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Research paper

Handling Words Duplication and Memory Management for Digital Quran Based on Hexadecimal Representation and Sparse Matrix

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Abstract

Al-Quran is the holy book of the Muslims and the most important scripture containing knowledge on many domains. The recent advent of smart technologies like smart phones, digital devices and tablets has connected the daily life routines under a single touch adopted by many, these new tools with an exponential growth. This paper presented a Digital Quran Model (DQM) using hexadecimal representation using Unicode Hexadecimal and UTF-8 for character encoding, which is backward compatible with ASCII code. DQM target to handle all duplicated words or verses in Al-Quran using sparse matrix with double offset indexing to handle memory optimization. Three approaches were discussed: indexing and representation of the digital Quran to optimize storage, organize verses structure using sparse matrix to handle repetition with double offset indexing to efficiently use the space. The algorithms were implemented using Visual studio and Java server and the solution quality was measured by the size of a file before and after applying DQM model. For surah Al-Baqarah, the longest chapter in the Al-Quran, the reduction of the storage size was 25.00% whereas surah Al-Fatihah was 47.89%. The proposed DQM model is able to optimize the memory space and can be extended to other non-Roman characters used for information retrieval such as Hindi, Chinese and Japanese that are categorized in unicode standards.

Keywords: *Digital Quran; Hexadecimal Representation; Sparse Matrix; Unicode.*

1. Introduction

The popularity of digital Quran shown by the rapid increase of online Quran learners worldwide have resulted the needs of software applications that facilitate knowledge retrieval from the Quran, being the major source of authentic Islamic knowledge. In this study, we proposed Digital Quran Model (DQM) a representation based on hexadecimal with sparse matrix techniques to optimize memory storage. DQM handle all duplicated words or verses in the Quran by proposing a new technique for indexing based on hexadecimal representation that use Unicode Hexadecimal UTF-8 for character encoding which is backward compatible with ASCII code. In this study, surah Al-Baqarah and Al-Fatiha were taken as a test case to demonstrate how the technique is able to handle the many repeated or duplicated words in the Al-Quran.

This paper is organized as follows: Section 2 presents the review of related literature. Section 3 highlights the motivations and objectives of this study. The steps and methods of constructing the Digital Quran representation and algorithms based on hexadecimal and sparse matrix are presented in section 4, this is followed by section 5 presenting the implementation, and the evaluation is provided in section 6. Finally, our work in this paper is summarized in the last section.

2. Related Works

Al-Quran is the most important source of knowledge and considered as a standard text reference which relate valuable stories, prophetic habits and inherited Muslims wisdom. This great Book is a corpus which consists of 30 juzu, 60 hizb, 114 chapters, 6236 verses, 77439 words and 320015 letters [1]. Al-Quran is preserved from tampering since 14 centuries. This section presents the background and literature review of Al-Quran in the original Arabic text and digital Quran representation techniques that have been used.

Most recent notable work in the area of Quran studies using the cutting edge technology is by [2] and also their published work in [3, 4]. The main objective of this research deals with the design and development of a complete and comprehensive online cloud-based Quran portal. The portal and its applications makes all the reading and resource sections accessible to the audience whether the users are using laptops, PC, mobile, tablet, or personal digital assistants. Another notable work in the Quranic applications is presented in [5]. This work is about cross language information retrieval (CLIR). It presents a semantic technique on queries for retrieving more relevant results in CLIR, that concentrate on the Arabic, Malay or English query translation (a dictionary based method) to retrieve documents according to query translation. The size of the applications varies from one application to another with the highest size found to be 638MB and the smallest size of 79KB [6]. These applications are developed with the advancement of multimedia technology [7] where a primarily reciter of Al-Quran accomplish the learning of the holy book through a variety of sources, either websites such as Quran portals or modern gadgets like the iPhone and android apps as done in [8].

A survey related to the use of the internet or mobile devices to read the Quran or hadith were conducted in [1] where 73 % of the participants rely on the internet to find a particular Quranic verse or hadith and 52.9 % preferred reading the Quran in a soft copy or mobile devices as shown in Figure 1, whereas quite a large number of respondents use various types of digital devices to read and memorize the Quran.

