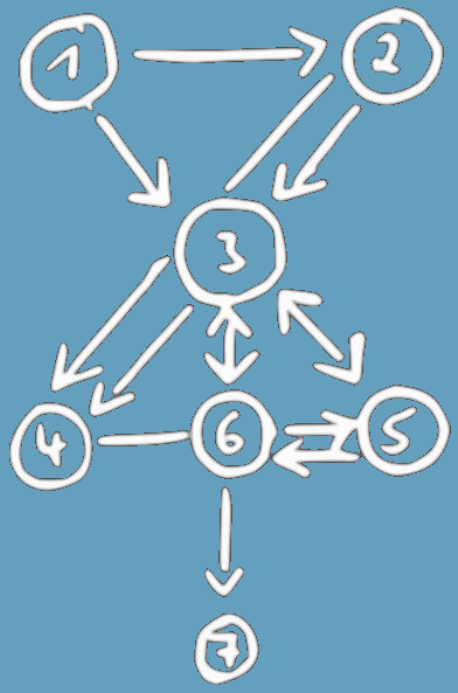
TECHNISCHE UNIVERSITÄT DRESDEN

Fakultät Informatik, Institut für Software- und Multimediatechnik, Lehrstuhl für Softwaretechnologie

Academic Skills in Computer Science (ASiCS)

Creating Diagrams with R



Subjects:
Motivation
What is R?
Introduction to R
Creating Diagrams with R

Dr.-Ing. Sebastian Götz, 04.06.2015

Literature

- All material is taken from these two sources:
  - https://stat.ethz.ch/R-manual/
  - http://www.statmethods.net/graphs/scatterplot.html
- Get R here: http://www.r-project.org/

What you'll learn

- You'll learn
  - What R is good for.
  - How to use R for typical diagrams.
    - Data types (arrays, matrices, data frames)
    - Im-/Export of data
    - Export of diagrams
    - Linecharts, Boxplots, Histograms
    - Linear Regression
    - Heatmaps
    - 3D charts

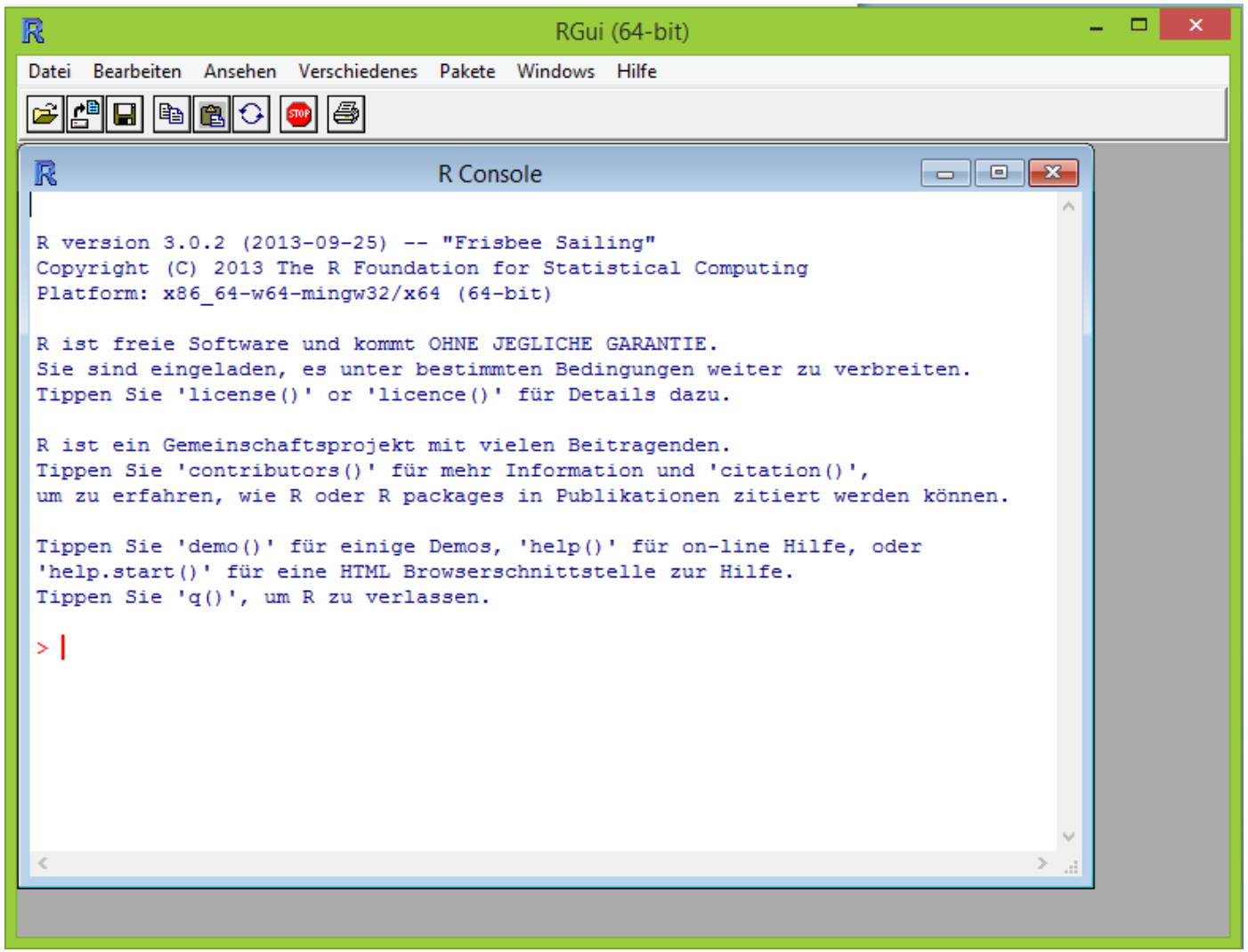
Motivation

- Why not just use Office?
  - Export of diagrams as image files possible (e.g., PNG, JPG, etc.)
  - **But**, images do not scale!
  - Today, most publications will be read using a device instead of being printed
  - Optimal resolution of image for print becomes secondary
  - Scalable vector graphics get important

What is R?

