# Running JavaScript Inside the Database

CLUSTERPOINT

# Data Base Management System (DBMS)

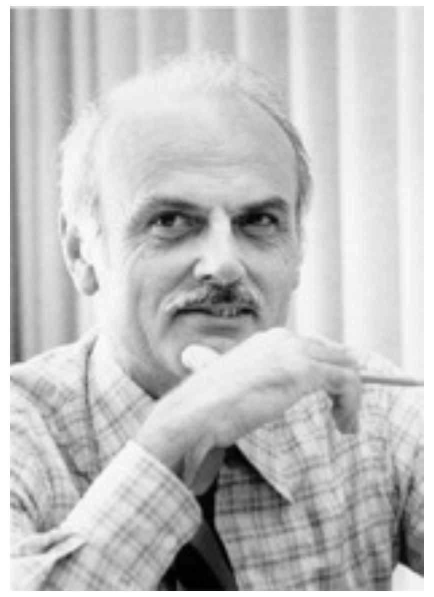
## Definition

- A database is an organized collection of data.
- DBMS is a computer software - toolset - that interacts with the user, other applications, and the database itself to capture and analyze data.
- DBMS is only as useful as what you can do with it.
- Everything Is about efficiency of computation.

# Relational Database

## History

Edgar F. Codd proposes a relational model



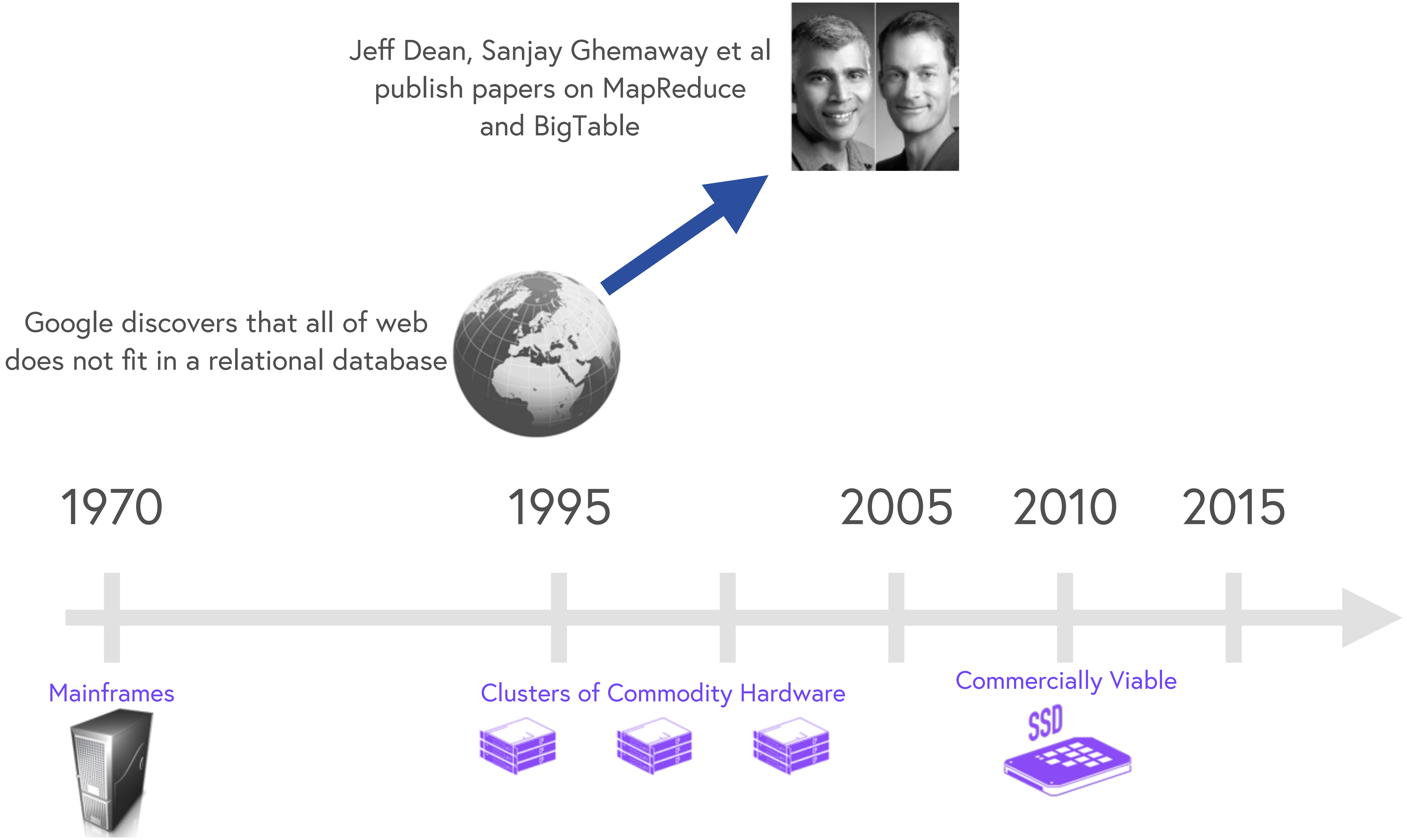
1970

Relational databases dominate data management

- Selection
- Projection
- Cartesian product (cross product, cross join)
- Union
- Set difference (complement, intersection)

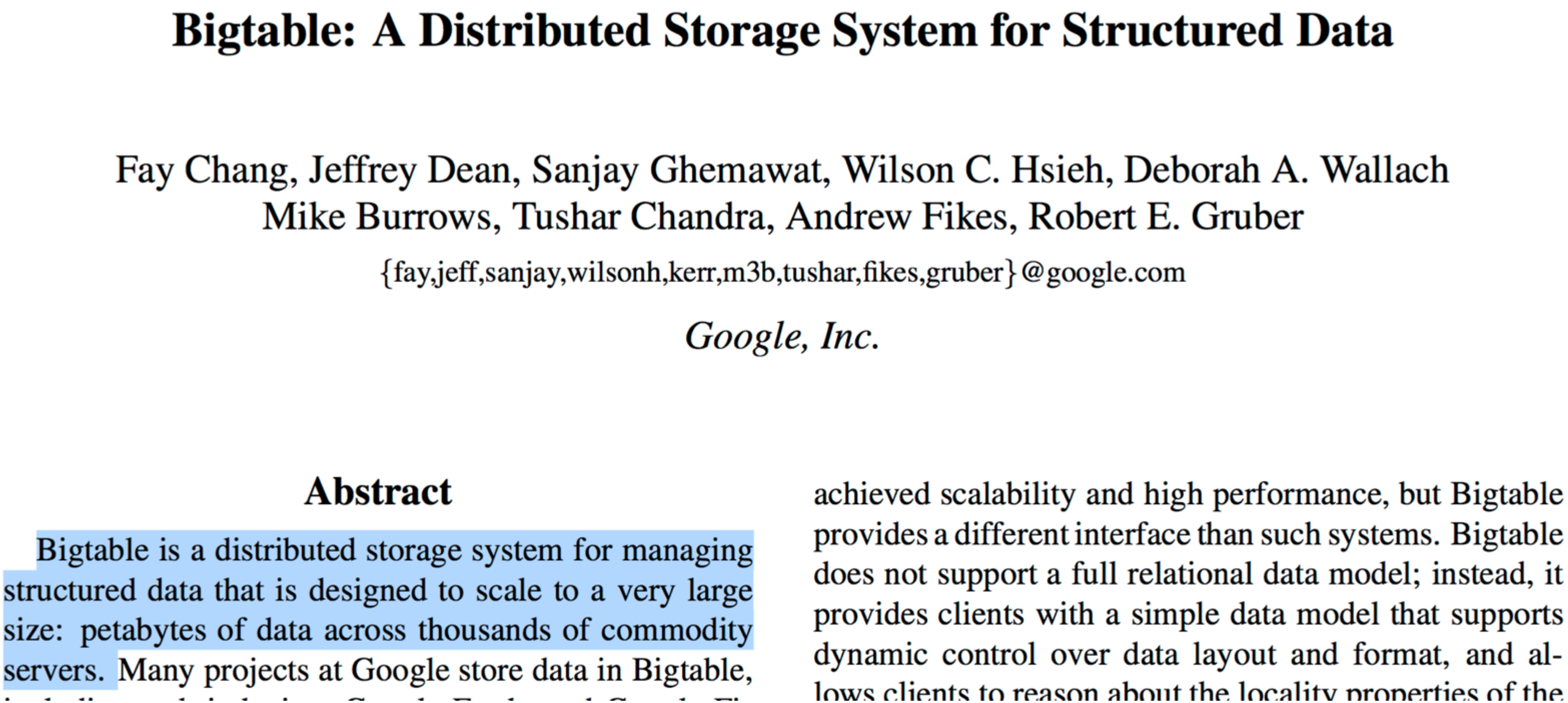
# Evolution of Computing Infrastructure

## History



Jeff Dean, Sanjay Ghemaway et al publish papers on MapReduce and BigTable

Google discovers that all of web does not fit in a relational database



# Bigtable: A Distributed Storage System for Structured Data

Fay Chang, Jeffrey Dean, Sanjay Ghemawat, Wilson C. Hsieh, Deborah A. Wallach
Mike Burrows, Tushar Chandra, Andrew Fikes, Robert E. Gruber

