JSON data in Relational Databases

Agenda

1. What is (good) JSON and when should I use it?
2. What's possible with a relational (Oracle) database?
3. Common use-cases, mistakes and best practices
4. NoSQL access to JSON, document stores
5. Questions

so,… what’s JSON?

What's JSON?

```
{
  "firstName":"John",
  "lastName":"Smith",
  "age":25
}
```

What's JSON?

```
{
  "firstName":"John",
  "lastName":"Smith",
  "age":25,
  "address":{
    "street":"21 2nd Street‟,"city":"New York",
    "state":"NY","postalCode":"10021",
    "isBusiness":false
  }
}
```

What's JSON?

```
{
  "firstName":"John",
  "lastName":"Smith",
  "age":25,
  "address":{
    "street":"21 2nd Street‟,"city":"New York",
    "state":"NY","postalCode":"10021",
    "isBusiness":false
  },
  "phoneNumbers":[
    {"type":"home","number":"212 555-1234"},
    {"type":"mobile","number":"646 555-4567"}
  ]
}
```

What's JSON?

```
{
  "firstName":"John",
  "lastName":"Smith",
  "age":25,
  "address":{
    "street":"21 2nd Street‟,"city":"New York",
    "state":"NY","postalCode":"10021",
    "isBusiness":false
  },
  "phoneNumbers":[
    {"type":"home","number":"212 555-1234"},
    {"type":"mobile","number":"646 555-4567"}
  ],
  "bankruptcies":null,
  ”lastUpdated":"2019-05-13T13:03:35+0000"
}
```

What's JSON?

```
{
  "firstName":"John",
  "lastName":"Smith"
  "age":25,
  "address":{
    "street":"21 2nd Street‟,"city":"New York",
    "state":"NY","postalCode":"10021",
    "isBusiness":false
  },
  "phoneNumbers":[
    {"type":"home","number":"212 555-1234"},
    {"type":"mobile","number":"646 555-4567"}
  ],
  "bankruptcies":null,
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}
```

What's JSON?


{
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"age":25,
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"street":"21 2nd Street",
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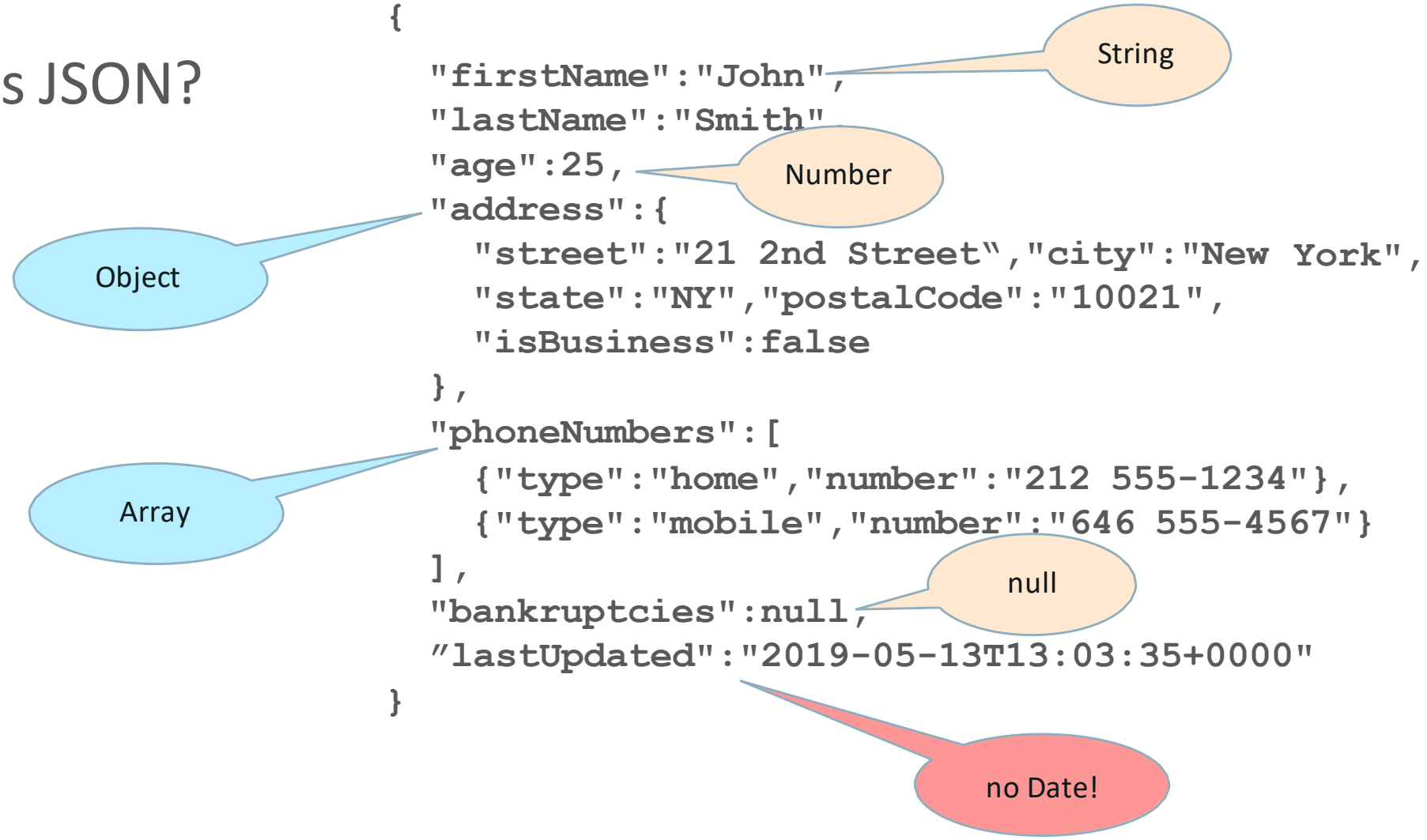
"state":"NY",
"postalCode":"10021",
"isBusiness":false
},
"phoneNumbers":[
{"type":"home","number":"212 555-1234"},
{"type":"mobile","number":"646 555-4567"}
],
"bankruptcies":null,
"lastUpdated":"2019-05-13T13:03:35+0000"
}
String
Number
Object
Array
null

What's JSON?


{
"firstName":"John",
"lastName":"Smith"
"age":25,
"address":{
"street":"21 2nd Street",
"city":"New York",
"state":"NY",
"postalCode":"10021",
"isBusiness":false
},
"phoneNumbers":[
{"type":"home","number":"212 555-1234"},
{"type":"mobile","number":"646 555-4567"}
],
"bankruptcies":null,
"lastUpdated":"2019-05-13T13:03:35+0000"
}
String
Number
Object
Array
null
no Date!

What's JSON?

