JSON and Graph model

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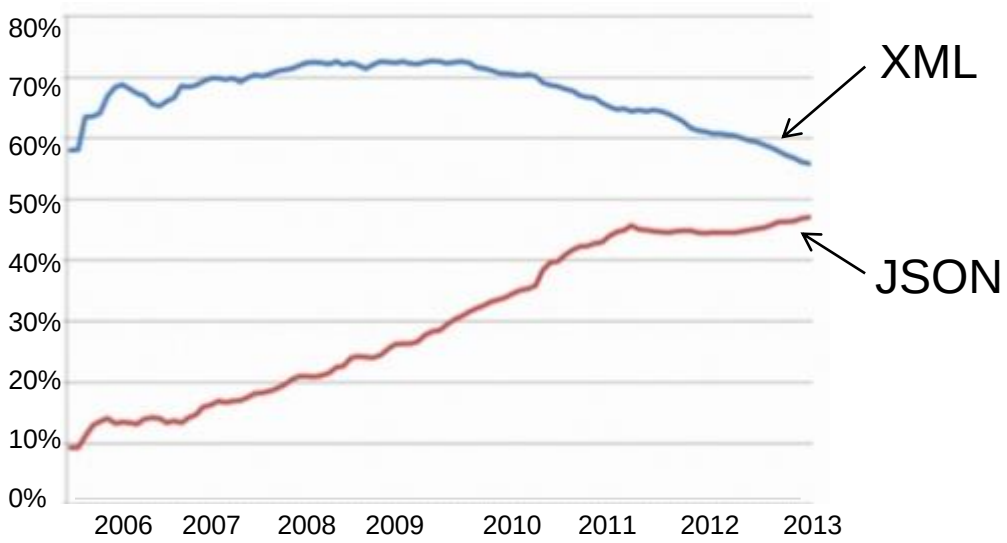
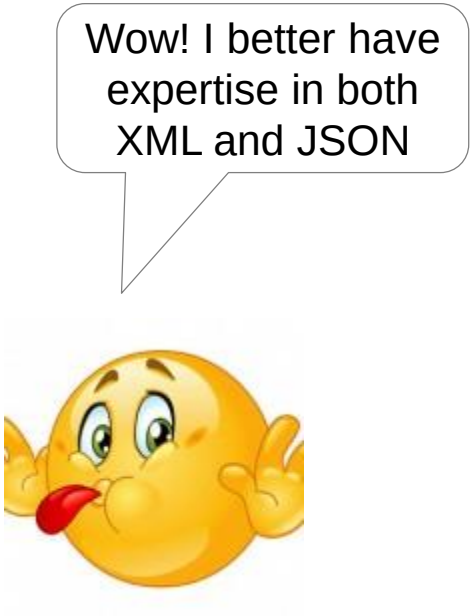
Review and outline

- History of databases (Why we use databases)
- Data models
  - Three features of data models
  - Relational model
  - Semi-structure model
    - XML model
    - JSON model
  - Graph model

Trends in XML and JSON usage





Based on directory of 11,000 web APIs listed at Programmable Web, December 2013

Example of XML-formatted data

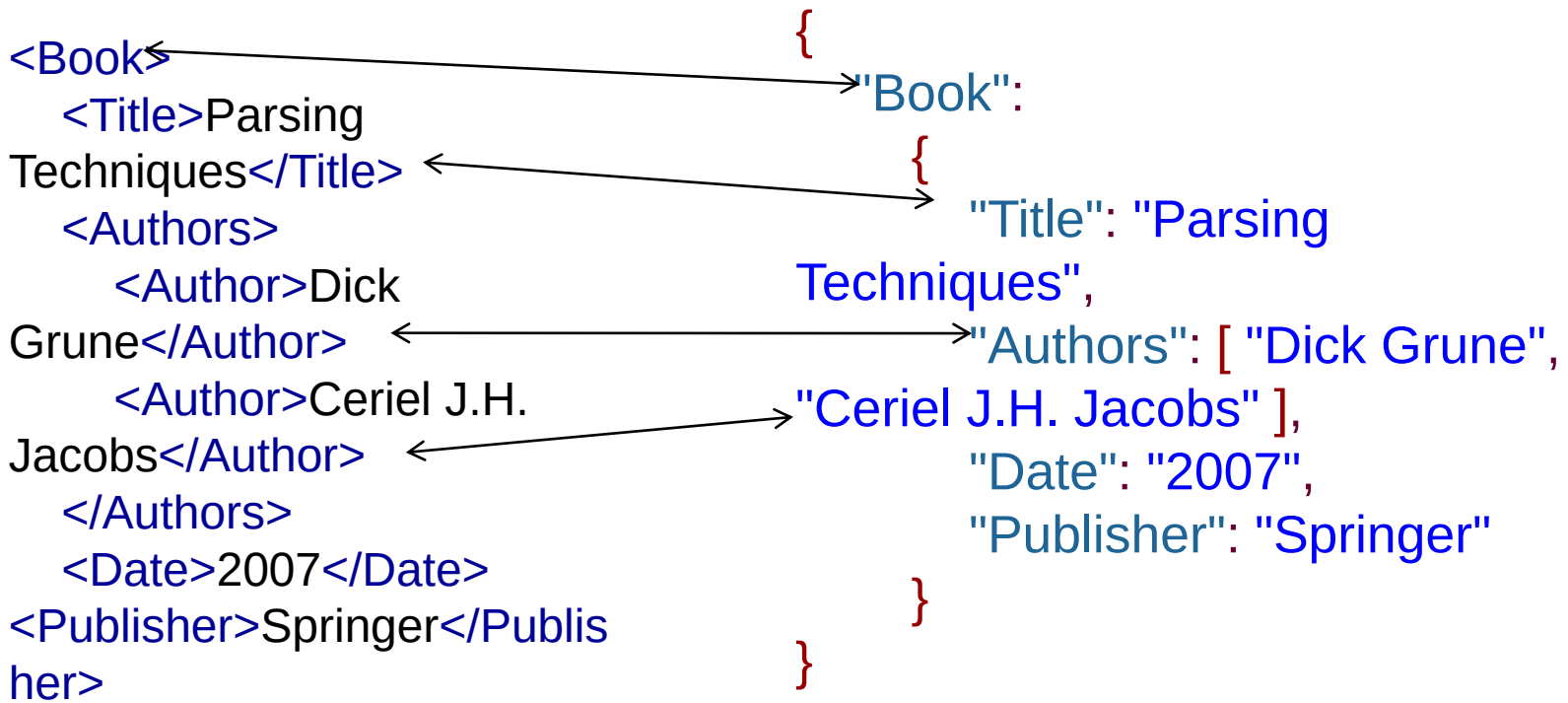
The below XML document contains data about a book: its title, authors, date of publication, and publisher.

```
<Book>
   <Title>Parsing Techniques</Title>
   <Authors>
      <Author>Dick Grune</Author>
      <Author>Ceriel J.H. Jacobs</Author>
   </Authors>
   <Date>2007</Date>
   <Publisher>Springer</Publisher>
</Book>
```