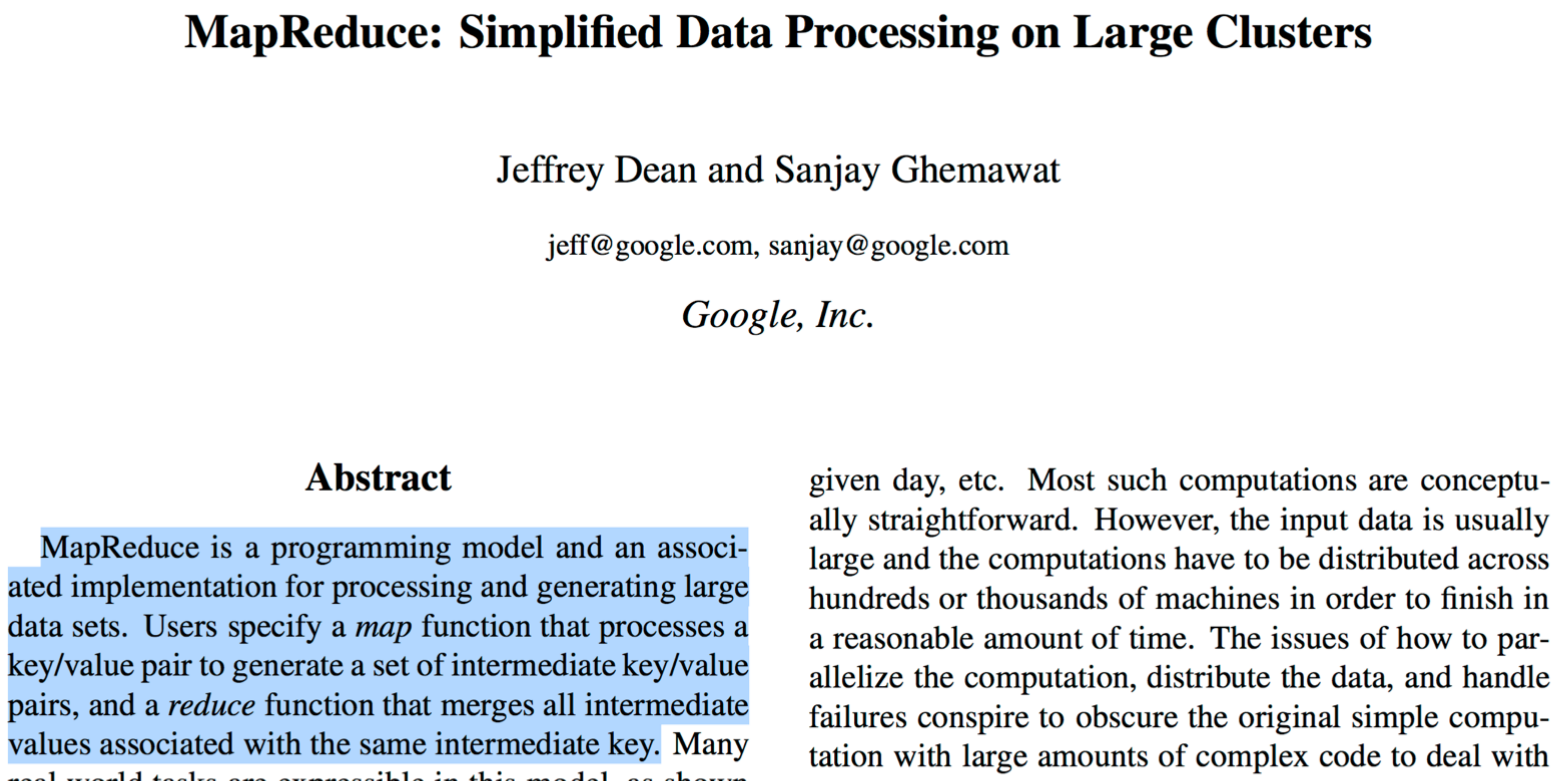
{fay,jeff,sanjay,wilsonh,kerr,m3b,tushar,fikes,gruber}@google.com

*Google, Inc.*

## Abstract

Bigtable is a distributed storage system for managing structured data that is designed to scale to a very large size: petabytes of data across thousands of commodity servers. Many projects at Google store data in Bigtable,

achieved scalability and high performance, but Bigtable provides a different interface than such systems. Bigtable does not support a full relational data model; instead, it provides clients with a simple data model that supports dynamic control over data layout and format, and allows clients to reason about the locality properties of the



# MapReduce: Simplified Data Processing on Large Clusters

Jeffrey Dean and Sanjay Ghemawat

jeff@google.com, sanjay@google.com

*Google, Inc.*

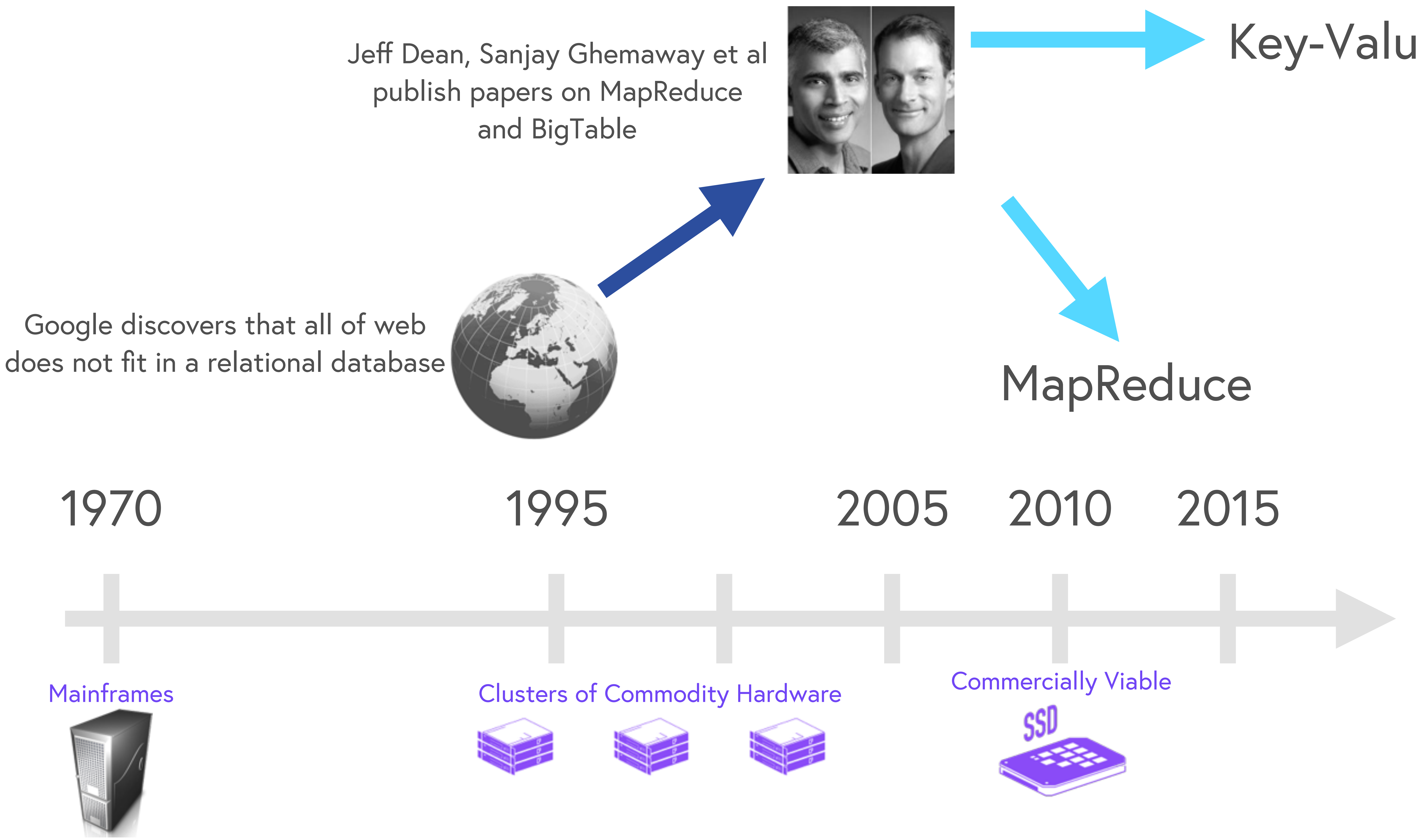
## Abstract

MapReduce is a programming model and an associated implementation for processing and generating large data sets. Users specify a *map* function that processes a key/value pair to generate a set of intermediate key/value pairs, and a *reduce* function that merges all intermediate values associated with the same intermediate key. Many real world tasks are expressible in this model, as shown

given day, etc. Most such computations are conceptually straightforward. However, the input data is usually large and the computations have to be distributed across hundreds or thousands of machines in order to finish in a reasonable amount of time. The issues of how to parallelize the computation, distribute the data, and handle failures conspire to obscure the original simple computation with large amounts of complex code to deal with