JSON vs XML :

- Both hierarchical
- JSON needs no schema
- Always UTF8-Unicode
- Fixed data types
- No type inheritance, or substitution groups
- no namespaces

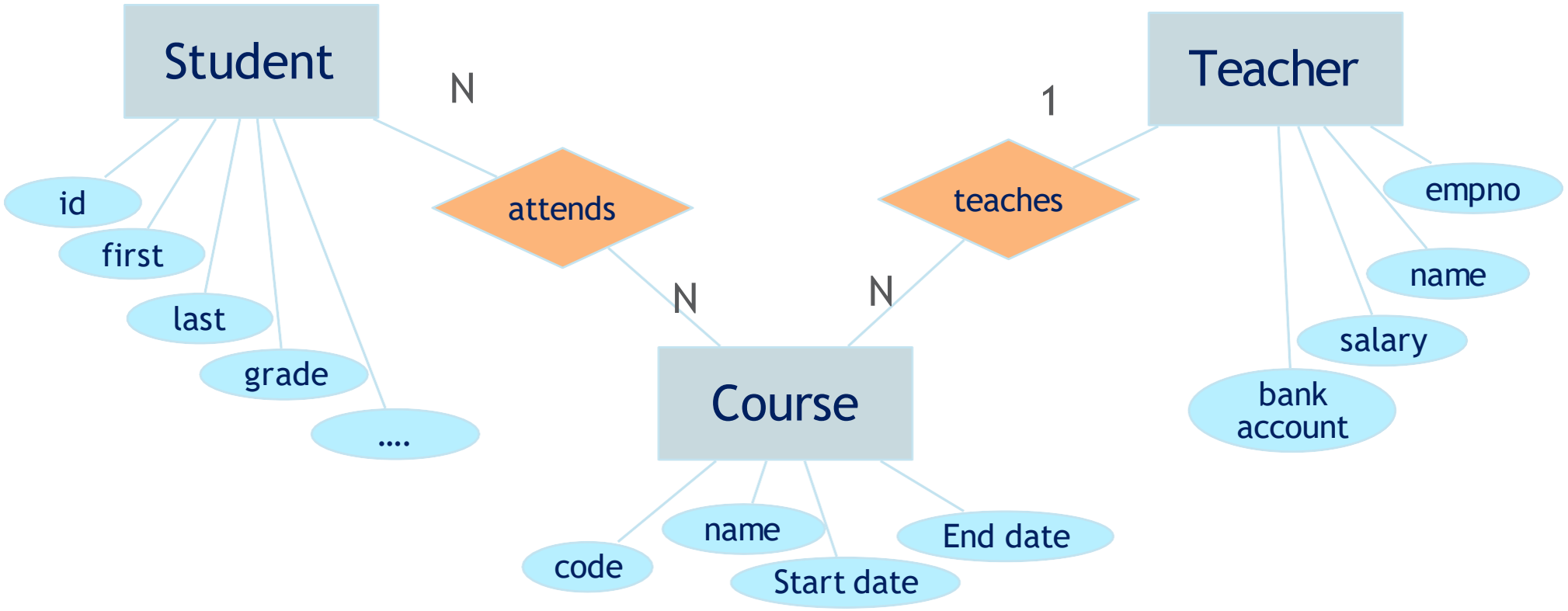
….

```
{
  "firstName":"John",
  "lastName":"Smith",
  "age":25,
  "address":{
    "street":"21 2nd Street‟,"city":"New York",
    "state":"NY","postalCode":"10021",
    "isBusiness":false
  },
  "phoneNumbers":[
    {"type":"home","number":"212 555-1234"},
    {"type":"mobile","number":"646 555-4567"}
  ],
  "bankruptcies":null,
  ”lastUpdated":"2019-05-13T13:03:35+0000"
}
```

The schema-less fallacy

The hierarchy problem: JSON data modelling
Sample Scenario: School/College

Entity Relationship Model (Peter Chen 1976)



Conversion to JSON

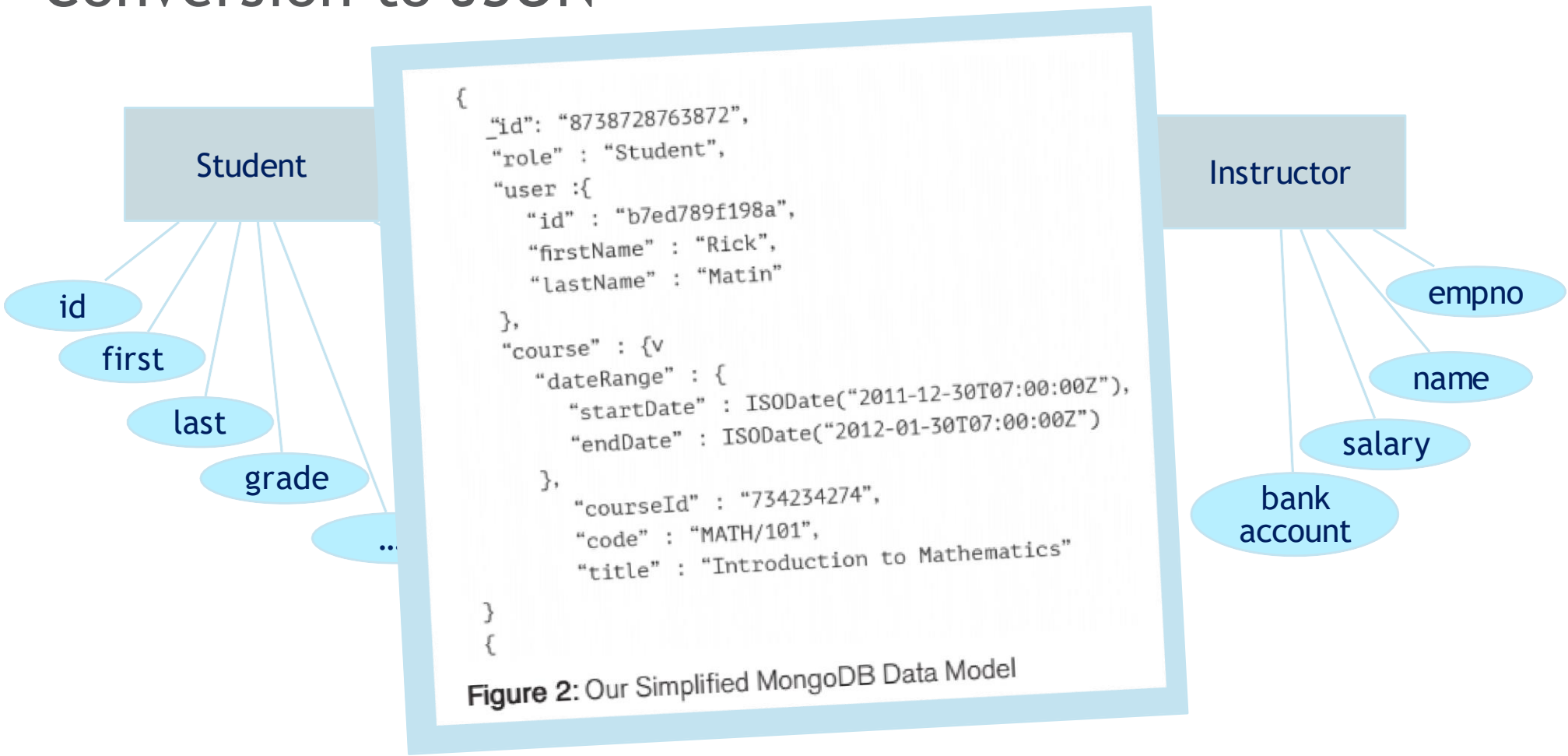
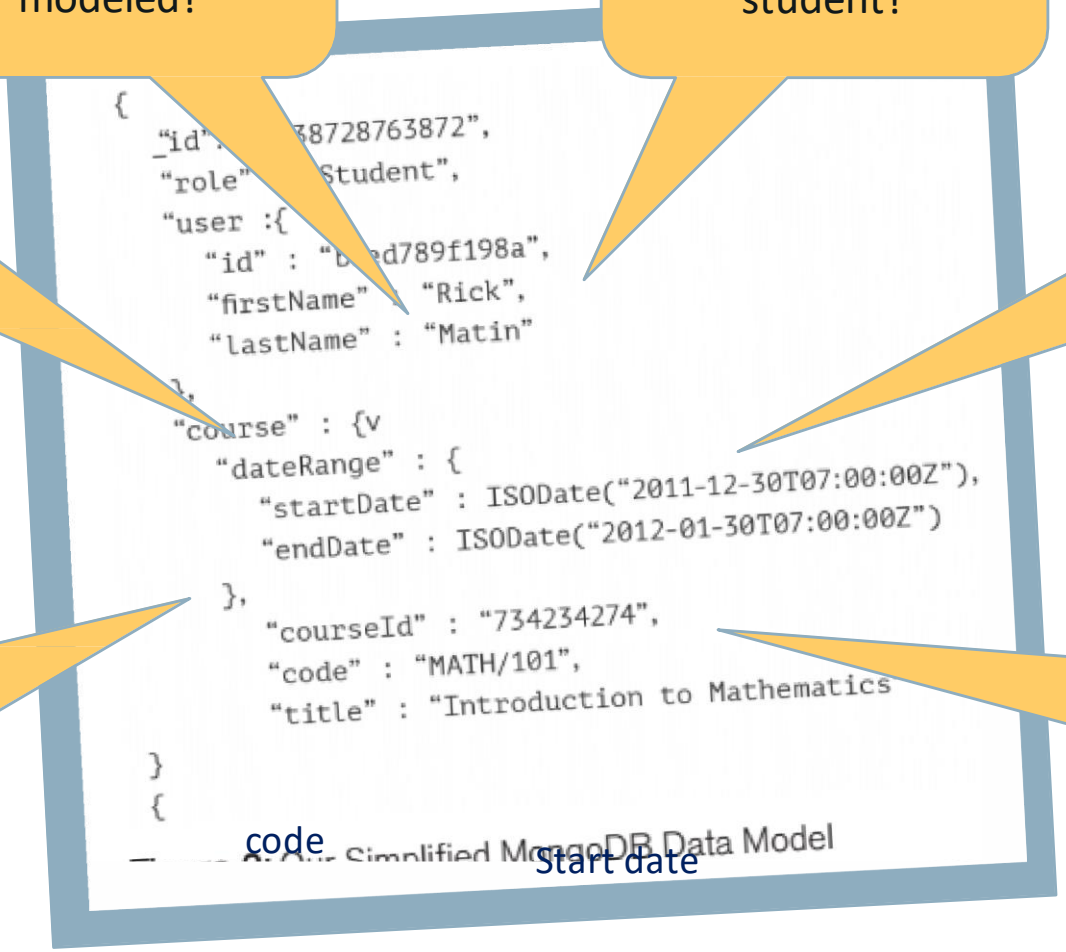


