Introduction to Database Systems
CSE 414

query language we use over JSON

Lecture 12: Json and SQL++

MONDAY OCT 22

Announcements

- Office hours changes this week
  - Check schedule
- HW 4 due next Tuesday
  - Start early
- WQ 4 due tomorrow

JSON - Overview

- JavaScript Object Notation = lightweight text-based open standard designed for human-readable data interchange. Interfaces in C, C++, Java, Python, Perl, etc.

- The filename extension is .json.

We will emphasize JSon as semi-structured data

JSon Terminology

- Data is represented in name/value pairs.
- Curly braces hold objects
  - Each object is a list of name/value pairs separated by , (comma)
  - Each pair is a name is followed by ':'(colon) followed by the value
- Square brackets hold arrays and values are separated by ,(comma).

lists of stuff of the same type

JSon Syntax

```
{  "book": [
      {"id":"01",
       "language": "Java",
       "author": "H. Javeson",
       "year": 2015
      },
      {"id":"07",
       "language": "C++",
       "edition": "second"
       "author": "E. Sepp",
       "price": 22.25
      }
   ]
}
```

JSon Data Structures

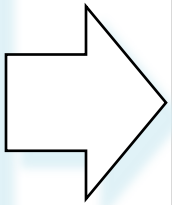
- Objects, i.e., collections of name-value pairs:
  - `{“name1”: value1, “name2”: value2, …}`
  - “name” is also called a “key”

- *Ordered* lists of values:
  - `[obj1, obj2, obj3, ...]`

Avoid Using Duplicate Keys

The standard allows them, but many implementations don't

```
{"id":"07",
   "title": "Databases",
   "author": "Garcia-Molina",
   "author": "Ullman",
   "author": "Widom"
}
```



```
{"id":"07",
   "title": "Databases",
   "author": ["Garcia-Molina",
              "Ullman",
              "Widom"]
}
```