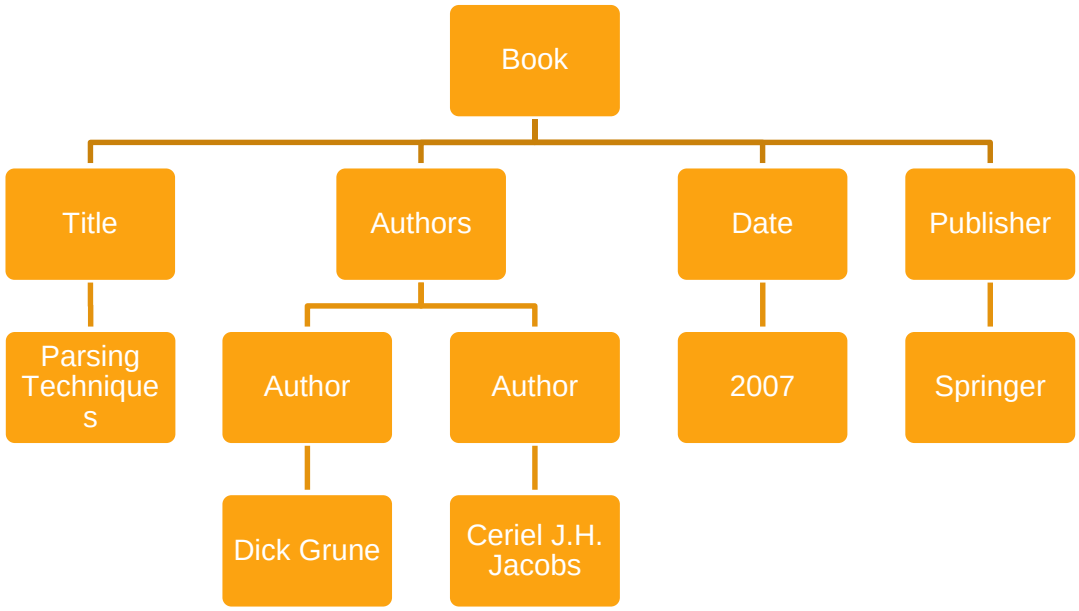
Same data, JSON-formatted

```
{
   "Book":
      {
         "Title": "Parsing Techniques",
         "Authors": [ "Dick Grune", "Ceriel J.H. Jacobs" ],
         "Date": "2007",
         "Publisher": "Springer"
      }
}
```