# Evolution of Computing Infrastructure

## History



Jeff Dean, Sanjay Ghemaway et al publish papers on MapReduce and BigTable

Key-Value Store

Google discovers that all of web does not fit in a relational database

MapReduce

1970

1995

2005

2010

2015

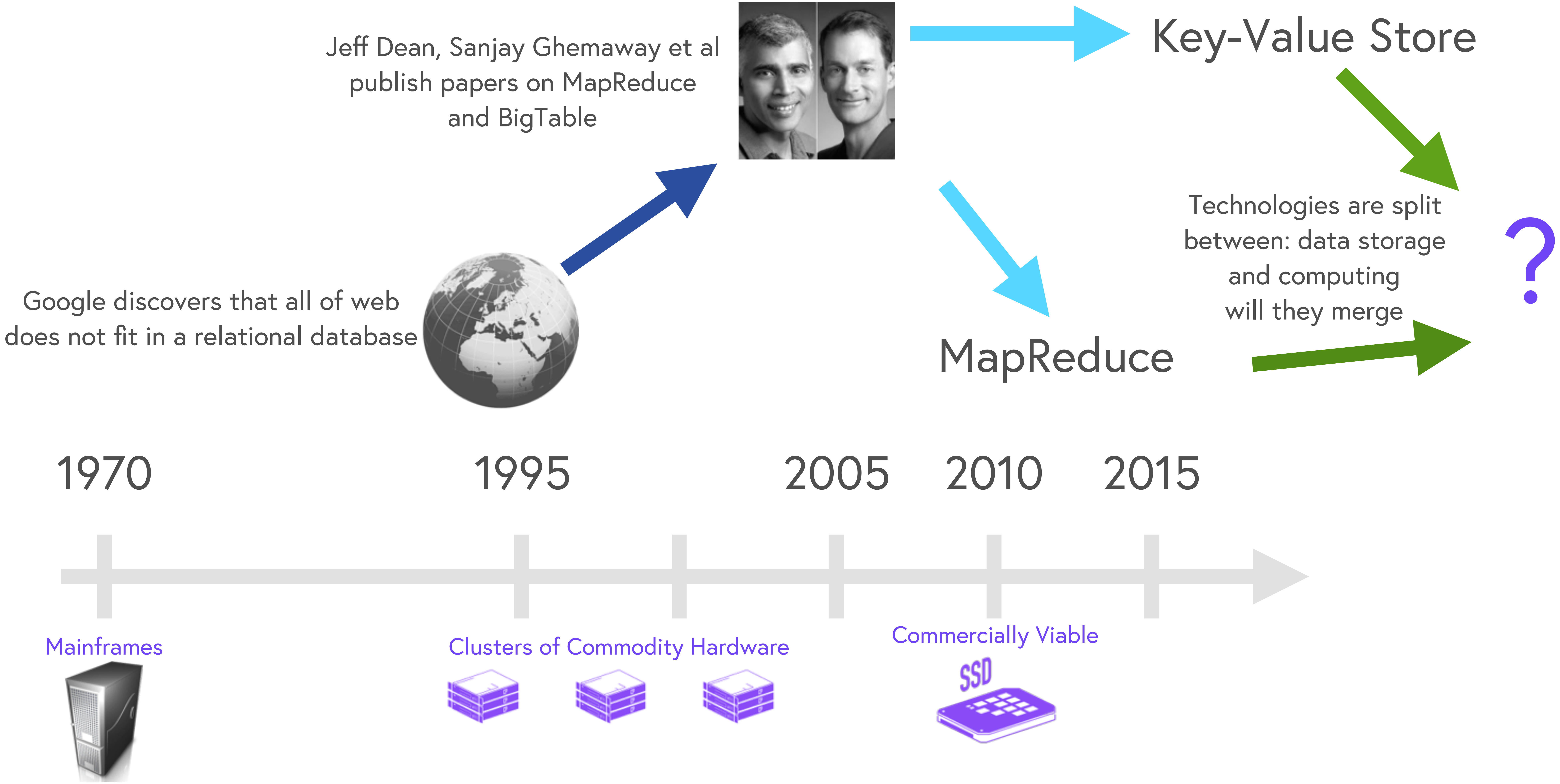
Mainframes

Clusters of Commodity Hardware

Commercially Viable

# Evolution of Computing Infrastructure

## History



Jeff Dean, Sanjay Ghemaway et al publish papers on MapReduce and BigTable

Key-Value Store

Google discovers that all of web does not fit in a relational database

Technologies are split between: data storage and computing will they merge

?