- „R is a language and environment for statistical computing and graphics.”
- Developed at Bell Laboratories by John Chambers and colleagues
- With R, you can analyze and visualize your data.
- R is open source and highly extensible
- R is available for almost all platforms

Introduction to R



Introduction to R

- R is used by commands and has it‘s own language

```
participation <- c(25,20,22,30,15,5,15,20,25)
participation
```

```
 [1] 25 20 22 30 15  5 15 20 25
```

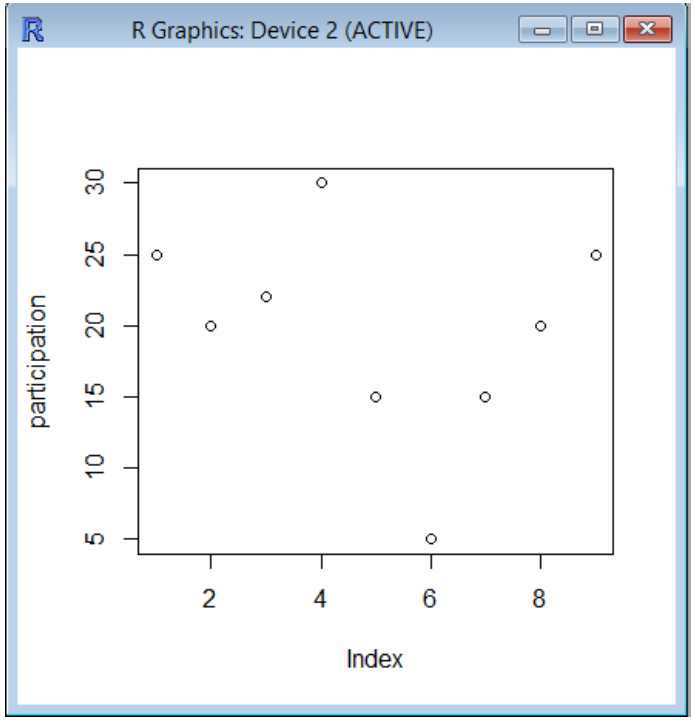
```
class(participation)
```

```
[1] "numeric"
```

Introduction to R


```
participation <- c(25,20,22,30,15,5,15,20,25)
```

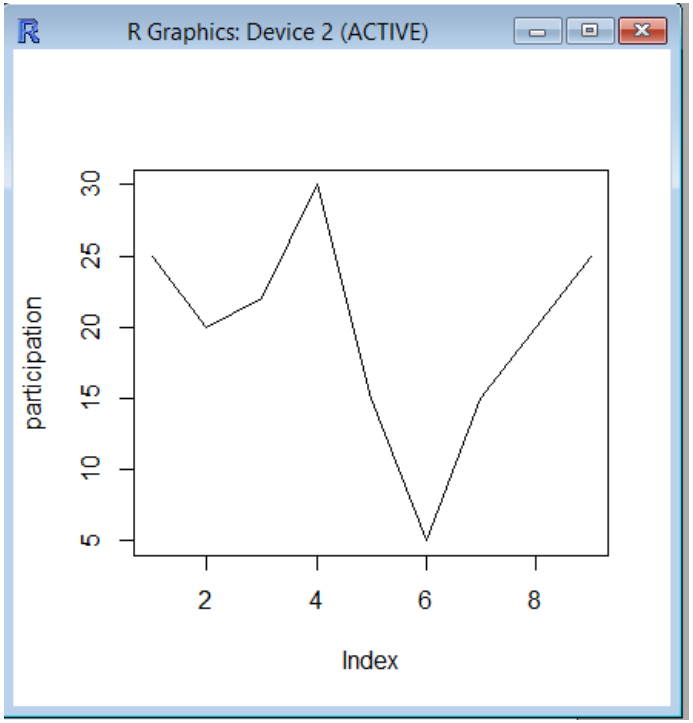
```
plot(participation)
```



Introduction to R


```
participation <- c(25,20,22,30,15,5,15,20,25)
```

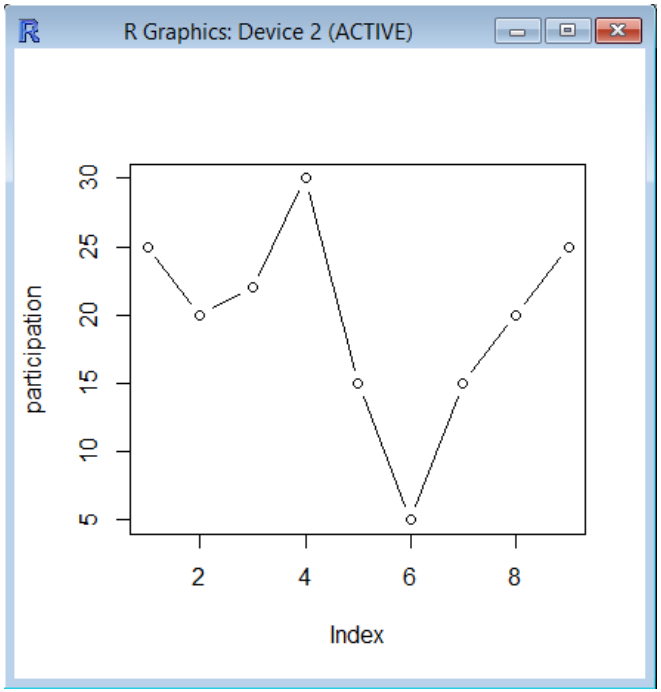
```
plot(participation, type="l")
```



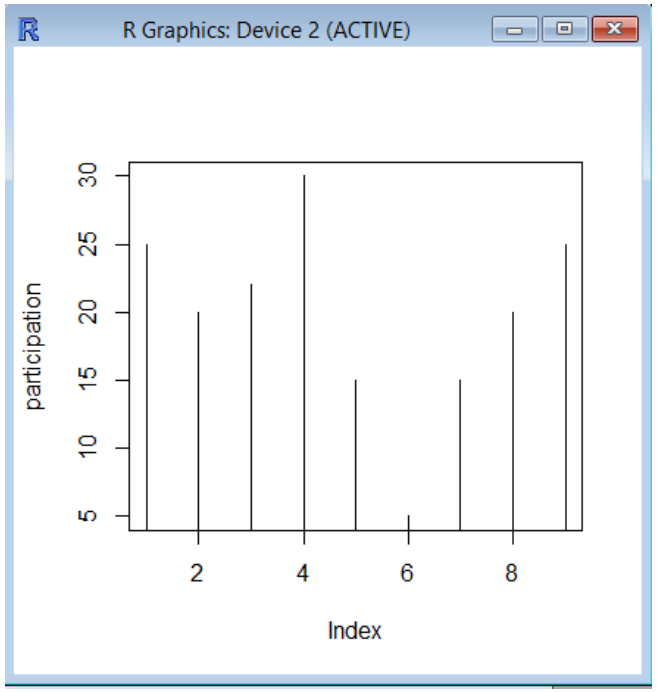
Introduction to R


```
participation <- c(25,20,22,30,15,5,15,20,25)
```

`type=„b“`



`type=„h“`



Introduction to R


```
participation <- c(25,20,22,30,15,5,15,20,25)
```

```
?plot
```

plot {graphics} R Documentation

Generic X-Y Plotting

Description

Generic function for plotting of R objects. For more details about the graphical parameter arguments, see `par`.