JSon Primitive Datatypes

- Number

  doubles or integers; doesnt specify between the two

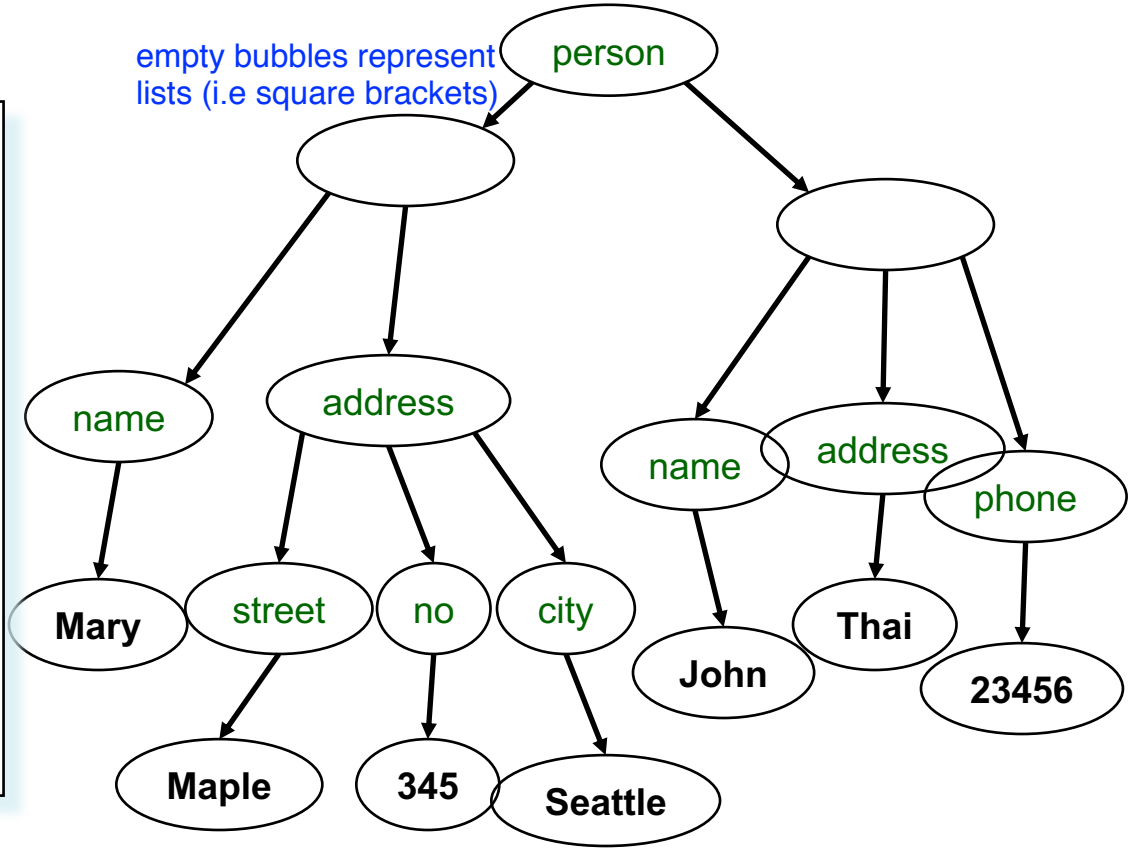
- String
  - Denoted by double quotes

- Boolean
  - Either `true` or `false`

- nullempty

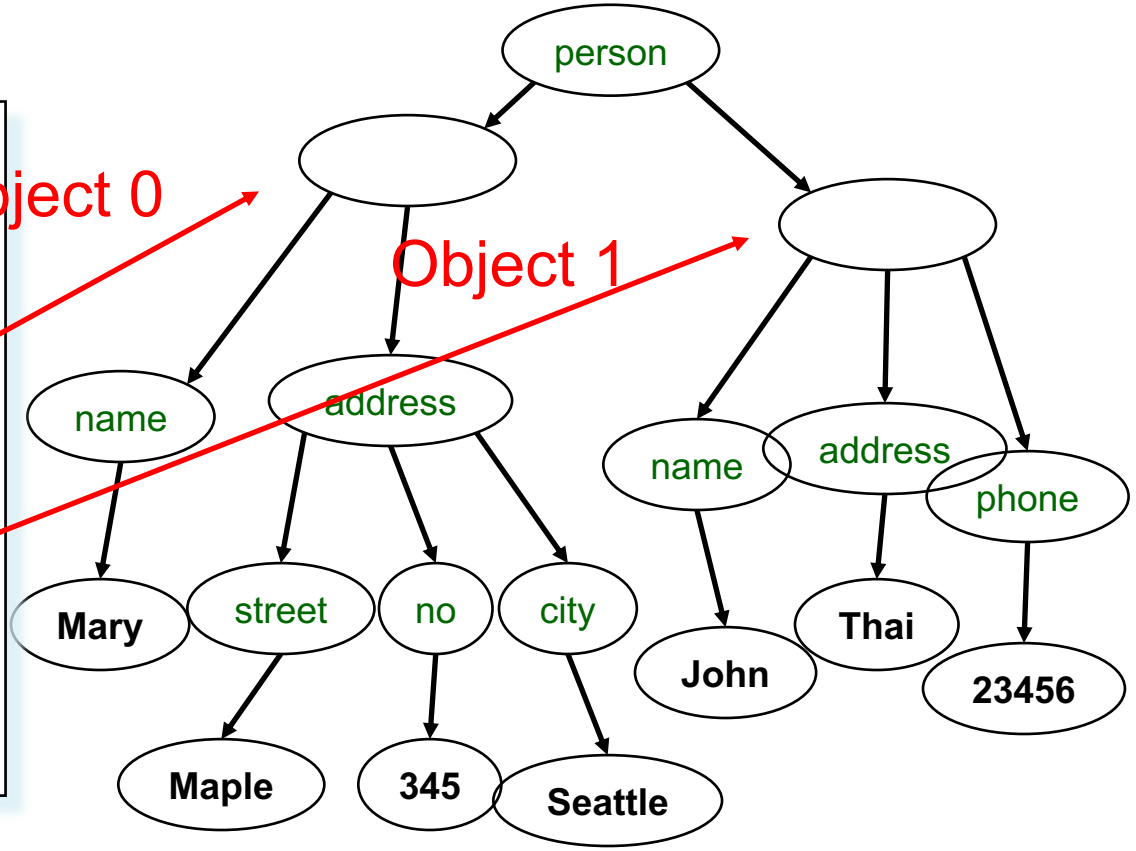
JSon Semantics: a Tree !

```
{"person":
   [ {"name": "Mary",
      "address":
        {"street":"Maple",
         "no":345,
         "city": "Seattle"}},
     {"name": "John",
      "address": "Thailand",
      "phone":2345678}}
   ]
}
```



JSon Semantics: a Tree !

```
{"person":
   [ {"name": "Mary",
      "address":
        {"street":"Maple",
         "no":345,
         "city": "Seattle"}},
     {"name": "John",
      "address": "Thailand",
      "phone":2345678}}
   ]
}
```



Recall: arrays are *ordered* in Json!