MapReduce

1970

1995

2005

2010

2015

Mainframes

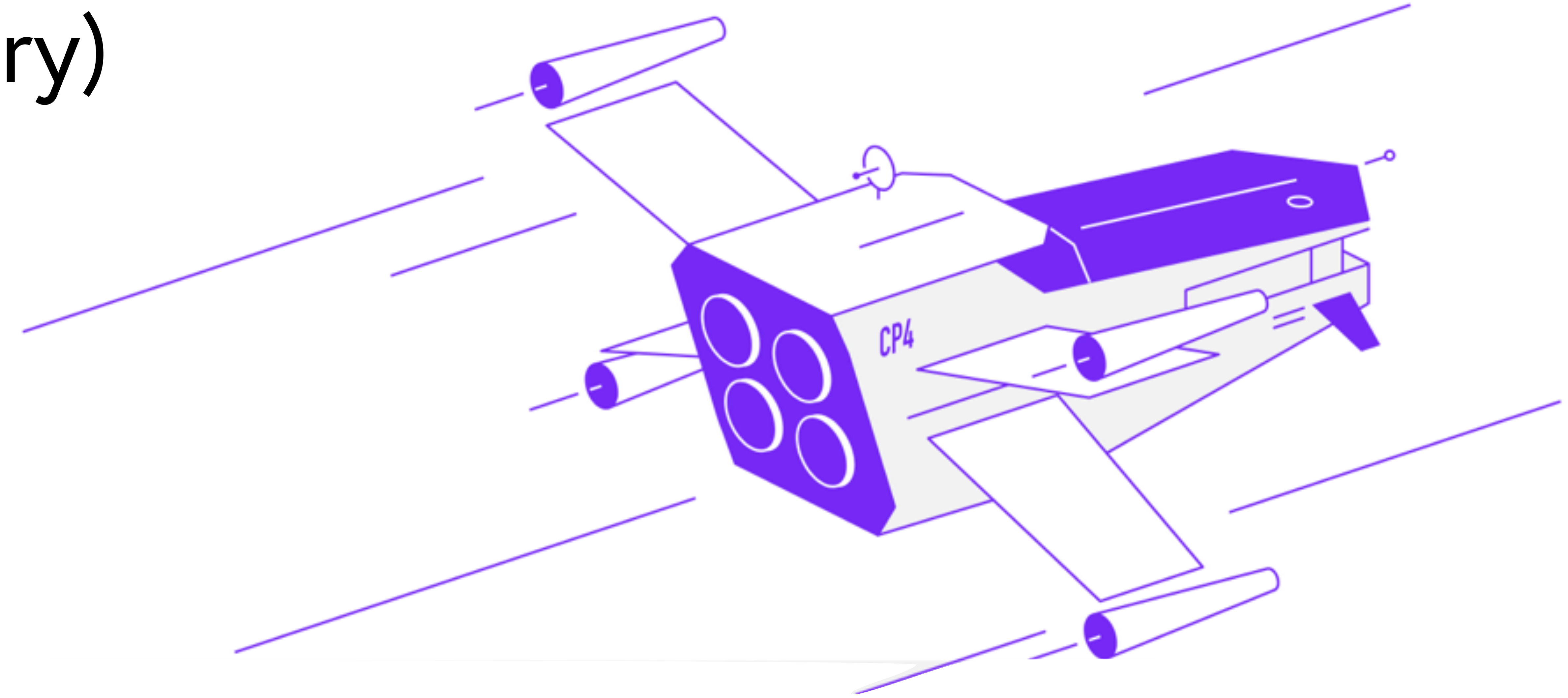
Clusters of Commodity Hardware

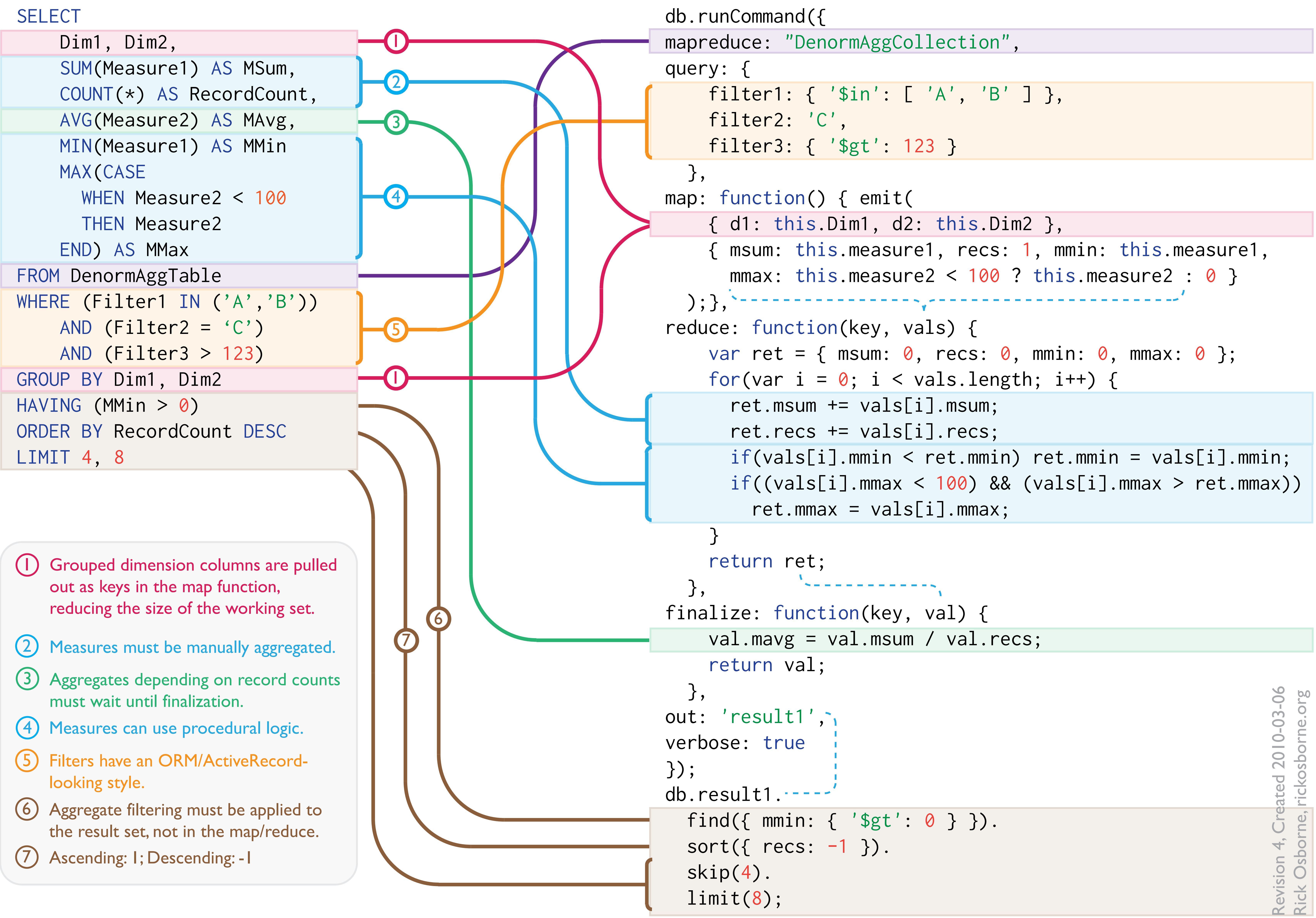
Commercially Viable

# Clusterpoint

## NoSQL Database

- Document oriented (JSON/XML/Binary)
- Distributed (sharded + replicated)
- Schema less
- Transactional (ACID)
- Cloud enabled
- **v4 introduces distributed computing engine**





```
SELECT
    Dim1, Dim2,
    SUM(Measure1) AS MSum,
    COUNT(*) AS RecordCount,
    AVG(Measure2) AS MAvg,
    MIN(Measure1) AS MMin
    MAX(CASE
      WHEN Measure2 < 100
      THEN Measure2
    END) AS MMax
FROM DenormAggTable
WHERE (Filter1 IN (’A’,’B’))
    AND (Filter2 = ‘C’)
    AND (Filter3 > 123)
GROUP BY Dim1, Dim2
HAVING (MMin > 0)
ORDER BY RecordCount DESC
LIMIT 4, 8
```

```
db.runCommand({
mapreduce: "DenormAggCollection",
query: {
    filter1: { '$in': [ 'A', 'B' ] },
    filter2: 'C',
    filter3: { '$gt': 123 }
  },
map: function() { emit(
    { d1: this.Dim1, d2: this.Dim2 },
    { msum: this.measure1, recs: 1, mmin: this.measure1,
      mmax: this.measure2 < 100 ? this.measure2 : 0 }
  );},
reduce: function(key, vals) {
    var ret = { msum: 0, recs: 0, mmin: 0, mmax: 0 };
    for(var i = 0; i < vals.length; i++) {
      ret.msum += vals[i].msum;
      ret.recs += vals[i].recs;
      if(vals[i].mmin < ret.mmin) ret.mmin = vals[i].mmin;
      if((vals[i].mmax < 100) && (vals[i].mmax > ret.mmax))
        ret.mmax = vals[i].mmax;
    }
    return ret;
  },
finalize: function(key, val) {
    val.mavg = val.msum / val.recs;
    return val;
  },
out: 'result1',
verbose: true
});
db.result1.
  find({ mmin: { '$gt': 0 } }).
  sort({ recs: -1 }).
  skip(4).
  limit(8);
```

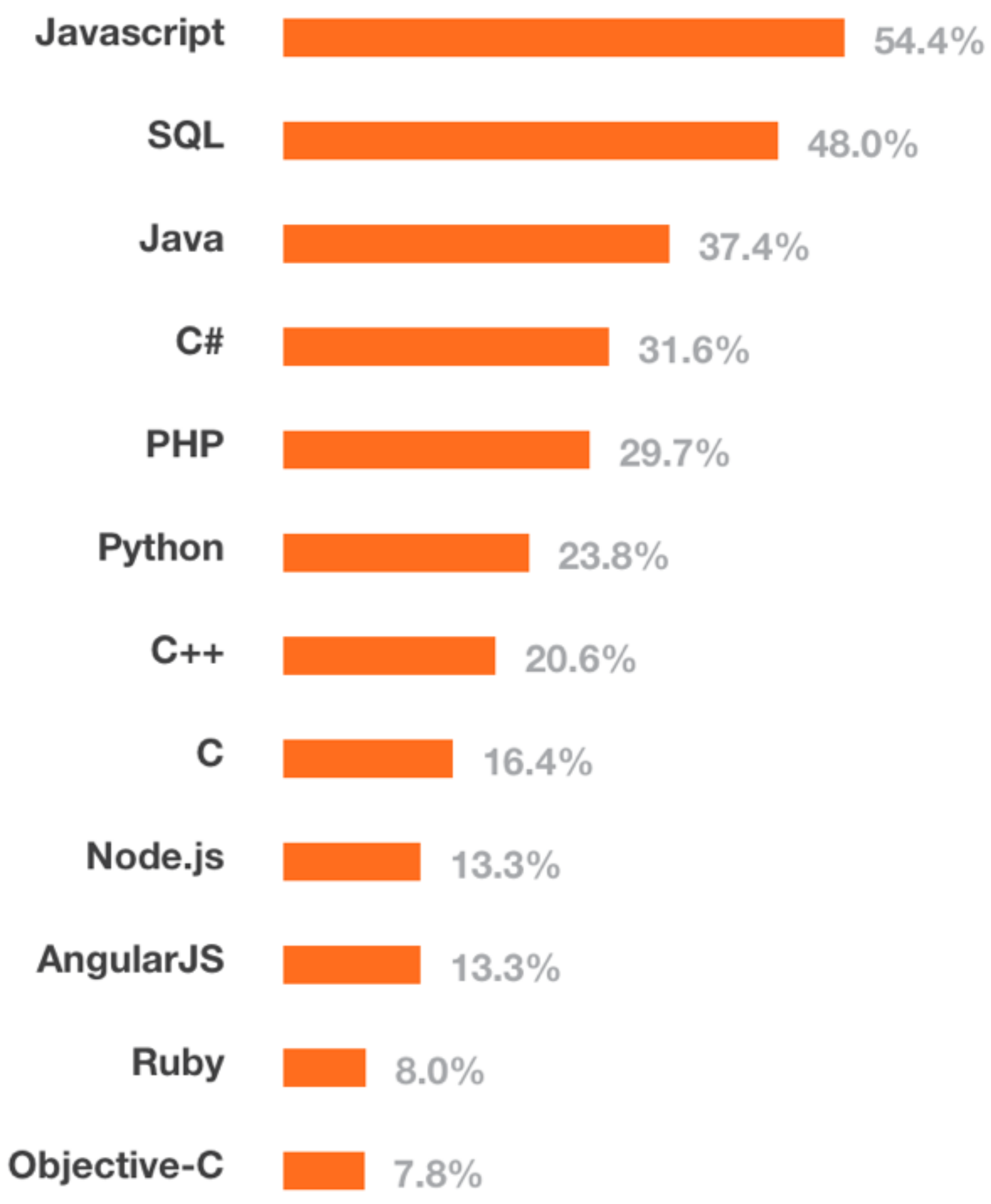
1. Grouped dimension columns are pulled out as keys in the map function, reducing the size of the working set.
2. Measures must be manually aggregated.
3. Aggregates depending on record counts must wait until finalization.
4. Measures can use procedural logic.
5. Filters have an ORM/ActiveRecord-looking style.
6. Aggregate filtering must be applied to the result set, not in the map/reduce.
7. Ascending: 1; Descending: -1

Revision 4, Created 2010-03-06
Rick Osborne, rickosborne.org

# New query language

**Query language you have never heard of but you are already an expert?!**

# Technology top 2015 (StackOverflow)



JS
+
SQL

| SQL | JavaScript |
|---|---|
| flexible to express queries | hard to express queries |
| executes in parallel | difficult to execute in parallel |
| static | dynamic |
| hard to define expressions | easy to define expressions |
| bad with custom routines | great with custom routines |

