Introduction to Database Systems
CSE 414

Lecture 12: Json and SQL++

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).

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"
}
```

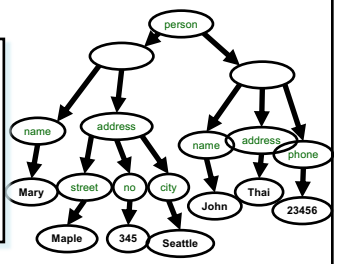
```
{"id":"07",
  "title": "Databases",
  "author": ["Garcia-Molina",
             "Ullman",
             "Widom"]
}
```


JSon Primitive Datatypes

- Number
- 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}}
  ]
}
```

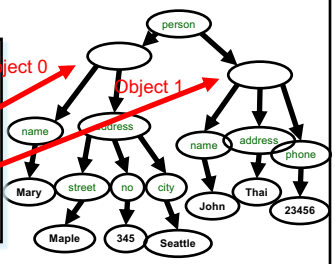


JSon Semantics: a Tree !

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

Object 0

Object 1

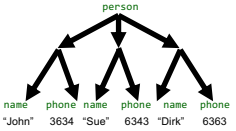


Recall: arrays are *ordered* in Json!

JSon Data

- JSon is self-describing
- 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

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}
  ]
}
```

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

- 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~~}`

Can't have repeated fields

- 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;
```

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

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

Datatypes

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

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

DROP DATAVERSE myDB
DROP DATAVERSE myDB IF EXISTS

USE myDB
```

Closed Types

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

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

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

-- 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;
```

Dataset with Auto Generated Key

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

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

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

Note: no `myKey` inserted as it is 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