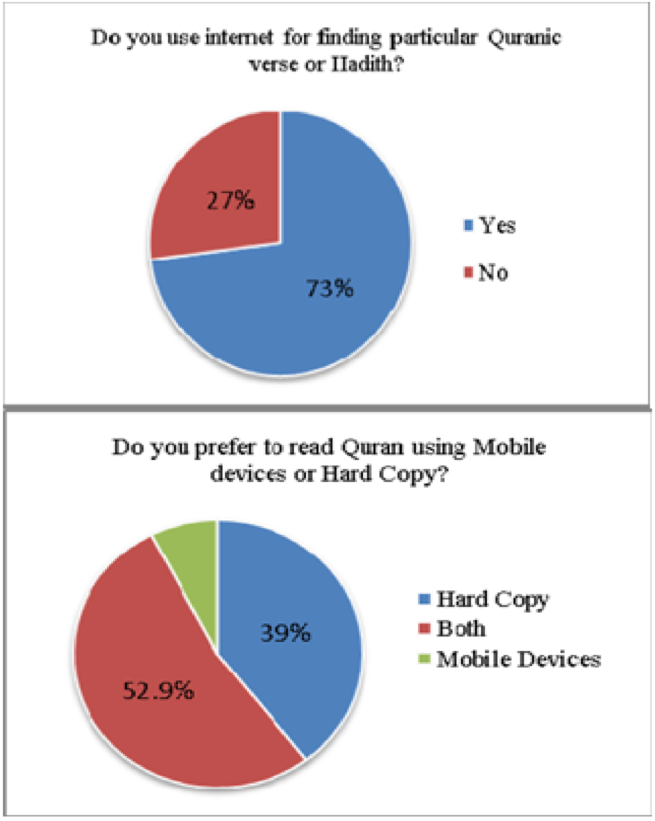


Fig. 1: Use of Internet for reading Quran and preference of reading Quran using mobile devices [1]

Watermarking of text-documents has been classified as linguistic and non-linguistic by [9]. Linguistic techniques manipulate the lexical, syntactic and semantic properties of a document while trying to preserve the meanings; however, in the non-linguistic approaches changes are made to the text by using different text-attributes to embed a message. Text-watermarking techniques have been based on shifting techniques such as line-shift coding, word-shift coding and feature/character-coding, and natural-language based watermarking techniques such as synonym-substitutions or semantic-transformation techniques which are language-dependent. A study in [10] proposed a fragile watermarking method to preserve the authenticity of the digital Al-Quran. The method is considered as fragile watermarking method, which works on wavelet and spatial domains of digital Quran images. The authentication bits are embedded into each block of wavelet transformed image. Then, the least significant bits of pixels are considered to embed another authentication bits. The experimental results show that the watermarked image is imperceptible and fragile to the common attacks.

Works have also been done in the field of Digital Quranic Information Retrieval on different format and techniques but most researchers use the normal preprocessing techniques of Quran words and verses such as stemming, tokenizing, POS tagging and image processing. However, all of these techniques need time and storage, and ignore words duplication. Therefore, this paper presents a new technique which saves time and storage using UTF-8 characters encoding which is backward compatible with ASCII code [11], implemented using sparse matrix with double off set indexing to handle word duplication. Unicode transformation format (UTF) is the universal character code standard to represent characters where UTF-8 is an alternative coded representation form for all the characters in Unicode while maintaining compatibility with ASCII code [12].

3. Motivations and Objectives

The motivations behind this work come from the fact that all of our daily routine is being transferred to smart tools such as smart phone, tablet, PC and other devices in a similar way, people are transferring to smart devices to read/brows their religious books. Millions of Muslims are also using smart devices to read/browse Quran and its sciences, which is easily available through the web or search engines. This inspired and motivated us to propose a new DQM that helps to optimized memory for the whole digital Quran by handling duplications. The purpose of this study is to propose DQM that can handle duplications and evaluate this implementation in terms of optimization of storage.

4. Methodology

The specific aim of this research work is to build a new model for digital Quran using hexadecimal representation and sparse matrix. The study begins with Arabic letters later develop the longest surah of the Al-Quran. By handling word duplication, it saves memory storage that may lead to ease of searching. Figure 2 shows DQM process flow. Letters, words, verses conversions and sparse matrix are discussed respectively in the next four sections as shown by the algorithm designed.

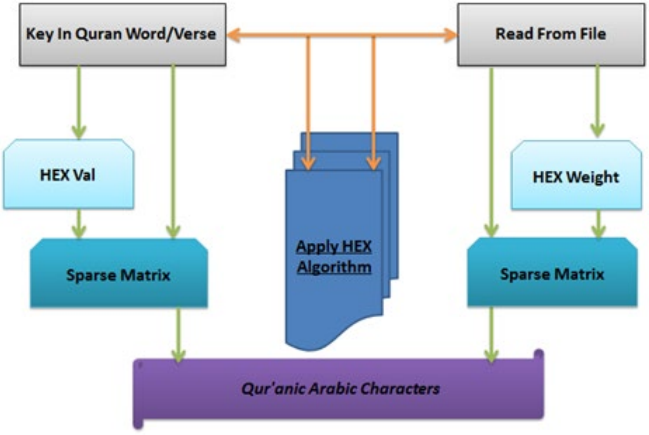
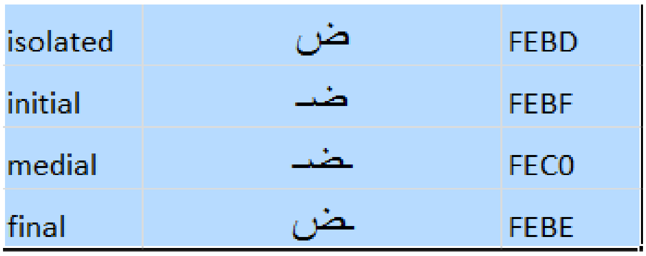


Fig. 2: DQM Process Flow.