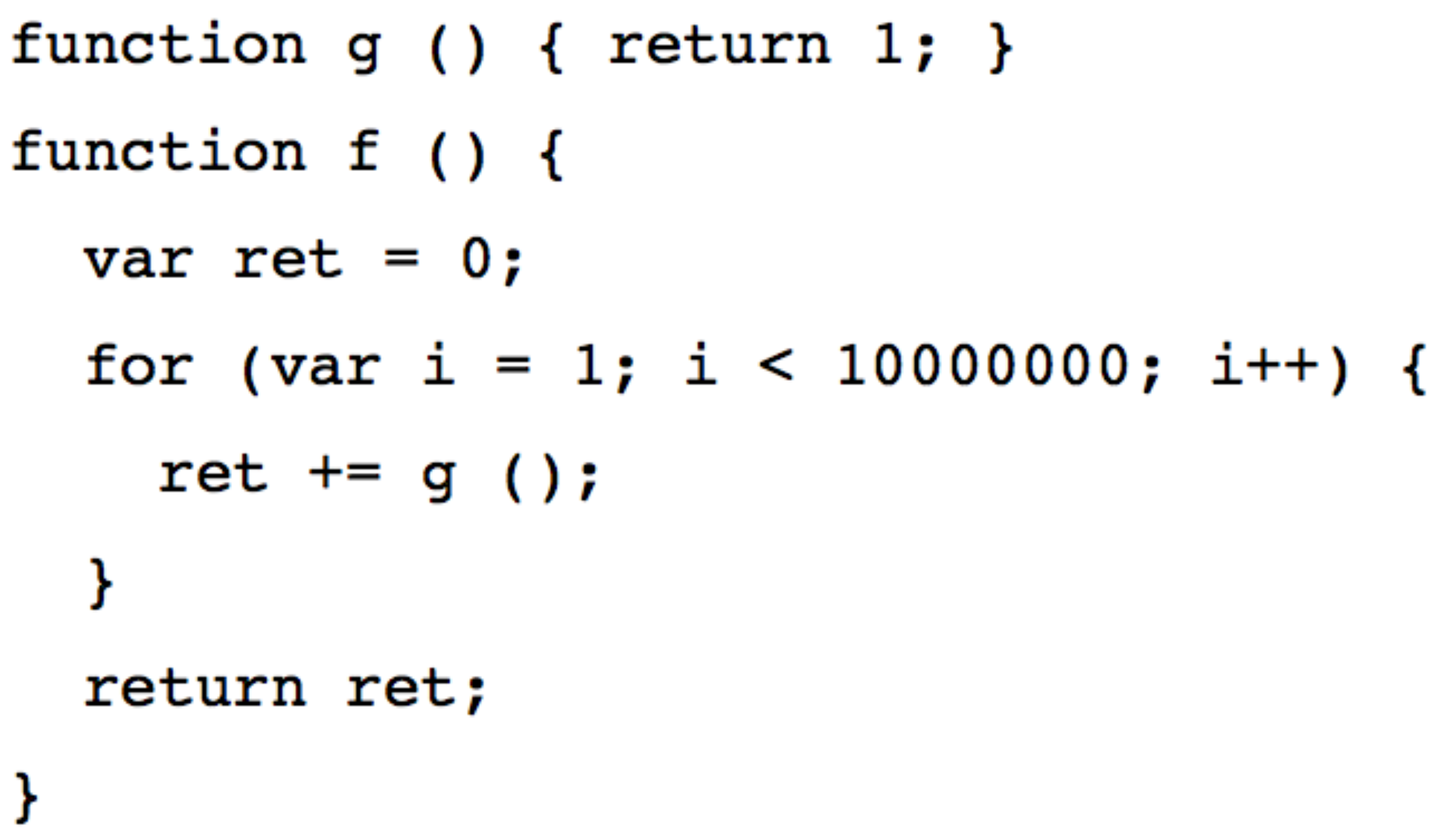
# Javascript - V8

**Too good to be used only in browsers**

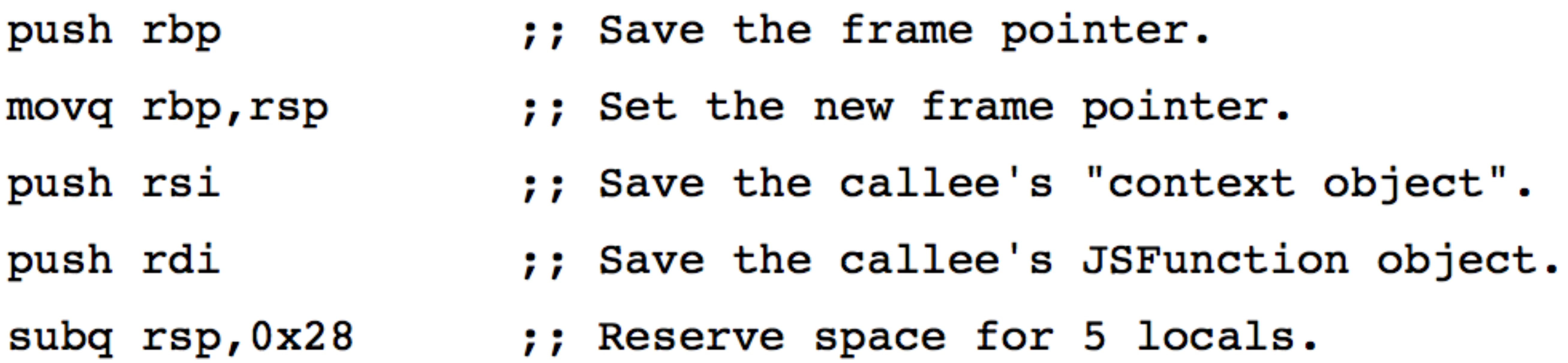
- Chrome
- Node.js
- MongoDB
- Google BigQuery UDF

# Javascript - V8

## Produces machine code (IA-32, x64, ARM)



```
function g () { return 1; }
function f () {
  var ret = 0;
  for (var i = 1; i < 10000000; i++) {
    ret += g ();
  }
  return ret;
}
```



```
push rbp          ;; Save the frame pointer.
movq rbp,rsp      ;; Set the new frame pointer.
push rsi          ;; Save the callee's "context object".
push rdi          ;; Save the callee's JSFunction object.
subq rsp,0x28     ;; Reserve space for 5 locals.
```

