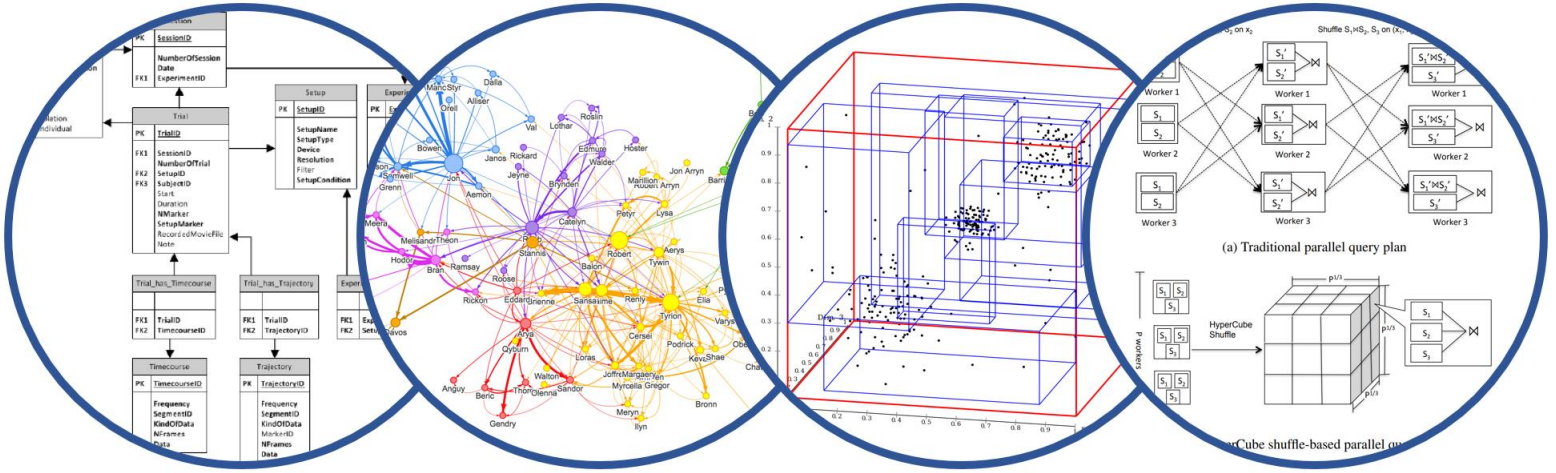

Introduction to Data Management

SQL++

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University of Washington, Seattle

Announcements

- Please fill out the course evals
- Monday, Dec. 9, Final Review session
  - CSE2 G10
  - 10:30 – 12:20 (we may finish earlier)

Recap: semistructure data

- Loose terminology; any "parsable" file qualifies
- Self-describing, “data first”
- We discuss only Json
- Other formats: protobuf, XML, csv

JSON Standard – Rules of the Game

- JavaScript Object Notation (JSON)
  - "Lightweight text-based open standard designed for **human-readable** data interchange"

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

Types

Primitives include:

- String (in quotes)
- Numeric (unquoted number)
- Boolean (unquoted true/false)
- Null (literally just null)

JSON Standard – Rules of the Game

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  - "Lightweight text-based open standard designed for **human-readable** data interchange"

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

Types

Objects are an *unordered* collection of name-value pairs:

- "name": <value>
- Values can be primitives, objects, or arrays
- Enclosed by { }

JSON Standard – Rules of the Game

- JavaScript Object Notation (JSON)
  - "Lightweight text-based open standard designed for **human-readable** data interchange"

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

Types

Objects are an *unordered* collection of name-value pairs:

- "name": <value>
- Values can be primitives, objects, or arrays
- Enclosed by { }

JSON Standard – Rules of the Game

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

Types

Arrays are an *ordered* list of values:
- Order is preserved in interpretation
- May contain any mix of types
- Enclosed by [ ]

JSON Standard – Rules of the Game

- JSON Standard too expressive
  - Implementations **restrict syntax**
  - Ex: Duplicate fields

