# HTML5 JavaScript Storage for Structured Data

Andy Gup, Esri

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@agup

# IndexedDB

## and the mobile web

# Why attend this session?

Have storage needs > 5MBs

Want to store data types other than Strings

Don’t want to manually serialize/deserialize

Looking into offline JavaScript

# Agenda

Intro to IndexedDB coding patterns

Fitting IndexedDB into overall application

Performance

Wet your appetite! Can’t cover it all

# Who am I?

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esri

# Structured data?

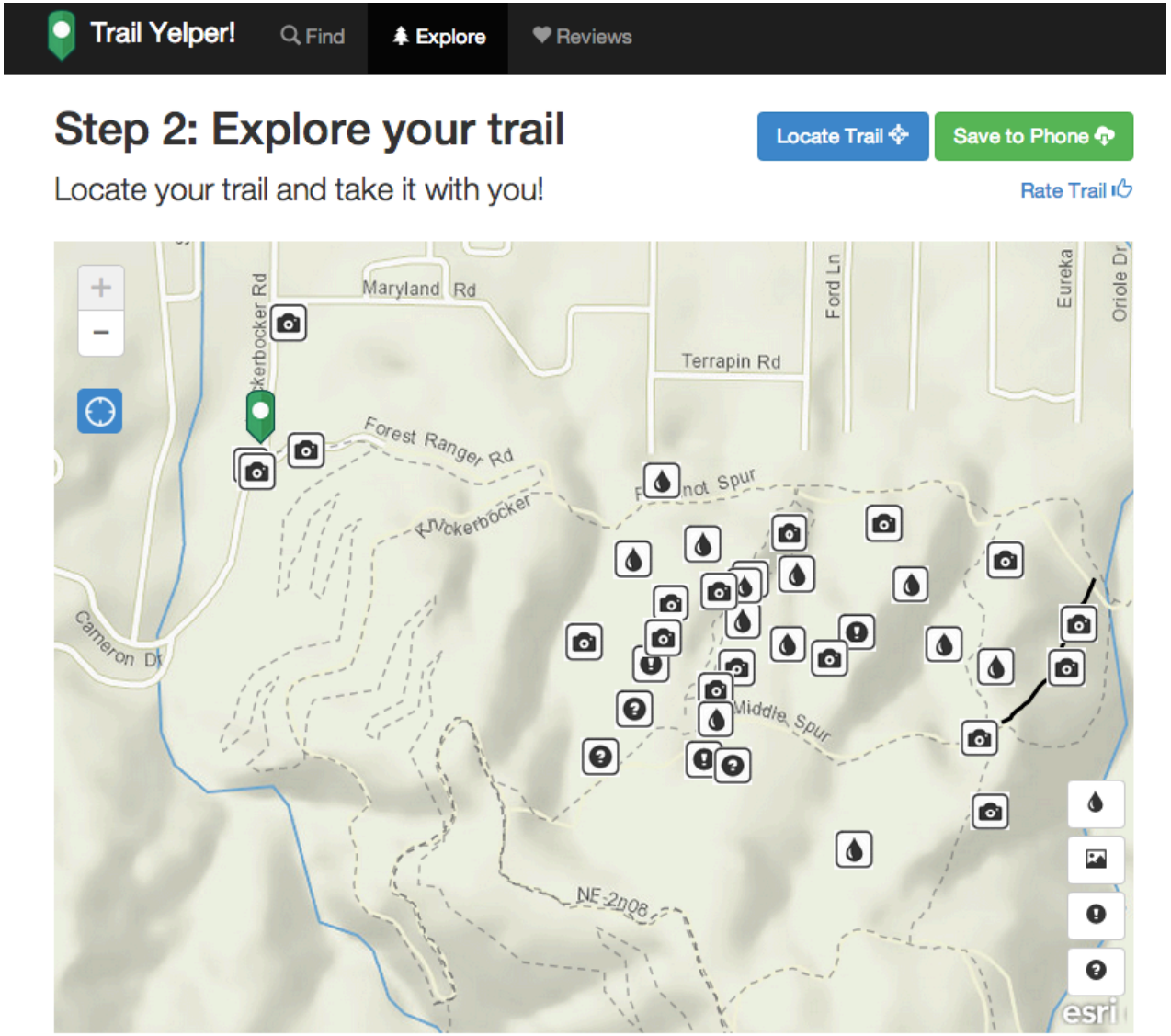
JSON Objects (not serialized)

Complex Objects (difficult serialize/deserialize)

