Couchbase

Architecture and Administration Basics

Data Modelling

1 | Data Access APIs

Document Modeling Process

1. Understand your application requirements
2. Understand the Couchbase APIs
3. Map application access paths to best Couchbase API
4. Logical data modeling
5. Physical data modeling

Understand your application requirements

- Inputs / Outputs
- Request rate, typical and peak
- Latency
- Consistency
- Scope of Aggregations
- Unique constraints
- Data set size & growth rate

Couchbase APIs

Couchbase API	Latency	Throughput	Scalability	Applicability
Key/Value	500us–10ms	> 1M ops/sec	Highest	General, best for high throughput, highly latency sensitive workloads
N1QL	5ms+	> 40K qps	High	General, best for secondary lookups, pushing complex logic to database
Views	10–100ms	< 4K qps	Moderate	Aggregations, best for large scale aggregations (>1B docs) with low latency and moderate latency requirements
Full Text Search	5ms+	> 20K qps	High	Text search, best for natural language queries, relevance ranking

Mapping application requirements to APIs

Application Requirements	Couchbase API
• Very high throughput • Latency sensitive • Needs strong consistency • Large data set / high growth	Key/Value
• Secondary key lookups • Operational aggregations • Filtered queries • Ad-hoc queries	N1QL
• Report on well defined metrics • Large scale aggregations • Latency sensitive	Views
• Find patterns within text fields • Provide search relevancy rankings	Full text search

2 | Data Modelling

Goals of Data Modeling for N1QL

1. Define entities
2. Define relationships
3. Define document boundaries
   - Identifying parent and child objects
   - Deciding whether to embed child objects
4. Express relationships

Defining Relationships

- Parent-child relationships
  - If we model the child as a separate document and not embedded, we have defined a relationship (parent-child)
- Independent relationships
  - Relationships between two independent objects
  - E.g. a person and a company where they work; deleting one does not delete the other (hopefully)

Identifying Parent and Child Objects

- A parent object has an independent lifecycle
  - It is not deleted as part of deleting any other object
  - E.g. a registered user of a site
- A child object has a dependent lifecycle; It has no meaningful existence without its parent
  - It must be deleted when its parent is deleted
  - E.g. an invoice line item (child of the invoice object)
  - E.g. a comment on a blog (child of the blog object)

