UMD DATA605 - Big Data Systems

7.3: Serialization Formats

Instructor: Dr. GP Saggese, gsaggese@umd.edu

Serialization Formats

- **Programs need to send data to each other**
  - Through network, disk
  - Examples:
    - Remote Procedure Calls (RPCs)
    - Data storage and retrieval
  - Technologies based on schemas:
    - JSON
    - YAML
    - Protocol Buffers
    - Python Pickle
- **Serialization formats are data models**
  - Define how data is structured and stored
  - Examples:
    - JSON: Human-readable, used for web APIs
    - YAML: Human-readable, used for configuration files
    - Protocol Buffers: Efficient, used by Google for internal APIs
    - Python Pickle: Python-specific, used for object serialization

Comma Separated Values (CSV)

- **CSV stores data row-wise**
  - As text without schema
  - Each line is a data record
  - Fields separated by commas
- **Pros**
  - Very portable
    - Text format
    - Supported by all tools
  - Human-friendly
- **Cons**
  - Large footprint
    - Requires compression
  - Parsing is CPU intensive
  - No easy random access
  - Can't read only a subset of columns
  - No schema/types
    - Annotate CSV with schema
  - Mainly read-only, hard to modify

Year	Make	Model	Description	Price
1997	Ford	E350	ac, abs, moon	3000.00
1999	Chevy	Venture "Extended Edition"		4900.00
1999	Chevy	Venture "Extended Edition, Very Large"		5000.00
1996	Jeep	Grand Cherokee	MUST SELL! air, moon roof, loaded	4799.00

```
Year,Make,Model,Description,Price
1997,Ford,E350,"ac, abs, moon",3000.00
1999,Chevy,"Venture ""Extended Edition""","",4900.00
1999,Chevy,"Venture ""Extended Edition, Very Large""","",5000.00
1996,Jeep,Grand Cherokee,"MUST SELL!
air, moon roof, loaded",4799.00
```

(Apache) Parquet

- **Parquet**
  - Reads data as tiles
  - Supports multi-dimensional, nested data
    - Generalizes dataframes
  - Column-storage
    - Stores each column together, uniform data type, compressed efficiently
  - IO layer executes queries
    - Reads only necessary data chunks from disk
- **Pros**
  - 10x smaller than CSV
  - 10x faster with multi-threading
  - Can read a subset of columns and rows
- **Cons**
  - Binary, not human-friendly
  - Requires an ingestion step to convert to Parquet
  - Mainly read-only, hard to modify

JSON

- **JavaScript Object Notation**
- **Nested dictionaries and arrays**
- **Similar to XML**
  - More human-readable
  - Less boilerplate
  - Sometimes executable in JavaScript and Python

```
{
  "firstName": "John",
  "lastName": "Smith",
  "isAlive": true,
  "age": 25,
  "height_cm": 167.6,
  "address": {
    "streetAddress": "21 2nd Street",
    "city": "New York",
    "state": "NY",
    "postalCode": "10021-3100"
  },
  "phoneNumbers": [
    {
      "type": "home",
      "number": "212 555-1234"
    },
    {
      "type": "office",
      "number": "646 555-4567"
    }
  ],
  "children": [],
  "spouse": null
}
```

Protocol Buffers

- **Open-source**
  - Developed by Google
- Represent data structures:
  - Language agnostic
  - Platform agnostic
  - Versioning
- **Schema is mostly relational**
  - Optional fields
  - Types
  - Default values
  - Structures
  - Arrays
- **Workflow**
  - Schema specified using a `.proto` file
  - Compiled by `protoc` to produce C++, Java, or Python code to initialize, read, serialize objects

```
import addressbook_pb2
person = addressbook_pb2.Person()
person.id = 1234
person.name = "John Doe"
person.email = "jdoe@example.com"
phone = person.phones.add()
phone.number = "555-4321"
phone.type = addressbook_pb2.Person.HOME
```

```
message Person {
  optional string name = 1;
  optional int32 id = 2;
  optional string email = 3;
  enum PhoneType {
    MOBILE = 0;
    HOME = 1;
    WORK = 2;
  }
  message PhoneNumber {
    optional string number = 1;
    optional PhoneType type = 2;
  }
  repeated PhoneNumber phones = 4;
}
```