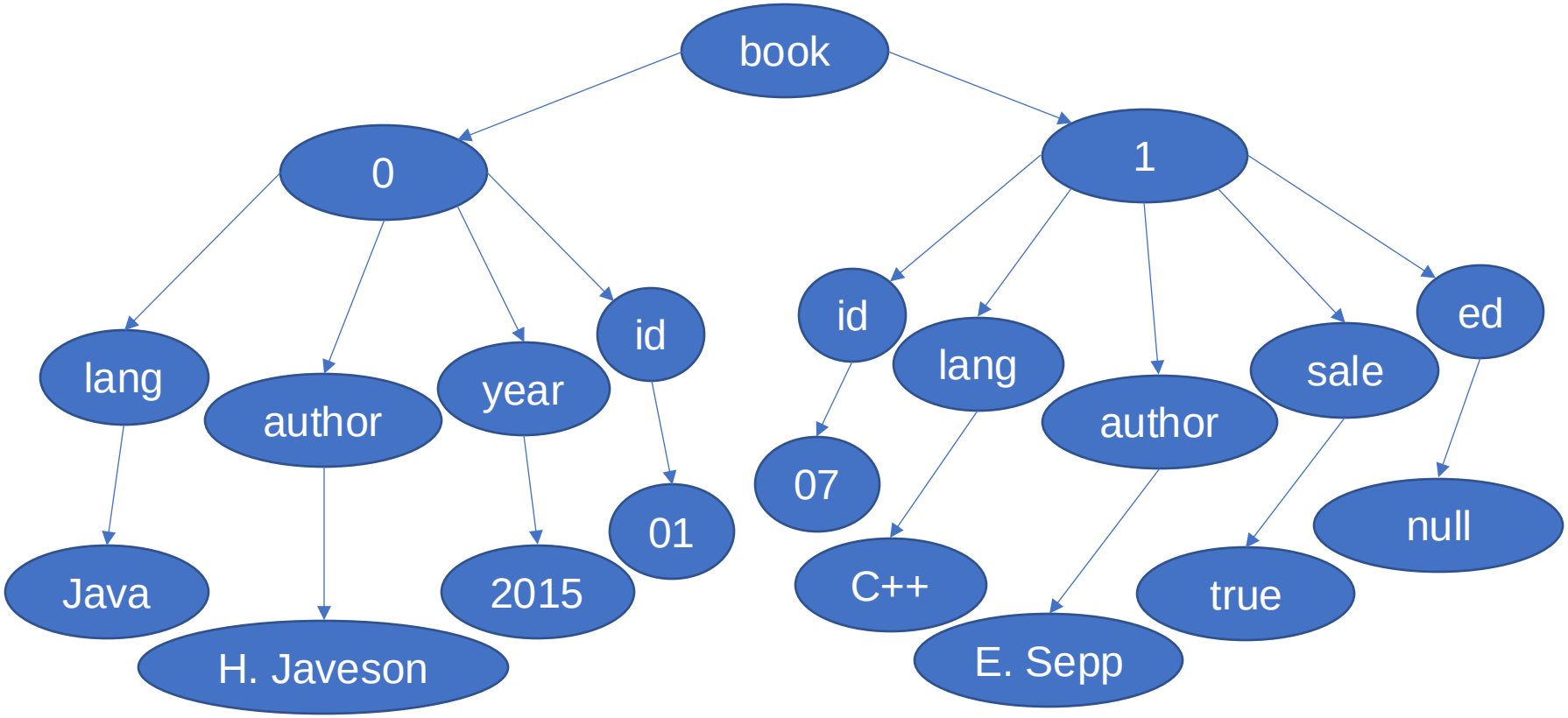
NOT ALLOWED
(duplicated authors)

```
{
   "id": "01",
   "language": "Java",
   "author": "H. Javeson",
   "author": "D. Suciu",
   "author": "A. Cheung",
   "year": 2015
}
```

OK
(author array)

```
{
   "id": "01",
   "language": "Java",
   "author": ["H. Javeson",
              "D. Suciu",
              "A. Cheung"],
   "year": 2015
}
```

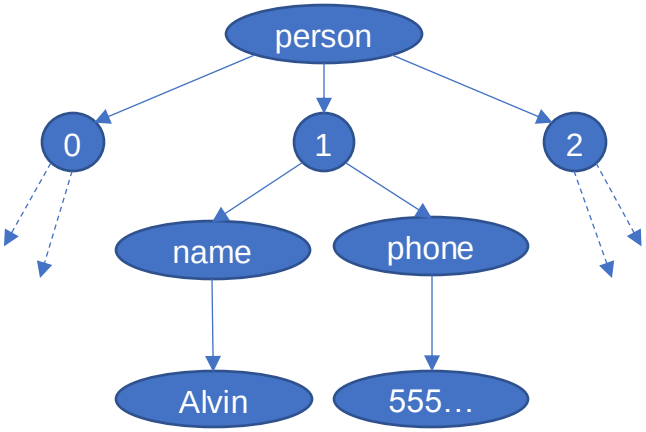
Semi-Structured Data Encodes a Tree



From Relational to Semi-Structured

Person

Name	Phone
Dan	555-123-4567
Alvin	555-234-5678
Magda	555-345-6789




```
{
   "person":[
      {
         "name": "Dan",
         "phone": "555-123-4567"
      },
      {
         "name": "Alvin",
         "phone": "555-234-5678"
      },
      {
         "name": "Magda",
         "phone": "555-345-6789"
      }
   ]
}
```