# Javascript - V8

## Performance - Problem

Compute the 25,000th prime

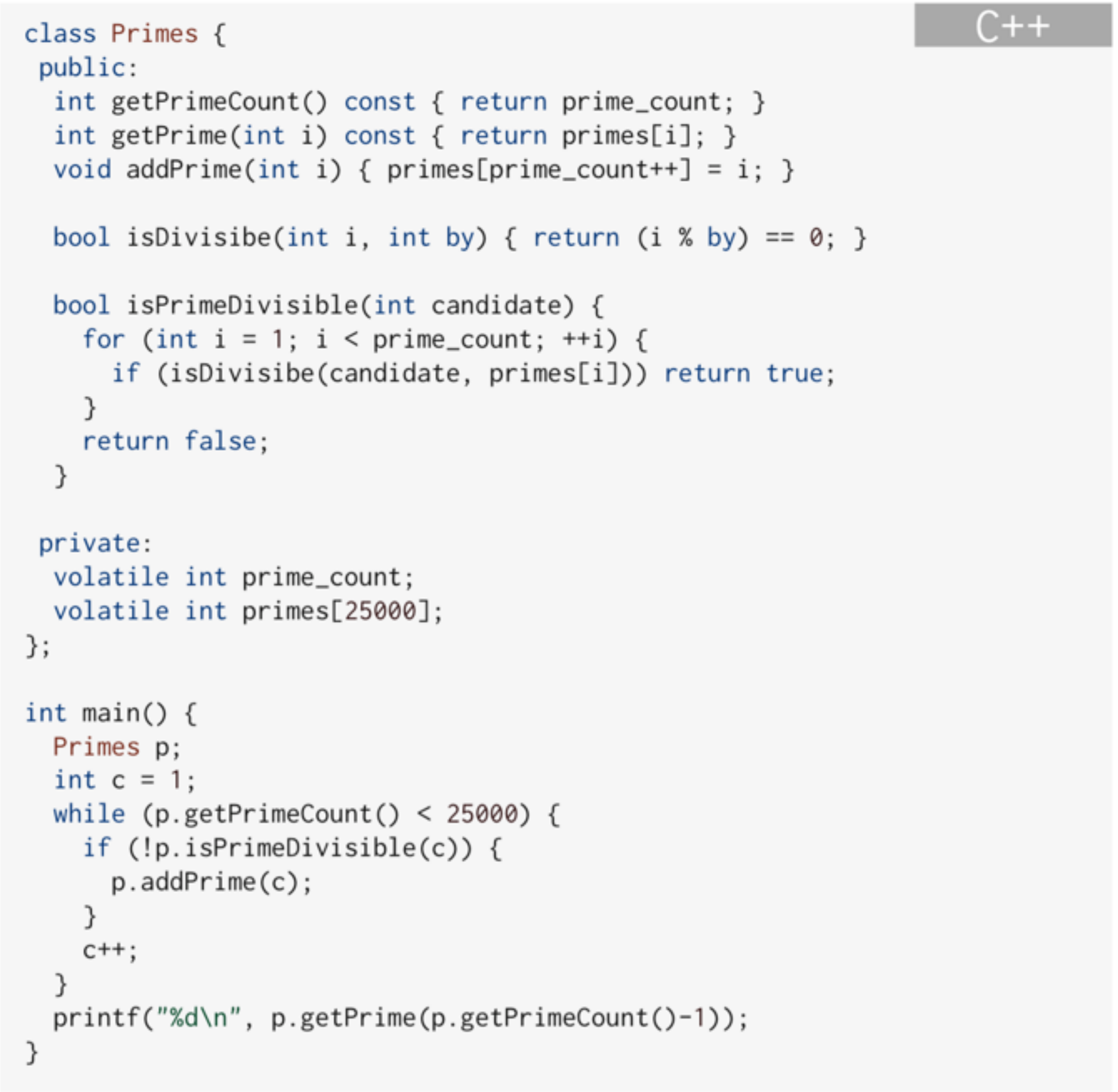
# Javascript - V8

## Performance - Algorithm

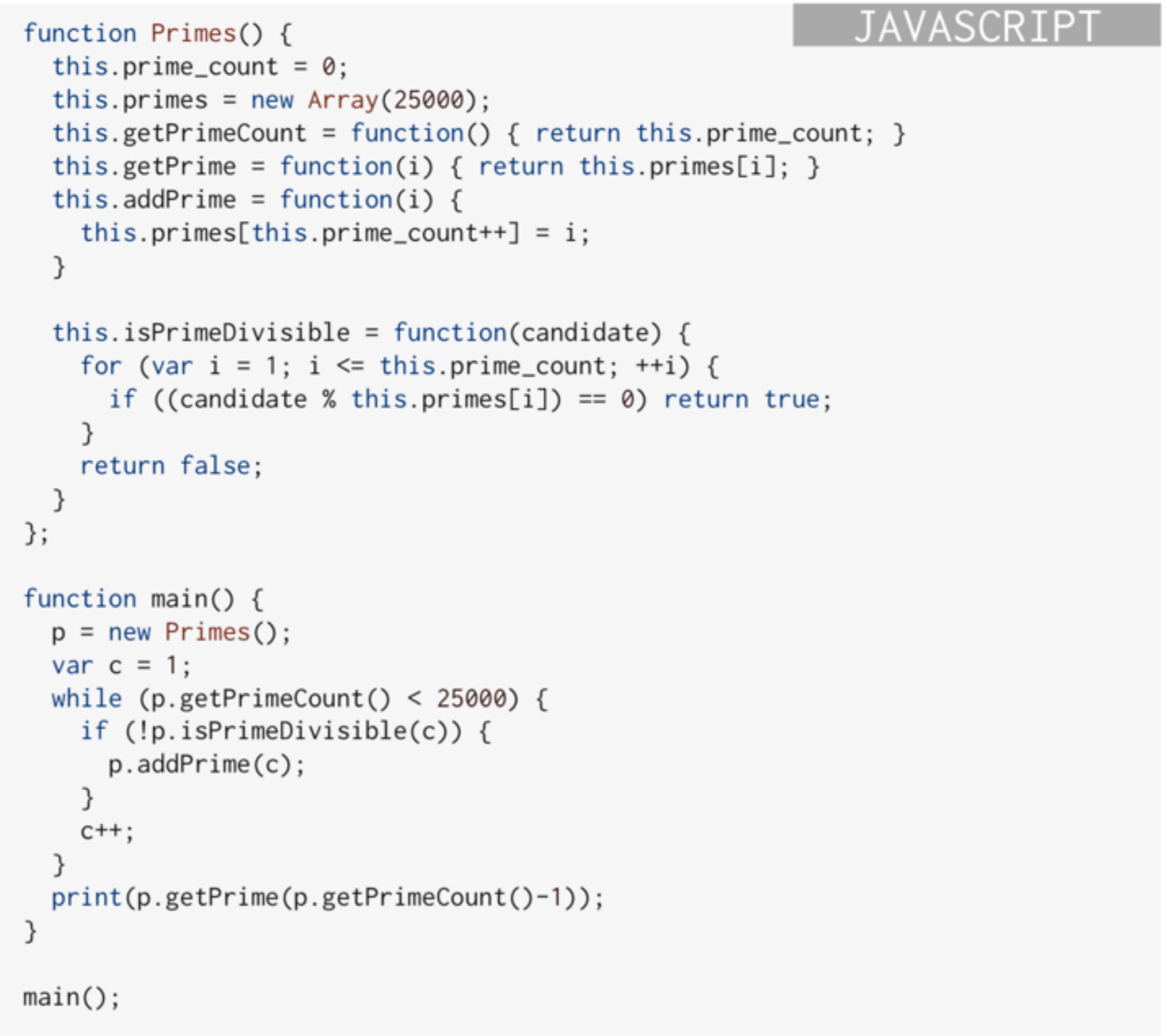
For x = 1 to infinity: if x not divisible by any member of an initially empty list of primes, add x to the list until we have 25,000

# Javascript - V8

## Performance - Contenders



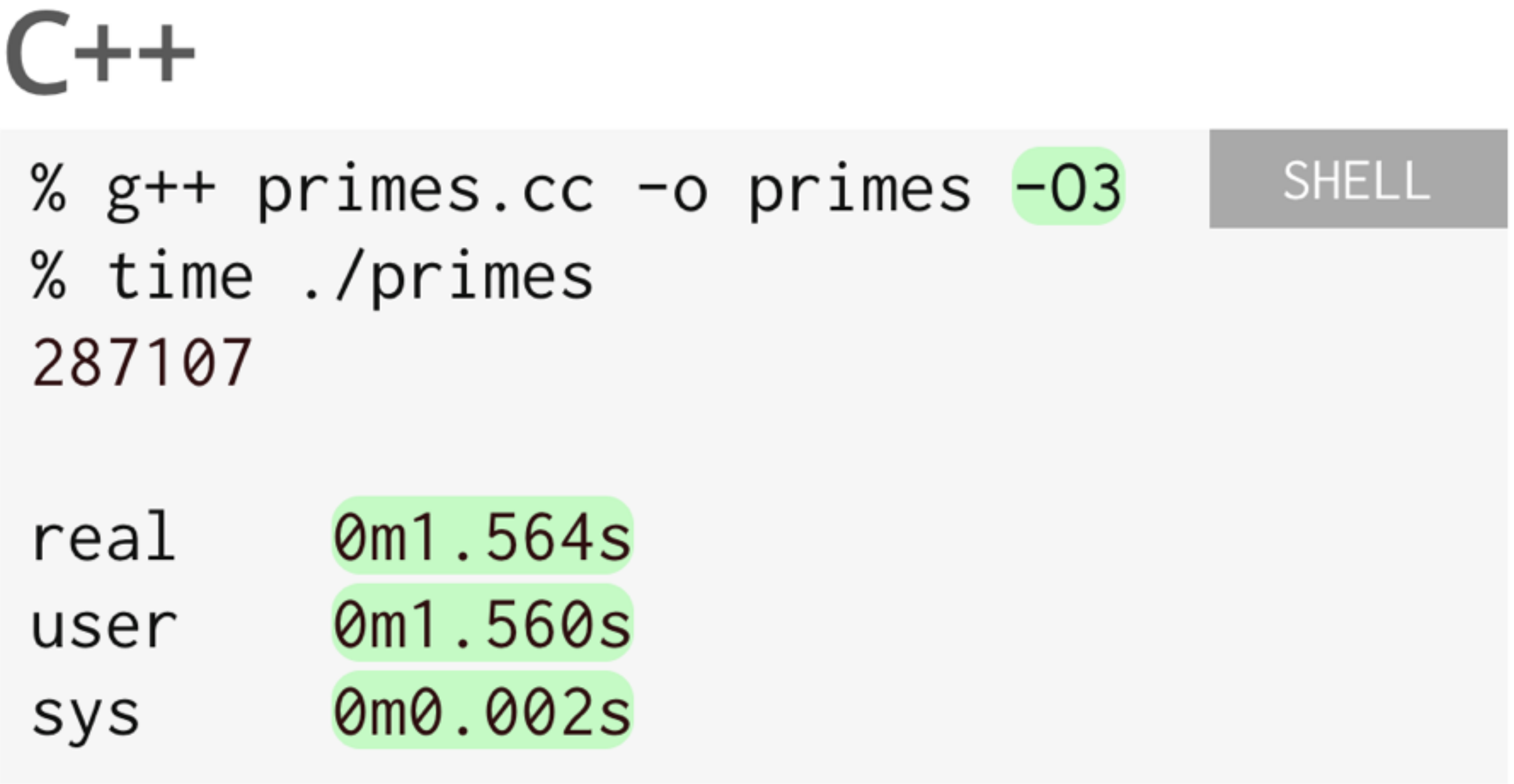
```cpp
class Primes {
 public:
  int getPrimeCount() const { return prime_count; }
  int getPrime(int i) const { return primes[i]; }
  void addPrime(int i) { primes[prime_count++] = i; }

  bool isDivisibe(int i, int by) { return (i % by) == 0; }

  bool isPrimeDivisible(int candidate) {
    for (int i = 1; i < prime_count; ++i) {
      if (isDivisibe(candidate, primes[i])) return true;
    }
    return false;
  }

 private:
  volatile int prime_count;
  volatile int primes[25000];
};

int main() {
  Primes p;
  int c = 1;
  while (p.getPrimeCount() < 25000) {
    if (!p.isPrimeDivisible(c)) {
      p.addPrime(c);
    }
    c++;
  }
  printf("%d\n", p.getPrime(p.getPrimeCount()-1));
}
```



```javascript
function Primes() {
  this.prime_count = 0;
  this.primes = new Array(25000);
  this.getPrimeCount = function() { return this.prime_count; }
  this.getPrime = function(i) { return this.primes[i]; }
  this.addPrime = function(i) {
    this.primes[this.prime_count++] = i;
  }

  this.isPrimeDivisible = function(candidate) {
    for (var i = 1; i <= this.prime_count; ++i) {
      if ((candidate % this.primes[i]) == 0) return true;
    }
    return false;
  }
};

function main() {
  p = new Primes();
  var c = 1;
  while (p.getPrimeCount() < 25000) {
    if (!p.isPrimeDivisible(c)) {
      p.addPrime(c);
    }
    c++;
  }
  print(p.getPrime(p.getPrimeCount()-1));
}

main();
```

# Javascript - V8

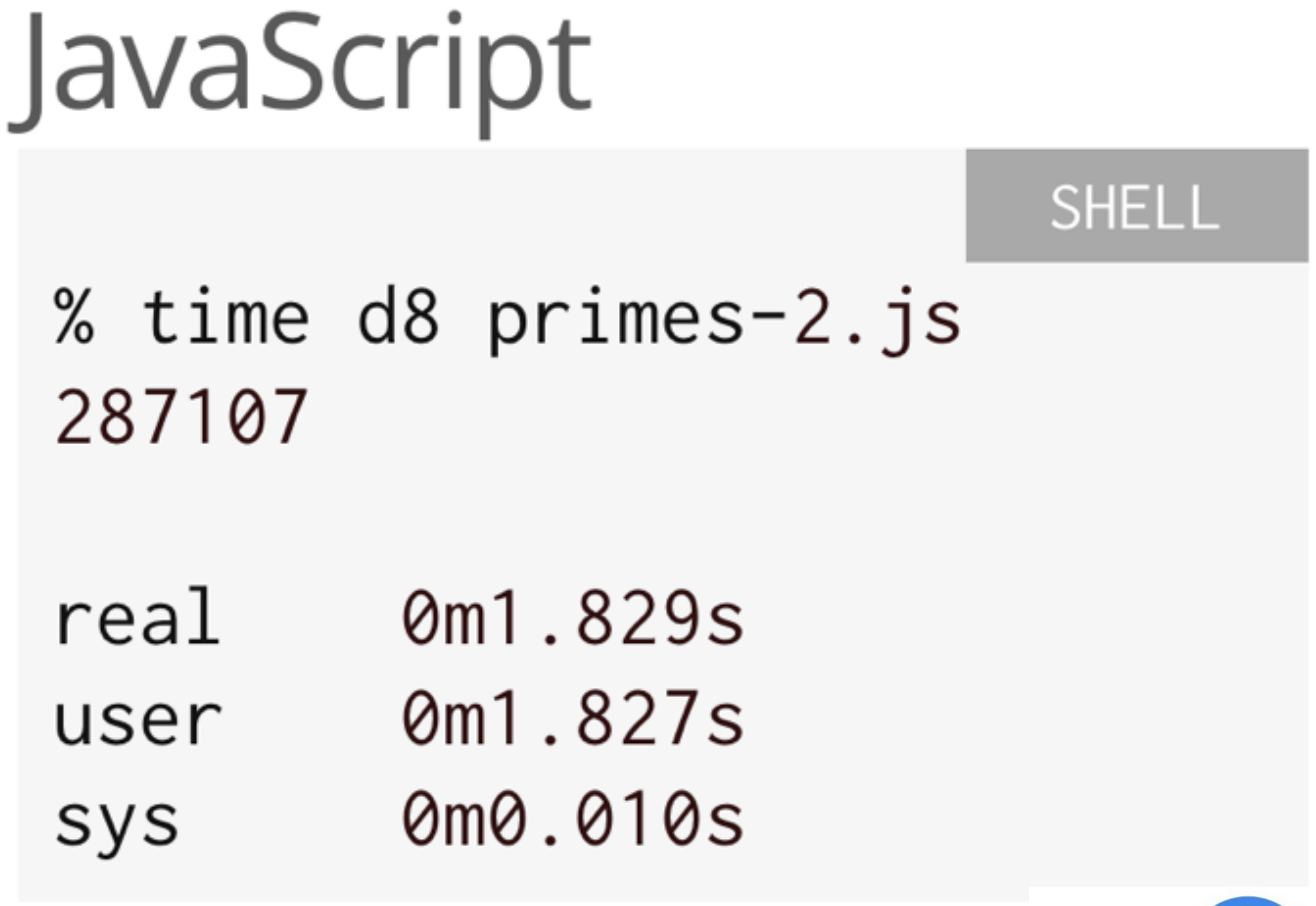
## Performance - Results (only 17% slower)