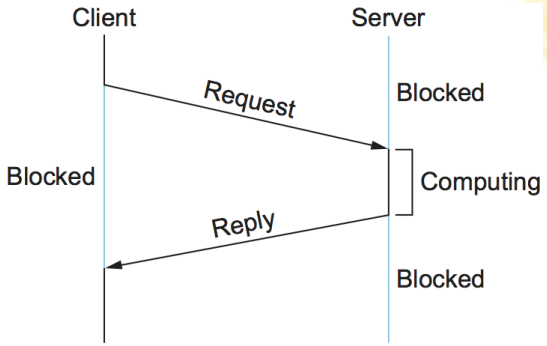
Serialization Formats

- **Avro**
  - Richer data structures
  - JSON-specified schema
- **Thrift**
  - Developed by Facebook
  - Now an Apache project
  - More languages supported
  - Supports exceptions and sets

```
{
  "namespace": "example.avro",
  "type": "record",
  "name": "User",
  "fields": [
    {
      "name": "name",
      "type": "string"
    },
    {
      "name": "favorite_number",
      "type": ["int", "null"]
    },
    {
      "name": "favorite_color",
      "type": ["string", "null"]
    }
  ]
}
```

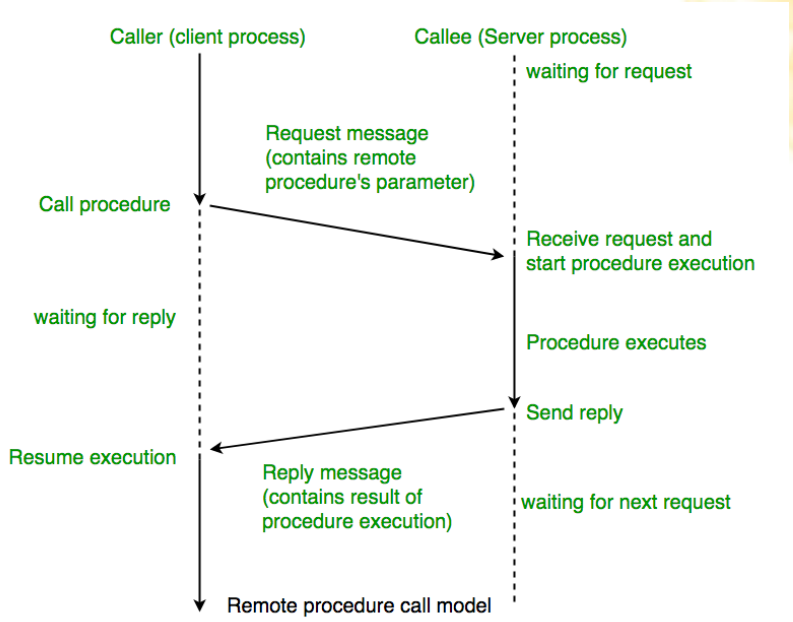
Remote Procedure Call

- **Remote Procedure Call** (RPC)
  - Requests services from programs on other computers
  - Abstracts network communication
- **Goal**: Make remote calls like local procedure calls without network details
  - Used in distributed systems
    - E.g., microservices, cloud services, client-server applications
  - Can be synchronous or asynchronous
- **Problems**
  - Can't serialize pointers
  - Handling asynchronous communication
  - Failures and retries



RPCs: Internals

- *Client procedure call*: Client calls stub function with arguments
- *Request marshalling*: Client stub serializes arguments for network transmission
- *Server communication*: Client's RPC runtime sends request to server
- *Server-side unmarshalling*: Server's RPC runtime deserializes arguments
- *Procedure execution*: Server calls procedure



- *Response marshalling*: Return values marshaled into response message
- *Client communication / response unmarshalling / return to client*: Return values passed back to client's stub call, execution continues locally