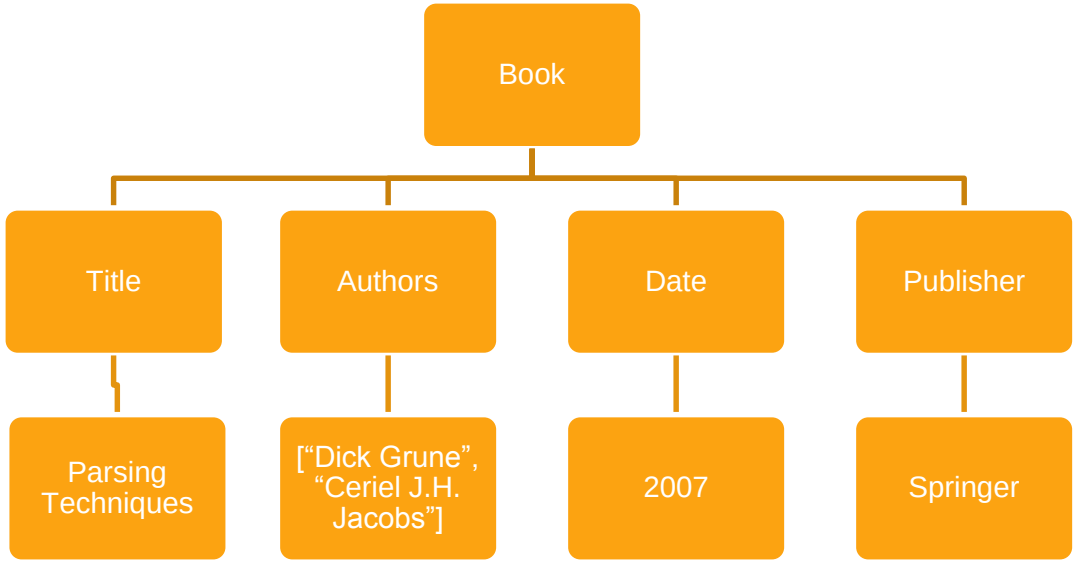
XML and JSON, side-by-side



An XML document is a tree



A JSON Object is a tree



JSON

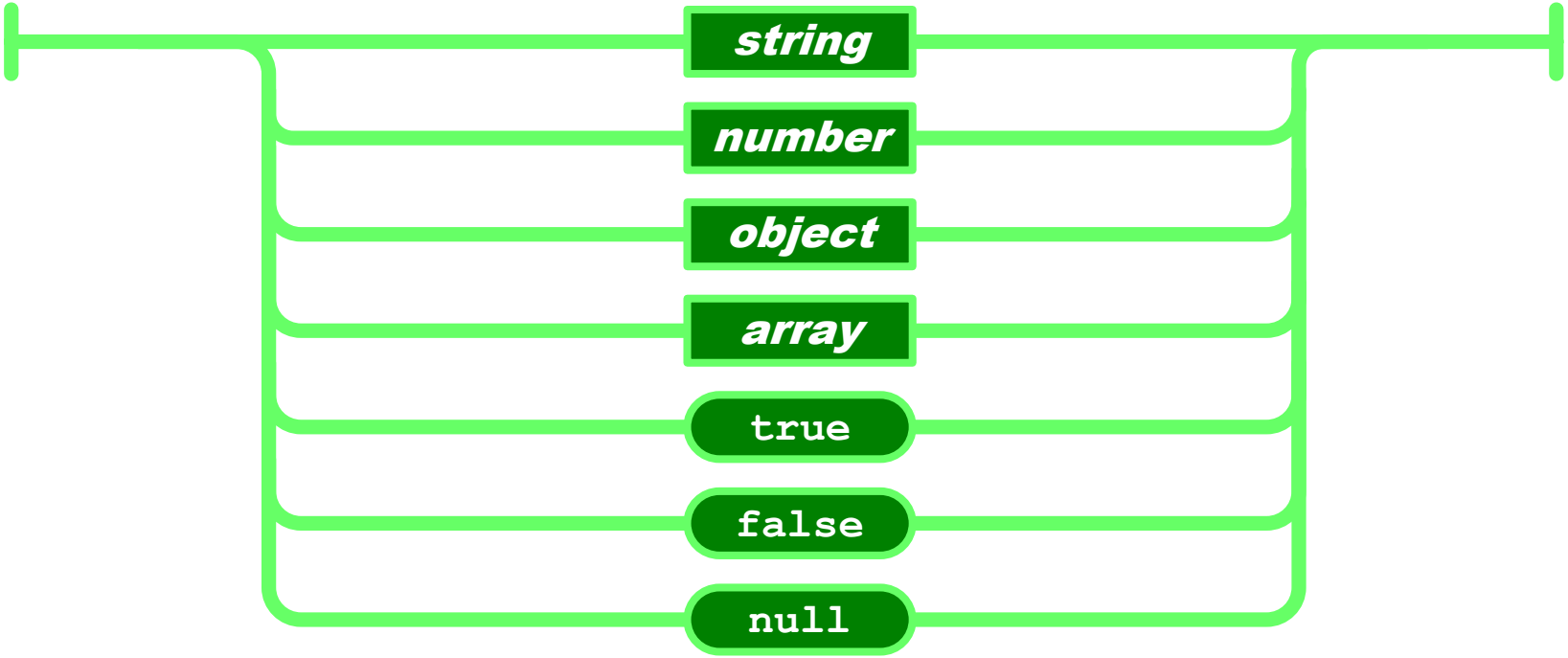
- JavaScript Object Notation
- Textual
- Light-weight.
- Easy to parse.

Values

- Strings
- Numbers
- Objects
- Arrays

- `true`
- `false`
- `null`

Value



This is a legal JSON instance

42

so is this

"Hello World"

and so is this

true

and this

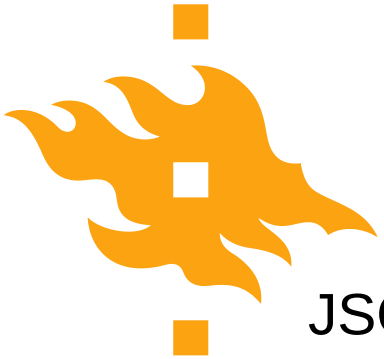
[true, null, 12, "ABC"]

Whitespace is irrelevant

```
{
  "name": "John Doe",
  "age": 30,
  "married": true
}
```

equivalent

```
{"name":"John Doe","age":30,"married":true}
```



No multiline strings

JSON does not allow multiline strings.

Legal:

```
{
   "comment": "This is a very, very long comment"
}
```

Not legal:

```
{
   "comment": "This is a very,
    very long comment"
}
```

No multiline strings (cont.)

Legal:

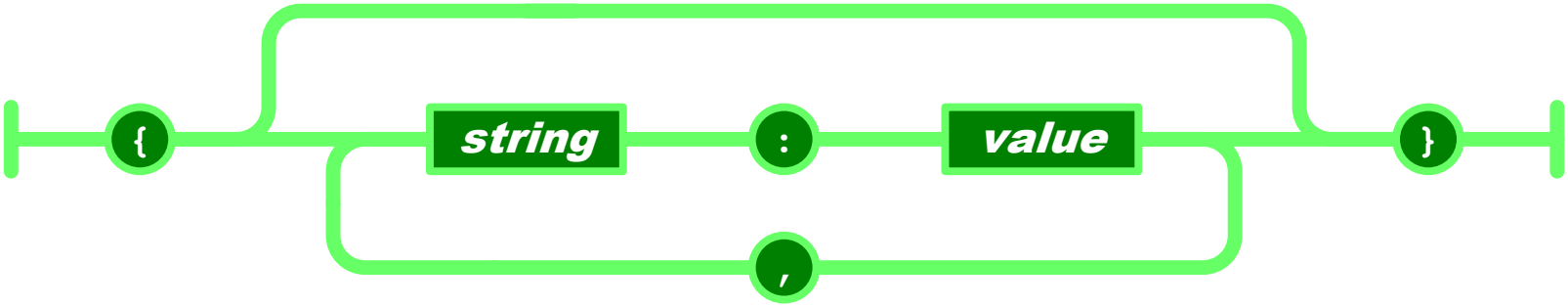
```
{
   "comment": "This is a very, \n very long comment"
}
```

Just 2 symbols

Objects in values

- Objects are unordered containers of key/value pairs
- Objects are wrapped in `{ }` (curly brackets)
- `,` (comma) separates key/value pairs
- `:` (colon) separates keys and values
- Keys are strings
- Values are JSON values

Object



Object

```
{   "format": {
        "type":       "rect",
        "width":       1920,
        "height":      1080,
        "interlace":  false,
        "framerate":  24
    }
}
```