For simple scatter plots, `plot.default` will be used. However, there are `plot` methods for many R objects, including `functions`, `data.frames`, `density` objects, etc. Use `methods(plot)` and the documentation for these.

Usage

```
plot(x, y, ...)
```

Arguments

`x`	the coordinates of points in the plot. Alternatively, a single plotting structure, function or *any R object with a `plot` method* can be provided.
`y`	the y coordinates of points in the plot, *optional* if `x` is an appropriate structure.
`...`	Arguments to be passed to methods, such as graphical parameters (see `par`). Many methods will accept the following arguments:

`type`

what type of plot should be drawn. Possible types are

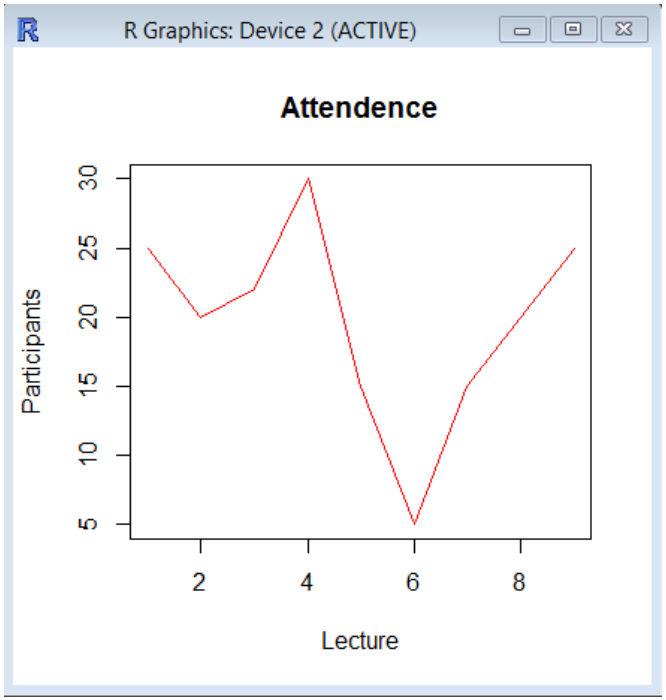
- "p" for points,

Introduction to R


```
participation <- c(25,20,22,30,15,5,15,20,25)
```

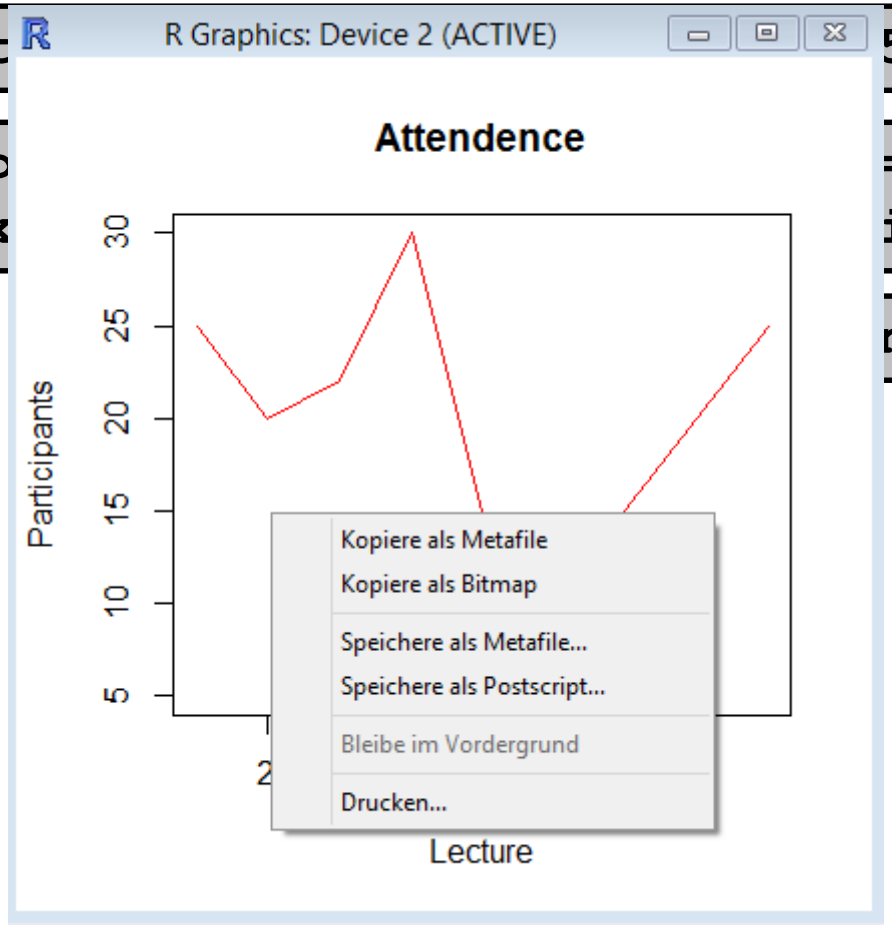
```
plot(participation, type=„l“, col=„red“,
     xlab=„Lecture“, ylab=„Participants“)
```

```
title(„Attendence“)
```



Introduction to R


```
participat                                    5,20,25)

plot(p                                        =„red“,
     x                                        ipants“)

                                              ndence“)
```



Introduction to R


```
participation <- c(25,20,22,30,15,5,15,20,25)
```

```
pdf()
```

```
plot(participation, type=„l“, col=„red“,
     xlab=„Lecture“, ylab=„Participants“)
```

```
title(„Attendence“)
```

```
dev.off()
```

- Rplots.pdf created in home folder.
- Sometimes important for right scaling.