C++

SHELL

```
% g++ primes.cc -o primes -O3
% time ./primes
287107

real    0m1.564s
user    0m1.560s
sys     0m0.002s
```



JavaScript

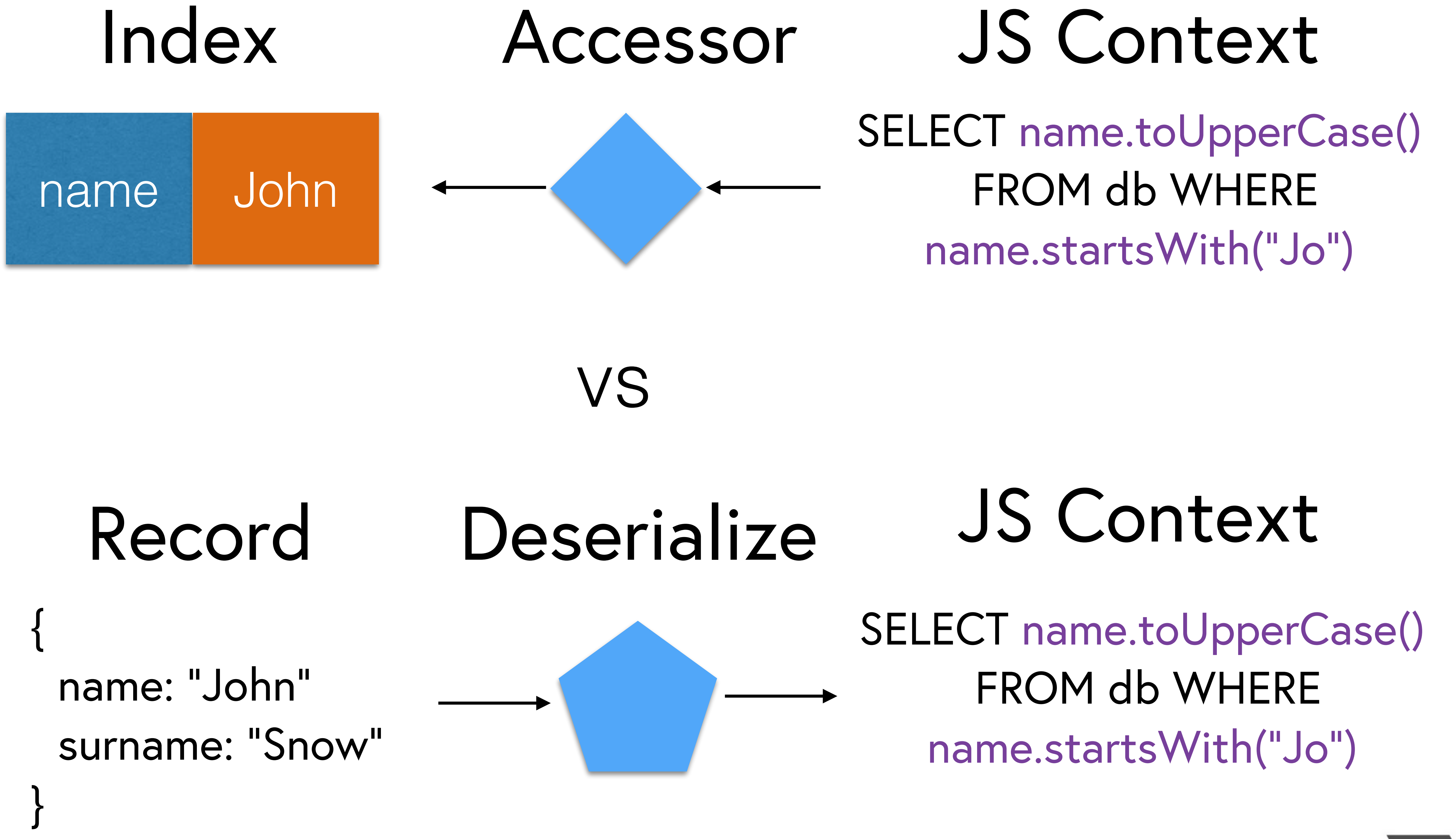
SHELL

```
% time d8 primes-2.js
287107

real    0m1.829s
user    0m1.827s
sys     0m0.010s
```

# Javascript - V8

## Efficiency

- Lazy field binding
- Bind field to index - performance gain
- If no index bind to document
- Concurrent execution
- Narrow down using indices



Index

Accessor

JS Context

SELECT name.toUpperCase()
FROM db WHERE
name.startsWith("Jo")

VS

Record

Deserialize

JS Context

```
{
  name: "John"
  surname: "Snow"
}
```

SELECT name.toUpperCase()
FROM db WHERE
name.startsWith("Jo")

# Javascript - V8

## Integration

- C++ Library
- Implements ECMAScript (ECMA-262 5th)
- Accessors - callback that calculates and returns a value when an object property is accessed by a JavaScript
- Interceptors - callback for whenever a script accesses any object property.

# JS/SQL

## Language structure

- Based on SQL-like structure
- Allows to execute arbitrary JavaScript in any clause of the SELECT or UPDATE statement.
- Native support of JSON and XML data types.
- Joins, nested documents (in v4.1, stay tuned!)

```sql
SELECT * FROM product
```

# JS/SQL

## Insert statement

```
INSERT INTO product JSON VALUE {
  "name": "Schwinn S29 Full Suspension Mountain Bike",
  "image_url": "schwinn_s29.jpeg",
  "description": "...",
  "color": ["black","red"],
  "order_price": 211.16,
  "price": 259.16,
  "packaging": {
    "height": 23,
    "width": 25,
    "depth": 12,
    "weight": 54
  },
  "availability": "In Stock"
}
```

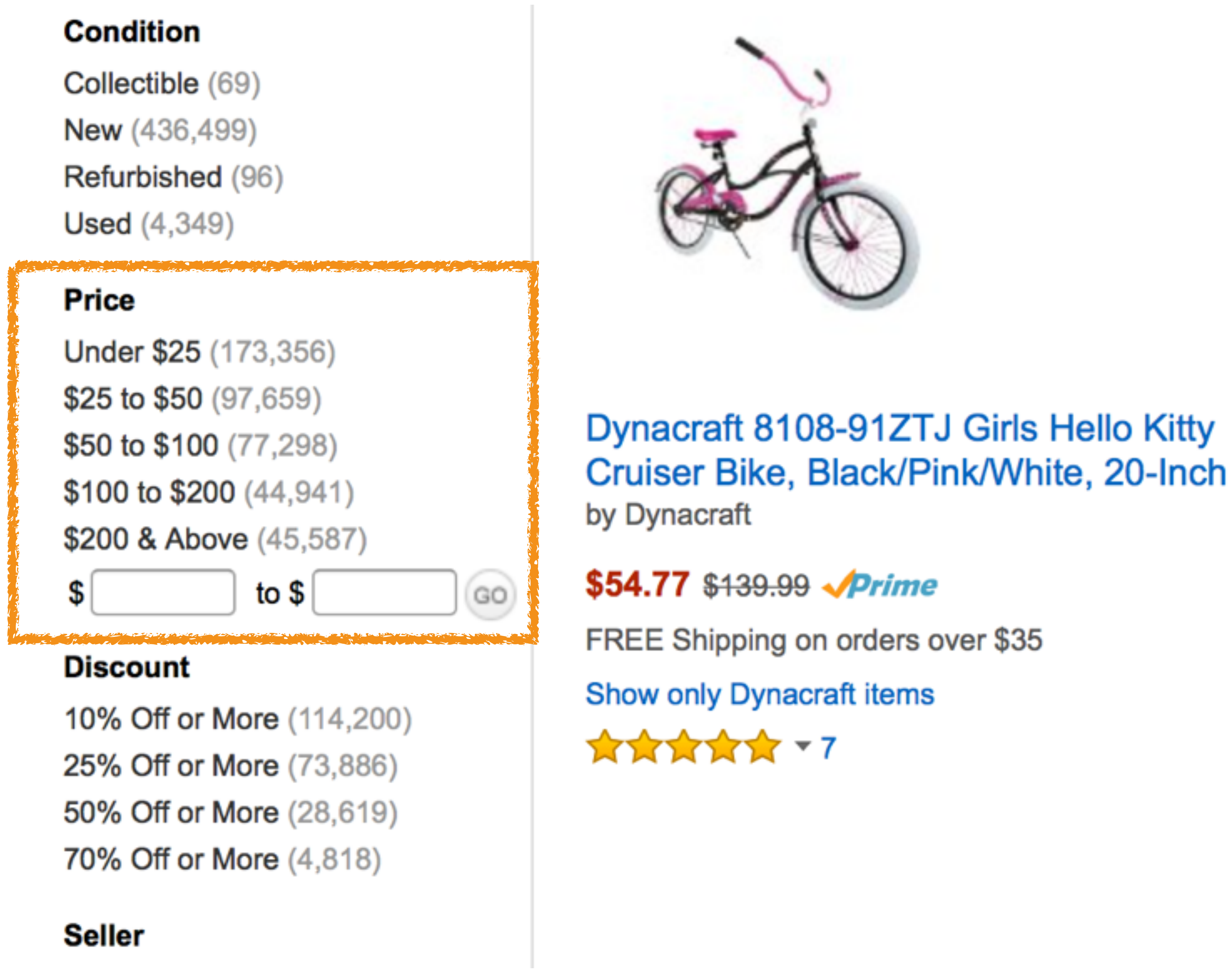
# JS/SQL

## Insert statement

```
INSERT INTO product
(name, image_url, description, color, price, availability)
VALUES ("Schwinn S29 Full Suspension Mountain Bike",
        "schwinn_s29.jpeg",
        "...",
        "black",
        259.16,
        "In Stock")
```