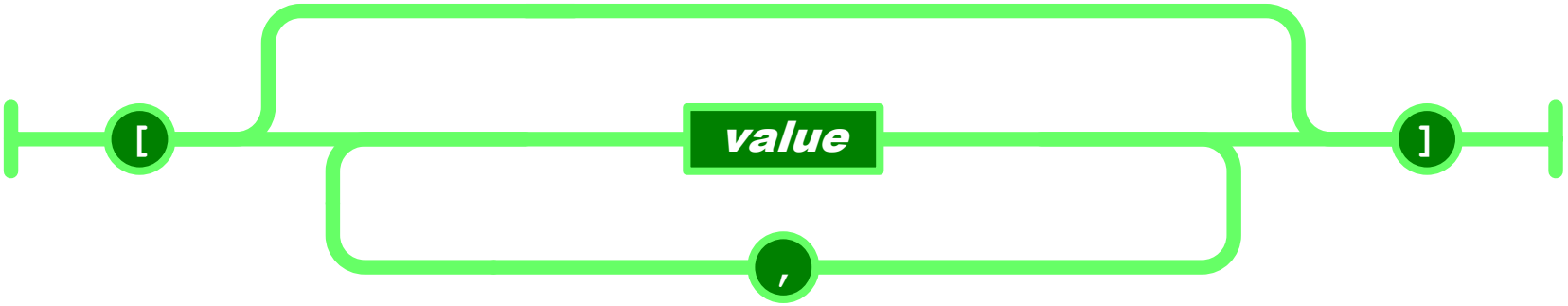
No duplicate keys

- You should consider JSON objects as containing key/value pairs.
- Just as in a database the primary keys must be unique, so too in a JSON object the keys must be unique.
- This JSON object has duplicate keys:

```
{ "Title": "A story by Mark Twain",
  "Title": "The Adventures of Huckleberry Finn" }
```

Array in values

- Arrays are ordered sequences of values
- Arrays are wrapped in `[]` (square bracket)
- `,` (comma) separates values



Array

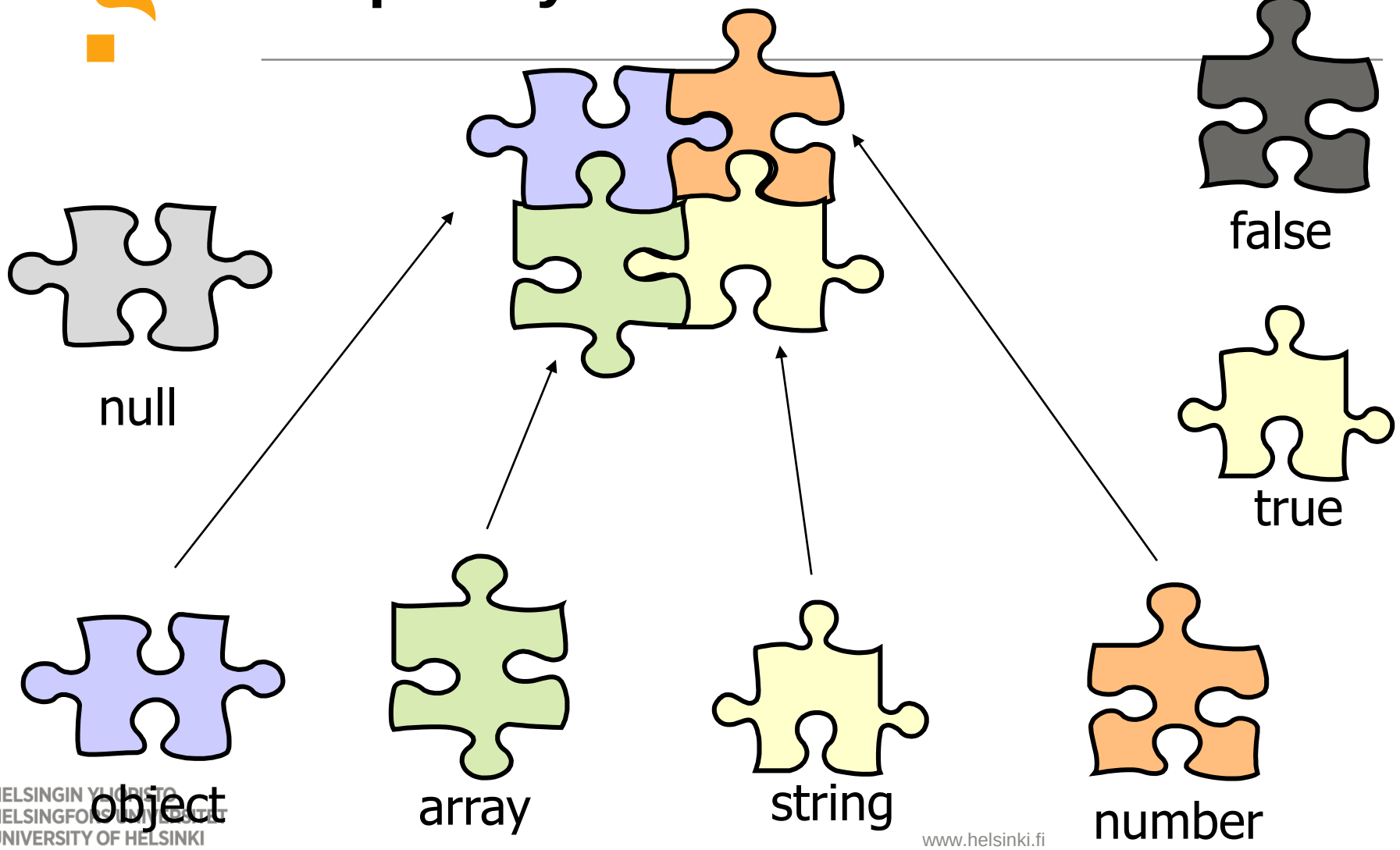
```
["Sunday", "Monday", "Tuesday",
  "Wednesday", "Thursday", "Friday",
  "Saturday"]


[
  [0, -1, 0],
  [1, 0, 0],
  [0, 0, 1]
]
```

Using JSON you can define arbitrarily complex structures

```
{
    "Book":
        {
            "Title": "Parsing Techniques",
            "Authors": [ "Dick Grune", "Ceriel J.H. Jacobs" ]
        }
}
```

```
{
    "Book":
        {
            "Title": "Parsing Techniques",
            "Authors": [
                {"name":"Dick Grune", "university": "Vrije Universiteit"},
                {"name":"Ceriel J.H. Jacobs", "university": "Vrije Universiteit"}
            ]
     }
}
```