- All relevant data for a boxplot!

```
participation <- c(25,20,22,30,15,5,15,20,25)
```

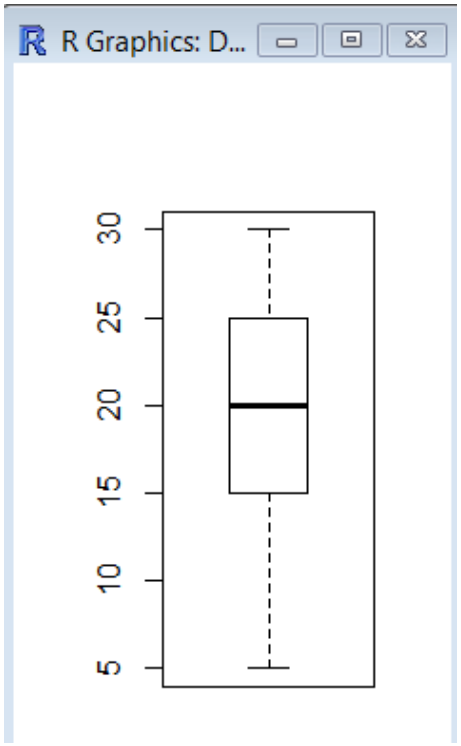
```
summary(participation)
```

```
Min. 1st Qu.  Median    Mean 3rd Qu.    Max.
 5.00   15.00   20.00   19.67   25.00   30.00
```

Introduction to R

- To draw a boxplot, use **`boxplot`**

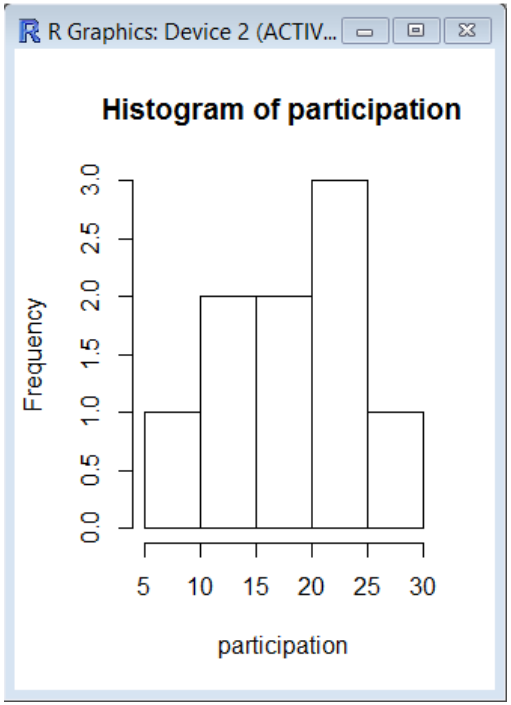
```
participation <- c(25,20,22,30,15,5,15,20,25)
```




```
boxplot(participation)
```

- To draw a histogram, use **`hist`**

```
participation <- c(25,20,22,30,15,5,15,20,25)
```




```
hist(participation)
```

Introduction to R

- How to estimate future participation? → Linear Regression!

```
participation <- c(25,20,22,30,15,5,15,20,25)
```

```
m <- lm(participation ~ seq(1:9))
```

```
m
```

```
Coefficients:
(Intercept)      seq(1:9)
      22.92         -0.65
```

$$f(x) = -0.65x + 22.92$$

- Number generating functions

```
seq(1,9)
```

```
[1] 1 2 3 4 5 6 7 8 9
```

```
1:9
```

```
[1] 1 2 3 4 5 6 7 8 9
```

```
seq(1,9,3)
```

```
[1] 1 4 7
```

```
seq(1,9,3)*2
```

```
[1] 2 8 14
```

```
rep(1,9)
```

```
[1] 1 1 1 1 1 1 1 1 1
```

Introduction to R


```
participation <- c(25,20,22,30,15,5,15,20,25)
```

```
m <- lm(participation ~ seq(1:9))
```

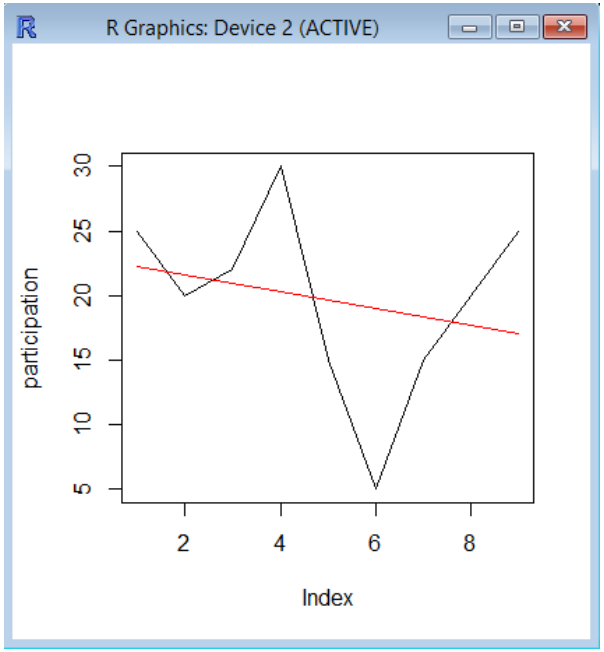
```
summary(m)
```

```
Residuals:
    Min      1Q  Median      3Q     Max
-14.017  -3.367   1.033   2.733   9.683

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept)  22.9167     5.5099   4.159  0.00425 **
seq(1:9)     -0.6500     0.9791  -0.664  0.52803
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 7.584 on 7 degrees of freedom
Multiple R-squared:  0.05923,   Adjusted R-squared:  -0.07517
F-statistic: 0.4407 on 1 and 7 DF,  p-value: 0.528
```

Introduction to R


```
participation <- c(25,20,22,30,15,5,15,20,25)
```

```
m <- lm(participation ~ seq(1:9))
```




```
                          c <- coef(m)
f <- function(x) c[2]*x + c[1]
```

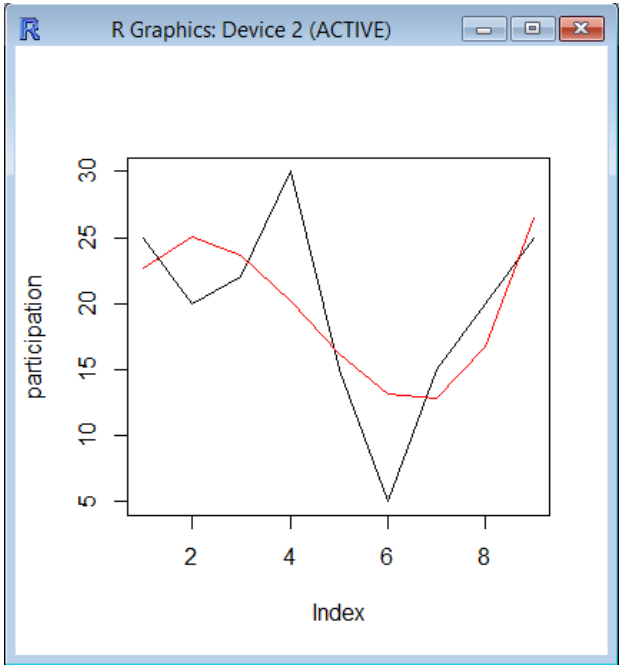
```
plot(participation,type=„b“)
```

```
lines(f(seq(1:9)),col=„red“)
```