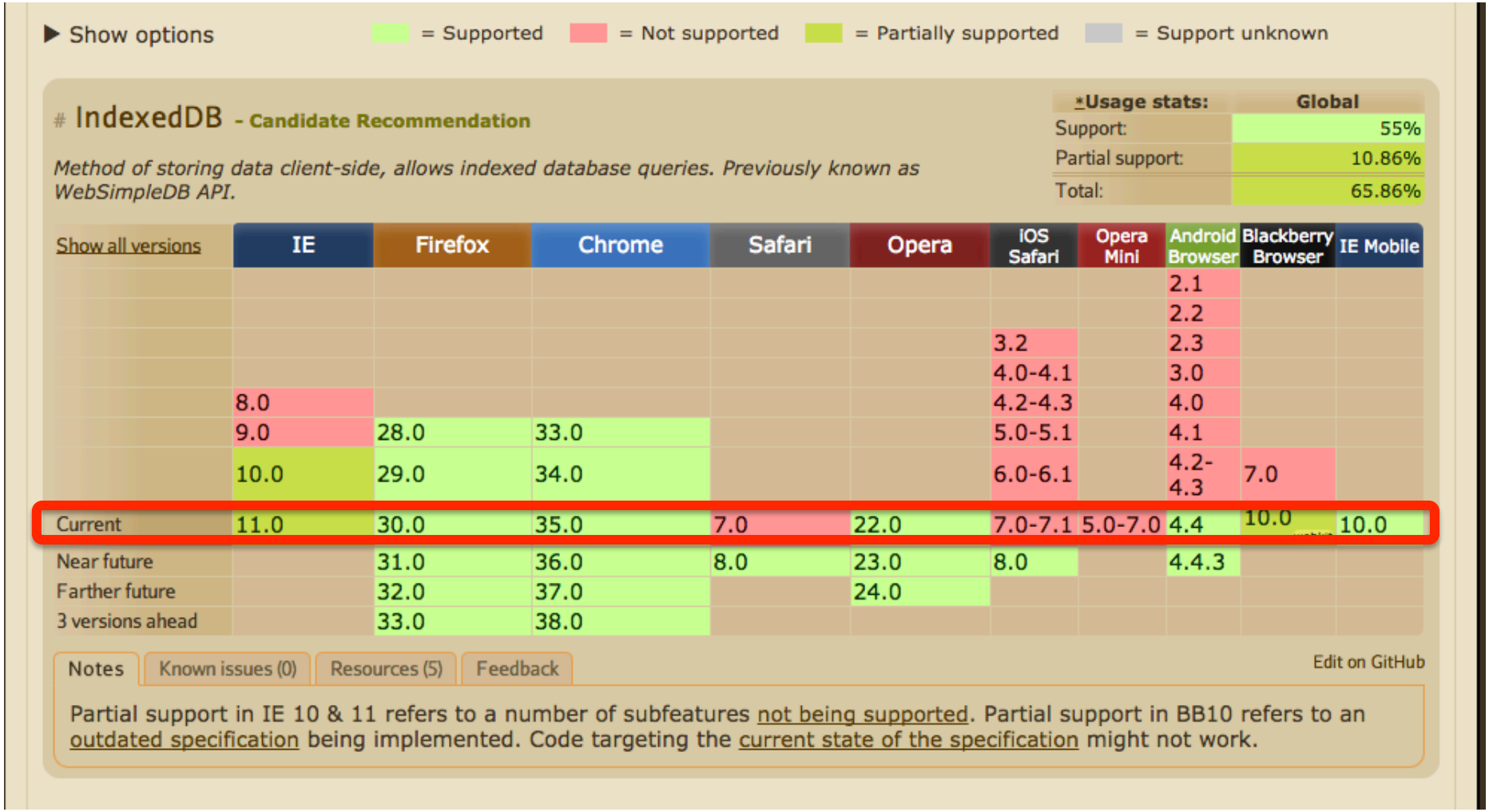
Binary data (e.g. images, files)

Arrays

# Offline JavaScript Demo



# IndexedDB browser support?



▶ Show options = Supported = Not supported = Partially supported = Support unknown

# IndexedDB - Candidate Recommendation

*Method of storing data client-side, allows indexed database queries. Previously known as WebSimpleDB API.*

| *Usage stats: | Global |
|---|---|
| Support: | 55% |
| Partial support: | 10.86% |
| Total: | 65.86% |