Figure 2: Our Simplified MongoDB Data Model

Conversion to JSON



How to find if a course if 'full'? How can this be modeled?

Limited queriability: How find all teachers of a student?

Inconsistencies possible if non-transactional.

Update all occurrences of same data

How to store a course without a teacher/student?

Data has to be repeated

Student

id

first

last

grade

Instructor

empno

name

salary

bank account

code

Start date

Conversi

How to find if a course if 'full'? How can this be modeled?

Limited queriability: How find all teachers of a student?

Inconsistencies possible if non-transactional.

Update all occurrences of same data

How to store a course without a teacher/student?

ta has to be repeated

This is 1966 IBM IMS hierarchical data model! We just embarked on a 50yr time travel!

JSON support in the Oracle Database

SQL/JSON -> SQL 2016

JSON Support in the Oracle database

- JSON storage

```
create table emp (
    empno   number,
    first   varchar2(50),
    last    varchar2(50),
    salary  number,
    flex    clob,
    check (flex IS JSON));

insert into emp values( 1, 'Jon', 'Smith', 2000,
    '{"skills":["Java", "C", "C++"],
      "photoUrl":"img/eydh763s.jpg"}');

insert into emp values( 2, 'Amanda', 'Jones', 2500,
    '{"skills":["JavaScript","nodeJs"]}');
```

JSON Support in the Oracle database

- JSON storage

```
create table emp (
    empno   number,
    first   varchar2(50),
    last    varchar2(50),
    salary  number,
    flex    clob,
    check (flex IS JSON));
```

Oracle performance tip:
JSON is always UTF8
-Use 'al32utf8' character set if possible
-Use BLOB instead of CLOB
CLOB stores data as UCS2/UTF16
-Use lob data api to insert/fetch data
- getBytes/setBytes instead of
- getBlob/setBlob!

```
mp values( 1, 'Jon', 'Smith', 2000,
':["Java", "C", "C++"],
rl":"img/eydh763s.jpg"}');

mp values( 2, 'Amanda', 'Jones', 2500,
':["JavaScript","nodeJs"]}');
```

JSON Support in the Oracle database

- JSON storage
- JSON value extraction

```
select e.flex.skills
from emp e
where e.flex.skills like '%Java%';
```

	SKILLS
1	["Java","C","C++"]
2	["JavaScript","nodeJs"]

JSON Support in the Oracle database

- JSON storage
- JSON value extraction

```
select e.flex.skills
from emp e
where e.flex.skills like '%Java%';
```

	SKILLS
1	["Java","C","C++"]
2	["JavaScript","nodeJs"]

```
select JSON_VALUE (flex,'$.photoUrl'
                   DEFAULT 'img/default.jpg' on empty)
from emp;
```

	JSON_VALUE(E.FLEX,'$.PHOTOURL'
1	img/eydh763s.jpg
2	img/default.jpg

JSON Support in the Oracle database

- JSON storage
- JSON value extraction

```
select e.flex.skills
from emp e
where e.flex.skills like '%Java%';
```

	SKILLS
1	["Java","C","C++"]
2	["JavaScript","nodeJs"]

Oracle functionality tip:
SQL/JSON operators have default for simple usage –
but also many options:

```
JSON_VALUE(flex, '$.path' RETURNING NUMBER(4,2),
                          ERROR ON ERROR
                          NULL ON EMPTY)
```

Default return type is VARCHAR2(4000)

```
flex,'$.photoUrl'
DEFAULT 'img/default.jpg' on empty)
```

	JSON_VALUE(E.FLEX,'$.PHOTOURL'
1	img/eydh763s.jpg
2	img/default.jpg

JSON Support in the Oracle database: Predicates

- JSON storage
- JSON value extraction

```
select e.flex.skills
from emp e
where e.flex.skills like '%Java%';
```

	SKILLS
1	["Java","C","C++"]
2	["JavaScript","nodeJs"]

```
select JSON_QUERY(flex, '$.skills')
from emp
where JSON_EXISTS (flex,'$.skills?(@ == "Java")');
```

