Project #2 – Big Data

Compressing large collections of web pages

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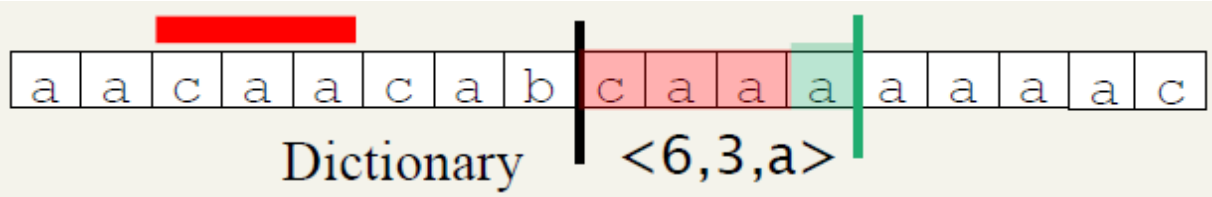
Problem Statement

INPUT: A file containing a collection of Web pages

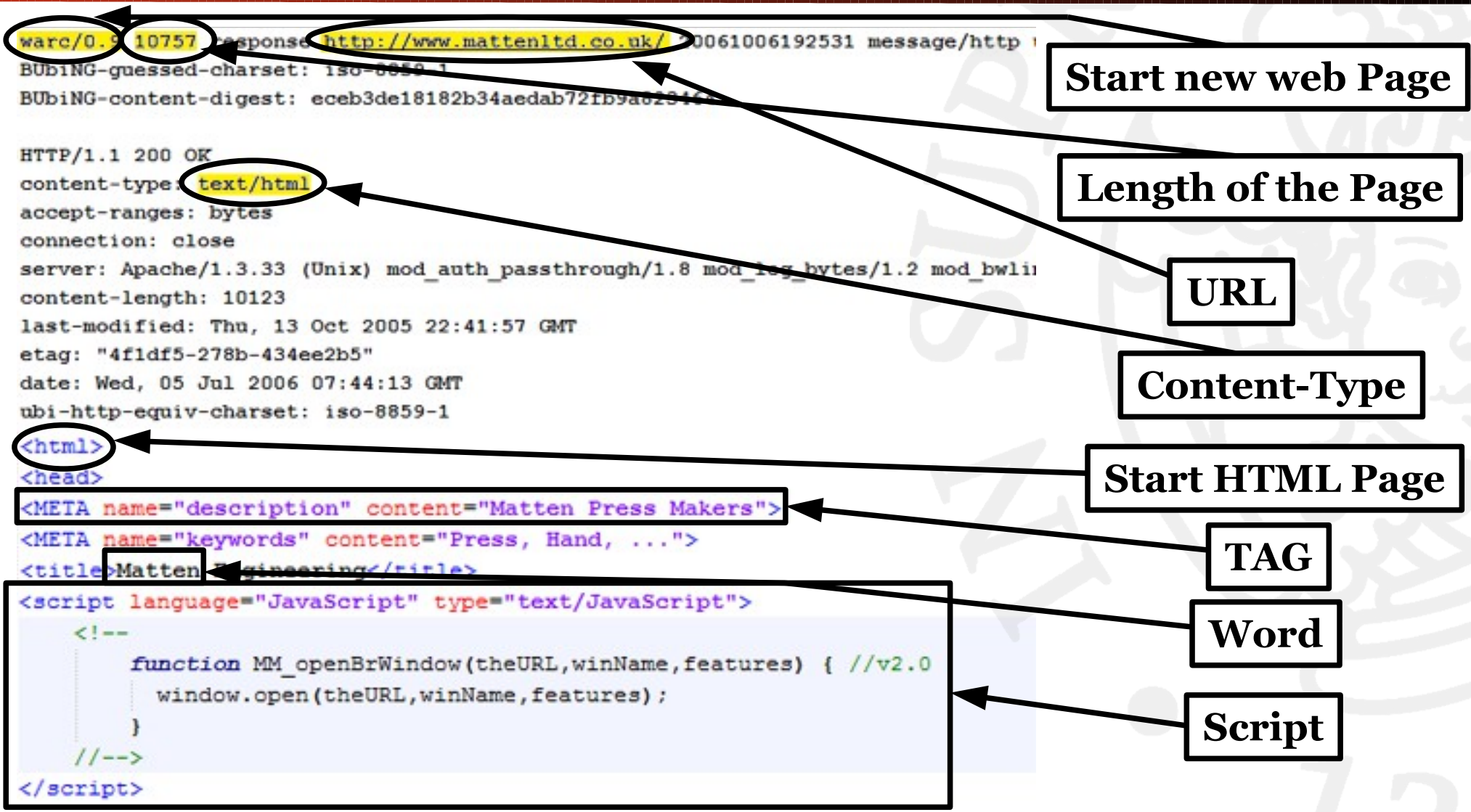
OUTPUT: A file containing the permuted collection, where the permutation is driven by the similarity between pages

