Advanced R Programming - Lecture 5

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(slides based on Leif Jonsson's and Måns Magnusson's)

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Today

Input and output

Basic I/O

Cloud storage

web APIs: Lab

web scraping

Shiny

Relational Databases

Questions since last time?

Input and output

Format, localization

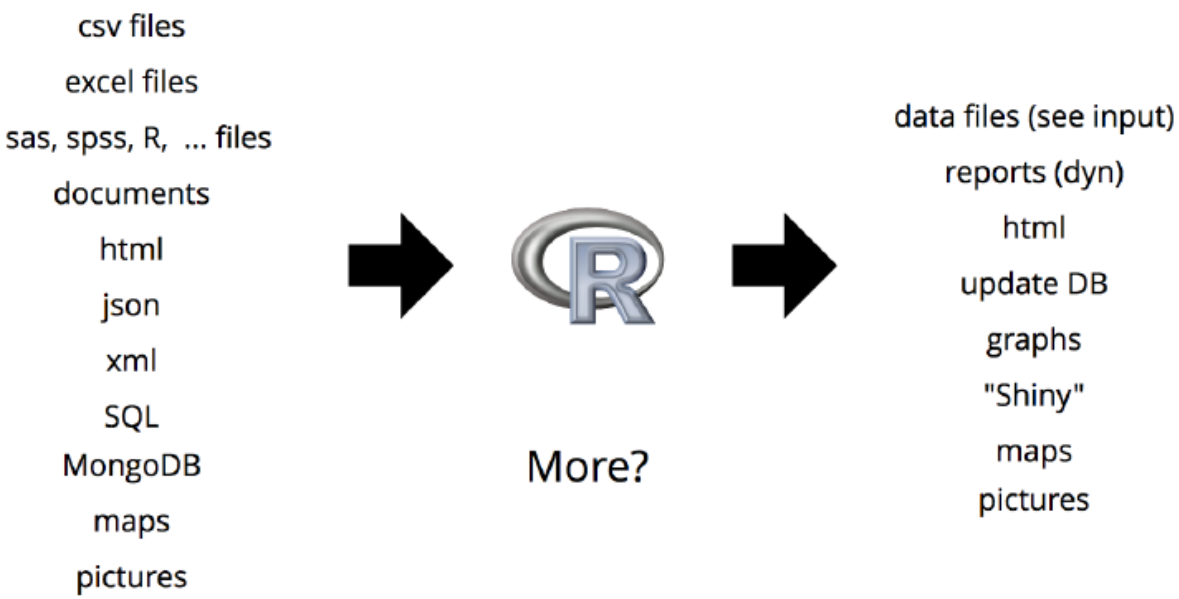
Input and output

Format, localization and encoding..... hell!

`http://www.joelonsoftware.com/articles/Unicode.html`
The Absolute Minimum Every Software Developer Absolutely, Positively Must Know About Unicode and Character Sets (No Excuses!)

Unicode defines codes for **all (?)** characters—multiple encodings (for a given language only small fraction of characters used)
`Content-Type` tag for HTML
BUT e–mail, `.txt`, `.csv`

"Formats"


csv files
excel files
sas, spss, R, ... files
documents
html
json
xml
SQL
MongoDB
maps
pictures
More?
data files (see input)
reports (dyn)
html
update DB
graphs
"Shiny"
maps
pictures

Localization

own Computer	Cloud Storage
local network	web pages
local database	web scraping
	web APIs
	remote database

Table: Local - Remote

Files on your computer

```
# Input simple data
read.table()
read.csv()
read.csv2()

load()


# Output simple data
write.table()
write.csv()
write.csv2()

save()
```

More complex formats

software/data	**package**
Excel	XLConnect
SAS, SPSS, STATA, ...	foreign
XML	xml
JSON (GeoJSON)	rjsonio, RJSON
Documents	tm
Maps	sp
Images	raster