From Relational to Semi-Structured

Person

Name	Phone
Dan	555-123-4567
Alvin	555-234-5678
Magda	NULL

```
{
   "person":[
      {
         "name": "Dan",
         "phone": "555-123-4567"
      },
      {
         "name": "Alvin",
         "phone": "555-234-5678"
      },
      {
         "name": "Magda",
         "phone": null
      }
   ]
}
```

From Relational to Semi-Structured

Person

Name	Phone
Dan	555-123-4567
Alvin	555-234-5678
Magda	NULL

```
{
   "person":[
      {
         "name": "Dan",
         "phone": "555-123-4567"
      },
      {
         "name": "Alvin",
         "phone": "555-234-5678"
      },
      {
         "name": "Magda"
      }
   ]
}
```

OK for field to be missing!

From Relational to Semi-Structured

Person

Name	Phone
Dan	???
Alvin	555-234-5678
Magda	555-345-6789

```
{
   "person":[
      {
         "name": "Dan",
         "phone": [
            "555-123-4567",
            "555-987-6543"
         ]
      },
      {
         "name": "Alvin",
         "phone": "555-234-5678"
      },
      {
         "name": "Magda",
         "phone": "555-345-6789"
      }
   ]
}
```

From Relational to Semi-Structured

Person

Name	Phone
???	555-123-4567
Alvin	555-234-5678
Magda	555-345-6789

```
{
   "person":[
      {
         "name": {
            "fname": "Dan",
            "lname": "Suciu"
          },
         "phone": "555-123-4567"
      },
      {
         "name": "Alvin",
         "phone": "555-234-5678"
      },
      {
         "name": "Magda",
         "phone": "555-345-6789"
      }
   ]
}
```

From Relational to Semi-Structured

Person

Name	Phone
Dan	555-123-4567
Alvin	555-234-5678
Magda	555-345-6789

Orders

PName	Date	Product
Dan	1997	Furby
Alvin	2000	Furby
Alvin	2012	Magic8

BCNF

Representing a one-to-many relationship

```
{
   "person":[
      {
         "name": "Dan",
         "phone": "555-123-4567",
         "orders": [
            {
               "date": 1997,
               "product": "Furby"
            }
         ]
      },
      {
         "name": "Alvin",
         "phone": "555-234-5678",
         "orders": [
            {
               "date": 2000,
               "product": "Furby"
            },
            {
               "date": 2012,
               "product": "Magic8"
            }
         ]
      },
      {
         "name": "Magda",
         "phone": "555-345-6789",
         "orders": []
      }
   ]
}
```

Unnormalized data

From Relational to Semi-Structured

Person

Name	Phone
Dan	555-123-4567
Alvin	555-234-5678
Magda	555-345-6789

Orders

PName	Date	Product
Dan	1997	Furby
Alvin	2000	Furby
Alvin	2012	Magic8

Product

ProdName	Price
Furby	9.99
Magic8	15.99
Tomagachi	18.99

Representing a many-to-many relationship is more difficult

Option 1:

Person→Orders→Product

duplicated/missing Products

Option 2:

Product→Orders→Person

duplicated/missing Persons

Option 3:

Go relational:

store 3 separate objects

Summary of Semistructured Data

- **Self-describing**
  - Data and its schema presented together
- **Irregular/flexible**
  - Missing attributes
  - Repeated attributes (or arrays)
  - Attribute may have different types in different objects
- **1-to-many relationships:** very natural
- **Many-many relationships:** cumbersome

AsterixDB and SQL++

- AsterixDB as a case study of Document Store
  - Semi-structured data model in JSON
  - SQL++

The 5 W's of AsterixDB

- Who
  - M. J. Carey & co.
- What
  - "A Scalable, Open Source DBMS"
  - It is now also an Apache project
- Where
  - UC Irvine, Cloudera Inc, Google, IBM, Amazon…
- When
  - 2014
- Why
  - To develop a next-gen system for managing semi-structured data

The 5 W's of SQL++

- Who
  - K. W. Ong & Y. Papakonstantinou
- What
  - A query language that is applicable to JSON native stores and SQL databases
- Where
  - UC San Diego
- When
  - 2015
- Why
  - Stand in for other semi-structured query languages that lack formal semantics.