	JSON_QUERY(FLEX,'$.SKILLS')
1	["Java","C","C++"]

JSON Support in the Oracle database

- JSON storage
- JSON value extraction
- JSON table projection

JSON_TABLE: ‘flatten’ the JSON

```
{
 "firstName":"John",
 "lastName":"Smith",
 "age":25,
 "address":{
    "street":"21 2nd Street‟,
    "city":"New York",
    "state":"NY","postalCode":"10021",
    "isBusiness":false
 },
 "phoneNumbers":[
    {"type":"home",
     "number":"212 555-1234"},
    {"type":"mobile",
     "number":"646 555-4567"}
 ],
 "bankruptcies":null,
 "lastUpdated":"2019-05-13T13:03:35"
}
```

JSON_TABLE: 'flatten' the JSON data

```
Select id, jt.* from
  custData,
  JSON_TABLE(jcol, '$' columns (
    "FIRST"                 path '$.firstName',
    "AGE"    number         path '$.age',
    "STATE"  varchar2(2)    path '$.address.state',
    "PHONE"  FORMAT JSON    path
                            '$.phoneNumbers.number'
                            with array wrapper
  )) jt;
```

JSON_TABLE: ‘flatten’ the JSON

```
{
 "firstName":"John",
 "lastName":"Smith",
 "age":25,
 "address":{
    "street":"21 2nd Street‟,
    "city":"New York",
    "state":"NY","postalCode":"10021",
    "isBusiness":false
 },
 "phoneNumbers":[
    {"type":"home",
     "number":"212 555-1234"},
    {"type":"mobile",
     "number":"646 555-4567"}
 ],
 "bankruptcies":null,
 "lastUpdated":"2019-05-13T13:03:35"
}
```

JSON_TABLE: 'flatten' the JSON data

```
Select id, jt.* from
  custData,
  JSON_TABLE(jcol, '$' columns (
    "FIRST"                 path '$.firstName',
    "AGE"    number         path '$.age',
    "STATE"  varchar2(2)    path '$.address.state',
    "PHONE"  FORMAT JSON path
                           '$.phoneNumbers.number'
                           with array wrapper
  )) jt;
```

ID	FIRST	AGE	STATE	PHONE

JSON_TABLE: ‘flatten’ the JSON

```
{
 "firstName":"John",
 "lastName":"Smith",
 "age":25,
 "address":{
    "street":"21 2nd Street‟,
    "city":"New York",
    "state":"NY","postalCode":"10021",
    "isBusiness":false
 },
 "phoneNumbers":[
    {"type":"home",
     "number":"212 555-1234"},
    {"type":"mobile",
     "number":"646 555-4567"}
 ],
 "bankruptcies":null,
 "lastUpdated":"2019-05-13T13:03:35"
}
```

JSON_TABLE: 'flatten' the JSON data

```
Select id, jt.* from
  custData,
  JSON_TABLE(jcol, '$' columns (
    "FIRST"                 path '$.firstName',
    "AGE"    number         path '$.age',
    "STATE"  varchar2(2)    path '$.address.state',
    "PHONE"  FORMAT JSON path
                           '$.phoneNumbers.number'
                           with array wrapper
  )) jt;
```

ID	FIRST	AGE	STATE	PHONE
1	John	25	NY	["212 555-1234", "646 555-4567"]

JSON_TABLE: ‘flatten’ the JSON

```
{
 "firstName":"John",
 "lastName":"Smith",
 "age":25,
 "address":{
    "street":"21 2nd Street‟,
    "city":"New York",
    "state":"NY","postalCode":"10021",
    "isBusiness":false
 },
 "phoneNumbers":[
    {"type":"home",
     "number":"212 555-1234"},
    {"type":"mobile",
     "number":"646 555-4567"}
 ],
 "bankruptcies":null,
 "lastUpdated":"2019-05-13T13:03:35"
}
```

JSON_TABLE: 'flatten' the JSON data

```
Select id, jt.* from
  custData,
  JSON_TABLE(jcol, '$' columns (
    "FIRST"                 path '$.firstName',
    "AGE"    number         path '$.age',
    "STATE"  varchar2(2)    path '$.address.state’,
     NESTED PATH '$.phoneNumbers[*] columns(
      "PHONES" path '$.number

     )
  )) jt;
```

ID	FIRST	AGE	STATE	PHONES
1	John	25	NY	212 555-1234
1	John	25	NY	646 555-4567

JSON_TABLE: ‘flatten’ the JSON

```
{
 "firstName":"John",
 "lastName":"Smith",
 "age":25,
 "address":{
    "street":"21 2nd Street",
    "city":"New York",
    "state":"NY","postalCode":"10021",
    "isBusiness":false
 },
 "ph
 ],
 "ba
 "la
}
```

JSON_TABLE: 'flatten' the JSON data

```
Select id, jt.* from
  custData,
  JSON_TABLE(jcol, '$' columns (
    "FIRST"                path '$.firstName',
    "AGE"    number        path '$.age',
    "STATE"  varchar2(2)   path '$.address.state',
             PATH '$.phoneNumbers[*] columns(
             " path '$.number
```

Oracle perfomance tip:

JSON_TABLE columns can have different semantics:
- JSON_VALUE, JSON_QUERY, JSON_EXISTS
- all options supported

Write on JSON_TABLE with multiple columns instead of
- SELECT JSON_VALUE, JSON_VALUE, JSON_QUERY
- FROM …
- WHERE JSON_EXISTS

STATE	PHONES
NY	212 555-1234
NY	646 555-4567

JSON Support in the Oracle database

- JSON storage
- JSON value extraction
- JSON table projection
- JSON generation

JSON Generation

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
7369	SMITH	CLERK	7902	17-DEC-80	800		20
7499	ALLEN	SALESMAN	7698	20-FEB-81	1600	300	30
7521	WARD	SALESMAN	7698	22-FEB-81	1250	500	30
7566	JONES	MANAGER	7839	02-APR-81	2975		20
7654	MARTIN	SALESMAN	7698	28-SEP-81	1250	1400	30
7698	BLAKE	MANAGER	7839	01-MAY-81	2850		30
7782	CLARK	MANAGER	7839	09-JUN-81	2450		10
7788	SCOTT	ANALYST	7566	19-APR-87	3000		20
7839	KING	PRESIDENT		17-NOV-81	5000		10
7844	TURNER	SALESMAN	7698	08-SEP-81	1500	0	30
7876	ADAMS	CLERK	7788	23-MAY-87	1100		20
7900	JAMES	CLERK	7698	03-DEC-81	950		30
7902	FORD	ANALYST	7566	03-DEC-81	3000		20
7934	MILLER	CLERK	7782	23-JAN-82	1300		10

```
Select JSON_OBJECT(
       'id' VALUE empno,
       'name' VALUE ename )
  from emp;
```

```
{"id":7969,"name":"SMITH"}
{"id":7499,"name":"ALLEN"}
{"id":7521,"name":"WARD"}
{"id":7566,"name":"JONES"}
```