GOAL: Find the best way of permuting in order to minimize the compression of the output file *(using Lzma2 compressor)*

LZ77



Analysis of the Web pages



Analysis of the Web pages

Assumption:

If someone COPY some TAGs / WORDs / SCRIPTs from an HTML page, he will NOT MODIFY them.

Start new web Page

Length of the Page

URL

Content-Type

```
<html>
<head>
<META name="description" content="Matten Press Makers">
<META name="keywords" content="Press, Hand, ...">
<title>Matten Engineering</title>
<script language="JavaScript" type="text/JavaScript">
    <!--
        function MM_openBrWindow(theURL,winName,features) { //v2.0
          window.open(theURL,winName,features);
        }
    //-->
</script>
```

Start HTML Page

TAG

Word

Script

Proposed Solution – 1st Version

```
Algorithm: CompressingWebPages(InputFile)
begin
    pi <- InitializePermutations(21)
    lsh <- new LSH(7 , 3)
    sf <- new ScanningFile(InputFile)
    categWP <- new Set(), notCategWP <- new Set()

    while(NOT sf.EOF)
    {
        wp <- Recognize in sf a Web page
        if (wp.Signature != NULL)
        {
            lsh.AddDocument(wp)
            categWP.Add(wp)
        }
        else notCategWP.Add(wp)
    }

    foreach wp in categWP
    {
        simDoc <- sort lsh.UnionFind(wp) by URL
        calculate permutation order of simDoc
    }
    simDoc <- sort notCategWP by URL
    calculate permutation order of simDoc

    foreach wp in (categWP union notCategWP)
        write wp in OutputFile
end
```

Initialize 21 **MURMUR HASH** *function*

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```

LSH-initialization:

- *pre-compute sampling of* ***3*** *elements from* ***Sketch***
- *create 7 hash tables with chaining*

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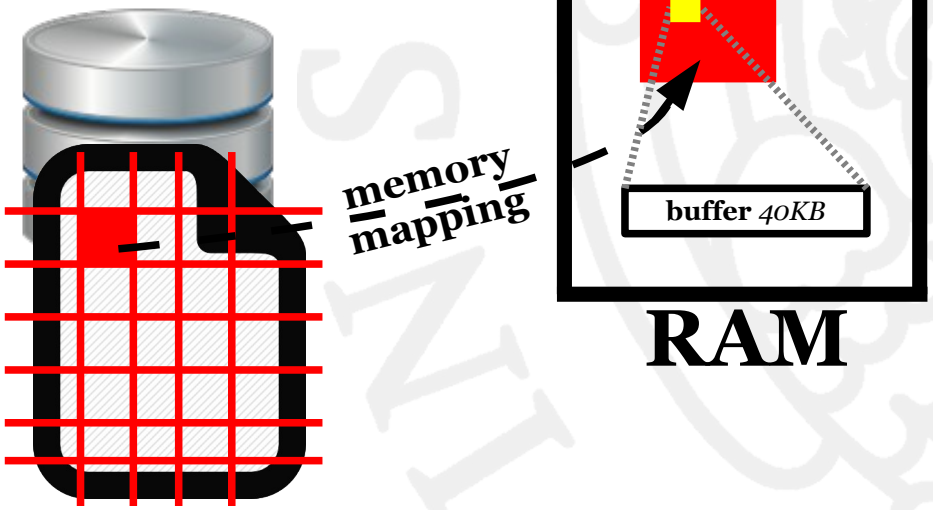
        write wp in OutputFile
end
```

Scanning File:



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    foreach wp in (categWP union notCategWP)
        write wp in OutputFile
end
```