Why We are Choosing SQL++

- Strong foundations
  - Original paper: https://arxiv.org/pdf/1405.3631.pdf
  - Nested relational algebra*: https://dl.acm.org/citation.cfm?id=588133
- Many systems adopting or converging to SQL++
  - Apache AsterixDB
  - CouchBase (N1QL)
  - Apache Drill
  - Snowflake
  - Amazon Partiql, https://partiql.org/

* There are much better papers on Nested Relational Algebra (ask DanS)

Asterix Data Model (ADM)

- ADM = nearly identical to JSON
- Adds: **multiset** or **bag**
  - Encapsulated by double curly braces {{ }}
- Adds: **universally unique identifier (uuid)**
  - Ex: 123e4567-e89b-12d3-a456-426655440000
  - Useful for auto-generating unique keys

Introducing the New and Improved SQL++

SQL++ Mini Demo

Demo Time!

Installing AsterixDB

(Details in HW7 spec)

Download from
https://asterixdb.apache.org/download.html

Start local cluster from:
<asterix root>/opt/local/bin/start-sample-cluster

Run by typing this in your browser:
127.0.0.1:19001

Stop cluster when you're done:
<asterix root>/opt/local/bin/stop-sample-cluster

SQL++ Hello World

```
SELECT x.phone
  FROM [
         {"name": "Dan", "phone": [300, 150]},
         {"name": "Alvin", "phone": 420}
       ] AS x;
```

SQL++ Hello World

```
SELECT x.phone
  FROM [
          {"name": "Dan", "phone": [300, 150]},
          {"name": "Alvin", "phone": 420}
       ] AS x;

-- output, same for-loop semantics like in SQL
-- array data
/*
{ "phone": [300, 150] }
{ "phone": 420 }
*/
```

SQL++ Hello World

```
SELECT x.phone
  FROM {{
          {"name": "Dan", "phone": [300, 150]},
          {"name": "Alvin", "phone": 420}
       }} AS x;
```

SQL++ Hello World

```
SELECT x.phone
  FROM {{
          {"name": "Dan", "phone": [300, 150]},
          {"name": "Alvin", "phone": 420}
       }} AS x;

-- same output as array data
-- multiset data
```

SQL++ Hello World

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

-- output
-- trying to query an object
/*
Type mismatch: function scan-collection expects its
1st input parameter to be type multiset or array,
but the actual input type is object
[TypeMismatchException]
*/
```

SQL++ Hello World

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

SQL++ Hello World

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

-- output, null works like in SQL
-- null values
/*
{ "phone": [300, 150] }
{ "phone": null }
*/
```

SQL++ Hello World

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

SQL++ Hello World

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

-- output, missing data is simply passed over (beware of typos!)
-- missing values
/*
{ "phone": [300, 150] }
{ }
*/
```

SQL++ Hello World

```
SELECT x.fone -- intentional typo
  FROM [
         {"name": "Dan", "phone": [300, 150]},
         {"name": "Alvin", "phone": 420}
       ] AS x;
```

SQL++ Hello World

```
SELECT x.fone -- intentional typo
  FROM [
         {"name": "Dan", "phone": [300, 150]},
         {"name": "Alvin", "phone": 420}
       ] AS x;

-- output, beware of typos! No errors are thrown
/*
{ }
{ }
*/
```

SQL++ Hello World

```
  FROM [
         {"name": "Dan", "phone": [300, 150]},
         {"name": "Alvin", "phone": 420}
       ] AS x
 WHERE is_array(x.phone) OR x.phone > 100
 GROUP BY x.name, x.phone
HAVING x.name = "Dan" OR x.name = "Alvin"
SELECT x.phone
 ORDER BY x.name DESC;
```

(Query doesn't make much sense; just to illustrate group by and having)

SQL++ Hello World

```
  FROM [
          {"name": "Dan", "phone": [300, 150]},
          {"name": "Alvin", "phone": 420}
       ] AS x
 WHERE is_array(x.phone) OR x.phone > 100
 GROUP BY x.name, x.phone
HAVING x.name = "Dan" OR x.name = "Alvin"
SELECT x.phone
 ORDER BY x.name DESC;

-- output:
/*
{ "phone": [300, 150] }
{ "phone": 420 }
*/
```

Next Time

- Patterns in querying semi-structured data
- SQL++ behind the mask