→ Looks more like a 3rd grade polynomial

```
p <- c(25,20,22,30,15,5,15,20,25)
```

```
m <- lm(p ~ seq(1:9) + I(seq(1:9)^2) + I(seq(1:9)^3))
```




```
c <- coef(m)
f <- function(x) c[4]*x^3 + … c[1]
```

```
plot(p,type="l")
```

```
lines(f(seq(1:9)),col="red")
```

```
summary(m)
```

→ R^2 still bad (0.1943)

```
?nls
```

Other classes of data

- By now, we only worked with a simple numeric array
- R offers more:
  - Data frames
  - Matrices

Data Import

- Often, you want to process data collected somewhere else
- Store it as a comma separated value file

```
data <- read.csv("radix.csv",sep=":",dec=".")
```

```
   0        10        20        30        40
 1 freq:x:algo:size:time:ac:dc
 2 1200:50:Radix:50000000:4543.03:652.674:512.033
 3 1200:50:Radix:50000000:4568.21:659.203:509.877
 4 1200:50:Radix:50000000:4550.33:651.38:510.229
 5 1200:50:Radix:50000000:4502.51:650.16:500.893
 6 1200:50:Radix:50000000:4546.79:650.422:510.643
 7 1200:50:Radix:50000000:4538.82:649.911:511.914
 8 1200:50:Radix:50000000:4498.63:643.195:505.479
 9 1200:50:Radix:50000000:4523.73:649.666:497.828
10 1200:50:Radix:50000000:4527.05:642.175:504.147
11 1200:50:Radix:50000000:4554.99:649.366:504.132
```

Data Import

- Imported data has more structure than a typical array

```
data <- read.csv("radix.csv",sep=":",dec=".")
```

```
class(data)
```

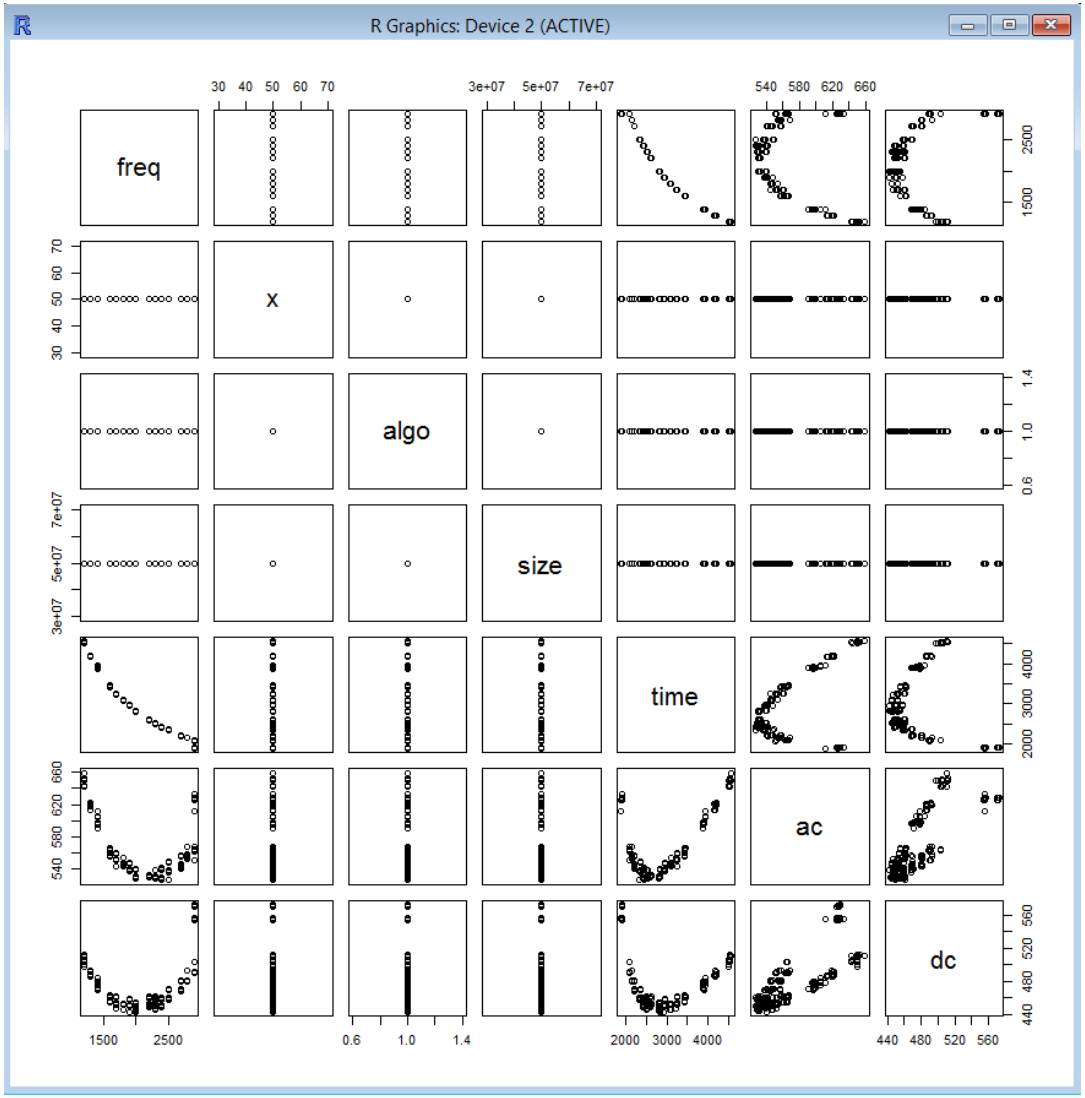
```
[1] "data.frame"
```

```
summary(data)
```

```
      freq            x          algo          size             time             ac              dc
 Min.   :1200   Min.   :50   Radix:320   Min.   :5e+07   Min.   :1880   Min.   :526.3   Min.   :442.3
 1st Qu.:1675   1st Qu.:50               1st Qu.:5e+07   1st Qu.:2302   1st Qu.:538.1   1st Qu.:452.6
 Median :2100   Median :50               Median :5e+07   Median :2712   Median :551.3   Median :460.8
 Mean   :2100   Mean   :50               Mean   :5e+07   Mean   :2902   Mean   :564.1   Mean   :472.8
 3rd Qu.:2550   3rd Qu.:50               3rd Qu.:5e+07   3rd Qu.:3304   3rd Qu.:573.3   3rd Qu.:486.0
 Max.   :2901   Max.   :50               Max.   :5e+07   Max.   :4568   Max.   :659.2   Max.   :572.8
```