ORDER MATTERS, both in queries and any other representation

JSon Data

- JSon is self-describing

the structure itself dictates the names;
i.e. schema isnt consistent across file

- Schema elements become part of the data
  - Relational schema: `person(name,phone)`
  - In Json "`person`", "`name`", "`phone`" are part of the data, and are repeated many times
- Consequence: JSon is much more flexible
- JSon = semistructured data

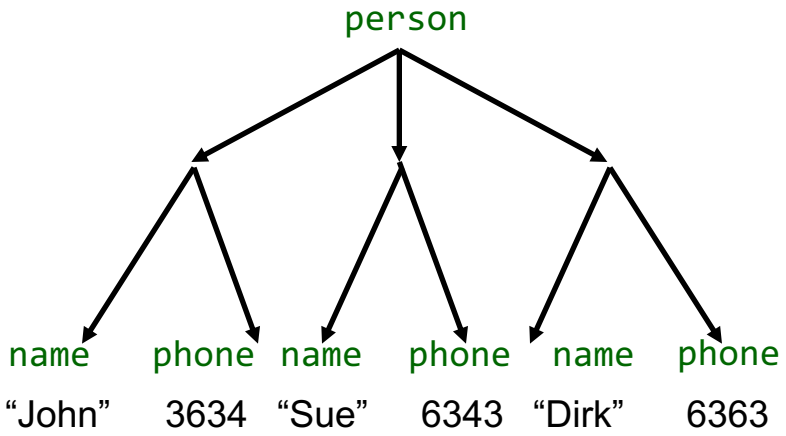
Semi-Structured Data

Monday oct 22

Missing attributes

{“person”: [ ]}

Mapping Relational Data to JSon



Person

name	phone
John	3634
Sue	6343
Dirk	6363

```
{“person”: [
   {“name”: “John”, “phone”:3634},
   {“name”: “Sue”,  “phone”:6343},
    {“name”: “Dirk”, “phone”:6383}
   ]
}
```

These nesting allows us to replace places before where we would used to use foreign keys, and then do a join.
—> rather than simply having a separate table, store an object at each attribute (i.e. look at Orders below)

Mapping Relational Data to JSon

May inline multiple relations based on foreign keys

Person

name	phone
John	3634
Sue	6343

Orders

personName	date	product
John	2002	Gizmo
John	2004	Gadget
Sue	2002	Gadget

```
{“Person”:
 [{"name": "John",
   "phone":3646,
   "Orders":[
    {"date":2002,"product":"Gizmo"},
    {“date”:2004,"product":"Gadget"}
   ]
  },
  {"name": "Sue",
   "phone":6343,
   "Orders":[
   {"date":2002,"product":"Gadget"}
   ]
  }
 ]
}
```

Discussion: Why Semi-Structured Data?

- Semi-structured data model is good as *data exchange formats*
  - i.e., exchanging data between different apps
  - Examples: XML, JSon, Protobuf (protocol buffers)

- Increasingly, systems use them as a data model for databases:
  - SQL Server supports for XML-valued relations
  - CouchBase, MongoDB: JSon as data model
  - Dremel (BigQuery): Protobuf as data model

Query Languages for Semi-Structured Data

- XML: XPath, XQuery (see textbook)
  - Supported inside many RDBMS (SQL Server, DB2, Oracle)
  - Several standalone XPath/XQuery engines

- Protobuf: SQL-ish language (Dremel) used internally by google, and externally in BigQuery

- JSon:
  - CouchBase: N1QL
  - Asterix: SQL++ (based on SQL)
  - MongoDB: has a pattern-based language
  - JSONiq http://www.jsoniq.org/

- AsterixDB
  - No-SQL database system
  - Developed at UC Irvine
  - Now an Apache project, being incorporated into CouchDB (another No-SQL DB)

- Uses Json as data model
- Query language: SQL++
  - SQL-like syntax for Json data

They are hiring!

Asterix Data Model (ADM)

- Based on the Json standard
- Objects:
  - `{“Name”: “Alice”, “age”: 40}`
  - Fields must be distinct:
    `{“Name”: “Alice”, “age”: 40, “age”:50}`

- Ordered arrays:
  - `[1, 3, “Fred”, 2, 9]`
  - Can contain values of different types
- Multisets (aka bags):
  - `{{1, 3, “Fred”, 2, 9}}`
  - Mostly internal use only but can be used as inputs
  - All multisets are converted into ordered arrays (in arbitrary order) when returned at the end

Examples

What do these queries return?

```
SELECT x.phone
FROM [{"name": "Alice", "phone": [300, 150]}] AS x;
```

```
SELECT x.phone
FROM {{ {"name": "Alice", "phone": [300, 150]} }} AS x;
```

returning from a collection of objects; needs a list

Can only query from multi-set or array (not object)

```
-- error
SELECT x.phone
FROM {"name": "Alice", "phone": [300, 150]} AS x;
```

Datatypes

uses more specific types

- Boolean, integer, float (various precisions), geometry (point, line, …), date, time, etc