Table: Format - R package

Cloud storage

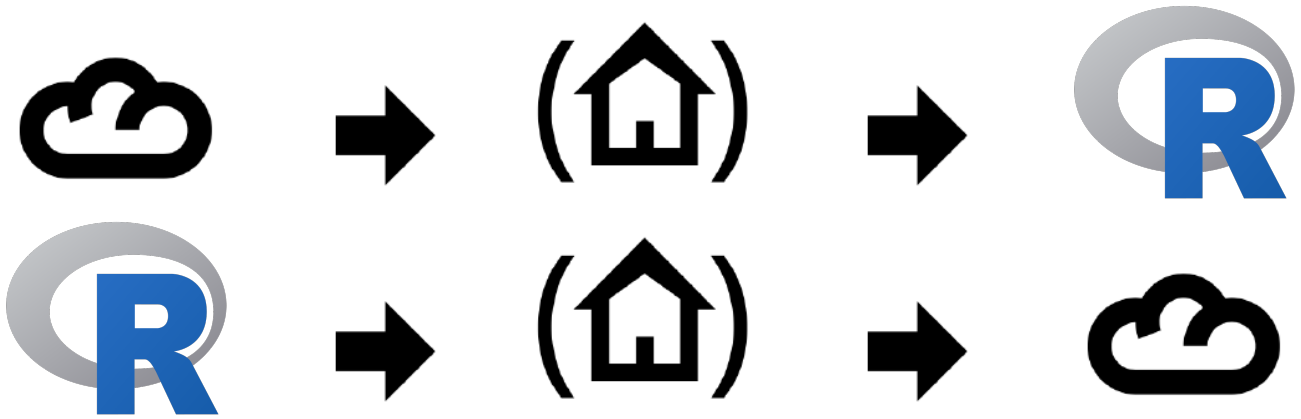


Table: Local - Remote

Why?

Robust

Backups

Cloud computing

can be tricky in the beginning

but

Why?

Robust

Backups

Cloud computing

can be tricky in the beginning

but how about safety? (data leaks, outsourcing)

But control on what is going on? (outsourcing, denial of service)

BUT requires internet connection

Localization

Arbitrary data

Structured data

API Packages

Remote	**package**
General	downloader
GitHub	repmis, downloader
Dropbox	rdrop
Amazon	RAmazonS3
Google Docs	googlesheets

web APIs

application program interface using http

"contract to 'get data' online"

more and more common

examples:

github

Riksdagen

Statistics Sweden

RESTful

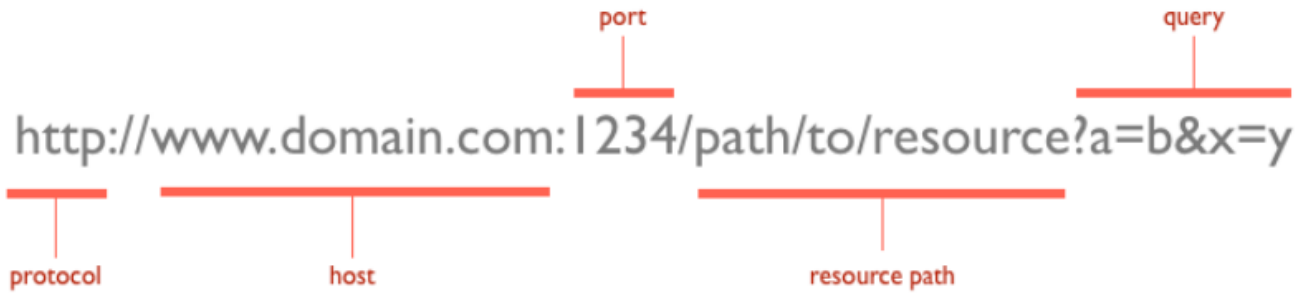
Basic principles:

Data is returned (JSON / XML)