7 simple JSON components, assemble to generate unlimited complexity



JSON Schema is used to define a valid JSON document

```
{
    "$schema": http://json-schema.org/draft-04/schema",
    "type": "object",
    "properties": {
        "Book": {
            "type": "object",
            "properties": {
                "Title": {"type": "string"},
                "Authors": {"type": "array", "minItems": 1, "maxItems": 5, "items": { "type": "string" }},
                "Date": {"type": "string"},
                "Publisher": {"type": "string", "enum": ["Springer", "MIT Press", "Harvard Press"]}
            },
            "required": ["Title", "Authors", "Date"],
        }
    },
    "required": ["Book"],
    "additionalProperties": false
}
```

"$schema" keyword

```
{
  "$schema": "http://json-schema.org/draft-04/schema#",
   …
}
```

"$schema" keyword

```
{
  "$schema": "http://json-schema.org/draft-04/schema#",
  …
}
```

The $schema keyword says: This object is a JSON schema, conforming to the schema at http://json-schema.org/draft-04/schema#.

Order of keywords is irrelevant

```
{
  "$schema": "http://json-schema.org/draft-04/schema#",
  "type": "boolean"
}
```

equivalent!

```
{
  "type": "boolean",
  "$schema": "http://json-schema.org/draft-04/schema#"
}
```

Number type

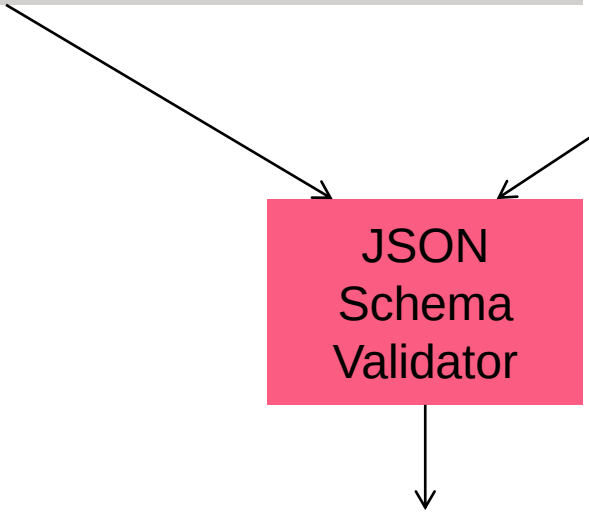
```
{
  "$schema": "http://json-schema.org/draft-04/schema#",
  "type": "number"
}
```

This schema constrains instances to contain only a number (integer, decimal, number with exponent).

Only numeric instances are valid

```
{
  "$schema": "http://json-schema.org/draft-04/schema#",
  "type": "number"
}
```

12.3



Examples of numeric values

12 99.1 12.123e3 12.123E3

12.123×10^3

"enum" keyword

- The value of enum is an array.
- The items in the array is a list of values that instances may have.
- The following schema says that the only allowable values in instances are the numbers: 2, 4, 6, 8, 10.

```
{
   "$schema": "http://json-schema.org/draft-04/schema#",
   "type": "number",
   "enum": [2, 4, 6, 8, 10]
}
```

"minimum" and "maximum" keywords

- A range of values can be specified using the "minimum" and "maximum" keywords.
- The following schema constrains instances to numbers in the range 0-100, inclusive.

```
{
    "$schema": "http://json-schema.org/draft-04/schema#",
    "type": "number",
    "minimum": 0,
    "maximum": 100
}
```

"multipleOf" keyword

- Instances can be constrained to a number that is a multiple of a number.
- The following schema says that a JSON instance must be a number 0-100, inclusive, and must be a multiple of 2.

```
{
    "$schema": "http://json-schema.org/draft-04/schema#",
    "type": "number",
    "minimum": 0,
    "maximum": 100,
    "multipleOf": 2
}
```

Here are four schema-valid values: 0 2 4 100

Integer type

```
{
  "$schema": "http://json-schema.org/draft-04/schema#",
  "type": "integer"
}
```

This schema constrains instances to contain only an integer.

Here are two schema-valid values: -900 129

String type

```
{
  "$schema": "http://json-schema.org/draft-04/schema#",
  "type": "string"
}
```

This schema constrains instances to contain only a string.

"maxLength" keyword

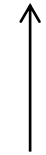
The maximum length of a string is constrained using the "maxLength" keyword.

```
{
    "$schema": "http://json-schema.org/draft-04/schema#",
    "type": "string",
    "maxLength": 20
}
```

Here is a schema-valid value: "Hello World"

Value of "maxLength"

```
{
    "$schema": "http://json-schema.org/draft-04/schema#",
    "type": "string",
    "maxLength": 5
}
```



Must be an integer, ≥ 0

"minLength" keyword

- The "minLength" keyword is used to specify the shortest string length allowed.
- The value of "minLength" must be an integer, greater than or equal to 0.
- The default value is 0.

```
{
    "$schema": "http://json-schema.org/draft-04/schema#",
    "type": "string",
    "minLength": 5,
    "maxLength": 20
}
```

"pattern" keyword

- The set of characters that can be used in a string can be constrained using the "pattern" keyword, whose value is a regular expression.
- The following schema constrains the set of characters to the lower- and upper-case letters of the English alphabet, plus the space character.

```
{
    "$schema": "http://json-schema.org/draft-04/schema#",
    "type": "string",
    "maxLength": 20,
    "pattern": "^[a-zA-Z ]*$"
}
```

"pattern" value is a regular expression

- The value of "pattern" is a regular expression.
- The regular expressions are not implicitly anchored so you must use the start and end anchors (^…$).

```
{
    "$schema": "http://json-schema.org/draft-04/schema#",
    "type": "string",
    "maxLength": 20,
    "pattern": "^[a-zA-Z ]*$"
}
```

This symbol indicates that a string must *end* with the letters of the alphabet plus space.

This symbol indicates that a string must *start* with the letters of the alphabet plus space.

