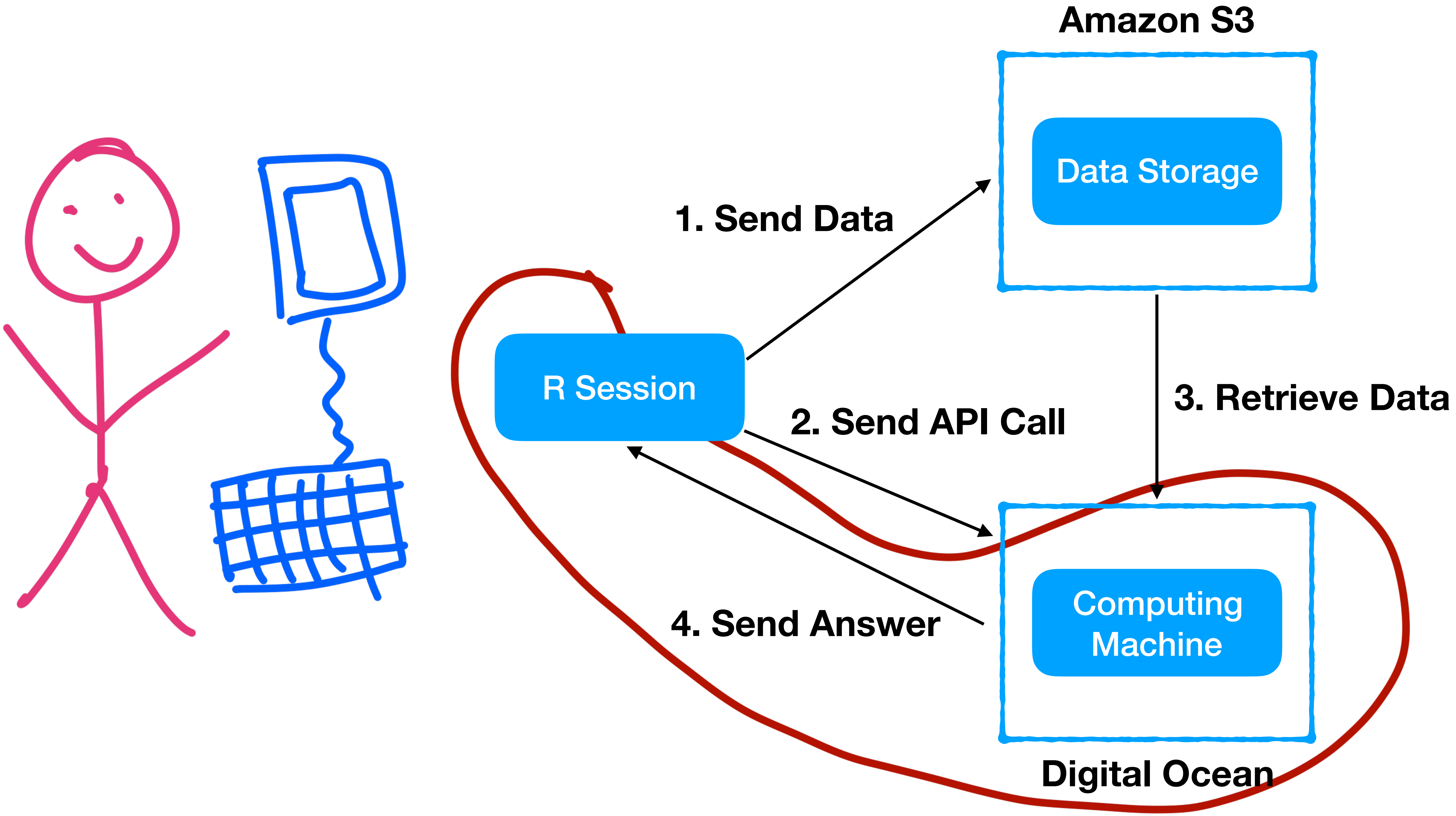
Retrieving Data from S3

```
#* Compute the 95% bootstrap confidence interval for the median
#* @param key the S3 key for the data
#* @param bucket the name of the bucket where the data live
#* @param N the number of bootstrap iterations
#* @get /confint
confint_median_compute <- function(key, bucket, N) {
        ## Make sure data is proper type
        key <- as.character(key)
        bucket <- as.character(bucket)
        N <- as.integer(N)

        ## Read data from S3
        x <- s3readRDS(key, bucket = bucket)

        ## Compute the confidence interval
        confint_median(x, N)
}
```

Running Your Algorithm



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Summary

- Creating APIs allows non-R-programmers access to your code in a standardized manner

- The plumber package translates R functions in to web API interfaces

- Amazon S3 can serve as a data intermediary if needed (via the aws.s3 package)

- Getting all the pieces to work right is tricky and everything will be different next month