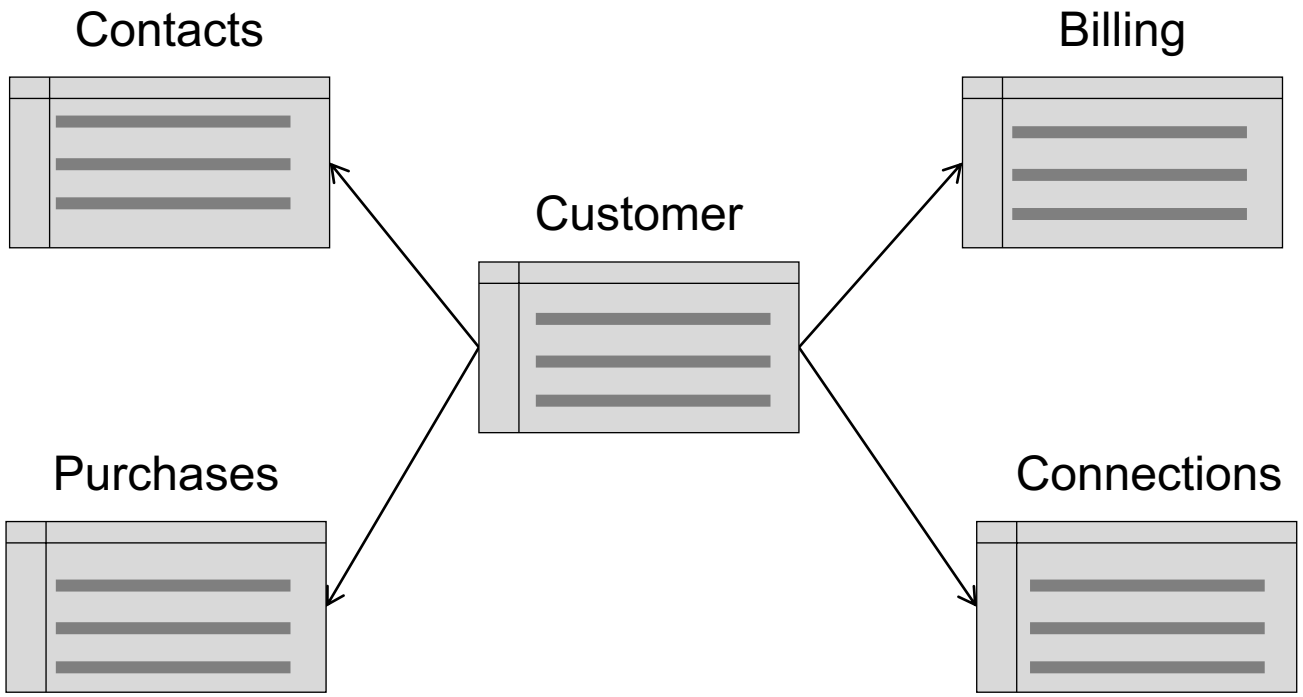
Deciding Whether to Embed Child Objects

- Couchbase provides per-document atomicity
  - If the child and parent must be atomically updated or deleted together, embedding the child facilitates this
  - E.g. if an order line subtotal and order total must be updated together atomically, embedding the order line item facilitates this
- There is a performance tradeoff
  - Embedding the child makes it faster to read the parent together with all its children (single document fetch)
  - If the child has high cardinality (its parent has many instances of the child), embedding the child makes the parent bigger and slower to store and fetch
  - If the child has high cardinality (its parent has many instances of the child), embedding the child makes it more expensive to update the parent or the child

Expressing Relationships

- 3 ways to express relationships in Couchbase
  1. Parent contains keys of children (outbound)
  2. Children contain key of parent (inbound)
  3. Both of the above (dual)
- High cardinality affects outbound relationships
  - Makes parent document bigger and slower
  - Makes it expensive to load a subset of relationships (e.g. paging through blog comments)

Data Modeling with JSON Example



Data Modeling with JSON Example

Table: Customer

CustomerID	Name	DOB
CBL2017	Jane Smith	1990-01-30

- The primary (CustomerID) becomes the DocumentKey
- Column name-Column value becomes KEY-VALUE pair.

Customer DocumentKey: CBL2017

```
{
   "Name" : "Jane Smith",
   "DOB"  : "1990-01-30”
}
```

OR

```
{
   "Name" : {
      "fname": "Jane",
      "lname": "Smith"
    }
   "DOB"  : "1990-01-30"
}
```

Data Modeling with JSON Example

Table: Customer

CustomerID	Name	DOB
CBL2017	Jane Smith	1990-01-30

Table: Billing

CustomerID	Type	Cardnum	Expiry
CBL2017	visa	5827…	2019-03

Customer DocumentKey: CBL2017

```
{
    "Name" : "Jane Smith",
    "DOB"  : "1990-01-30",
    "Billing" : [
        {
            "type"    : "visa",
            "cardnum" : "5827-2842-2847-3909",
            "expiry"  : "2019-03"
        }
    ]
}
```

- **Rich Structure & Relationships**
  - Billing information is stored as a sub-document
  - There could be more than a single credit card. So, use an array.

Data Modeling with JSON Example

Table: Customer

CustomerID	Name	DOB
CBL2017	Jane Smith	1990-01-30

Table: Billing

CustomerID	Type	Cardnum	Expiry
CBL2017	visa	5827…	2019-03
CBL2017	master	6274…	2018-12

Customer DocumentKey: CBL2017

```
{
    "Name" : "Jane Smith",
    "DOB"  : "1990-01-30",
    "Billing" : [
        {
            "type"    : "visa",
            "cardnum" : "5827-2842-2847-3909",
            "expiry"  : "2019-03"
        },
        {
            "type"    : "master",
            "cardnum" : "6274-2542-5847-3949",
            "expiry"  : "2018-12"
        }
    ]
}
```

- **Value evolution**
  - Simply add additional array element or update a value.

Data Modeling with JSON Example

Table: Connections

CustomerID	ConnId	Name
CBL2017	XYZ987	Joe Smith
CBL2017	SKR007	Sam Smith

- **Structure evolution**
  - Simply add new key-value pairs
  - No downtime to add new KV pairs
  - Applications can validate data
  - Structure evolution over time.
- **Relations via Reference**

Customer DocumentKey: CBL2017

```
{
    "Name" : "Jane Smith",
    "DOB"  : "1990-01-30",
    "Billing" : [
        {
            "type"    : "visa",
            "cardnum" : "5827-2842-2847-3909",
            "expiry"  : "2019-03"
        },
        {
            "type"    : "master",
            "cardnum" : "6274-2542-5847-3949",
            "expiry"  : "2018-12"
        }
    ],
    "Connections" : [
        {
            "ConnId"   : "XYZ987",
            "Name"     : "Joe Smith"
        },
        {
            "ConnId"   : ”SKR007",
            "Name"     : ”Sam Smith"
        }
    ]
}
```

Data Modeling with JSON Example

CustomerID	ConnId	Name
CBL2017	XYZ987	Joe Smith
CBL2017	SKR007	Sam Smith

Contacts

CustomerID	Type	Cardnum	Expiry
CBL2017	visa	5827…	2019-03
CBL2017	master	6274…	2018-12