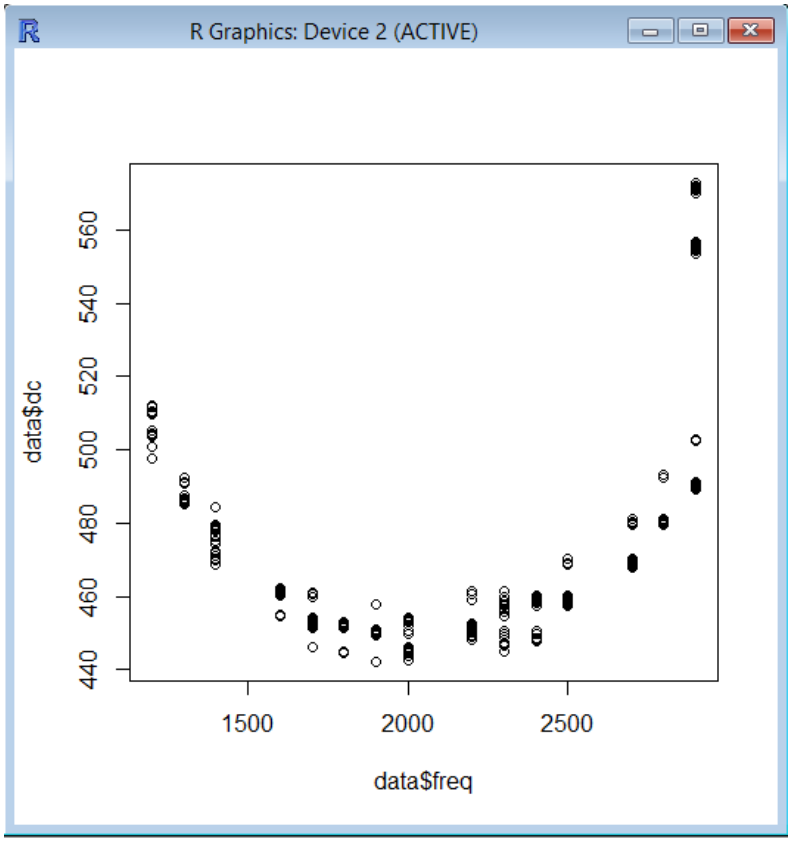
Data Import


```
plot(data)
```

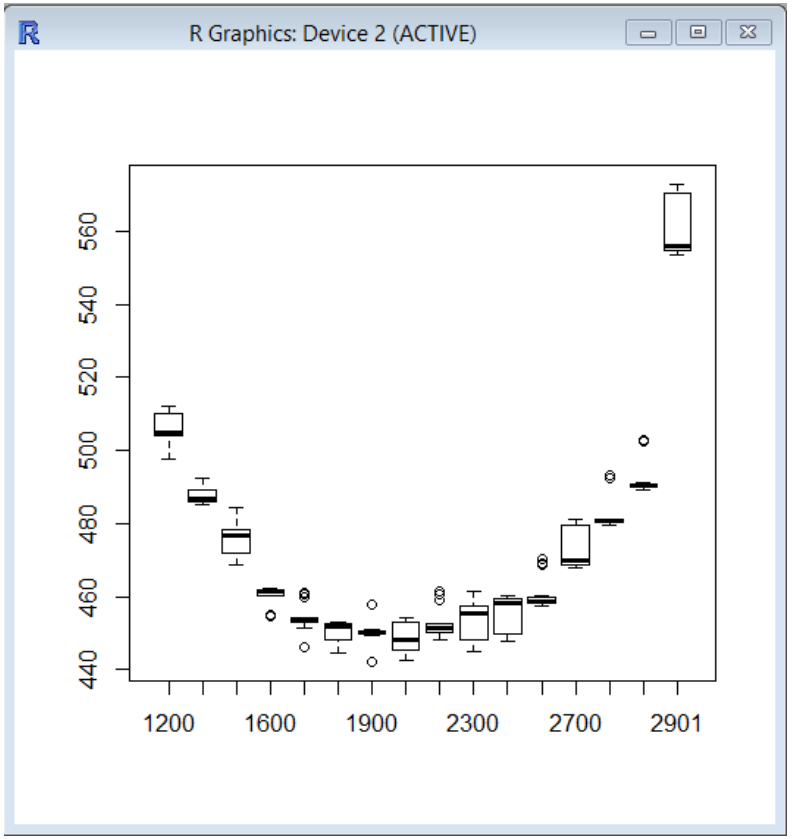


Data Import


```
plot(data$dc~data$freq)
```




```
boxplot(data$dc~data$freq)
```



Data Import

- Often, prefixing is boilerplate as only one dataset is in use

```
data <- read.csv("radix.csv",sep=":",dec=".")
```

```
attach(data)
```

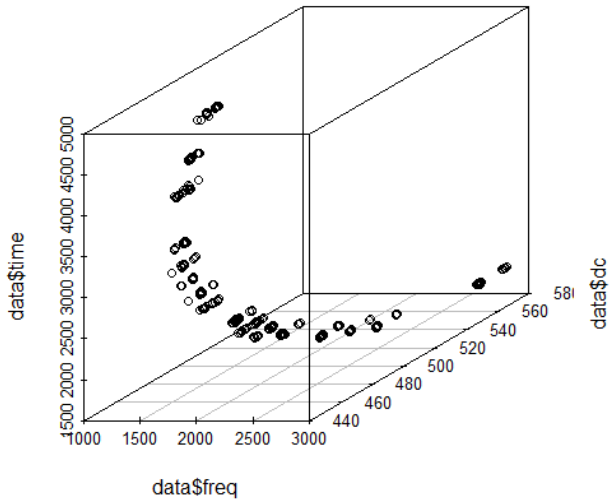
```
boxplot(dc~freq)
```

More than 2 dimensions

- What if you want to compare more than 2 dimensions?

```
library(scatterplot3d)
```

```
scatterplot3d(data$freq,data$dc,data$time)
```



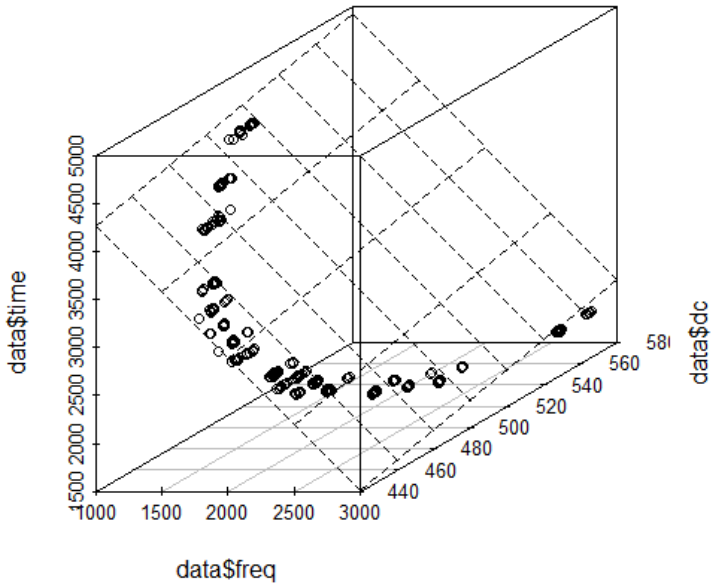
More than 2 dimensions


```
library(scatterplot3d)
```

```
s3d <- scatterplot3d(data$freq,data$dc,data$time)
```

```
fit <- lm(data$time ~ data$freq+data$dc)
```

```
s3d$plane3d(fit)
```