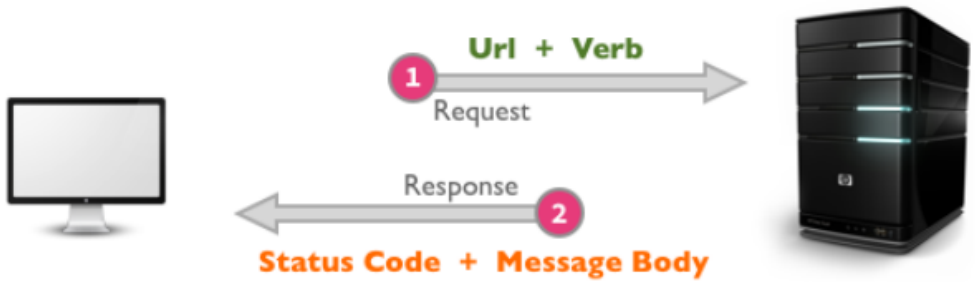
Each specific data has its own URI

Communication is based on HTTP verbs

Hypertext Transfer Protocol (http)



Hypertext Transfer Protocol (http)



Verbs

Verb	**Description**
GET	Get "data" from server.
POST	Post "data" to server (to get something)
PUT	Update "data" on server
DELETE	Delete resource on server

Status codes

Code	Description
1XX	Information from server
2XX	Yay! Gimme' data!
3XX	Redirections
4XX	You failed
5XX	Server failed

Example REST API's

`http://www.linkoping.se/open/data/Luftkvalitet/`
Linköping Luftkvalitet API

`https://developers.google.com/maps/documentation/geocoding/intro`
Google Map Geocode API

Common API formats

JavaScript Object Notation (JSON)
Think of named lists in R
R Packages: RJSONIO, rjsonlite

Extensible Markup Language (XML)
Older format (using nodes)
xpath
R Packages: XML

JSON

```
{
  "firstName": "John",
  "lastName": "Smith",
  "age": 25,
  "address": {
        "streetAddress": "21 2nd Street",
        "city": "New York",
        "state": "NY",
        "postalCode": "10021"
  },
  "phoneNumber": [
        { "type": "home", "number": "212 555" },
        { "type": "fax", "number": "646 555" }
  ],
  "newSubscription": false,
  "companyName": null
}
```

XML

```
<?xml version="1.0" encoding="utf-8"?>
<wikimedia>
<projects>
<project name="Wikipedia" launch="2001-01-05">
<editions>
<edition language="English">en.wikipedia.org</edition>
<edition language="German">de.wikipedia.org</edition>
<edition language="French">fr.wikipedia.org</edition>
<edition language="Polish">pl.wikipedia.org</edition>
<edition language="Spanish">es.wikipedia.org</edition>
</editions>
</project>
<project name="Wiktionary" launch="2002-12-12">
<editions>
<edition language="English">en.wiktionary.org</edition>
<edition language="French">fr.wiktionary.org</edition>
<edition language="Vietnamese">vi.wiktionary.org</edition>
<edition language="Turkish">tr.wiktionary.org</edition>
<edition language="Spanish">es.wiktionary.org</edition>
</editions>
</project>
</projects>
</wikimedia>
```

web scraping

Unstructured http(s) data

Often HTML format

Spiders / scraping / web crawlers

Basics behind search engines

HTML

```
<!DOCTYPE html>
<html>
  <head>
    <title>This is a title</title>
  </head>
  <body>
    <p>Hello world!</p>
  </body>
</html>
```

(har)rvest

JavaScript Object Notation (JSON)
Simplify spider activity

Download data
Parse data
Follow links
Fill out forms
Store crawling history

Difficulties and bad spiders

Scraping is fragile!
Difficulties and bad spiders
www.domain.se/robot.txt
Politeness

robot traps
javascript
delays

Shiny?

Interactive dashboards made easy

online or local

R as "backend"

Shiny?