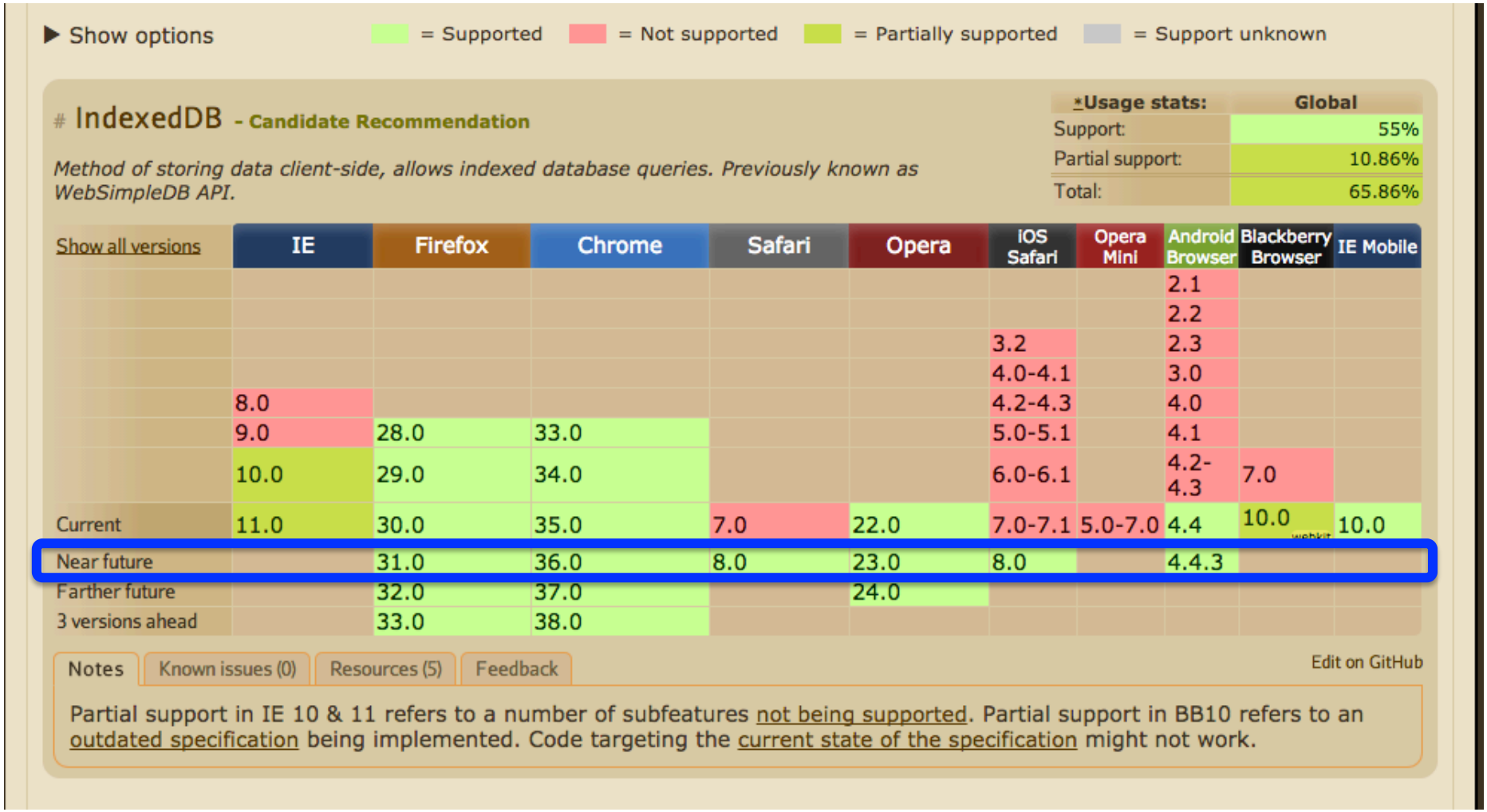
| Show all versions | IE | Firefox | Chrome | Safari | Opera | iOS Safari | Opera Mini | Android Browser | Blackberry Browser | IE Mobile |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 2.1 | | |
| | | | | | | | | 2.2 | | |
| | | | | | | 3.2 | | 2.3 | | |
| | | | | | | 4.0-4.1 | | 3.0 | | |
| | 8.0 | | | | | 4.2-4.3 | | 4.0 | | |
| | 9.0 | 28.0 | 33.0 | | | 5.0-5.1 | | 4.1 | | |
| | 10.0 | 29.0 | 34.0 | | | 6.0-6.1 | | 4.2-4.3 | 7.0 | |
| Current | 11.0 | 30.0 | 35.0 | 7.0 | 22.0 | 7.0-7.1 | 5.0-7.0 | 4.4 | 10.0 | 10.0 |
| Near future | | 31.0 | 36.0 | 8.0 | 23.0 | 8.0 | | 4.4.3 | | |
| Farther future | | 32.0 | 37.0 | | 24.0 | | | | | |
| 3 versions ahead | | 33.0 | 38.0 | | | | | | | |

Notes | Known issues (0) | Resources (5) | Feedback — Edit on GitHub

Partial support in IE 10 & 11 refers to a number of subfeatures not being supported. Partial support in BB10 refers to an outdated specification being implemented. Code targeting the current state of the specification might not work.

Source: Caniuse.com

# IndexedDB browser support?



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|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | 2.1 | | |
| | | | | | | | | 2.2 | | |
| | | | | | | 3.2 | | 2.3 | | |
| | | | | | | 4.0-4.1 | | 3.0 | | |
| | 8.0 | | | | | 4.2-4.3 | | 4.0 | | |
| | 9.0 | 28.0 | 33.0 | | | 5.0-5.1 | | 4.1 | | |
| | 10.0 | 29.0 | 34.0 | | | 6.0-6.1 | | 4.2-4.3 | 7.0 | |
| Current | 11.0 | 30.0 | 35.0 | 7.0 | 22.0 | 7.0-7.1 | 5.0-7.0 | 4.4 | 10.0 -webkit | 10.0 |
| Near future | | 31.0 | 36.0 | 8.0 | 23.0 | 8.0 | | 4.4.3 | | |
| Farther future | | 32.0 | 37.0 | | 24.0 | | | | | |
| 3 versions ahead | | 33.0 | 38.0 | | | | | | | |

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# How does IndexedDB work?

Key-Value pairs

Search Indexes

NoSQL

Cursors

Asynchronous via callbacks

Notifications via DOM events

# Key/Value pairs?

Key

- String, Number, Date, Array

Value (partial list)

- String
- Object
- Array
- Blob
- ArrayBuffer
- Uint8Array
- File

# Will IndexedDB work offline?

YES!