# JS/SQL

## Price buckets



**Condition**

Collectible (69)

New (436,499)

Refurbished (96)

Used (4,349)

**Price**

Under $25 (173,356)

$25 to $50 (97,659)

$50 to $100 (77,298)

$100 to $200 (44,941)

$200 & Above (45,587)

$ ______ to $ ______ GO

**Discount**

10% Off or More (114,200)

25% Off or More (73,886)

50% Off or More (28,619)

70% Off or More (4,818)

**Seller**

Dynacraft 8108-91ZTJ Girls Hello Kitty Cruiser Bike, Black/Pink/White, 20-Inch

by Dynacraft

$54.77 ~~$139.99~~ ✓Prime

FREE Shipping on orders over $35

Show only Dynacraft items

★★★★★ ▾ 7

# JS/SQL

## Grouping/Aggregation

```
function PriceBucket(price) {
  var boundaries = [0, 1, 5, 10, 50, 100, 200, 500, 1000];
  for (var i = 1; i < boundaries.length; i++) {
    if (price >= boundaries[i - 1] && price < boundaries[i])
      return boundaries[i - 1].toString() + " to " + boundaries[i].toString();
  }
  return "above " + boundaries[boundaries.length - 1].toString();
}

SELECT PriceBucket(price), COUNT()
FROM product
GROUP BY PriceBucket(price);
```

# JS/SQL

## Aggregating nested documents

```
 {
  "user": "3e9cde95-8077-4386-a35b-fc3b4489dec3",
  "items": [
  {
   "name": "Orange",
   "price": 5,
   "descr": "Special for juice",
   "count": 25
  },
  {
   "name": "Orange",
   "price": 5,
   "descr": "Special for juice",
   "count": 25
  }
}
```

# JS/SQL

## Aggregating nested documents

```
function sum_items()
{
  var sum = 0;
  for (var i = 0; i < items.length; i++)
      sum += items[i].count * items[i].price;
  return sum;
}
SELECT SUM(sum_items()), AVG(sum_items()), MIN(sum_items()),
MAX(sum_items())
FROM baskets
GROUP BY 1
```

# JS/SQL

## Nested documents (v4.1)

```
{
  name: "Schwinn S29 Full Suspension Mountain Bike",
  price: 259.16,
  inventory : [
   {location: “Warehouse–East", items: 17},
   {location: “Warehouse–West", items: 50}
  ]
};
```

# JS/SQL

## Nested documents (v4.1)

```
INSERT INTO product["34A40855"] JSON VALUE {
  name: "Schwinn S29 Full Suspension Mountain Bike",
  price: 259.16
};

INSERT INTO product["34A40855"].inventory JSON VALUE {
  location: "Warehouse-East",
  items: 17
};

INSERT INTO product["34A40855"].inventory JSON VALUE {
  location: "Warehouse-West",
  items: 17
};
```

# JS/SQL

## Nested documents (v4.1)

```
SELECT price, inventory
FROM product

SELECT location, items, SUPER().name
FROM inventory
WHERE SUPER().price > 30
```

```
{
  name: "Schwinn S29 Full Suspension Mountain Bike",
  price: 259.16,
  inventory : [
    {location: “Warehouse-East", items: 17},
    {location: “Warehouse-West", items: 50}
  ]
};
```

# JS/SQL

## Joins (v4.1)

```
INSERT INTO product["34A40855"] JSON VALUE {
  name: "Schwinn S29 Full Suspension Mountain Bike",
  price: 259.16
};

INSERT INTO order JSON VALUE {
  product_key: "34A40855",
  delivery_address: "My Office"
};

SELECT delivery_address, product[product_key].price
FROM order
WHERE product[product_key].price > 20
```

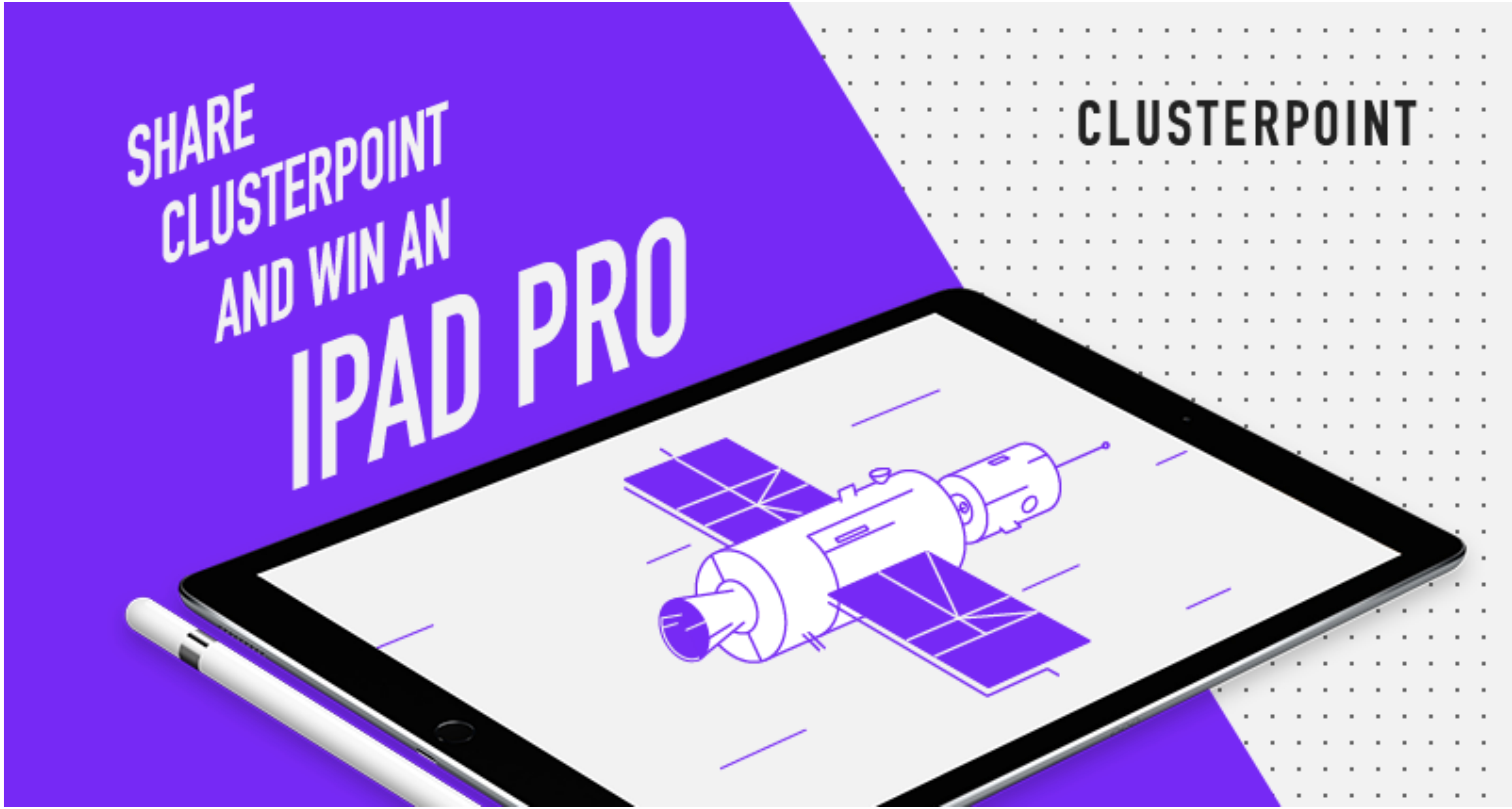
# API

## REST & more APIs coming soon!

```
$.ajax({
  url       : 'https://api-eu.clusterpoint.com/v4/ACCOUNT_ID/DATABASE/_query',
  type      : 'POST',
  dataType  : 'json',
  data      : 'SELECT * FROM DATABASE',
  beforeSend: function (xhr) {
    xhr.setRequestHeader('Authorization', 'Basic ' + btoa('USERNAME:PASSWORD'));
  },
  success   : function (data) {
    if (typeof success != 'undefined') {
      success(data);
    }
  },
  fail      : function (data) {
    alert(data.error);
    if (typeof fail != 'undefined') {
      fail(data);
    }
  }
});
```

# Try it!

- Signup for Clusterpoint Cloud account: http://cloud.clusterpoint.com
- Free of charge 10GB of storage
- Be part of community!



http://friends.clusterpoint.com

Thank you!