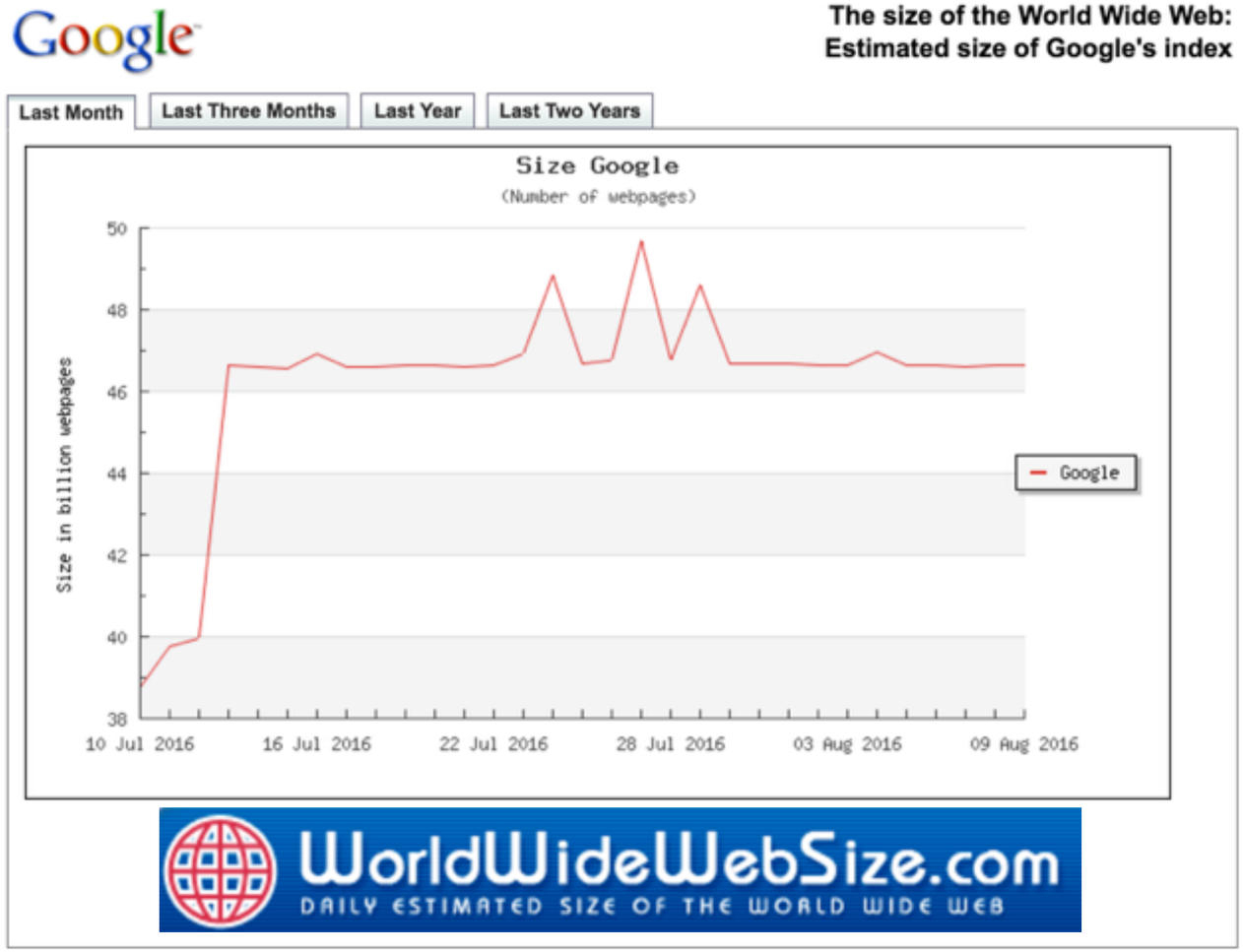
# Overview

Understand the role of an inverted index in building search engines

Implement a MapReduce for an inverted index

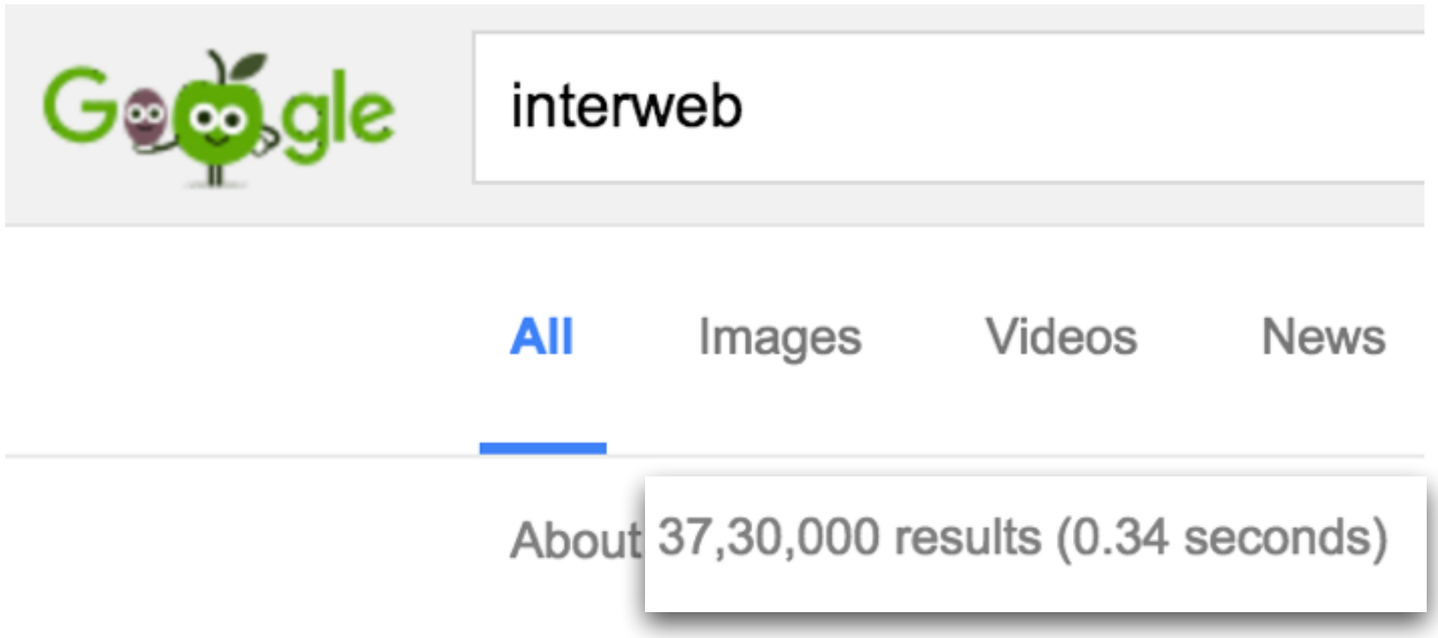
# Google Search

# The Internet has more than 40 billion webpages



# Google Search

## Yet, Google can return a search result in less than a second

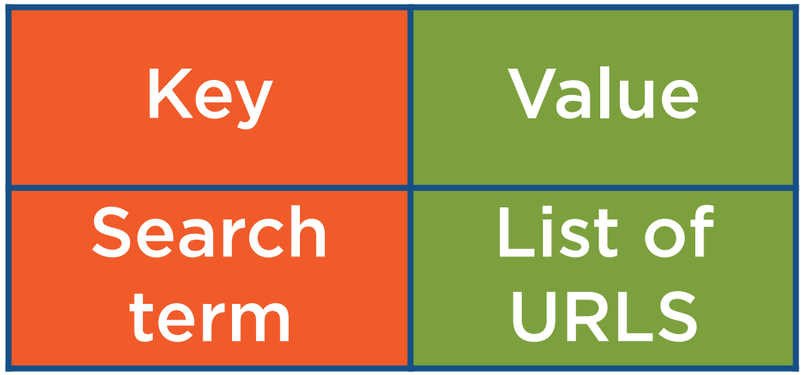


# Google Search

Google Search is powered by a massive index

# Building an Index

**An Index is a Map with a really fast way to look up values**



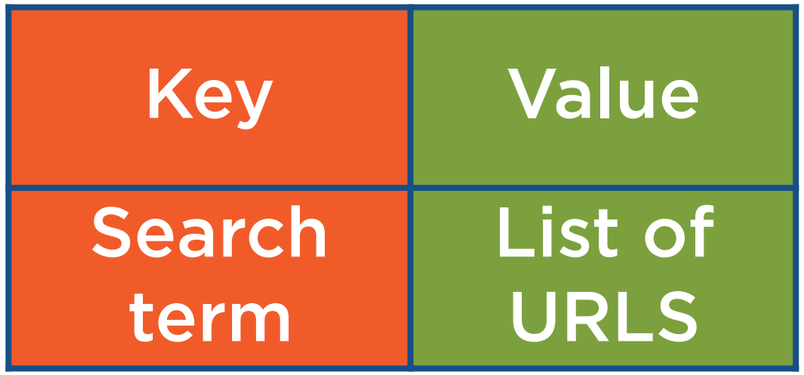
# Building an Index

**Given a search term, find all pages where that term occurs**

| Key | Value |
| --- | --- |
| Search term | List of URLS |

# Building an Index

**Search is just a lookup into an index of all the webpages in the world**



# Building an Index

**Hugely data intensive**

**Process the complete set of webpages known to the search engine**

**Repetitive**

**Rebuild the index periodically**

- Hourly, daily