Can also be used with Application Cache.

# How to use? Six basic steps

1. Include shim (if necessary)
2. Set vendor prefixes
3. Validate functionality
4. Open (or upgrade)
5. Add, update, delete data
6. Capture events via callbacks

# How to use? IndexedDBShim.js

Required for Safari 7 on iOS and Mac

Safari 7 only comes with Web SQL

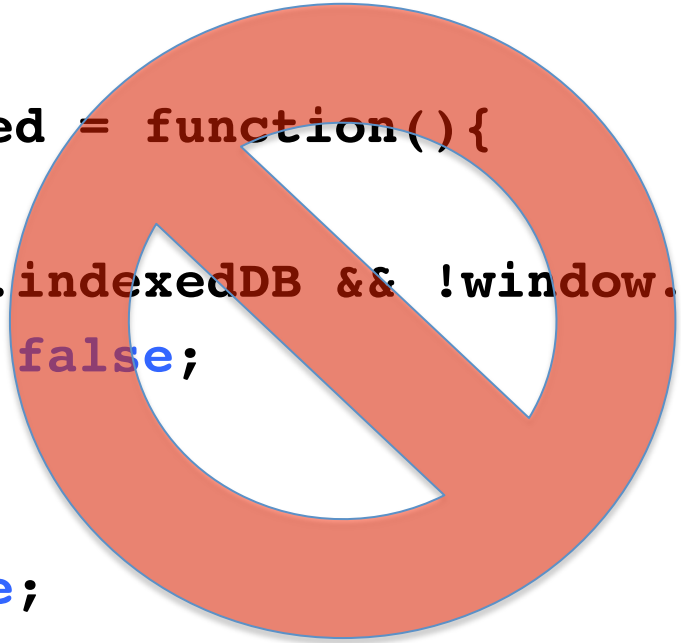
```
<script src="IndexedDBShim.js"></script>
```

# How to use? Set Prefixes

```
window.indexedDB = window.indexedDB ||
    window.mozIndexedDB ||
    window.webkitIndexedDB ||
    window.msIndexedDB;

var transaction = window.IDBTransaction ||
    window.webkitIDBTransaction;
```

# How to use? Validate functionality

```
this.isSupported = function(){

    if(!window.indexedDB && !window.openDatabase){
        return false;
    }

    return true;
};
```

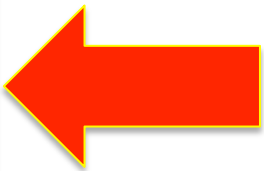


# How to use? Validate functionality

```
this.isSupported = function(callback){

    if(!window.indexedDB && !window.openDatabase){
        return callback(false);
    }
    else{
      testFunctionality(function(success,result){
            return callback(success,result);
      });
    }
};
```

# How to use? Validate functionality

```
function testFunctionality(callback){
    . . .
    var objectStore = transaction.objectStore("table1");
    var request = objectStore.put(myBlob,"test1key");
    request.onsuccess = function(event)
    {
        callback(true,event.target.result);
    };

    request.onerror = function(error)
    {
        callback(false,error);
    };
}
```



# How to use? Open database

```
var db = null;

var request =
    indexedDB.open("customerDB", /*version*/ 2);

request.onsuccess = function(event){
    db = event.target.result;
    callback(true);
}

request.onerror = function(error){
    callback(false,error);
}
```

STEP 1

STEP 2

# How to use? Transactions

Handles ALL reading and writing

```
var transaction =
    db.transaction(["customerDB"], "readwrite");
```

Provides events

Three modes

- “readonly”
- “readwrite”
- “versionchange”

# How to use? Transaction events

```
var transaction =
   db.transaction(["customerDB"], "readwrite");

transaction.onerror = function(error){ . . . }

//
// Careful! This always returns
//
transaction.oncomplete = function(event){
   . . .
}
```

# How to use? Transaction requests

```
var transaction =
    db.transaction(["customerDB"], "readwrite");

var objectStore =
    transaction.objectStore("customerDB");

var request =
    objectStore.put({test:1},"myKey");

// Did transaction request work or not?
request.onerror = function(error){ . . . }
request.onsuccess = function(event){ . . . }
```




# How to use? Write data

```
add(anyValue, /*optional*/ key)
```

Write only unique values

Duplicate entries fail with error

```
put(anyValue, /*optional*/ key)
```

Overwrites existing entries with same key

# How to use? Write data

```
request =
  objectStore.put({test:1},"myKey");

request.onsuccess = function(event){
   callback(true,event.target.result);
}

request.onerror = function(error){
   callback(false,error);
}
```

# How to use? Get data

```
request =
   objectStore.get("aUniqueKey");

request.onsuccess = function(event){
   callback(true,event.target.result);
}

request.onerror = function(error){
   callback(false,error);
}
```

# Read/Write performance

Know thy data!