How to read this JSON Schema

```
{
    "$schema": "http://json-schema.org/draft-04/schema#",
    "type": "string",
    "maxLength": 20,
    "pattern": "^[a-zA-Z ]*$"
}
```

> “
>
> The string in a JSON instance cannot have a length greater than 20 characters and the characters must be a-z, A-Z, or space.
>
> ”

Components of regular expression

Basic pattern	Matching string
x	The character x
.	Any character, except newline
[xyz ...]	Any of the characters, x, y, z, …
Repetition operators:	
R?	R is optional (zero or one occurrence)
R*	Zero or more occurrences of R
R+	One or more occurrences of R
Compositional operators:	
R_1R_2	An R_1 followed by an R_2
$R_1\|R_2$	Either an R_1 or an R_2

Acknowledgement: This table comes from *Modern Compiler Design* by Grune et al, p62.

Use a JSON Schema validator from a Java program

Want to validate a JSON instance against a JSON Schema from a Java program? Download:

json-schema-validator-2.2.5-lib.jar

from:

https://bintray.com/fge/maven/json-schema-validator/view

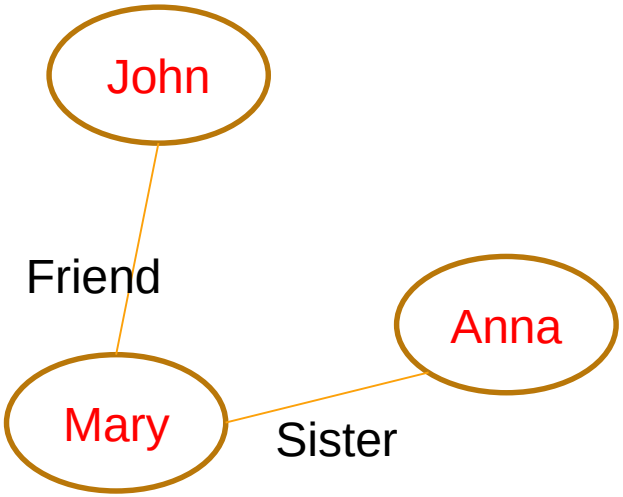
and then read the documentation on the Java API.

- Watch a video on JSON tutorial
- https://www.youtube.com/watch?v=_NFkzw6oFtQ

Outline

- History of databases
- Data models
  - Relational model
  - Semi-structure model
    - XML model
    - JSON model
  - Graph model

Graph data model

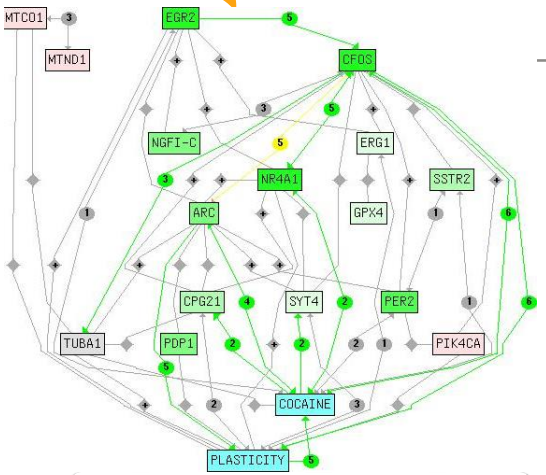


Nodes table:

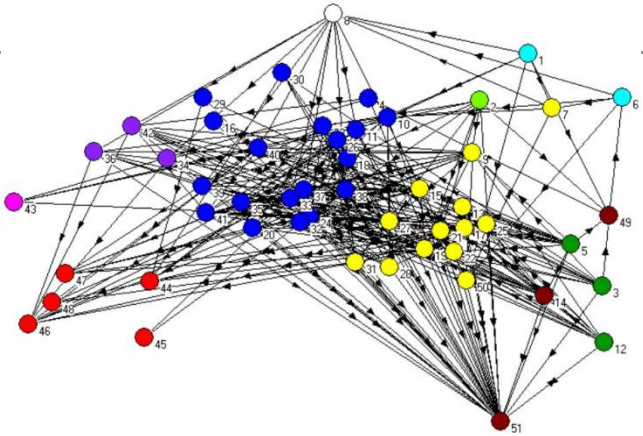
1. John
2. Mary
3. Anna

Edge table:
John, Mary, Friend
Mary, Anna, Sister

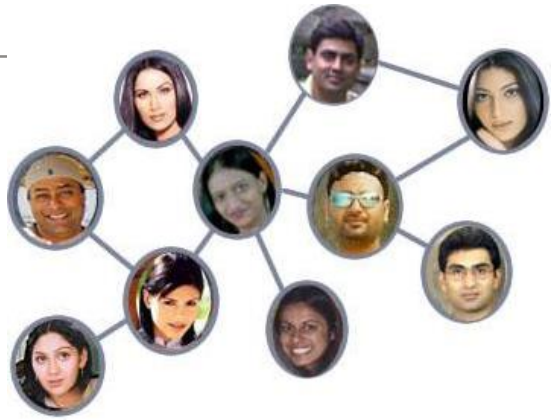
Graphs from the Real World



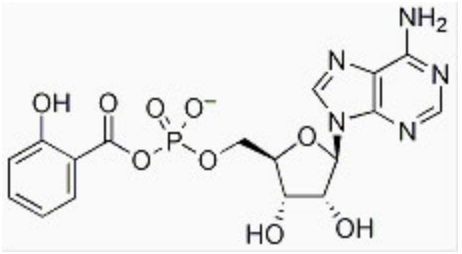
Biological Network



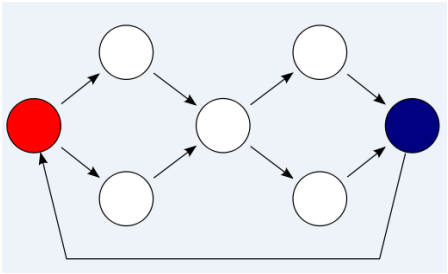
Ecological Network



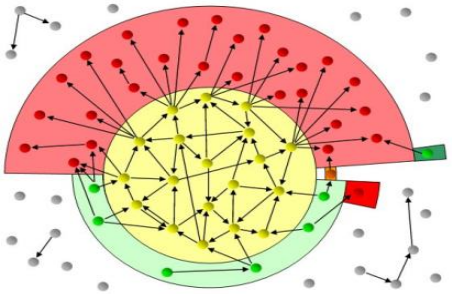
Social Network



Chemical Network



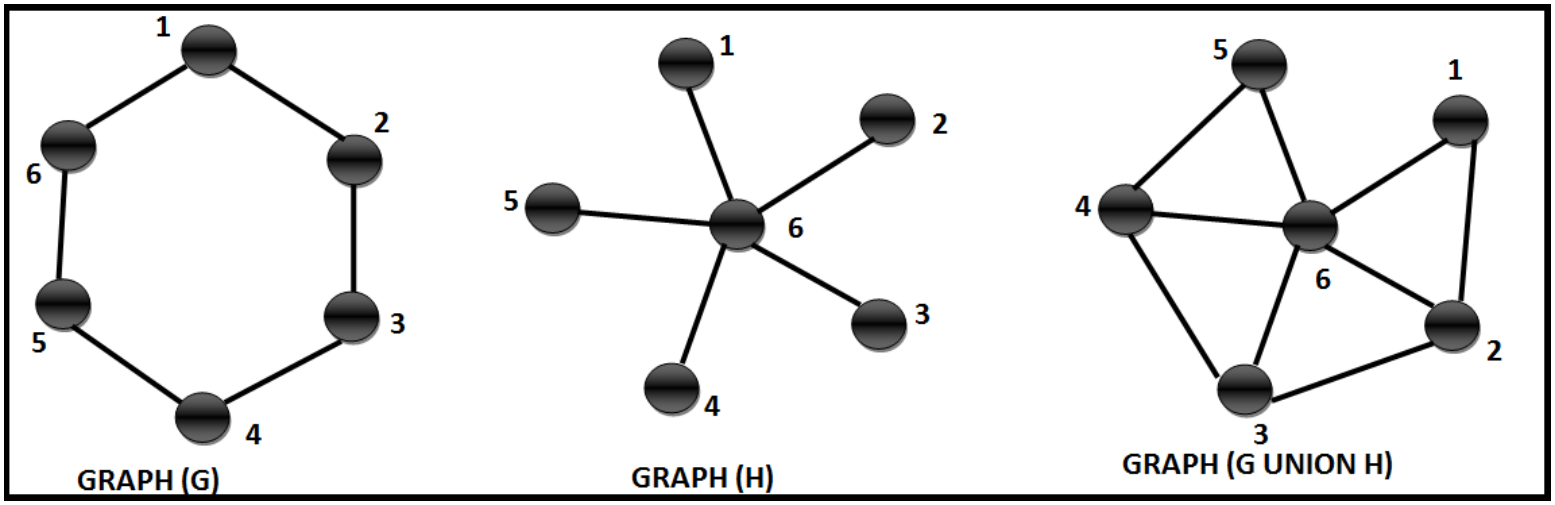
Program Flow



Web Graph

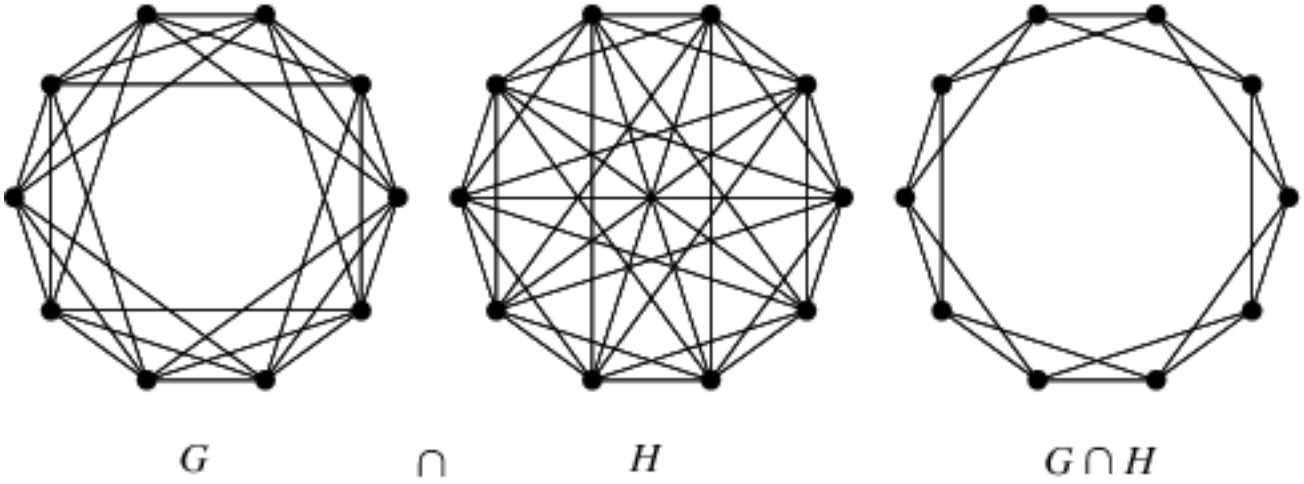
Some operations on graphs

- Graph union and graph intersection



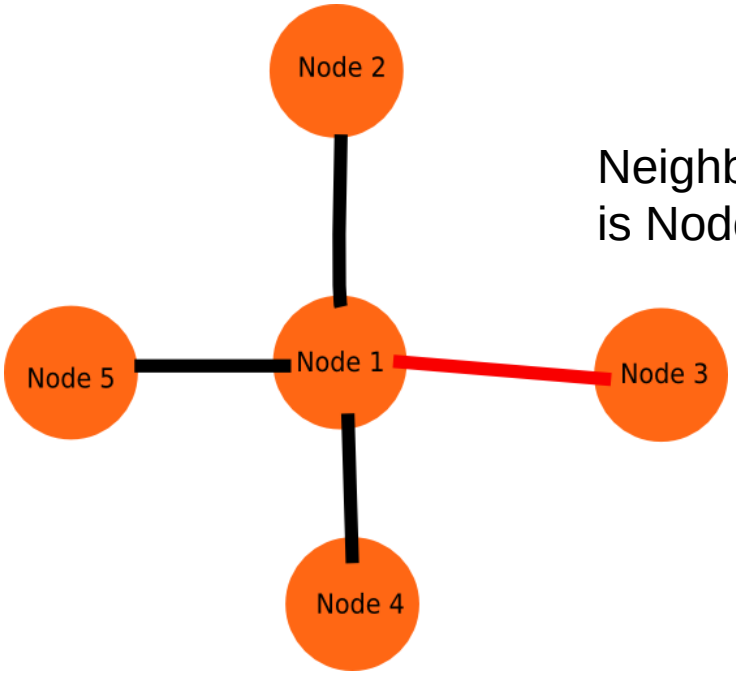
Some operations on graphs

- Graph union and graph intersection



Some operations on graphs

- Graph union and graph intersection
- GetNeighbour



Neighbour of Node 3
is Node 1

Some operations on graphs

- Graph union and graph intersection
- GetNeighbour
- Community detection

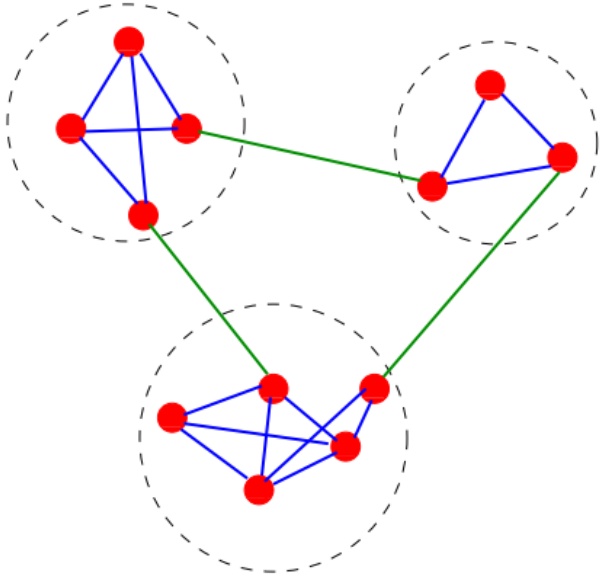
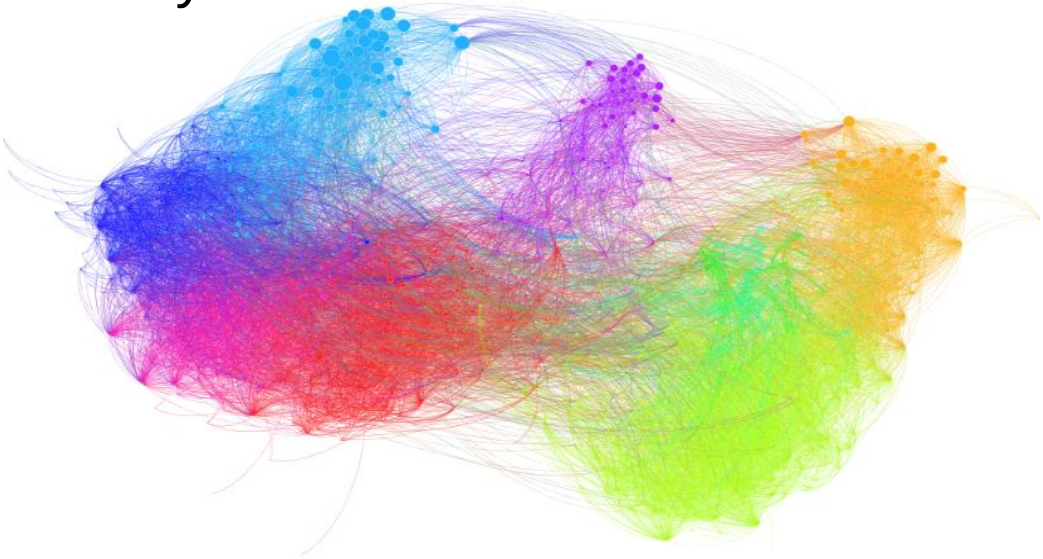