- Scan the entire data set each time

# Building an Index

Hugely data intensive

Repetitive

**A great use case for MapReduce**

The index used in search engines is an inverted index

# Inverted Index

An inverted index is like the index found at the back of a dense textbook

# Inverted Index

Let’s first define a book in big data terms

# Books and Indexes

**A book = an index**

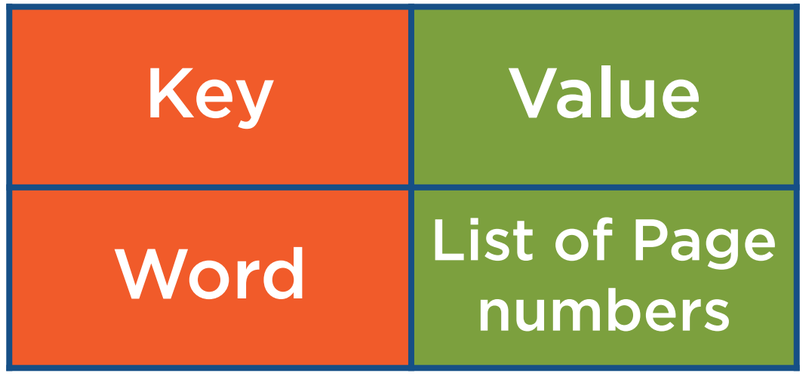
# Books and Indexes

| Key | Value |
| --- | --- |
| Page Number | Words on the Page |

An index where words can be looked up by page numbers

# Books and Indexes

**Most books have an index at the back of the book**




**Word Index**

# Books and Indexes

## Book

| Key | Value |
| --- | --- |
| Page Number | Words on the Page |

## Word Index

| Key | Value |