Recognize Web page:

- Divide the Web page in **words** *(TAGs / WORDs / SCRIPTs)* → pair (start, length)
- **Karp-Rabin** hashing for every **word**
- **Shingling** of ***x***-words, with ***x*** depending **#**characters *(Q=25)*
- **Karp-Rabin** hashing for every **shingle**
- **Sketch Vector** using **Min-Hashing** *(pi)*
- **Return** the end of the page → next step will start here

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    calculate permutation order of simDoc

    foreach wp in (categWP union notCategWP)
        write wp in OutputFile
end
```

LSH-AddDocument:

- *pick **3** elements from the Sketch*
- *compute the sum*
- *add result to 1 of 7 buckets*
- *if there are collision → we list them*

Threshold ~52%

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    calculate permutation order of simDoc

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        write wp in OutputFile
end
```

Calculate Permutation: *For every page:*

- *find all similar pages (union find LSH)*
- *sort by URL*
- *calculate the position of the permutation* ***(NewStartPage)***

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    foreach wp in (categWP union notCategWP)
        write wp in OutputFile
end
```

Write on OutputFile:

Since we have calculated the new position that the Web pages will occupy:

- *scan sequentially the **input file***
- *write randomly into **output file***

Proposed Solution – 2nd Version

```
Algorithm: CompressingWebPages(InputFile)
begin
    sf <- new ScanningFile(InputFile)
    webpages <- new List()
    while(NOT sf.EOF)
        webpages.Add ( Recognize in sf a Web page )

    pi <- InitializePermutations(21)
    lsh <- new LSH(7 , 3)
    swp = new ScanningWebPages(InputFile)
    categWP <- new Set(), notCategWP <- new Set()
    foreach wp in webpages
    {
        if (wp.IsHTML)
        {
            swp.WebPageContent(wp)
            wp.Signature <- CalculateSignature(swp.Container, pi)
            lsh.AddDocument(wp)
            categWP.Add(wp)
        }
        else
            notCategWP.Add(wp)
    }

    Calculate_Permutation()

    foreach 25K wp in webpages
    {
        swp.WebPageContent(25K wp)
        sort swp.Container by NewStartPage
        write 25K wp in OutputFile
    }
end
```

<u>Do not process entire page</u>:
We analyse only the "header" information and then we skip to the next pages ***(Length of Page)***

Proposed Solution – 2nd Version

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begin
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    foreach 25K wp in webpages
    {
        swp.WebPageContent(25K wp)
        sort swp.Container by NewStartPage
        write 25K wp in OutputFile
    }
end
```

Scanning Web Pages:
Similar to ***ScanningFile*** but the ***chunks*** are made by **100K** pages for a time

Proposed Solution – 2nd Version

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Algorithm: CompressingWebPages(InputFile)
begin
    sf <- new ScanningFile(InputFile)
    webpages <- new List()
    while(NOT sf.EOF)
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    categWP <- new Set(), notCategWP <- new Set()
    foreach wp in webpages
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            swp.WebPageContent(wp)
            wp.Signature <- CalculateSignature(swp.Container, pi)
            lsh.AddDocument(wp)
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    Calculate_Permutation()

    foreach 25K wp in webpages
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        swp.WebPageContent(25K wp)
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    }
end
```

Web Pages Content:
Depending on ***wp***, we store the appropriate ***chunk*** in memory, and we **copy** the content of ***wp*** into the ***swp.Container***, adapting it if necessary

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    {
        swp.WebPageContent(25K wp)
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        write 25K wp in OutputFile
    }
end
```