Billing

Customer

CustomerID	Name	DOB
CBL2017	Jane Smith	1990-01-30

Purchases

CustomerID	item	amt
CBL2017	mac	2823.52
CBL2017	ipad2	623.52

Connections

CustomerID	ConnId	Name
CBL2017	XYZ987	Joe Smith
CBL2017	SKR007	Sam Smith

DocumentKey: **CBL2017**


```
{
   "Name" : "Jane Smith",
   "DOB"  : "1990-01-30",
   "Billing" : [
      {
         "type"    : "visa",
         "cardnum" : "5827-2842-2847-3909",
         "expiry"  : "2019-03"
      },
      {
         "type"    : "master",
         "cardnum" : "6274-2842-2847-3909",
         "expiry"  : "2019-03"
      }
   ],
   "Connections" : [
      {
         "CustId"   : "XYZ987",
         "Name"     : "Joe Smith"
      },
      {
         "CustId"   : "PQR823",
         "Name"     : "Dylan Smith"
      }
      {
         "CustId"   : "PQR823",
         "Name"     : "Dylan Smith"
      }
   ],
   "Purchases" : [
      { "id":12, item: "mac",   "amt": 2823.52 }
      { "id":19, item: "ipad2", "amt": 623.52 }
   ]
}
```

Models for Representing Data

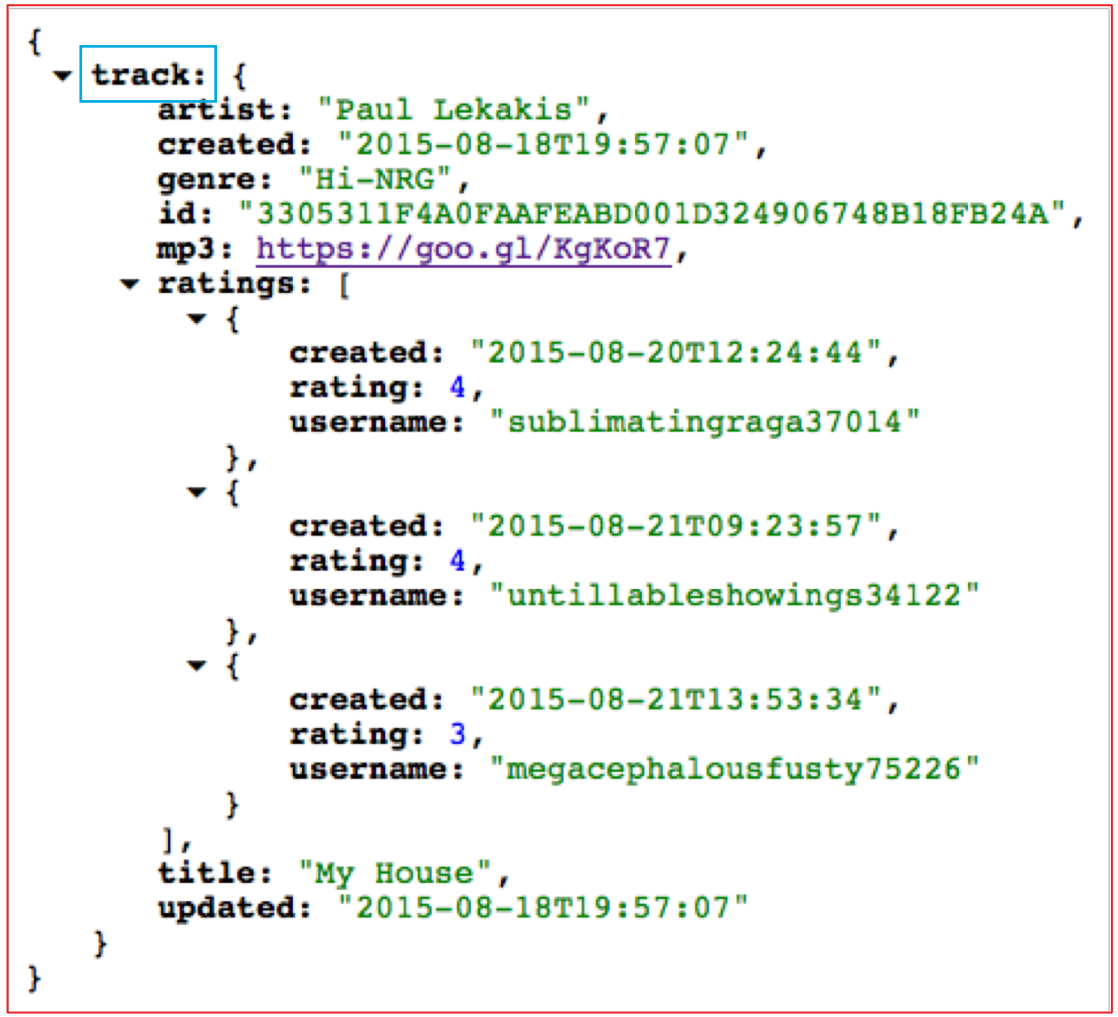
Model	Relational Model	JSON Document Model (NoSQL)
1:1	▪ Foreign Key ▪ Denormalize	▪ Embedded Object (implicit) ▪ Document Key Reference
1:N	▪ Foreign Key	▪ Embedded Array of Objects ▪ Document key Reference
N:M	▪ Foreign Key	▪ Embedded Array of Objects, arrays of arrays with references

3 | JSON Design Choices

JSON Design Choices

- Single Root Attributes vs. "type"/"class" parameter
- Objects vs. Arrays
- Array Element Types
- Timestamp Formats
- Property Names
- Empty and Null Property Values
- JSON Schema