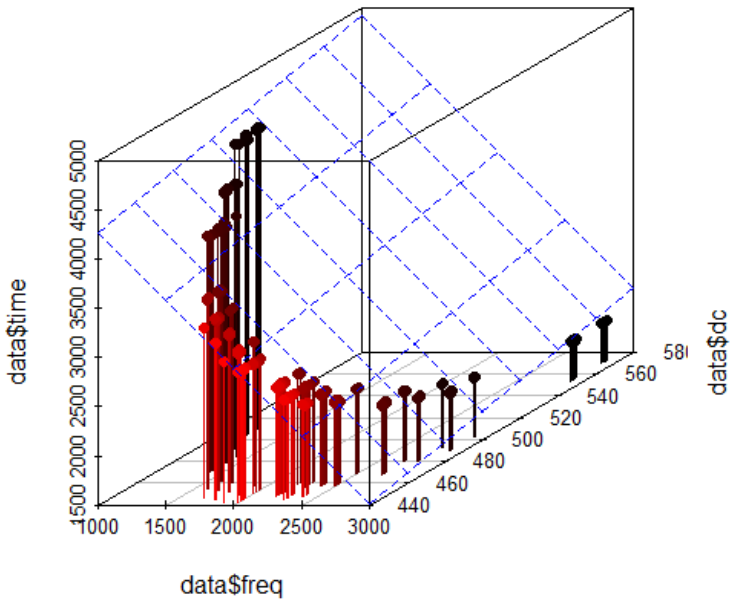
More than 2 dimensions


```
library(scatterplot3d)
```

```
s3d <- scatterplot3d(data$freq,data$dc,data$time,
highlight.3d=TRUE, type="h", pch=16)
```

```
fit <- lm(data$time ~ data$freq+data$dc)
```

```
s3d$plane3d(fit, col="blue")
```

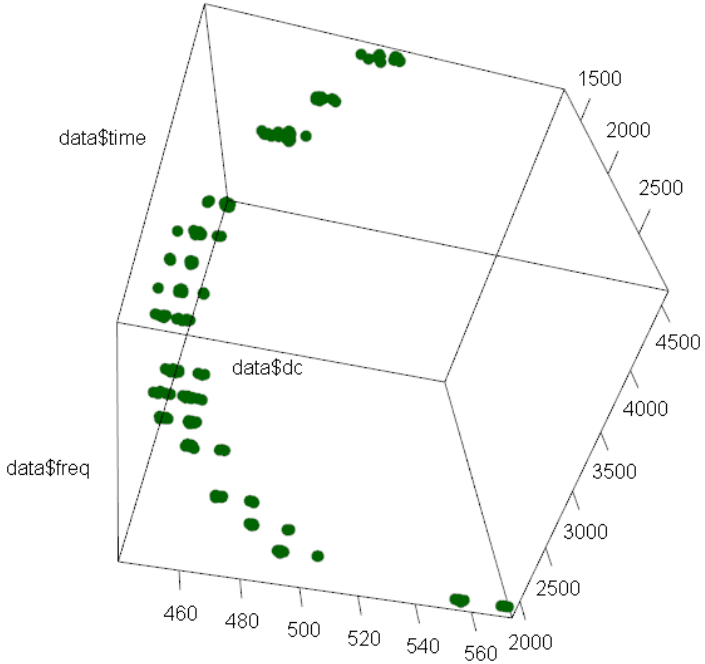


More than 2 dimensions

- Are there alternatives?

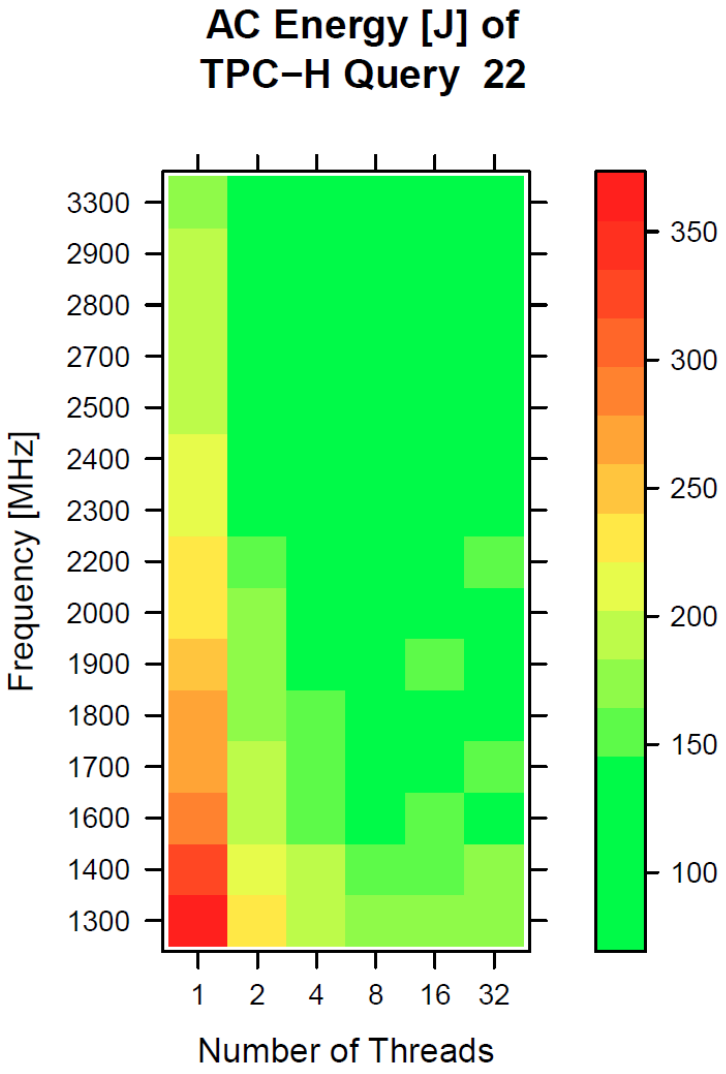
```
library(rgl)
```

```
plot3d(data$freq,data$dc,data$time,size=10)
```



More than 2 dimensions

- Are there alternatives?
- Visualization as heatmap
- 2 of 3 dimensions are axis
- The 3rd dimension is encoded as color
- Heatmaps work on matrices instead of data frames!