Not all data types perform equally

Pre- and post-processing is expensive

# DEMO

Use case: Write-once, read-many

Test: data-type read performance

Data: 319KB JPEG

**https://github.com/andygup/indexeddb-typetest-js**

# Chrome 35.0.1916 – MacBook

## 319KB JPEG

| Initial Type | Type | Test | Image | Elapsed Time to get() |
|---|---|---|---|---|
| Simple String | string | test7 |  | 2.29400000534951 7ms |
| Object | object | test8 |  | 38.4040000626687ms |
| Array | array | test9 |  | 24.0179999964311 72ms |
| Blob | string | test10 | | 9.40799999807495 6ms |
| Uint8Array | uint8array | test11 |  | 1.10300000233110 04ms |
| ArrayBuffer | arraybuffer | test12 |  | 2.98299999849405 14ms |
| **Size** | 318679 bytes | | | |

# Safari 7.0.3 – MacBook (Shim)

## 319KB JPEG

| Initial Type | Type | Test | Image | Elapsed Time to get() |
|---|---|---|---|---|
| Simple String | string | test7 |  | 4ms |
| Object | object | test8 |  | 11ms |
| Array | array | test9 |  | 7ms |
| Blob | blob | test10 |  | 10ms |
| Uint8Array | arraybuffer | test11 |  | 210ms |
| ArrayBuffer | arraybuffer | test12 | | 10ms |
| **Size** | 318679 bytes | | | |

Whoa!!

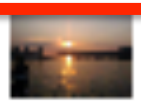
# Safari 7.1.1 iPad 3 (Shim)

## 319KB JPEG

| Initial Type | Type | Test | Image | Elapsed Time to get() |
|---|---|---|---|---|
| Simple String | string | test7 |  | 35ms |
| Object | object | test8 |  | 18ms |
| Array | array | test9 |  | 18ms |
| Blob | blob | test10 |  | 30ms |
| Uint8Array | arraybuffer | test11 |  | 54ms |
| ArrayBuffer | arraybuffer | test12 | | 2ms |
| **Size** | 318679 bytes | | | |

# Safari 7 iPhone 5 (Shim)

## 319KB JPEG

| Initial Type | Type | Test | Image | Elapsed Time to get() |
|---|---|---|---|---|
| Simple String | string | test7 |  | 24ms |
| Object | object | test8 |  | 45ms |
| Array | array | test9 |  | 54ms |
| Blob | blob | test10 |  | 64ms |
| Uint8Array | arraybuffer | test11 |  | 973ms |
| ArrayBuffer | arraybuffer | test12 | | 56ms |
| **Size** | 318679 bytes | | | |

Whoa!!

# Safari 8 iPhone 5S (no shim!)

## 319KB JPEG

| Initial Type | Type | Test | Image | Elapsed Time to get() |
|---|---|---|---|---|
| Simple String | string | test7 |  | 27.638375000606175ms |
| Object | object | test8 |  | 21.70512500015320 3ms |
| Array | array | test9 |  | 63.42466666683322ms |
| Blob | string | test10 | | 8.576708332839189ms |
| Uint8Array | uint8array | test11 |  | 13.27020833377901ms |
| ArrayBuffer | arraybuffer | test12 |  | 15.185874999588123ms |
| **Size** | 318679 bytes | | | |

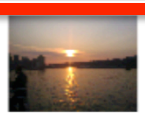
# Firefox 29.0.1 Desktop – MacBook

## 319KB JPEG

| Initial Type | Type | Test | Image | Elapsed Time to get() |
|---|---|---|---|---|
| Simple String | string | test7 |  | 7.0438659999998ms |
| Object | object | test8 |  | 28.012715000000014ms |
| Array | array | test9 |  | 14.23775900000096ms |
| Blob | blob | test10 |  | 10.76418899999874ms |
| Uint8Array | uint8array | test11 |  | 18.1950860000006ms |
| ArrayBuffer | arraybuffer | test12 |  | 23.28420900000033ms |
| **Size** | 318679 bytes | | | |

# Android 4.4.4 – Nexus 4

## 319KB JPEG

| Initial Type | Type | Test | Image | Elapsed Time to get() |
|---|---|---|---|---|
| Simple String | string | test1 |  | 72.63899999816203ms |
| Object | object | test2 |  | 53.34899999341284ms |
| Array | array | test3 |  | 53.89899999863701ms |
| Blob | | | | |
| Uint8Array | uint8array | test5 |  | 11.01800000469666ms |
| ArrayBuffer | arraybuffer | test6 |  | 14.10000000325963ms |

# Pre- and Post-processing

What final data type does your app need?