| --- | --- |
| Word | List of Page numbers |

# Books and Indexes

## Book

| Key | Value |
| --- | --- |
| Page Number | Words on the Page |

## Word Index

| Key | Value |
| --- | --- |
| Word | List of Page numbers |

# Books and Indexes

## Book

| Key | Value |
| --- | --- |
| Page Number | Words on the Page |

## Word Index

| Key | Value |
| --- | --- |
| Word | List of Page numbers |

# Books and Indexes

## Book

| Key | Value |
| --- | --- |
| Page Number | Words on the Page |

## Word Index

| Key | Value |
| --- | --- |
| Word | List of Page numbers |

**The word index is an inverted index of the book**

# Inverted Index

| Key | Value |
| --- | --- |
| Word | List of Page numbers |

**The word index helps us find things in the book**

# Inverted Index

**The word index helps us find things in the book**

**But what we're really interested in is the internet**

# The World Wide Web

**The internet = an index**

# The World Wide Web

| Key | Value |
| --- | --- |
| Page URL | Words on the Page |

An index where web page contents can be looked up by URLs

# The World Wide Web

| Key | Value |
| --- | --- |
| Page URL | Words on the Page |

**Invert this index**

# Inverted Index

**www**

| Key | Value |
| --- | --- |
| Page URL | Words on the Page |

| Key | Value |
| --- | --- |
| Word | List of Page URLS |

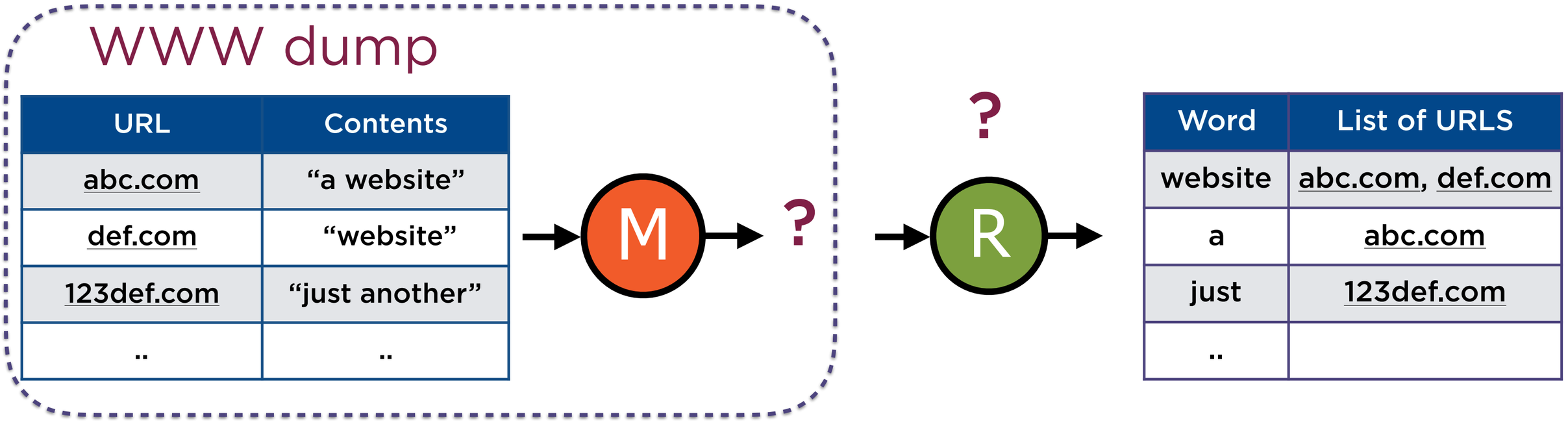
# Inverted Index

| Key | Value |
| --- | --- |
| Word | List of Page URLS |

**This index helps us find things on the internet**

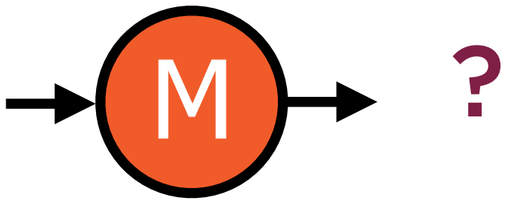
**This is exactly what Search Engines use!**

# MapReduce Inverted Index



# Map Step

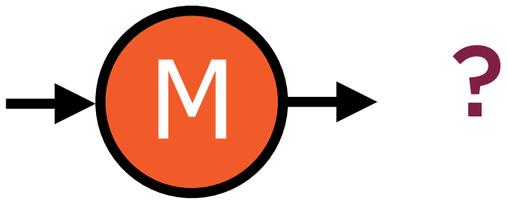
| URL | Contents |
| --- | --- |
| abc.com | “a website” |
| def.com | “website” |
| 123def.com | “just another” |
| .. | .. |