`https://www.rstudio.com/products/shiny/shiny-user-showcase/`
Shiny Examples

How it works

Application

Reactive

modify using HTML

`MyAppName/server.R`
`MyAppName/ui.R`

server.R define working directory

Shiny Example

```
library(shiny)
# Examples with code
runExample("01_hello")
runExample("03_reactivity")
```

Publish Shiny

locally
zip-file in cloud
github (see runGithub())

Publish Shiny

locally
zip-file in cloud
github (see runGithub())

your own server
shinyapps.io

Relational Databases

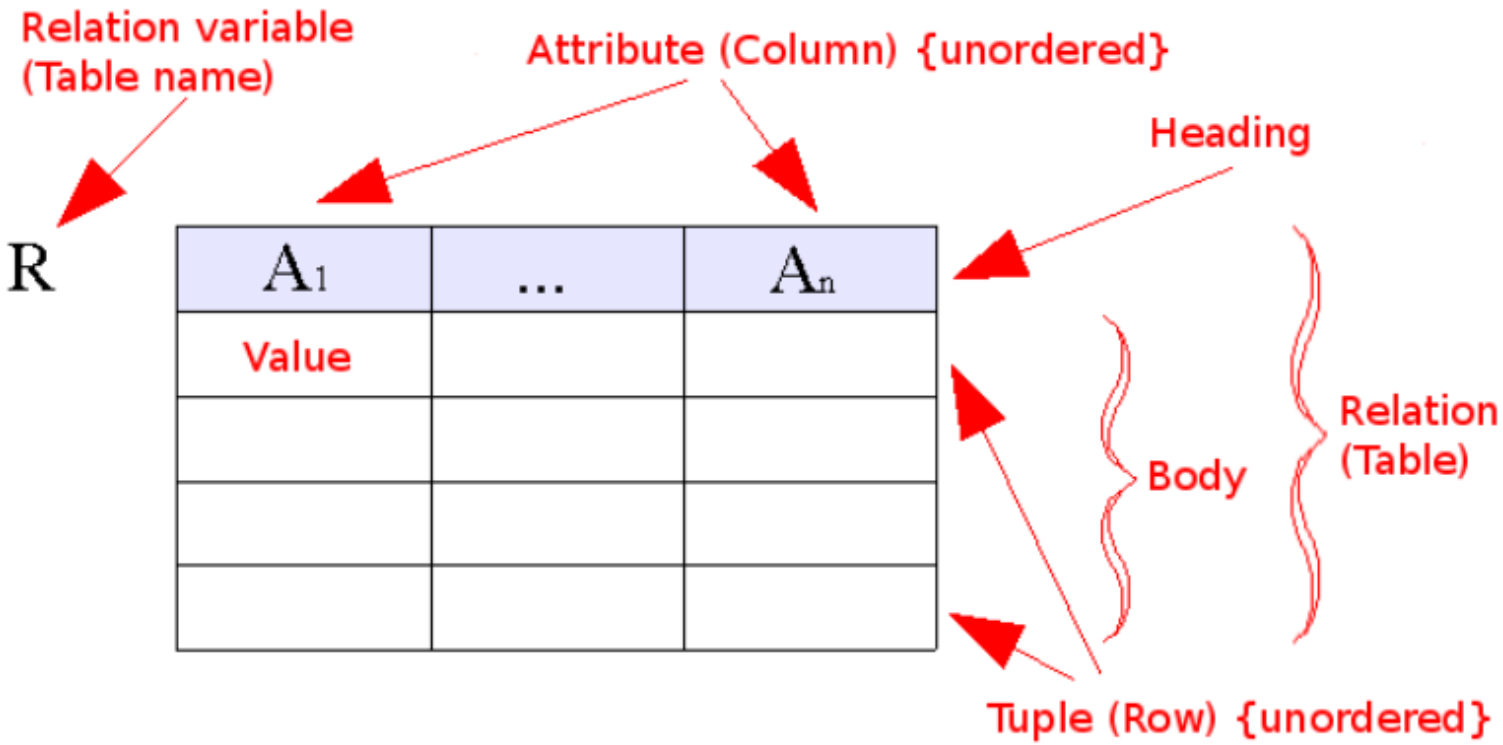
Structured database in tables

local or online

query language for I/O

effective for big data

difficult to design


Relation variable
(Table name)
Attribute (Column) {unordered}
Heading
R
A1
...
An
Value
Body
Relation
(Table)
Tuple (Row) {unordered}