JSON Generation: Aggregates

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
7369	SMITH	CLERK	7902	17-DEC-80	800		20
7499	ALLEN	SALESMAN	7698	20-FEB-81	1600	300	30
7521	WARD	SALESMAN	7698	22-FEB-81	1250	500	30
7566	JONES	MANAGER	7839	02-APR-81	2975		20
7654	MARTIN	SALESMAN	7698	28-SEP-81	1250	1400	30
7698	BLAKE	MANAGER	7839	01-MAY-81	2850		30
7782	CLARK	MANAGER	7839	09-JUN-81	2450		10
7788	SCOTT	ANALYST	7566	19-APR-87	3000		20
7839	KING	PRESIDENT		17-NOV-81	5000		10
7844	TURNER	SALESMAN	7698	08-SEP-81	1500	0	30
7876	ADAMS	CLERK	7788	23-MAY-87	1100		20
7900	JAMES	CLERK	7698	03-DEC-81	950		30
7902	FORD	ANALYST	7566	03-DEC-81	3000		20
7934	MILLER	CLERK	7782	23-JAN-82	1300		10

```
Select JSON_ARRAYAGG(EMPNO)
  from emp;
```

```
[7369, 7499, 7521, 7566, …..]
```

JSON Generation: Departments with all employees

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
7369	SMITH	CLERK	7902	17-DEC-80	800		20
7499	ALLEN	SALESMAN	7698	20-FEB-81	1600	300	30
7521	WARD	SALESMAN	7698	22-FEB-81	1250	500	30
7566	JONES	MANAGER	7839	02-APR-81	2975		20
7654	MARTIN	SALESMAN	7698	28-SEP-81	1250	1400	30
7698	BLAKE	MANAGER	7839	01-MAY-81	2850		30
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7839	KING	PRESIDENT		17-NOV-81	5000		10
7844	TURNER	SALESMAN	7698	08-SEP-81	1500	0	30
7876	ADAMS	CLERK	7788	23-MAY-87	1100		20
7900	JAMES	CLERK	7698	03-DEC-81	950		30
7902	FORD	ANALYST	7566	03-DEC-81	3000		20
7934	MILLER	CLERK	7782	23-JAN-82	1300		10

DEPTNO	DNAME	LOC
10	ACCOUNTING	NEW YORK
20	RESEARCH	DALLAS
30	SALES	CHICAGO
40	OPERATIONS	BOSTON

```
Select JSON_OBJECTAGG(
   dname VALUE


 ) from dept d;
```

JSON Generation: Departments with all employees

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
7369	SMITH	CLERK	7902	17-DEC-80	800		20
7499	ALLEN	SALESMAN	7698	20-FEB-81	1600	300	30
7521	WARD	SALESMAN	7698	22-FEB-81	1250	500	30
7566	JONES	MANAGER	7839	02-APR-81	2975		20
7654	MARTIN	SALESMAN	7698	28-SEP-81	1250	1400	30
7698	BLAKE	MANAGER	7839	01-MAY-81	2850		30
7782	CLARK	MANAGER	7839	09-JUN-81	2450		10
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7902	FORD	ANALYST	7566	03-DEC-81	3000		20
7934	MILLER	CLERK	7782	23-JAN-82	1300		10

DEPTNO	DNAME	LOC
10	ACCOUNTING	NEW YORK
20	RESEARCH	DALLAS
30	SALES	CHICAGO
40	OPERATIONS	BOSTON

```
Select JSON_OBJECTAGG(
   dname VALUE ..

 ) from dept d;
```

```
{
        "ACCOUNTING":…,
        "RESEARCH":…,
        "SALES":…,
        "OPERATIONS":…
}
```

……

JSON Generation: Departments with all employees

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
7369	SMITH	CLERK	7902	17-DEC-80	800		20
7499	ALLEN	SALESMAN	7698	20-FEB-81	1600	300	30
7521	WARD	SALESMAN	7698	22-FEB-81	1250	500	30
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7654	MARTIN	SALESMAN	7698	28-SEP-81	1250	1400	30
7698	BLAKE	MANAGER	7839	01-MAY-81	2850		30
7782	CLARK	MANAGER	7839	09-JUN-81	2450		10
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7900	JAMES	CLERK	7698	03-DEC-81	950		30
7902	FORD	ANALYST	7566	03-DEC-81	3000		20
7934	MILLER	CLERK	7782	23-JAN-82	1300		10

DEPTNO	DNAME	LOC
10	ACCOUNTING	NEW YORK
20	RESEARCH	DALLAS
30	SALES	CHICAGO
40	OPERATIONS	BOSTON

```
Select JSON_OBJECTAGG(
   dname VALUE select JSON_ARRAYAGG(..

   ) from emp e where e.deptno = d.deptno
  ) from dept d;
```

```
{
        "ACCOUNTING":[…],
        "RESEARCH"[..],
        "SALES”:[…],
        "OPERATIONS”:[…]
}
                ……
```

JSON Generation: Departments with all employees

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
7369	SMITH	CLERK	7902	17-DEC-80	800		20
7499	ALLEN	SALESMAN	7698	20-FEB-81	1600	300	30
7521	WARD	SALESMAN	7698	22-FEB-81	1250	500	30
7566	JONES	MANAGER	7839	02-APR-81	2975		20
7654	MARTIN	SALESMAN	7698	28-SEP-81	1250	1400	30
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7839	KING	PRESIDENT		17-NOV-81	5000		10
7844	TURNER	SALESMAN	7698	08-SEP-81	1500	0	30
7876	ADAMS	CLERK	7788	23-MAY-87	1100		20
7900	JAMES	CLERK	7698	03-DEC-81	950		30
7902	FORD	ANALYST	7566	03-DEC-81	3000		20
7934	MILLER	CLERK	7782	23-JAN-82	1300		10

DEPTNO	DNAME	LOC
10	ACCOUNTING	NEW YORK
20	RESEARCH	DALLAS
30	SALES	CHICAGO
40	OPERATIONS	BOSTON

```
Select JSON_OBJECTAGG(
   dname VALUE select JSON_ARRAYAGG(
      JSON_OBJECT('name' VALUE
      ename)
   ) from emp e where e.deptno = d.deptno
  ) from dept d;
```

```
{
        "ACCOUNTING": [{
                "name": "CLARK"
        }, {
                "name": "KING"
        }, {
                "name": "MILLER"
        }],
        "RESEARCH": [{
                "name": "SMITH"
        }, {
                "name": "JONES"
        }, {.....
                ......
```

JSON Generation: Departments with all employees

EMPNO	ENAME	JOB	MGR	HIREDATE	SAL	COMM	DEPTNO
7369	SMITH	CLERK	7902	17-DEC-80	800		20
7499	ALLEN	SALESMAN	7698	20-FEB-81	1600	300	30
7521	WARD	SALESMAN	7698	22-FEB-81	1250	500	30
7566	JONES	MANAGER	7839	02-APR-81	2975		20
7654	MARTIN	SALESMAN	7698	28-SEP-81	1250	1400	30
7698	BLAKE	MANAGER	7839	01-MAY-81	2850		30
7782	CLARK	MANAGER	7839	09-JUN-81	2450		10
7788	SCOTT	ANALYST	7566	19-APR-87	3000		20
7839	KING	PRESIDENT		17-NOV-81	5000		10
78							
78							
79							
79							
79							

Oracle perfomance tip:

total output size may require lob data type
(use RETURNING CLOB clause)

intermediate results may not be as big
try to avoid intermediate lobs if possible