**The key has to be a word**

# Map Step

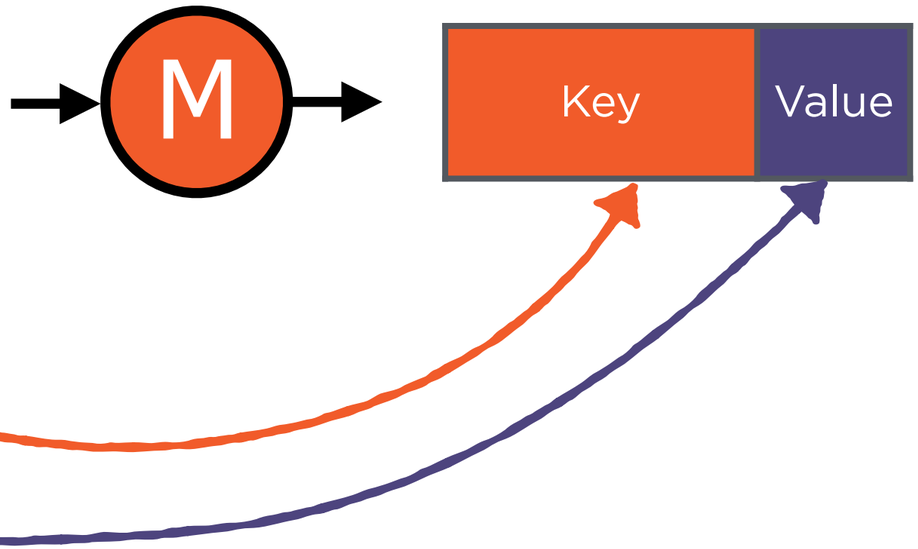
| URL | Contents |
| --- | --- |
| abc.com | “a website” |
| def.com | “website” |
| 123def.com | “just another” |
| .. | .. |




**The value has to contain URLs**

# Map Step

| URL | Contents |
| --- | --- |
| abc.com | “a website” |
| def.com | “website” |
| 123def.com | “just another” |
| .. | .. |