Single Root Attributes

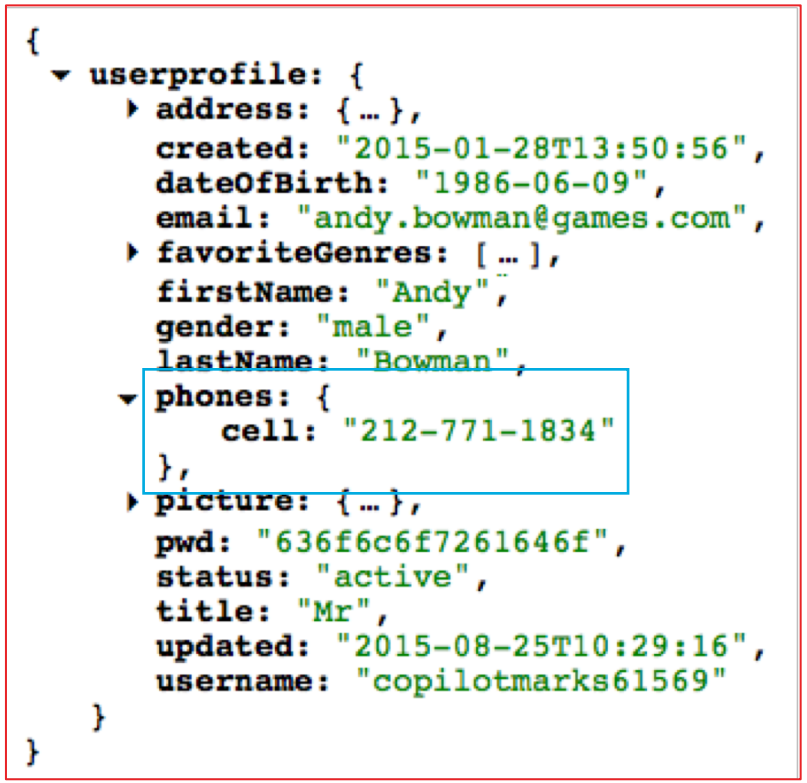


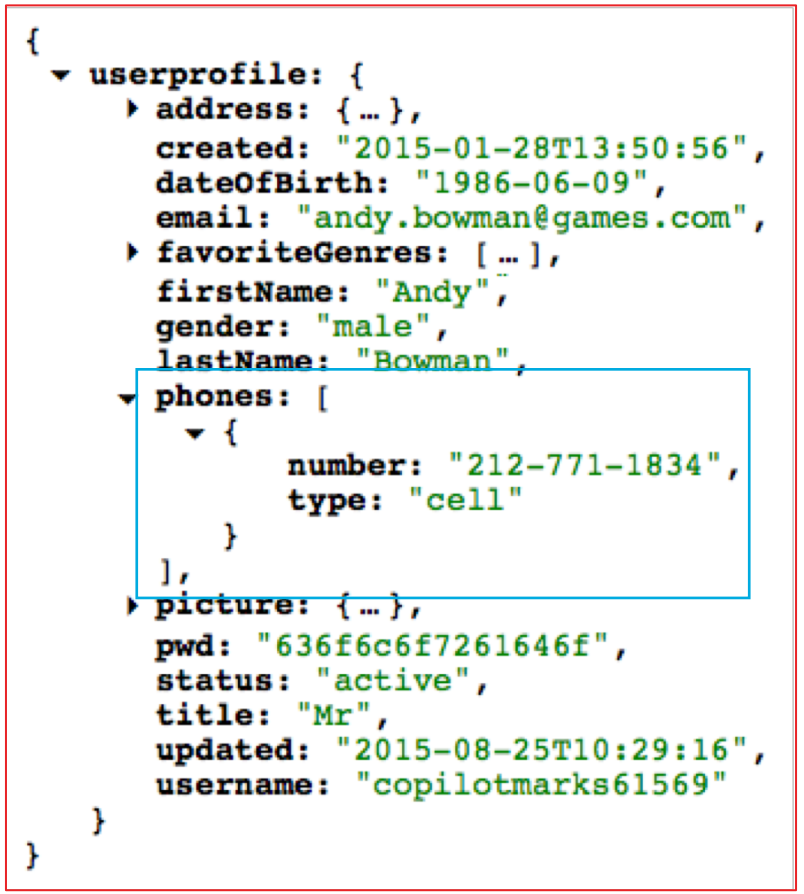
```
{
  track: {
      artist: "Paul Lekakis",
      created: "2015-08-18T19:57:07",
      genre: "Hi-NRG",
      id: "3305311F4A0FAAFEABD001D324906748B18FB24A",
      mp3: https://goo.gl/KgKoR7,
    ratings: [
      {
          created: "2015-08-20T12:24:44",
          rating: 4,
          username: "sublimatingraga37014"
      },
      {
          created: "2015-08-21T09:23:57",
          rating: 4,
          username: "untillableshowings34122"
      },
      {
          created: "2015-08-21T13:53:34",
          rating: 3,
          username: "megacephalousfusty75226"
      }
    ],
    title: "My House",
    updated: "2015-08-18T19:57:07"
  }
}
```

```
{
  artist: "Paul Lekakis",
  created: "2015-08-18T19:57:07",
  genre: "Hi-NRG",
  id: "3305311F4A0FAAFEABD001D324906748B18FB24A",
  mp3: https://goo.gl/KgKoR7,
  ratings: [
    {
        created: "2015-08-20T12:24:44",
        rating: 4,
        username: "sublimatingraga37014"
    },
    {
        created: "2015-08-21T09:23:57",
        rating: 4,
        username: "untillableshowings34122"
    },
    {
        created: "2015-08-21T13:53:34",
        rating: 3,
        username: "megacephalousfusty75226"
    }
  ],
  title: "My House",
  type: "track",
  updated: "2015-08-18T19:57:07"
}
```