More than 2 dimensions


```
library(lattice)
library(RColorBrewer)

my_palette <- colorRampPalette(
    c("green", "yellow", "orange", "brown",
      "red", "black"))(n = 299)

levelplot(mat,col.regions=my_palette,
          main="XXX",
          ylab="Frequency [MHz]",
          xlab="MaxTime",
          axes=FALSE)
```

- How to get the matrice **`mat`**?

Working with data.frames

data

```
  freq  x  algo     size    time       ac       dc
1 1200 50 Radix 50000000 4543.03 652.674 512.033
2 1200 50 Radix 50000000 4568.21 659.203 509.877
3 1200 50 Radix 50000000 4550.33 651.380 510.229
…
```

data[2,]

```
  freq  x  algo     size    time       ac       dc
2 1200 50 Radix 50000000 4568.21 659.203 509.877
```

data[,2]

data$x

```
  [1] 50 50 50 50 50 50 50 50 50 50 50 50 50 50
 [15] 50 50 50 50 50 50 50 50 50 50 50 50 50 50
…
```

data[3,5]

```
[1] 4550.33
```

Working with matrices


```
m <- matrix(c(1,2,3,4,5,6),nrow=2,ncol=3)
m
```

```
     [,1] [,2] [,3]
[1,]    1    3    5
[2,]    2    4    6
```

```
m <- matrix(nrow=7,ncol=16)
ct <- 0
for(nt in c(2000,2500,3000,3500,4000,4500,5000))
{
  ct <- ct+1
  ci <- 0
  for(f in c(1200,1300,1400,1600,1700,1800,1900,2000,2200,2300,2400,
             2500,2700,2800,2900,2901))
  {
    ci <- ci+1
    d <- data[data$freq==f,]
    x <- nrow(d[d$time<nt,])
    m[ct,ci] <- x
  }
}
```

Working with matrices


```
colnames(m) <- c(1200,1300,1400,1600,1700,1800,
1900,2000,2200,2300,2400,2500,2700,2800,2900,3300)
```

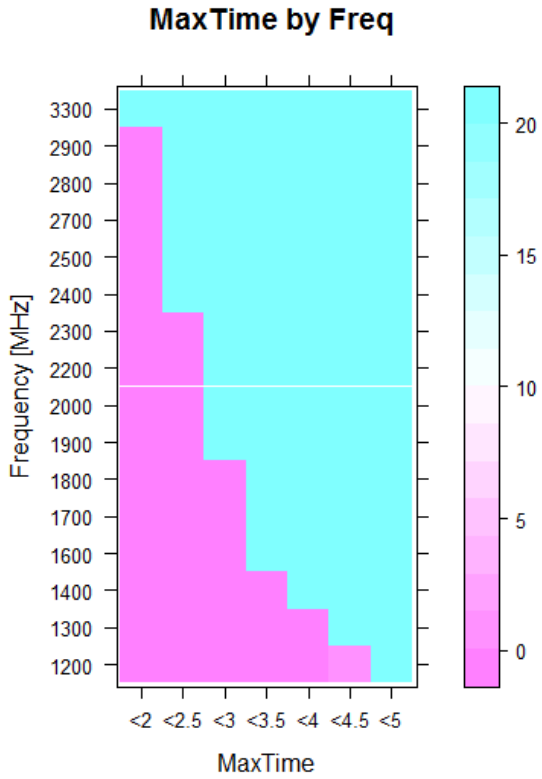
```
rownames(m) <- c("<2", "<2.5", "<3", "<3.5", "<4",
"<4.5", "<5")
```

```
m
```

	1200	1300	1400	1600	1700	1800	1900	2000	2200	2300	2400	2500	2700	2800	2900	3300
<2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	20
<2.5	0	0	0	0	0	0	0	0	0	0	20	20	20	20	20	20
<3	0	0	0	0	0	0	20	20	20	20	20	20	20	20	20	20
<3.5	0	0	0	20	20	20	20	20	20	20	20	20	20	20	20	20
<4	0	0	20	20	20	20	20	20	20	20	20	20	20	20	20	20
<4.5	1	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20
<5	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20	20

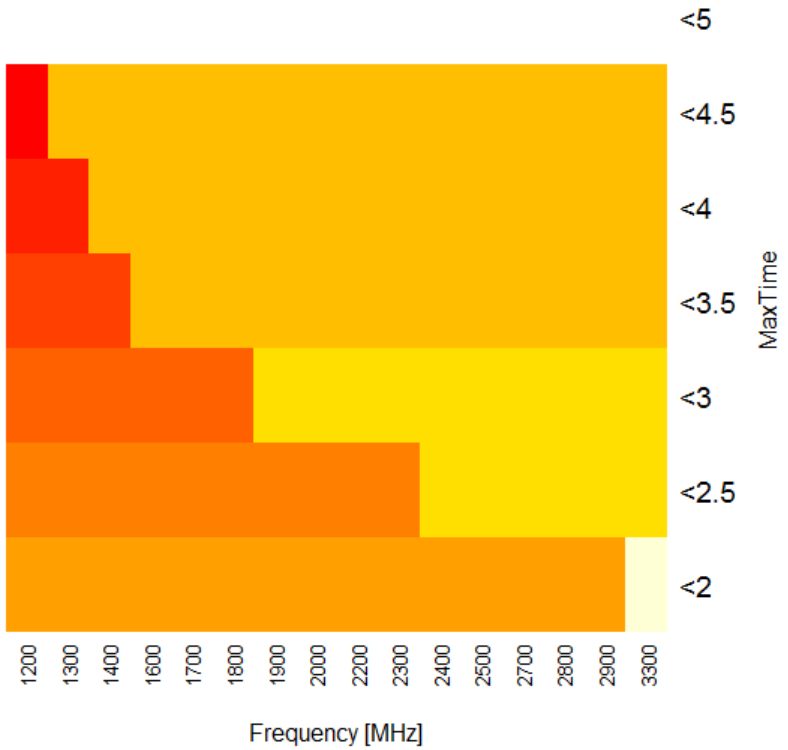
Working with matrices


```
levelplot(m,main="MaxTime by Freq",
          ylab="Frequency [MHz]",
          xlab="MaxTime",axes=FALSE)
```



Working with matrices


```
heatmap(m,Colv=NA,Rowv=NA,
          xlab="Frequency [MHz]",
          ylab="MaxTime")
```



Outlook

- There‘s a lot more you can do with R
  - Statistics (e.g., ?anova, ?kruskal.test, …)
  - More types of diagrams
  - Many libraries