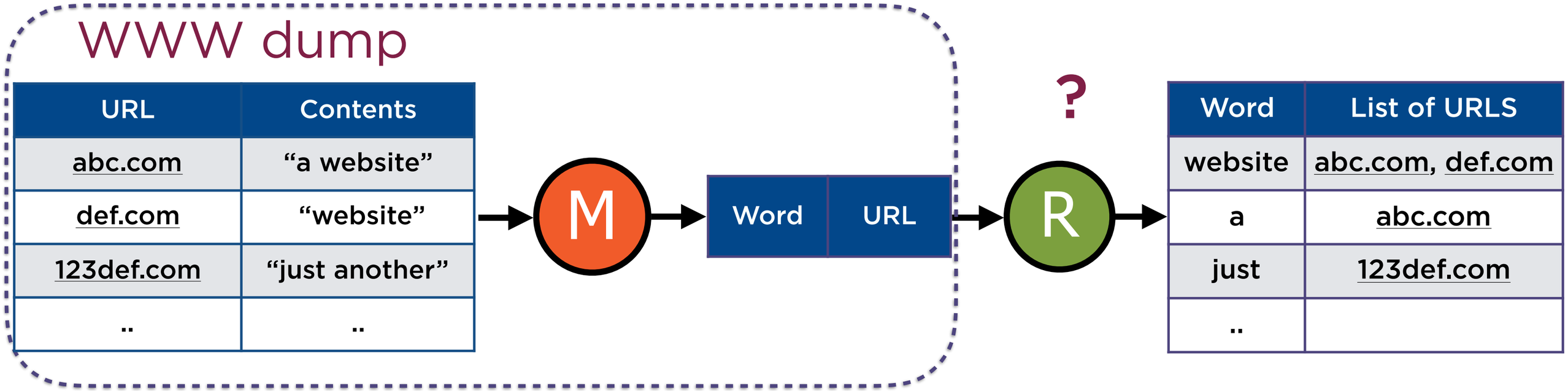


# Map Step

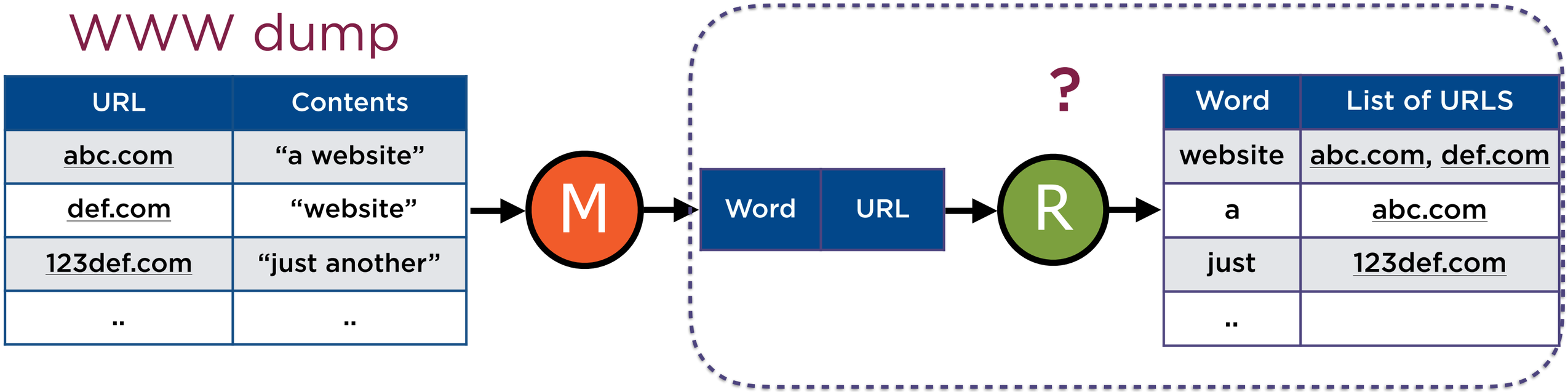
| URL | Contents |
| --- | --- |
| abc.com | “a website” |
| def.com | “website” |
| 123def.com | “just another” |
| .. | .. |


| Key | Value |
| --- | --- |
| Word | URL |
| a | abc.com |
| website | abc.com |
| website | def.com |
| just | 123def.com |