Varchar2 goes up to 32767 bytes

40	OPERATIONS	BOSTON

```
Select JSON_OBJECTAGG(
   dname VALUE select JSON_ARRAYAGG(
      JSON_OBJECT('name' VALUE
      ename)
   ) from emp e where e.deptno = d.deptno
  ) from dept d;
```

```
{
                "ACCOUNTING": [{
                , { "name": "CLARK"

                , { "name": "KING"

                ],  "name": "MILLER"
               'RESEARCH": [{
                   "name": "SMITH"
                , {
                   "name": "JONES"
                , {……
```

JSON Support in the Oracle database

- JSON storage
- JSON value extraction
- JSON table projection
- JSON generation
- JSON Indexing

Functional index for one path: B-Tree

```
create index cost_idx on emp (
       json_value(flex, '$.costcenter'
                  returning number
                  error on error
                  null on empty));
```

Search Index (index all): posting list

```
create search index search_idx
    on emp (flex) for JSON;
```

(Search index allows full text search, e.g. contains)

JSON Support in the Oracle database

- JSON storage
- JSON value extraction
- JSON table projection
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- JSON Indexing
- JSON Dataguide

```
select JSON_DATAGUIDE(e.flex)
from emp e;
```

JSON Support in the Oracle database

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- JSON Dataguide

```
select JSON_DATAGU
from emp e;
```

```
[{
    "o:path": "$.skills",
    "type": "array",
    "o:length": 32
}, {
    "o:path": "$.skills[*]",
    "type": "string",
    "o:length": 16
}, {
    "o:path": "$.photoUrl",
    "type": "string",
    "o:length": 16
}]
```

Data Guide: Relational access to JSON content

```
call DBMS_JSON.CREATE_VIEW_ON_PATH(
        'THEATER_VIEW',
        'THEATER',
        'JSON_DOCUMENT',
        '$.id'
    )
```

- Automatically create a relational view of your JSON content
  - Views are based on JSON_TABLE operator
- Use the PATH argument to control which keys are included in the view
- Automatically generates unique column names

```
desc THEATER_VIEW
Name                          Null?     Type
----------------------------  --------  -------------
ID                            NOT NULL  VARCHAR2(255)
CREATED_ON                    NOT NULL  TIMESTAMP(6)
LAST_MODIFIED                 NOT NULL  TIMESTAMP(6)
VERSION                       NOT NULL  VARCHAR2(255)
JSON_DOCUMENT$id                        NUMBER
JSON_DOCUMENT$name                      VARCHAR2(64)
JSON_DOCUMENT$city                      VARCHAR2(32)
JSON_DOCUMENT$state                     VARCHAR2(2)
JSON_DOCUMENT$street                    VARCHAR2(64)
JSON_DOCUMENT$zipCode                   VARCHAR2(8)
JSON_DOCUMENT$phoneNumber               VARCHAR2(4)


select count(*) COUNT
  from THEATER_VIEW
 where "JSON_DOCUMENT$zipCode" = 94115

   COUNT
--------
       3
```

Data Guide: Capturing changes to the structure of your JSON

```
CREATE INDEX SCREENING_SEARCH
          ON "Screening" (JSON_DOCUMENT) FOR JSON
              PARAMETERS ('SEARCH_ON NONE
                           DATAGUIDE ON
                           CHANGE LOG_JSON_CHANGES')


select JSON_PATH, JSON_TYPE, USERID, TIMESTAMP
  from JSON_CHANGE_LOG


JSON_PATH            JSON_TYPE  USERID   TIMSTAMP
-------------------  ---------- --------- ----------
$.movieId                     3  STUDENT01 2017-02-05T14:57:37Z
$.screenId                    3  STUDENT01 2017-02-05T14:57:37Z
$.startTime                   4  STUDENT01 2017-02-05T14:57:37Z
$.theaterId                   3  STUDENT01 2017-02-05T14:57:37Z
$.ticketPricing               5  STUDENT01 2017-02-05T14:57:37Z
$.ticketPricing.adultPrice    3  STUDENT01 2017-02-05T14:57:37Z
$.ticketPricing.childPrice    3  STUDENT01 2017-02-05T14:57:37Z
$.ticketPricing.seniorPrice   3  STUDENT01 2017-02-05T14:57:37Z
$.seatsRemaining              3  STUDENT01 2017-02-05T14:57:37Z

9 rows selected.
```

- Create a data guide enabled search index
  - "SEARCH_ON NONE" prevents the index functioning as a search index
  - Attach the procedure to the index
- The change procedure is called once for each new path found while building the index
- The change procedure is called every time a new path is found during insert and update operations

JSON Support in the Oracle database

- JSON storage
- JSON value extraction
- JSON table projection
- JSON generation
- JSON Indexing
- JSON Dataguide
- JSON Cross Functional

Oracle uses a binary **in-memor**y representation for JSON:
Post-parse format allowing ‘jump’ navigation.

Exadata pushdown pf predicates is done for JSON_VALUE, JSON_EXISTS and JSON_QUERY with WHERE CLAUSE.
Data/lob size limit 4k!

Partitioning possible on JSON value but preferably done on relational columns.

Security features like Encryption, VPD, Redaction, … usable with JSON data

JSON Support in the Oracle database

- JSON storage
- JSON value extraction
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- JSON generation
- JSON Indexing
- JSON Dataguide
- JSON Cross Functional
- JSON in PL/SQL

```
create or replace function addSkill(skills varchar2,
                                    newSkill varchar2)
                                    return varchar2 is
 skillsArr JSON_ARRAY_T;
 result    varchar2(4000);
begin
  skillsArr  := JSON_ARRAY_T(skills);
  skillsArr.append(newSkill);
  result := skillsArr.stringify;
  return result;
end;
/

select addSkill('["C++"]', 'Java') from dual;
```

	ADDSKILL('["C++"]','JAVA')
1	["C++","Java"]

JSON Support in the Oracle database

- JSON storage
- JSON value extraction
- JSON table projection
- JSON generation
- JSON Indexing
- JSON Dataguide
- JSON Cross Functional
- JSON in PL/SQL
- JSON Updates

- JSON_TRANSFORM in progress
  - In standardization process
  - Declarative Updates
- Available today:
  - Pl/SQL programmatic updates (12.2)
  - JSON_MERGEPATCH (18c)
  - Update entire document (12.1.0.1)

Common use cases

Common JSON use cases

- 1) JSON Ingestion to relational application (import)
  - Examples: Google Clickstream, travel bookings, tax-filing, social media feeds,…
  - Often no control over JSON structure (schema). Sometimes originating from XML
  - JSON_TABLE to 'shred' relational data, (materialized) views
  - Often JSON is not only imported but also stored and queried (schema-less storage)
- 2) JSON Generation (Export)
  - Export of data and message generation
  - Often from relational (legacy) applications
  - Example: modern JSON-based UI on top of 'old' and working application
  - Sometimes PL/SQL used to generate complex (conditional) messages
    - Example: Oracle RAC autonomous health framework: node status as JSON record

Common JSON use cases

- 3) Flexfields (hybrid storage)
  - Core of application is relational but 'new' fields are in a (flat) JSON column
  - Schema flexibility, easier/faster to extend application
  - Data augmentation by third parties: fields are unknown and never defined,
    - JSON Search index (index all values)