Calculate Signature:
Knowing exactly the web page content the process is faster and more precise respect the first version

Proposed Solution – 2nd Version

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        write 25K wp in OutputFile
    }
end
```

Same as before, but we have improved **LSH UnionFind**

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    {
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    }
end
```

Sorting in memory 25K pages at a time:
In this way we can read and write sequentially

Results – 1° & 2° phase

```
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    Calculate_Permutation()

    foreach 25K wp in webpages
    {
        swp.WebPageContent(25K wp)
        sort swp.Container by NewStartPage
        write 25K wp in OutputFile
    }
end
```

#Pages	Time 1°	Time 2°
1	00:00:00	00:00:00
10	00:00:02	00:00:06
100	00:00:14	00:00:42
500	00:02:29	00:05:57
1000	00:05:05	00:13:00
3000	00:15:00	00:36:35

Results – 1° & 2° phase

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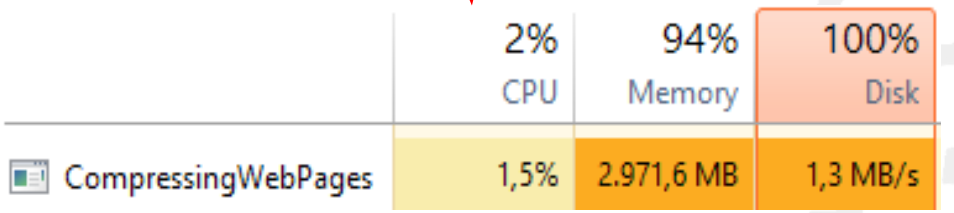
end
```

comparison between v1 & v2

#Pages	Version 1	Version 2
1	00:00:01	00:00:00
10	00:00:26	00:00:08
100	00:05:26	00:00:56
500	00:36:58	00:08:26
1000	00:57:16	00:18:05
3000	≫2 days	00:51:35



Results – 3° & 4° phase

```
Algorithm: CompressingWebPages(InputFile)
begin
    sf <- new ScanningFile(InputFile)
    webpages <- new List()
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    }
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    calculate permutation order of simDoc

    Calculate_Permutation()

    foreach 25K wp in webpages
    {
        swp.WebPageContent(25K wp)
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        write 25K wp in OutputFile
    }
end
```

#Pages	Version 1	Version 2
1	00:00:01	00:00:00
10	00:01:07	00:00:00
100	00:27:46	00:06:30
500	02:18:35	01:22:27
1000	05:29:42	04:34:51
3000	-	32:35:03

Results – 3° & 4° phase

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        write 25K wp in OutputFile
    }
end
```

comparison between v1 & v2

#Pages	Time 3°	Time 4°
1	00:00:00	00:00:00
10	00:00:00	00:00:00
100	00:01:13	00:05:17
500	00:27:34	00:54:53
1000	03:14:25	01:26:26
3000	25:07:45	07:27:18

Results – compression

# Pages	Original Compression	Achieved Compression
1	89.75%	99.79%
10	91.41%	93.00%
100	93.53%	95.08%
500	94.57%	96.17%
1000	94.25%	95.99%
3000	93.83%	95.69%

Future Work

- **Parallelize:** Divides ***#pages*** in group depending ***#CPU***
  - Computes **signature** of each group in **parallel**
  - After found the final permutation, in **parallel**, reads each group of pages and write them into the output file, accordingly the permutation

- **Improve Algorithms:**
  - **Union Find** → the **3th phase** is too slow despite there are no ***I/Os***
  - **Sorting** → use **Multi-Way MergeSort *(4th phase)***

Questions

Thanks !