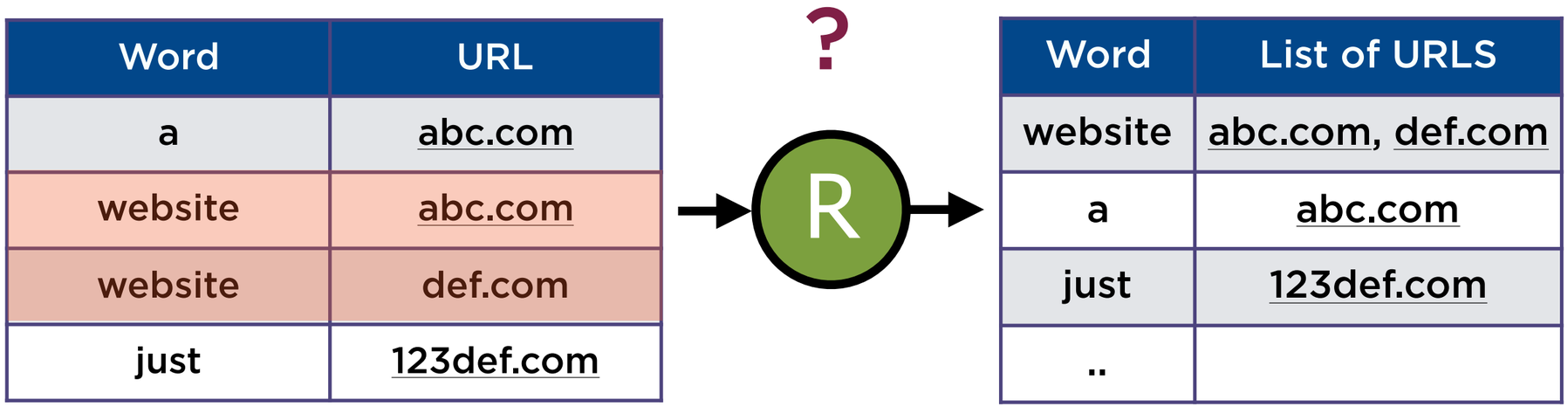
# MapReduce Inverted Index



# MapReduce Inverted Index



# Reduce Step



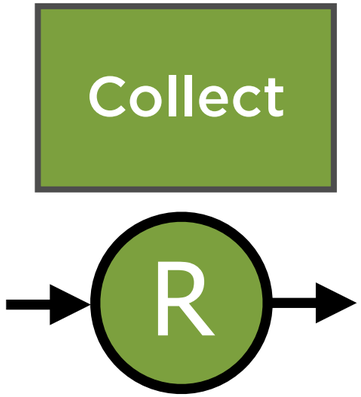

| Word | URL |
|---|---|
| a | abc.com |
| website | abc.com |
| website | def.com |
| just | 123def.com |

| Word | List of URLS |
|---|---|
| website | abc.com, def.com |
| a | abc.com |
| just | 123def.com |
| .. | |

**The reduce step combines values with the same key**

# Reduce Step

| Word | URL |
|---|---|
| a | abc.com |
| website | abc.com |
| website | def.com |
| just | 123def.com |