- 4) Sparse columns (Avoid the 1000 column limits)
  - metadata of financial assets (>1000 values), more added dynamically
  - Storage in multiple JSON varchar2(4000) columns
    - Exadata pushdown on JSON_EXISTS queries, no index
  - JSON_TABLE views, to select relevant values as columns (<1000 cols per view)

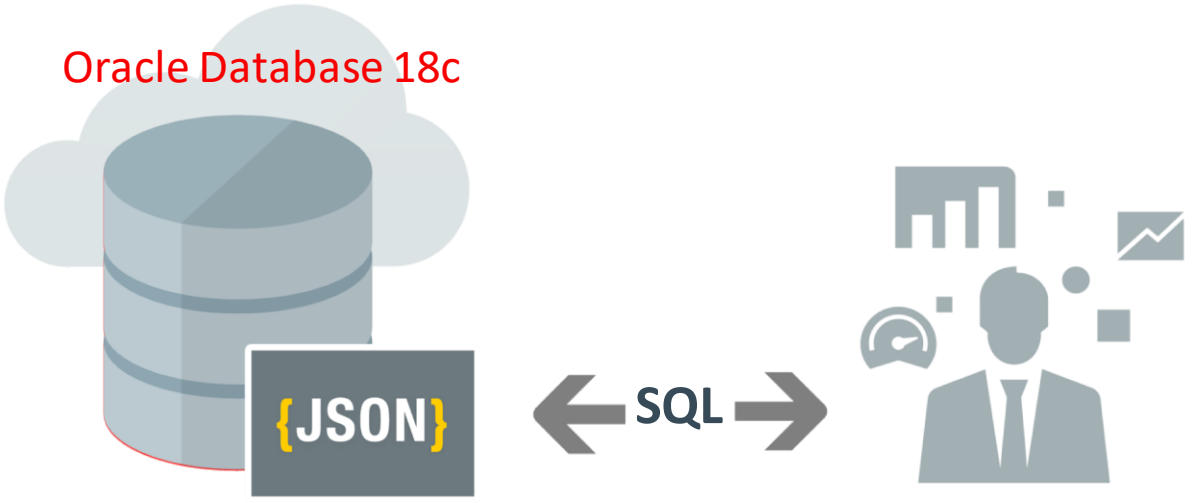
Common JSON use: Oracle as a document store

- 5) Document-Store:
  - Entire data-model is JSON based - similar to MongoDB
  - Example: point of sales (super market; consumer electronics vendor)
    - Every sale/order become a JSON document (1Kb to 100s of Kbs, average under 5kb)
  - Why JSON and not relational?
    - Perception: JSON is modern, productivity, developers want No-SQL, "today it's done this way"
  - Why Oracle?
    - Richer feature- set: e.g. Transactions, Joins, Views, Generation (Reporting)
    - Co-Existence of JSON and non-JSON data (multi-model DB)
    - DBA skills: apply existing skills and experience to JSON
- Simple Oracle Document Access (SODA) caters to this use case

Simple Oracle Document Access (SODA)

Conclusion: JSON storage and easy access Api(SODA)

Simple NoSQL Development experience

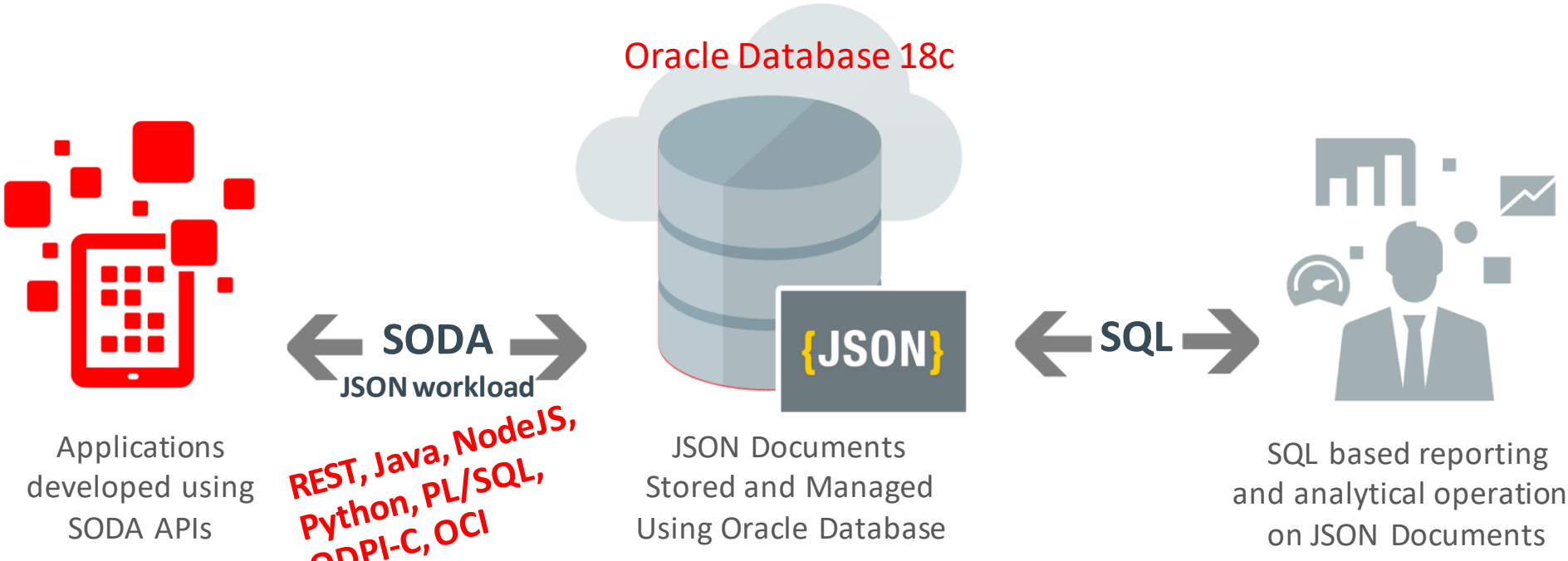


JSON Documents
Stored and Managed
Using Oracle Database

SQL based reporting
and analytical operations
on JSON Documents

Conclusion: JSON storage and easy access Api(SODA)

Simple NoSQL Development experience



Document Store Model

- A **document** is a JSON (or binary) instance
  - Document is identified by a key (get, update, delete by key)
- Store documents inside a ***collection***
  - Collection stores similar documents
  - Collection is identified by name
- One or more collections reside in a ***database***
  - Application connects to database