FIG. 1 A simple graph with three communities, enclosed by the dashed circles. Reprinted figure with permission from Ref. (Fortunato and Castellano, 2009). ©2009 by Springer.

Some operations on graphs

- Graph union and graph intersection
- GetNeighbour
- Community detection



Defining Communities

- Intuition: There are more edges inside a community than edges connected with the rest of the graph

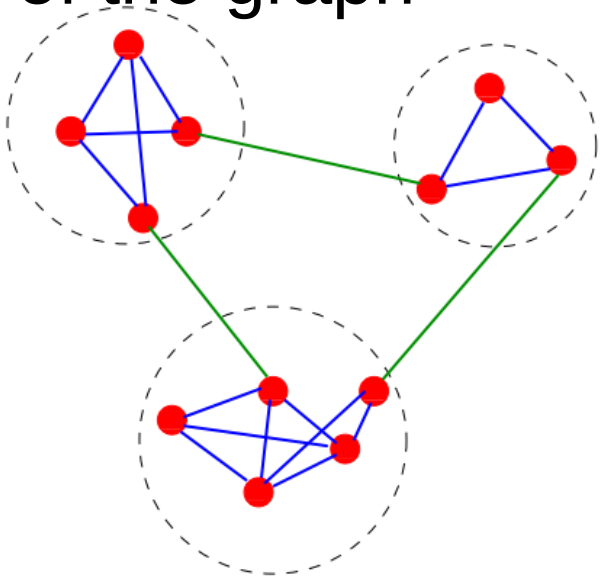


FIG. 1 A simple graph with three communities, enclosed by the dashed circles. Reprinted figure with permission from Ref. (Fortunato and Castellano, 2009). ©2009 by Springer.

General Challenges for community detection

- Many clustering problems are **NP**-hard. Even polynomial time approaches may be too expensive
  - Call for scalable solutions
- Concepts of “cluster”, “community” are not quantitatively well defined

Graph data model

First watch a video on graph modelling

https://www.youtube.com/watch?v=NH6WoJHN4UA

Summary

- JSON is a widely used semi-structure model like XML
- Graph model is an important data model in NoSQL databases