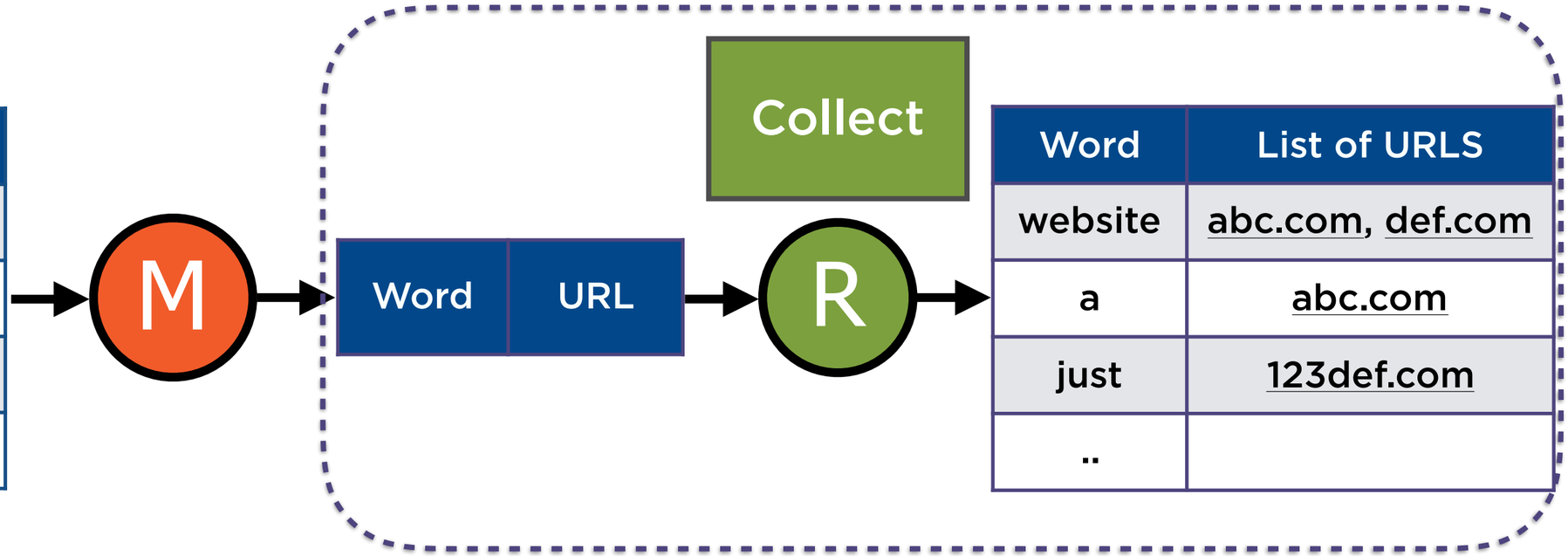

| Word | List of URLS |
|---|---|
| website | abc.com, def.com |
| a | abc.com |
| just | 123def.com |
| .. | |

**The combining logic is simply to collect the values into a list**

# MapReduce Inverted Index

## WWW dump

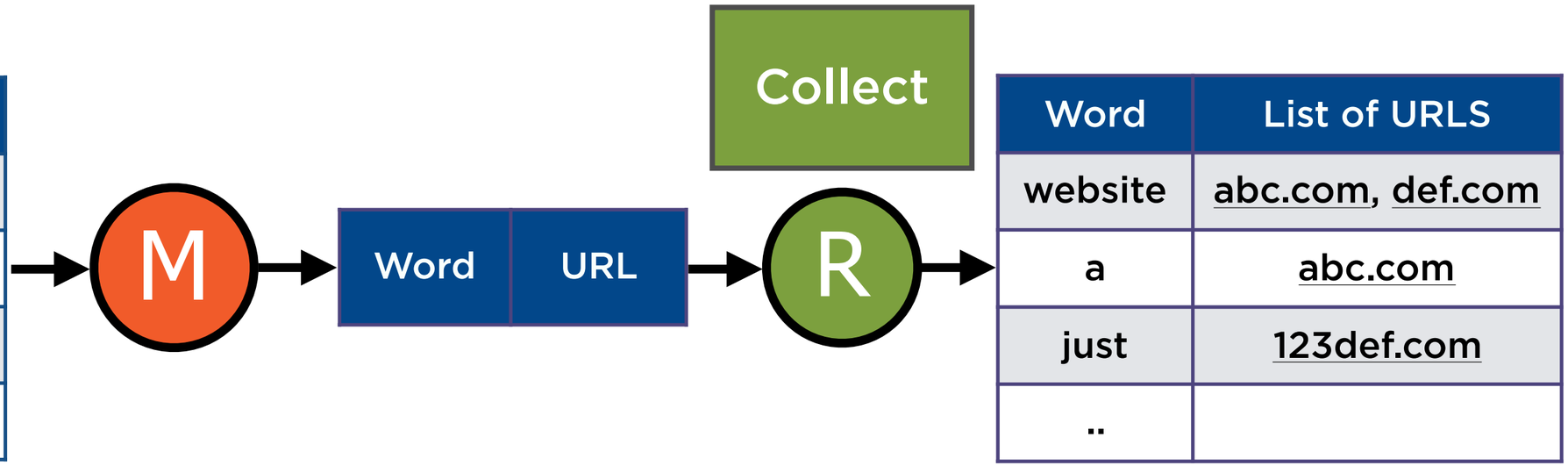
| URL | Contents |
|---|---|
| abc.com | “a website” |
| def.com | “website” |
| 123def.com | “just another” |
| .. | .. |



# MapReduce Inverted Index

## WWW dump

| URL | Contents |
|---|---|
| abc.com | “a website” |
| def.com | “website” |
| 123def.com | “just another” |
| .. | .. |




| Word | List of URLS |
|---|---|
| website | abc.com, def.com |
| a | abc.com |
| just | 123def.com |
| .. | |

Demo

## Implementing an Inverted Index

# Summary

Understood what is an inverted index and its role in building search engines

Implemented a MapReduce for an inverted index