Pre-process

Work done before ‘writing’ data to DB

Post-process

Work done after ‘getting’ data from DB

# Pre- and Post-processing

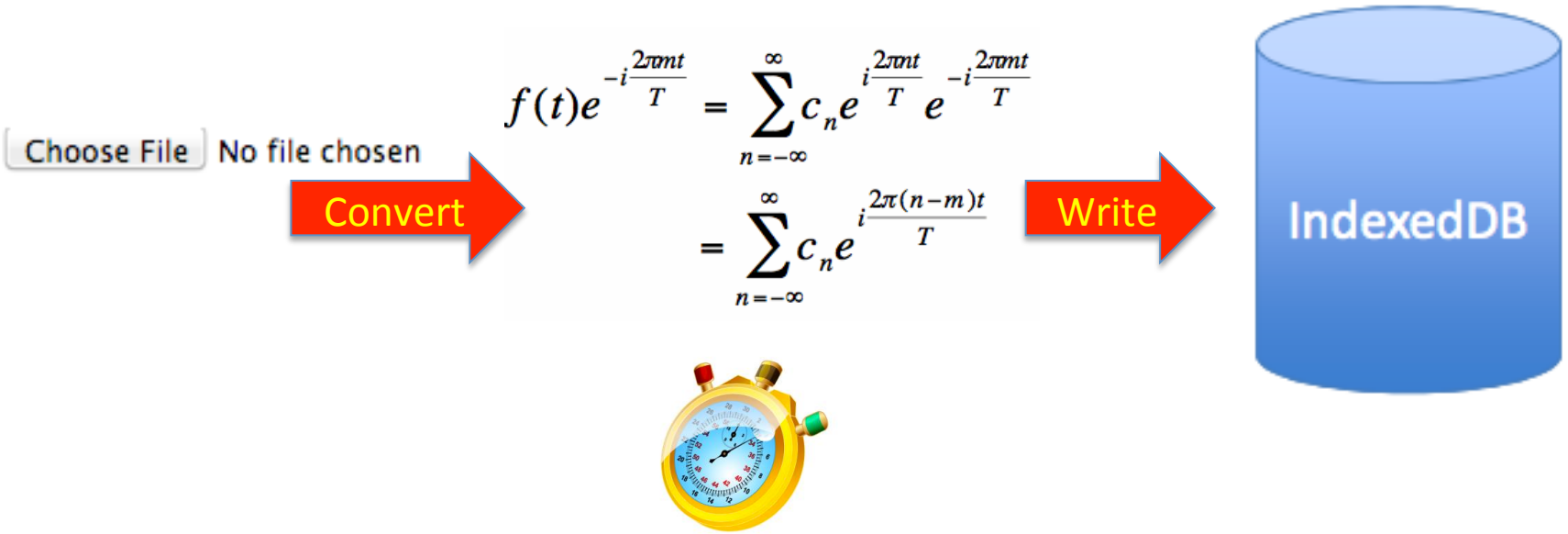
Potentially huge performance differences

Examples

- FileReader
- Canvas
- Bitwise conversion
- createObjectURL()

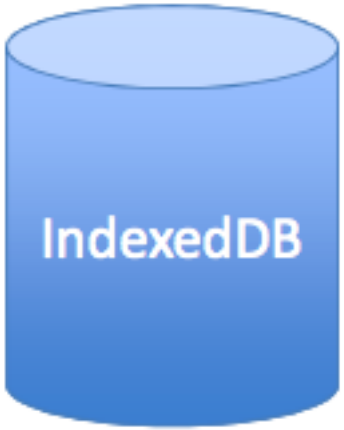
# Pre-processing

1. Retrieve data from <input> or server
2. Convert data (if needed)
3. Write to database



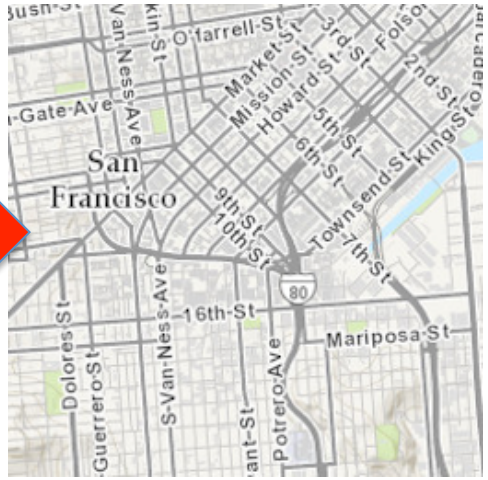
# Post-processing

1. Retrieve data from database
2. Convert data (if needed)
3. Display/use data





```
var uInt8Array = new Uint8Array(result);
var blob = new Blob([uInt8Array],{type:"image/png"});
var image = document.createElement("img");
var urlCreate = window.URL || window.webkitURL;
var url = urlCreate.createObjectURL(blob);
image.src = url;
image.height = 30;
image.onload = function(e){
    URL.revokeObjectURL(this.src);
}

value.appendChild(image)
break;
```

# Pre- and Post-processing

## XMLHTTPRequest response types

| Value | Response data type |
|---|---|
| “” | `String` (Default) |
| “arraybuffer” | `ArrayBuffer` |
| “blob” | `Blob` |
| “document” | `Document` |
| “json” | `Object` |
| “text” | `String` |

# FileReader pattern

```
function doFileReader(response,path,callback){
    var imageType = getImageType(response);
    var start2 = performance.now();
    var uInt8Array = new Uint8Array(response);
    var blob = new Blob([uInt8Array],{type:imageType})
    var reader = new FileReader();
    reader.path = path;
    reader.time = start2;
    reader.onloadend = function(evt){
        var endTime = performance.now() - reader.time;
        console.log("FILEREADER TIME: " + endTime)
        var path = reader.path;
        callback(path,endTime);
    }

    reader.readAsDataURL(blob);
}
```