Objects vs. Arrays

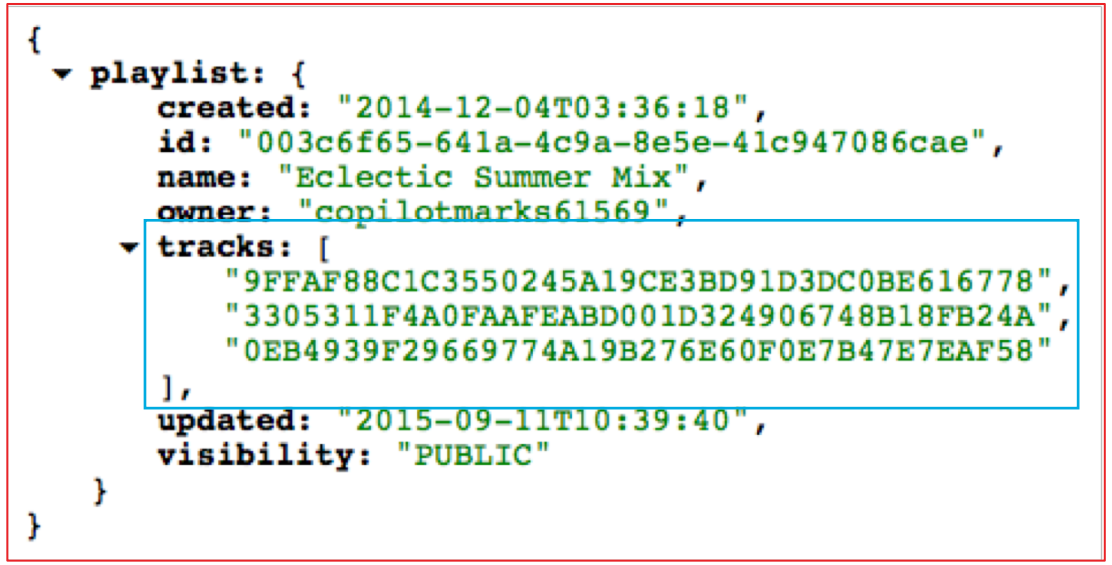
- Two different ways to represent attributes:





Array Element Types

- Array elements can be simple types, objects or arrays:

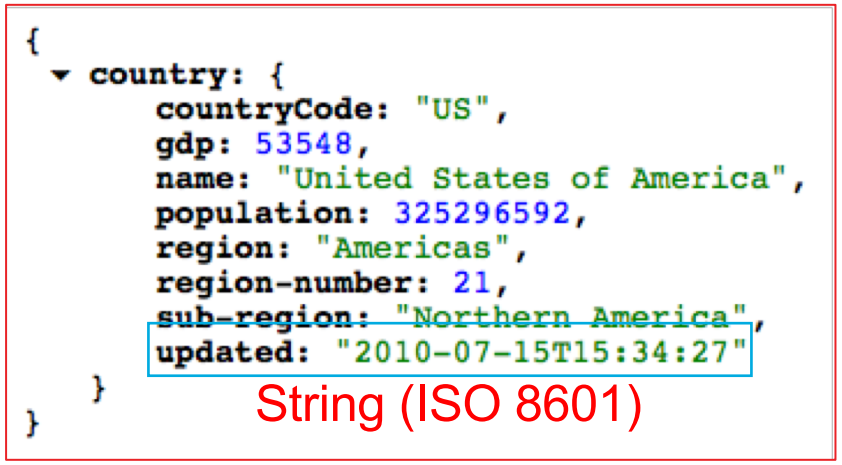


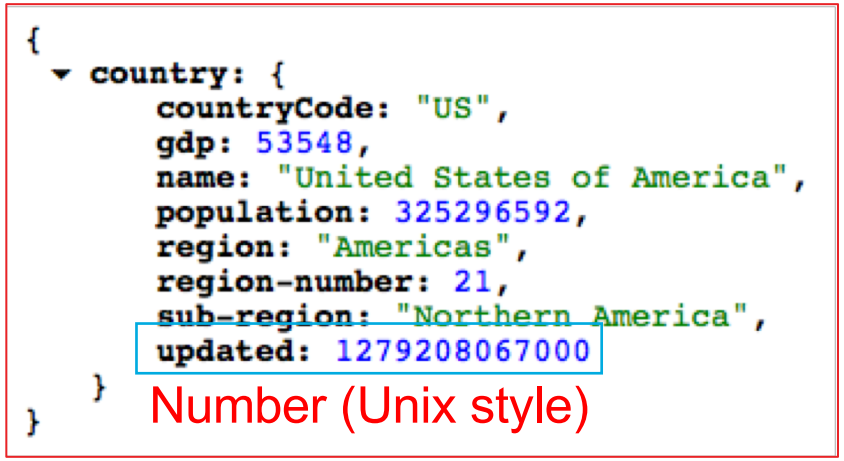
Array of strings

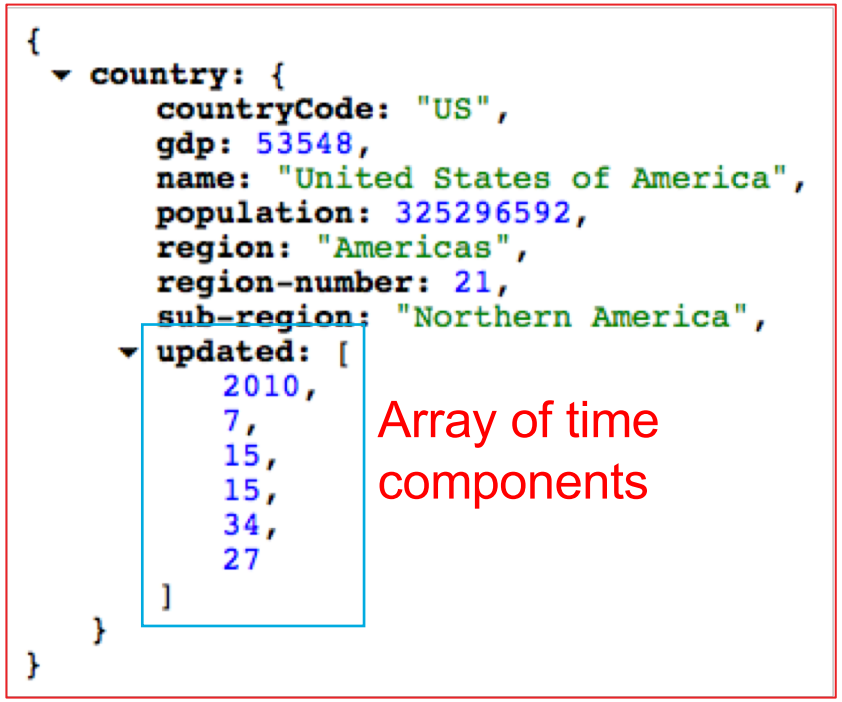
Array of objects

Timestamp Formats

- When storing timestamps, you have at least 3 options:







- Make timestamp values relative to UTC

Property Names

- Choose meaningful property names
- Be consistent in naming properties
  - e.g. country_code vs. countryCode (preferred)
- Array types should have plural property names
- All other property names should be singular
- Avoid (if possible) reserved words in your database system and programming language(s)
  - e.g. `user` // Reserved word in Couchbase Server
- Avoid (if possible) special characters such as hypens
  - e.g. `region-number` // Contains a hyphen

Empty and Null Property Values

- Keep in mind that JSON supports optional properties
- If a property has a null value, consider dropping it from the JSON, unless there's a good reason not to
- N1QL makes it easy to test for missing or null property values

```
SELECT * FROM couchmusic1 WHERE userprofile.address IS NULL;

SELECT * FROM couchmusic1 WHERE userprofile.gender IS MISSING;
```

- Be sure your application code handles the case where a property value is missing

JSON Schema

- Couchbase Server pays absolutely no attention to the shape of your JSON documents so long as they are well-formed
- There are times when it is useful to validate that a JSON document conforms to some expected shape
- JSON Schema is a JSON-based format for defining the structure of JSON data
- There are implementations for most popular programming languages

```
{
   id: "http://couchmusic.org/schema/couchmusic2-country.json",
   $schema: http://json-schema.org/draft-04/schema#,
   type: "object",
 ▾ properties: {
    ▾ countryCode: {
          type: "string",
          minLength: 2,
          maxLength: 2
      },
    ▾ gdp: {
          type: "integer",
          minimum: 0
      },
    ▾ name: {
          type: "string"
      },
    ▾ population: {
          type: "number",
          minimum: 0
      },
    ▾ region-number: {
          type: "integer",
          minimum: 0
      },
    ▾ type: {
       ▾ enum: [
             "country"
         ]
      },
    ▾ updated: {
          type: "string",
          format: "date-time"
      }
   },
 ▾ required: [
      "countryCode",
      "gdp",
      "name",
      "population",
      "region-number",
      "updated"
   ],
   additionalProperties: false
}
```

4 | Data Nesting

Data Nesting (aka Denormalization)