Document Store Model mapped to relational model

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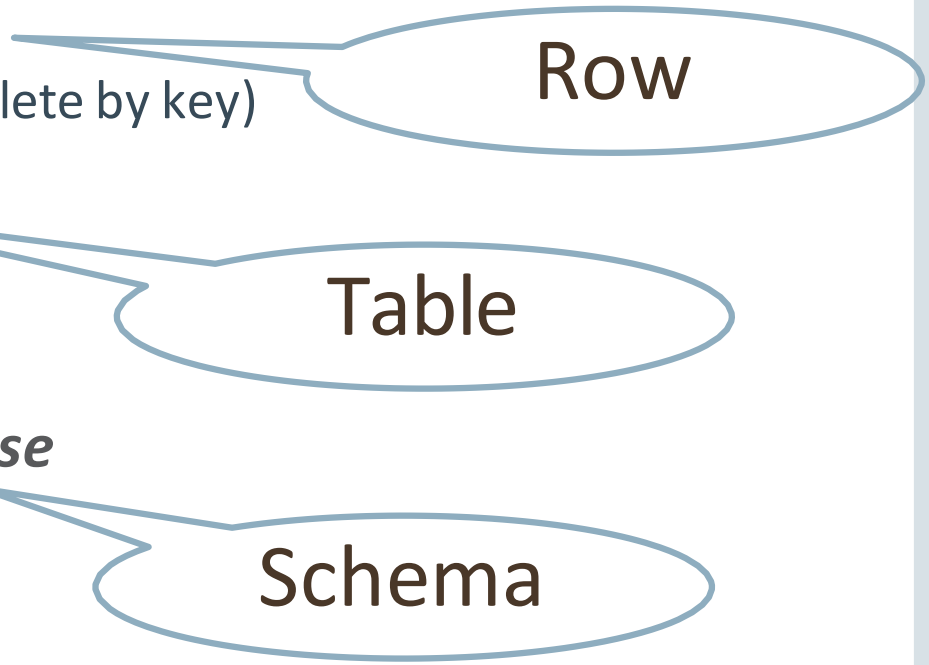

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Row

Table

Schema

KEY	JSON_DOC	VERSION	CREATED_ON	LAST_MODIFIED
3C990A8D39…	{“name” : “Alex”}	75611B292…	2018-09-12T00:00:00Z	2018-09-12T00:00:00Z

Creating and dropping collections

Node.js

```
conn = await oracledb.getConnection(…);

db = conn.getSodaDatabase();

coll = await db.createCollection(“sweets");

await coll.drop();
```

Python

```
conn = cx_Oracle.connect(…);

db =  conn.getSodaDatabase();

coll = db.createCollection(“sweets");

coll.drop();
```

Java

```
OracleClient cl = new OracleRDBMSClient();

db = cl.getDatabase(jdbcConn);

OracleCollection coll =
db.admin().createCollection(“sweets");

coll.admin().drop();
```

PL/SQL

```
coll := dbms_soda.create_collection(‘sweets’);


select dbms_soda.drop_collection(‘sweets’)
from dual;
```

Inserting, finding, updating documents

Node.js (*other implementations have similar syntax*)

- `resultDoc = await coll.insertOneAndGet({name : "Alexander"});`
- `key = resultDoc.key;`

- `col.find().key("k1");`
- `col.find().key("k1"). replaceOne(newDoc);`
- `col.find().filter({"name" : "alex"});`
- `col.find().filter({"name" : "alex"}).remove();`
- `col.find().filter({"name" : "chris"}).skip(10).limit(10).getCursor();`

QBEs can be sophisticated!

```
{ "$query" : {
                "empno" : { "$lte": 10041 },
                "name" : { "$startsWith" : "Melissa" },
                "salary" : { "$gt" : 200000 },
                "title" : { "$contains" : "President" },
              },
  "$orderby" : [
                 {"path" : "salary", "order" : "asc"},
                 {"path" : "department.name", "order" : "desc"}
               ]
}
```

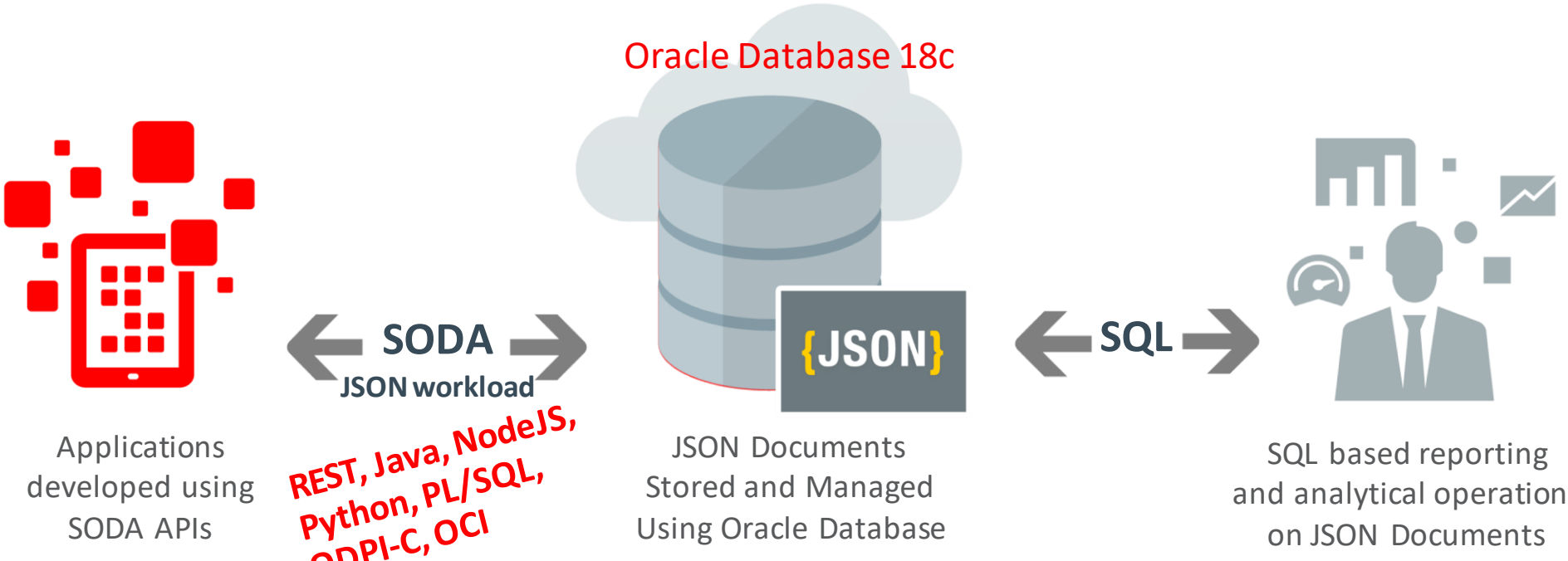
QBE rewritten to SQL

```
SELECT "ID", "JSON_DOCUMENT" FROM "Employees" coll
WHERE JSON_Exists(coll."JSON_DOCUMENT",
                  '$?(@.empno <= $B0 &&
                      @.salary > $B1 &&
                      @.name starts with $B2)'
                  PASSING 10041 AS "B0", 200000 AS "B1", 'Melissa' AS "B2")
AND JSON_TextContains(coll."JSON_DOCUMENT",
                      '$.title', 'President')
ORDER BY JSON_Value(coll."JSON_DOCUMENT", '$.salary') ASC,
         JSON_Value(coll."JSON_DOCUMENT", '$.department.name') DESC;
```

Conclusion

Conclusion: JSON storage and easy access Api(SODA)

Simple NoSQL Development experience



Learn more

https://www.oracle.com/database/technologies/appdev/json.html

https://docs.oracle.com/en/database/oracle/simple-oracle-document-access/index.html

https://github.com/oracle/soda-for-java

https://github.com/oracle/node-oracledb

https://github.com/oracle/python-cx_Oracle