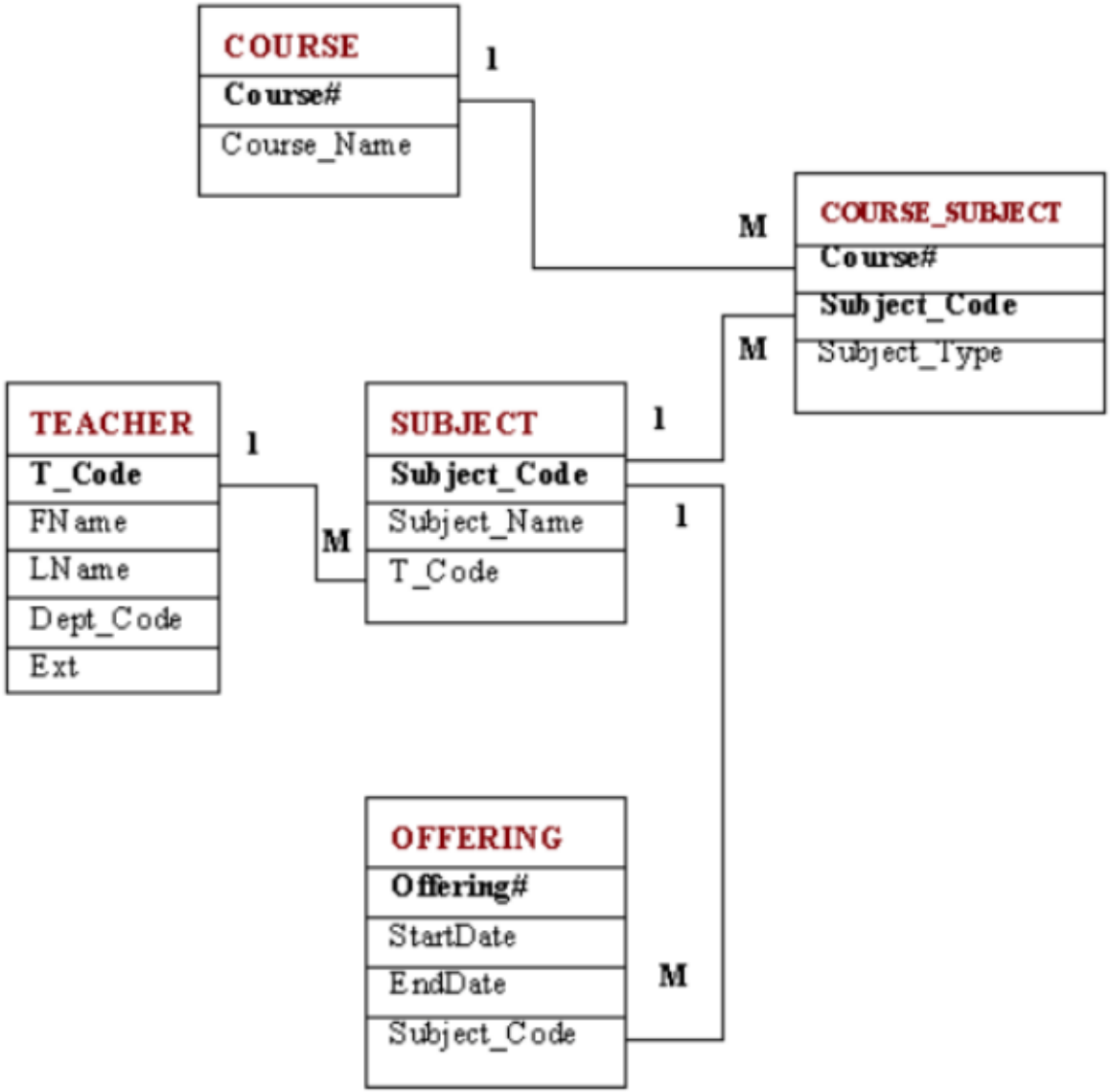
Keys

Superkey "set of attributes such that two distinct rows that do not have the same values for these attributes"