START

END

# Canvas pattern

```
function doCanvas(response,path,callback){
    var start3 = performance.now();
    var canvas = document.createElement('CANVAS');
    var ctx = canvas.getContext('2d');
    var img = new Image;
    img.time = start3;
    img.path = path
    img.crossOrigin = 'Anonymous';
    img.onload = function(){
        canvas.height = img.height;
        canvas.width = img.width;
        ctx.drawImage(img,img.height,img.width);
        var endTime3 = performance.now() - img.time;
        var path = img.path.split("/");
        console.log("CANVAS TIME " + endTime3 + ", path: " + path[1]);
        callback(path[1],endTime3);
        canvas = null;
    };
    img.src = path;
}
```

START

END

```
// Main loop deals with bytes in chunks of 3
for (var i = 0; i < mainLength; i = i + 3) {
    // Combine the three bytes into a single integer
    chunk = (bytes[i] << 16) | (bytes[i + 1] << 8) | bytes[i + 2]

    // Use bitmasks to extract 6-bit segments from the triplet
    a = (chunk & 16515072) >> 18 // 16515072 = (2^6 - 1) << 18
    b = (chunk & 258048)   >> 12 // 258048   = (2^6 - 1) << 12
    c = (chunk & 4032)     >>  6 // 4032     = (2^6 - 1) << 6
    d = chunk & 63               // 63       = 2^6 - 1

    // Convert the raw binary segments to the appropriate ASCII encoding
    base64 += encodings[a] + encodings[b] + encodings[c] + encodings[d]
}

// Deal with the remaining bytes and padding
if (byteRemainder == 1) {
    chunk = bytes[mainLength]

    a = (chunk & 252) >> 2 // 252 = (2^6 - 1) << 2

    // Set the 4 least significant bits to zero
    b = (chunk & 3)   << 4 // 3   = 2^2 - 1

    base64 += encodings[a] + encodings[b] + '=='
} else if (byteRemainder == 2) {
    chunk = (bytes[mainLength] << 8) | bytes[mainLength + 1]

    a = (chunk & 64512) >> 10 // 64512 = (2^6 - 1) << 10
    b = (chunk & 1008)  >>  4 // 1008  = (2^6 - 1) << 4

    // Set the 2 least significant bits to zero
    c = (chunk & 15)    <<  2 // 15    = 2^4 - 1

    base64 += encodings[a] + encodings[b] + encodings[c] + '='
}
```

# Bitwise pattern

# Pre- and Post-processing (Example)

```
var uInt8Array = new Uint8Array(arrBuffer);
var blob = new Blob(
    [uInt8Array],
    {type:"image/jpeg"});
var image = document.createElement("img");
var urlCreate = window.URL || window.webkitURL;
var url = urlCreate.createObjectURL(blob);
image.src = url;
image.height = 30;
image.onload = function(e){
    callback(image);
    URL.revokeObjectURL(this.src);
}
```

INPUT

OUTPUT

# DEMO

Test image processing patterns

3 different image types: PNG, GIF, PNG

**https://github.com/andygup/image-parsing-test-js**

# Convert ArrayBuffer to Image*

GIF

| Test | FileReader | Canvas | Bitwise |
|---|---|---|---|
| type | image/gif | image/gif | image/gif |
| Size | 402629 | 402629 | 402629 |
| Avg. (ms) | 5.4146 | 34.0201 | 25.9631 |

PNG

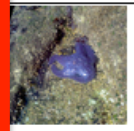
| Test | FileReader | Canvas | Bitwise |
|---|---|---|---|
| Type | image/png | image/png | image/png |
| Size | 409317 | 409317 | 409317 |
| Avg. (ms) | 5.8122 | 25.5615 | 23.3734 |

JPG

| Test | FileReader | Canvas | Bitwise |
|---|---|---|---|
| Type | image/jpeg | image/jpeg | image/jpeg |
| Size | 404699 | 404699 | 404699 |
| Avg. (ms) | 5.7540 | 39.6070 | 27.0127 |

* Chrome 35

# Convert ArrayBuffer to Image*

| Type | image_3.9mb.jpg | image_2.1mb.jpg | image_1.5mb.jpg | image_800kb.jpg | image_405kb.jpg |
|---|---|---|---|---|---|
| Size | 3863500 | 2763687 | 1532129 | 796339 | 404699 |
| FileReader | 15.434999993885867 | 13.084999998682179 | 8.228999999118969 | 3.608999992138706 | 4.256000000168569 |
| Bitwise | 266.4130000048317 | 118.2589999953052 | 89.66300000611227 | 42.74499999883119 | 20.90400000452064 |
| Canvas | 370.2860000048531 | 202.9599999950733 | 188.9939999964554 | 114.50199999671895 | 45.574999996460974 |
| Images |  |  |  |  |  |

| Type | image_3.9mb.png | image_2.1mb.png | image_1.5mb.png | image_800kb.png | image_405kb.png | |
|---|---|---|---|---|---|---|
| Size | 3863521 | 2144014 | 1460123 | 799053 | 409317 | 2 |
| FileReader | 15.855999998166226 | 8.312999998452142 | 7.406999997328967 | 3.715999991982244 | 3.6010000039823353 | 2 |
| Bitwise | 228.63900000811554 | 141.73300001129974 | 90.87899999576621 | 43.76300000876654 | 23.245999997016042 | 1 |
| Canvas | 299.7310000064317 | 94.530999995186 | 75.66400000359863 | 49.11300000094343 | 25.834000000031665 | 2 |
| Images |  |  |  |  |  |  |