{1 … n} standard list of integers

- UUID = universally unique identifier
  Use it as a system-generated unique key

null v.s. missing

- {"age": null} = the value NULL (like in SQL)
- {"age": missing} = { } = really missing

```
SELECT x.b
FROM [{"a":1, "b":2},
      {"a":3, "b":null }] AS x;
```

Answer
```
{"b": 2}
{"b": null }
```

null v.s. missing

- {"age": null} = the value NULL (like in SQL)
- {"age": missing} = { } = really missing

```
SELECT x.b
FROM [{"a":1, "b":2},
      {"a":3}]
AS x;
```

Answer
```
{"b": 2}
{ }
```

```
SELECT x.b
FROM [{"a":1, "b":2},
      {"a":3, "b":missing }]
AS x;
```

Answer
```
{"b": 2}
{ }
```

Finally, a language that we can use!

```
SELECT x.age
FROM Person AS x
WHERE x.age > 21
GROUP BY x.gender
HAVING x.salary > 10000
ORDER BY x.name;
```

is exactly the same as

```
FROM Person AS x
WHERE x.age > 21
GROUP BY x.gender
HAVING x.salary > 10000
SELECT x.age
ORDER BY x.name;
```

FWGHOS lives!!

SQL++ Overview

- Data Definition Language: create a
  - Type
  - Dataset (like a relation)
  - Dataverse (a collection of datasets)
  - Index
    - For speeding up query execution

- Data Manipulation Language: `SELECT-FROM-WHERE`

Dataverse

A Dataverse is a Database (i.e., collection of tables)

always working in a dataverse in SQL++

```
CREATE DATAVERSE myDB
CREATE DATAVERSE myDB IF NOT EXISTS

DROP DATAVERSE myDB
DROP DATAVERSE myDB IF EXISTS

USE myDB
```

ALWAYS have to put this at top of hw file

Closed Types

```
USE myDB;
DROP TYPE PersonType IF EXISTS;
CREATE TYPE PersonType AS CLOSED {
    name: string,
    age: int,
    email: string?
}
```

optional field

```
{"name": "Alice", "age": 30, "email": "a@alice.com"}

{"name": "Bob", "age": 40}
```

In closed types, you canNOT define tuples that have attribute names not found within type, although you may leave some out (but only those marked as optional)

```
-- not OK:
{"name": "Carol", "phone": "123456789"}
```

Type

- Defines the schema of a collection
- It lists all *required* fields
- Fields followed by `?` are *optional*

- `CLOSED` type = no other fields allowed
- `OPEN` type = other fields allowed

Open Types

```
USE myDB;
DROP TYPE PersonType IF EXISTS;
CREATE TYPE PersonType AS OPEN {
    name: string,
    age: int,
    email: string?
}
```

```
{"name": "Alice", "age": 30, "email": "a@alice.com"}

{"name": "Bob", "age": 40}

-- now it's OK:
{"name": "Carol", "age":20, "phone": "123456789"}
```

Types with Nested Collections

```
USE myDB;
DROP TYPE PersonType IF EXISTS;
CREATE TYPE PersonType AS CLOSED {
   Name : string,
   phone: [string]
}
```

```
{"Name": "Carol", "phone": ["1234”]}
{"Name": "David", "phone": [“2345”, “6789”]}
{"Name": "Evan",  "phone": [ ]}
```

Datasets

- Dataset = relation

- Must have a type
  - Can be a trivial `OPEN` type
- Must have a key
  - Can also be a trivial one

Dataset with Existing Key

```
USE myDB;
DROP TYPE PersonType IF EXISTS;
CREATE TYPE PersonType AS CLOSED {
   name: string,
   email: string?
}
```

```
{“name”: “Alice”}
{“name”: “Bob”}
…
```

```
USE myDB;
DROP DATASET Person IF EXISTS;
CREATE DATASET Person(PersonType) PRIMARY KEY Name;
```

type of dataset we use (i.e. schema)

Dataset with Auto Generated Key

```
USE myDB;
DROP TYPE PersonType IF EXISTS;
CREATE TYPE PersonType AS CLOSED {
    myKey: uuid,
    Name : string,
    email: string?
}
```

autogenerated; do NOT put in tuple

```
{"name": "Alice"}
{"name": "Bob"}
…
```

Note: no myKey inserted as it is autogenerated

```
USE myDB;
DROP DATASET Person IF EXISTS;
CREATE DATASET Person(PersonType)
    PRIMARY KEY myKey AUTOGENERATED;
```

This is no longer 1NF

- NFNF = Non First Normal Form
- One or more attributes contain a collection
- One extreme: a single row with a huge, nested collection
- Better: multiple rows, reduced number of nested collections