Primary key (attribute): choice of superkey, relationships between tables are done through the primary key

`https://en.wikipedia.org/wiki/Superkey`

`https://en.wikipedia.org/wiki/Primary_key`


COURSE
Course#
Course_Name
1
M
COURSE_SUBJECT
Course#
Subject_Code
Subject_Type
M
1
TEACHER
T_Code
FName
LName
Dept_Code
Ext
1
M
SUBJECT
Subject_Code
Subject_Name
T_Code
1
1
M
OFFERING
Offering#
StartDate
EndDate
Subject_Code

A good database

Can be difficult to design ?
No duplicates
No redundancies
Easy to update
"Normal forms"

Easy to query

A good database: normalization

Database normalization: "is the process of restructuring a relational database in accordance with a series of so–called normal forms in order to reduce data redundancy and improve data integrity"
(usually divide table into separate tables linked by primary keys)

Denormalization: create redundancies for increased performance:
(preferred) store normalized data and allow DBMS to create additional redundancies (DBMS is responsible for inconsistencies)
(common) designed denormalized DB (designer is responsible for inconsistencies)

`https://en.wikipedia.org/wiki/Database_normalization`

`https://en.wikipedia.org/wiki/Denormalization`

A good database: normal forms in brief

First normal form: in each attribute (column) entry there is a single atomic value:
for Telephone Number you cannot have two telephone numbers

Second normal form: 1NF and each non–primary attribute depends functionally only on the primary attribute and not on any other attribute:
(Course_code, Course_name, University, University_country) is not in 2NF as University_country is defined through University
here (Course_code, University) is the (composite) primary key

`https://en.wikipedia.org/wiki/X_normal_form`, X appropriate form

A good database: normal forms in brief

Third normal form: 2NF and "Every non–prime attribute of R is non–transitively dependent on every key of R.": (University, Year, Vice–Chancellor, Vice–Chancellor DOB)
composite primary key (University,Year)
Vice–Chancellor DOB depends on key via Vice–Chancellor
(what if someone made a typo when entering a second time?)

Boyce–Codd normal form or 3.5NF: more strict than 3NF, no functional dependencies between two attributes of which neither is a superkey:
(city, land_plot, postal_code) fails due to relationship between city and postal_code

`https://en.wikipedia.org/wiki/X_normal_form`, X appropriate form

A good database: normal forms in brief

Fourth normal form: 3NF and no multiple multivalued dependencies:
(Teacher, Language, Course), primary key is whole entry
Version 1 (redundant)
KB, Polish, 732A94
KB, Polish, 732A63
KB, English, 732A94
KB, English, 732A63
KB, Swedish, 732A94
KB, Swedish, 732A63
Version 2 (what if I stop teaching R?)
KB, Polish, 732A94
KB, English, 732A94
KB, Swedish, 732A63

`https://en.wikipedia.org/wiki/X_normal_form`, X appropriate form

A good database: normal forms in brief

Fifth normal form: when there are complex constraints on the possible combinations of values
Sixth normal form: when there are temporal dependencies in data (can lead to table explosion)

Domain–key normal form: values only constrained by permissable values for attributes and key uniquely identifying row:
(Lecturer, Lecturer_description, University) fails (but 1NF?):
KB, **LiU** Statistician, **LiU**
TB, **SU** Mathematician, **SU**
TE, **LiU** Mathematician, **LiU**
FR, **SU** Biologist, **SU**

`https://en.wikipedia.org/wiki/X_normal_form`, X appropriate form

Using databases from R

Database system	**R package**
ODBC (Microsoft Access)	RODBC
PostgreSQL	RPostgresql
Oracle	ROracle
MySQL	RMySql
MongoDB	rmongodb

Table: Database - R package

The End... for today.
Questions?
See you next time!