* Chrome 35

# Convert ArrayBuffer to Image

| Type | | image_100kb.jpg | image_58kb.jpg | image_27kb.jpg |
|---|---|---|---|---|
| Size | | 16984 | 11603 | 7332 |
| FileReader | | 0.7210000039776787 | 0.6870000070193782 | 1.4530000044032931 |
| Bitwise | 3 | 1.141000000643544 | 0.5819999933009967 | 0.5549999914364889 |
| Canvas | | 7.279999990714714 | 6.057999999029562 | 7.644999990588985 |
| Images | |  |  |  |

JPG

| Type | | image_100kb.png | image_58kb.png | image_27kb.png |
|---|---|---|---|---|
| Size | | 98133 | 57550 | 27332 |
| FileReader | | 1.224999999976717 | 0.9160000045085326 | 0.9369999897899106 |
| Bitwise | | 4.690000001573935 | 2.7799999952549115 | 1.3840000028721988 |
| Canvas | | 11.365000013029203 | 9.47699999960605 | 8.04000000061933 |
| Images | |  |  |  |

PNG

# DEMO

Offline mapping

Storing large amounts of images

**https://github.com/Esri/offline-editor-js**

JS Offline Mapping esri up

**Min Zoom Level (farthest from ground)**

13

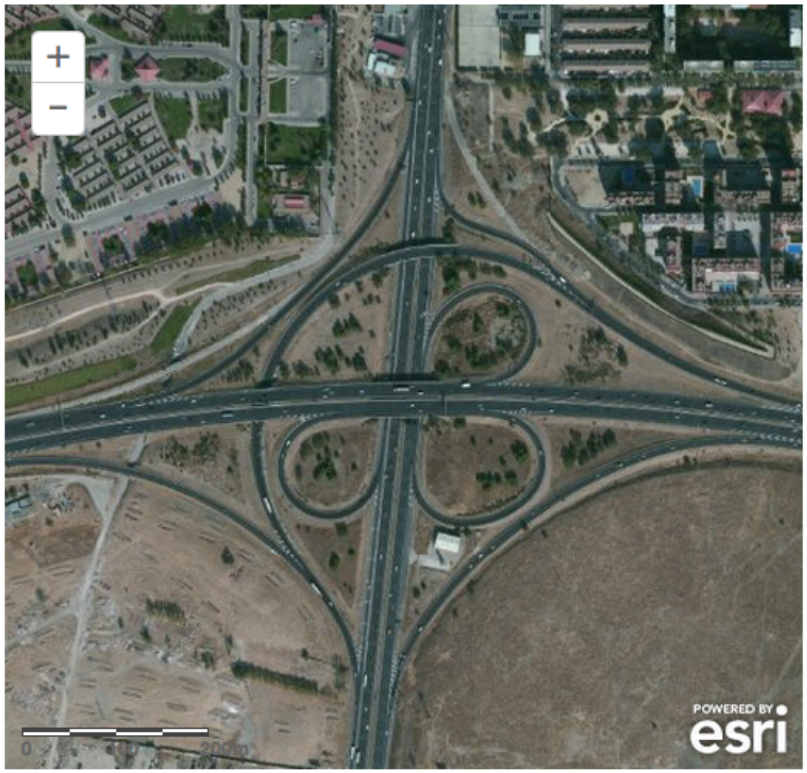
**Current Zoom Level**

16

**Max Zoom Level (closer to ground)**

19

| Level | Tile Count | Size Mb (aprox.) |
|---|---|---|
| 13 | 1 | 0.03 Mb |
| 14 | 2 | 0.05 Mb |
| 15 | 4 | 0.11 Mb |
| 16 | 9 | 0.24 Mb |
| 17 | 20 | 0.53 Mb |
| 18 | 72 | 1.89 Mb |
| 19 | 240 | 6.32 Mb |
| **Total** | **348** | **9.15 Mb** |




Prepare for Offline | Delete All Tiles | Go Offline | Usage: 4.16 Mb (127 tiles)

Show Stored Tiles | Save to File | Load from File | Using proxy: Yes

1. Navigate to your area of interest

2. Click 'Prepare for Offline' button

3. Go Offline and enjoy!

# Database size – how big??

General suggestion (smartphones/tablet):

- Less than 100 MB

Why? Depends on:

- Remaining free memory
- How much memory used by browser
- How many tabs are already open
- If other applications already running

# Can I use too much memory?

YES!

The device OS will shutdown the browser

Greater potential for data corruption/loss

- If shutdown occurs during a ‘write’ operation

# Summary - IndexedDB

Designed to work with complex data.

High performance/Asynchronous

Compatible with many offline workflows

Browser support continues to improve

# References

https://github.com/andygup/indexeddb-typetest-js

https://github.com/andygup/image-parsing-test-js

https://github.com/Esri/offline-editor-js

https://github.com/axemclion/IndexedDBShim

http://developers.arcgis.com/javascript

# Questions?

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