- As you know, relational database design promotes separating data using normalization, which doesn't scale
- For NoSQL systems, we often avoid normalization so that we can scale
- Nesting allows related objects to be organized into a hierarchical tree structure where you can have multiple levels of grouping
- Rule of thumb is to nest no more than 3 levels deep unless there is a very good reason to do so
- You will often want to include a timestamp in the nested data

Example #1 of Data Nesting

Playlist with owner attribute containing username of corresponding userprofile


```
{
  ▼ playlist: {
        created: "2014-12-04T03:36:18",
        id: "003c6f65-641a-4c9a-8e5e-41c947086cae",
        name: "Eclectic Summer Mix",
        owner: "copilotmarks61569",
      ▸ tracks: [ … ],
        updated: "2015-09-11T10:39:40",
        visibility: "PUBLIC"
    }
}
```

```
{
  ▼ userprofile: {
      ▸ address: { … },
        created: "2015-01-28T13:50:56",
        dateOfBirth: "1986-06-09",
        email: "andy.bowman@games.com",
      ▸ favoriteGenres: [ … ],
        firstName: "Andy",
        gender: "male",
        lastName: "Bowman",
      ▸ phones: { … },
      ▸ picture: { … },
        pwd: "636f6c6f7261646f",
        status: "active",
        title: "Mr",
        updated: "2015-08-25T10:29:16",
        username: "copilotmarks61569"
    }
}
```

Example #1 of Data Nesting

Playlist with owner attribute containing a subset of the corresponding userprofile

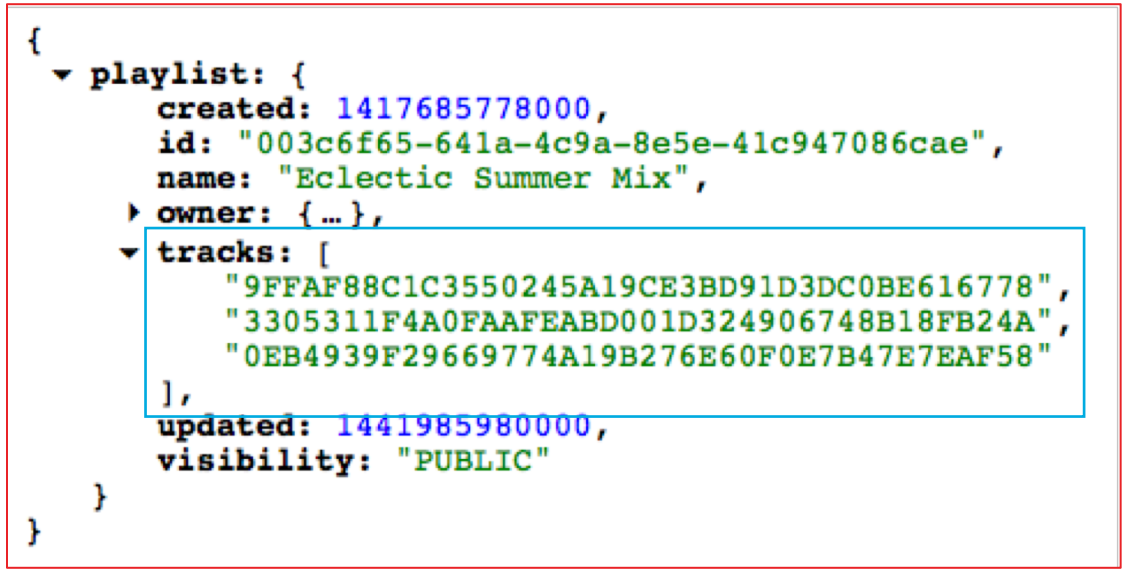

```
{
  playlist: {
      created: "2014-12-04T03:36:18",
      id: "003c6f65-641a-4c9a-8e5e-41c947086cae",
      name: "Eclectic Summer Mix",
      owner: {
          created: "2015-01-28T13:50:56",
          firstName: "Andy",
          lastName: "Bowman",
          title: "Mr",
          updated: "2015-08-25T10:29:16",
          username: "copilotmarks61569"
      },
      tracks: [ … ],
      updated: "2015-09-11T10:39:40",
      visibility: "PUBLIC"
  }
}
```


* Note the inclusion of the **updated** attribute


```
{
  userprofile: {
      address: { … },
      created: "2015-01-28T13:50:56",
      dateOfBirth: "1986-06-09",
      email: "andy.bowman@games.com",
      favoriteGenres: [ … ],
      firstName: "Andy",
      gender: "male",
      lastName: "Bowman",
      phones: { … },
      picture: { … },
      pwd: "636f6c6f7261646f",
      status: "active",
      title: "Mr",
      updated: "2015-08-25T10:29:16",
      username: "copilotmarks61569"
  }
}
```

Example #2 of Data Nesting

Playlist with tracks attribute containing an array of track IDs



Example #2 of Data Nesting

Playlist with tracks attribute containing an array of track IDs

* Note the inclusion of the **updated** attribute

5 | Key Design

Natural Keys

- A key formed of attributes that exist in the real world:
  - Phone numbers
  - Usernames
  - Social security numbers
  - Account numbers
  - SKU, UPC or QR codes
  - Device IDs
- Often the first choice for document keys

- Be careful when working with any personally identifiable information (PII), sensitive personal information (SPI) or protected health information (PHI)

Surrogate Keys

- We often use surrogate keys when no obvious natural key exist
- They are not derived from application data
- They can be generated values
  - 3305311F4A0FAAFEABD001D324906748B18FB24A (SHA-1)
  - 003C6F65-641A-4CGA-8E5E-41C947086CAE (UUID)
  - They can be sequential numbers (often implemented using the Counter feature of Couchbase Server)
  - 456789, 456790, 456791, …

Key Value Patterns

- Common practice for users of Couchbase Server to follow patterns for formatting key values by using symbols such as single or double colons
- DocType::ID
  - userprofile::fredsmith79
  - playlist::003c6f65-641a-4c9a-8e5e-41c947086cae
- AppName::DocType::ID
  - couchmusic::userprofile::fredsmith79
- DocType::ParentID::ChildID
  - playlist::fredsmith79::003c6f65-641a-4c9a-8e5e-41c947086cae
- Supports easy document viewing in the Couchbase web console

Lookup Key Pattern

- The purpose of the Lookup Key Pattern is to allow multiple ways to reach the same data, essentially a secondary index
    - For example, we want to lookup a Userprofile by their email address instead of their ID
- To accomplish this, we create another small document that refers to the Userprofile document we are interested in
- Implementing this pattern is straightforward, just create an additional document containing a single property that stores the key to the primary document
- With the introduction of N1QL, this pattern will be less commonly used

Example of Lookup Key Pattern

- Lookup document can be JsonDocument or StringDocument

userprofile::copilotmarks61569


```
{
  userprofile: {
      address: {…},
      created: "2015-01-28T13:50:56",
      dateOfBirth: "1986-06-09",
      email: "andy.bowman@games.com",
      favoriteGenres: […],
      firstName: "Andy",
      gender: "male",
      lastName: "Bowman",
      phones: {…},
      picture: {…},
      pwd: "636f6c6f7261646f",
      status: "active",
      title: "Mr",
      updated: "2015-08-25T10:29:16",
      username: "copilotmarks61569"
    }
}
```


andy.bowman@games.com


```
{
    username: "copilotmarks61569"
}
```


JSON

andy.bowman@games.com

```
copilotmarks61569
```

String

6 | Making Trade-Offs

Making Tough Choices

- Eric Brewer is famous for showing the trade-offs that are necessary when dealing with distributed systems
  - Consistency, availability and partition tolerance are all desirable properties but we must choose the ones that are most important for our use cases
- We must also make trade-offs in data modeling:
  - Document size
  - Complexity
  - Speed
  - Atomicity

Document Size

- Couchbase Server supports documents up to 20 Mb
- Larger documents take more disk space, more time to transfer across the network and more time to serialize/deserialize
- If you are dealing with documents that are potentially large (greater than 1 Mb), you must test thoroughly to find out if speed of access is adequate as you scale. If not, you will need to break up the document into smaller ones.
- You may need to limit the number of dependent child objects you embed

Complexity

- Complexity affects every area of software systems including data modeling
- Space saving sometimes comes at the complexity of data processing
- E.g., consider the complexity of queries (N1QL)

```
SELECT c.name, COUNT(*) AS playlist_count
FROM couchmusic1.playlist p JOIN couchmusic1.userprofile u
   ON KEYS 'userprofile::' || p.owner JOIN couchmusic1.country c
      ON KEYS 'country::' || u.address.countryCode
WHERE c.`region-number` = 154
   AND p.visibility = 'PUBLIC'
   AND u.status = 'active'
GROUP BY c.name
ORDER BY c.name;
```

Speed

- As it relates to data modeling, speed of access is critical
- When using N1QL to access data, keep in mind that query by document key is fastest and query by secondary index is usually much slower
- If implementing an interactive use case, you will want to avoid using JOINs
- You can use data duplication to improve the speed of accessing related data and thus trade improved speed for greater complexity and larger document size
- Keep in mind that Couchbase Views can be used when up to the second accuracy is not required

Atomicity

- Atomicity in Couchbase Server is at the document level
- Couchbase Server does not support transactions
  - They can be simulated if you are willing to write and maintain additional code to implement them (generally not recommended)
- If you absolutely need changes to be atomic, they will have to be part of the same document
- The maximum document size for Couchbase Server may limit how much data you can store in a single document
- Multi-document transactions will be introduced in Couchbase 6.5

Embed vs. Refer

- When to embed:
  - Reads greatly outnumber writes
  - You're comfortable with the slim risk of inconsistent data across the multiple copies
  - You're optimizing for speed of access

- When to refer:
  - Consistency of the data is a priority
  - You want to ensure your cache is used efficiently
  - The embedded version would be too large or complex

Summary

- In this module, you have learned to:
  - Make full use of JSON capabilities
  - Use data nesting to minimize the need for JOINs
  - Establish key value patterns and use them consistently
  - Be clear about the trade-offs you are making, document your decisions and the assumptions they are based on

Thank you

Couchbase