4.1. Arabic Letters Conversion

Letters conversion is the backbone of the proposed technique using UTF-8 for character encoding, which is backward compatible with ASCII code. The placement of the letter in a word is significant which are: initial, medial, final and isolated such structure of Arabic letters make the process of digital Quran complex. The next example shows Thad (ض) letter in four expected positions and drawings on the word in addition to the hexadecimal representation that have been inherited from Unicode Standard 7.0, Copyright © 2014 Arabic Presentation, refer to Figure 3 and 4.



isolated	ض	FEBD
initial	ضـ	FEBF
medial	ـضـ	FEC0
final	ـض	FEBE

Fig. 3: Thad (ض) letter in four expected position on the word.

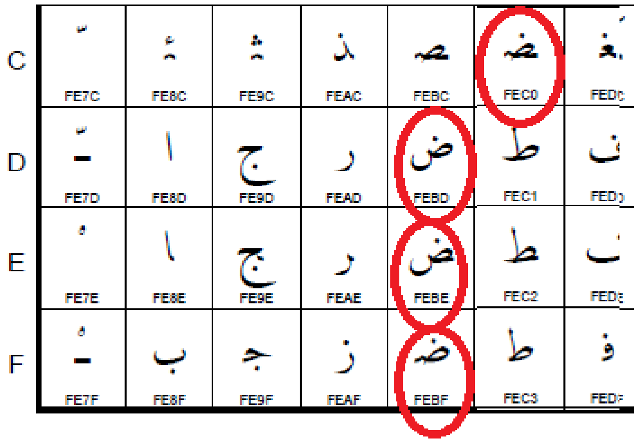

C
D
E
F
FE7C
FE8C
FE9C
FEAC
FEBC
FEC0
FEDC
FE7D
FE8D
FE9D
FEAD
FEBD
FEC1
FED
FE7E
FE8E
FE9E
FEAE
FEBE
FEC2
FED
FE7F
FE8F
FE9F
FEAF
FEBF
FEC3
FED

Fig. 4: Unicode Standard 7.0, Copyright © 2014 Arabic Presentation.

4.2. Words Conversion

The Al-Quran contains 77439 words and 18800 unique words, implying not only a huge amount of words but also repeated words. The new proposed technique represents the words of Al-Quran using Unicode by calculating the hexadecimal representation of each word. Transformed words are stored in an array. The word conversion is based on letter conversion as in the previous section constructed by the formula in Equation (1):

$$W(k) \quad = L\,(h1, h2, \ldots hn) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

$$= \sum_{1}^{n} hi \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

where *W(k)* is the hexadecimal value of the words and L is the function that calculates the value based on each letter representation in hexadecimal.

In addition, one must take into consideration the letter position on each word. The following example shows the weight of the word (قدير) QADEER in hexadecimal; according to Equation (1), calculated as follows:

W (قدير) = L (قـ + ـد + ـيـ + ـر)
= L (FED7+FEAA+FEF3+FEAE)
= 3FB22

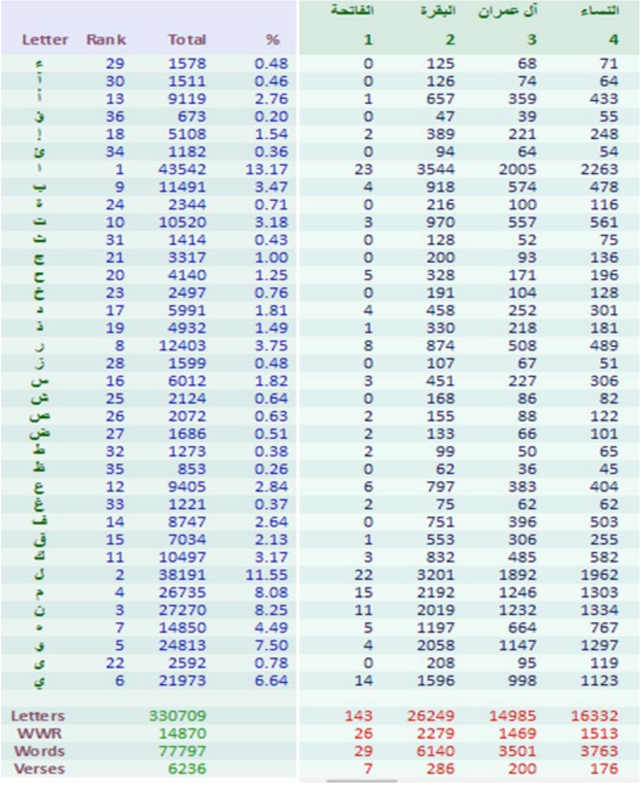
The size of the word (قدير) is 8 bytes compared to 5 bytes size of the same word in hexadecimal representation according to the above formula. This approach is useful in optimizing memory space, thus, may increase the speed in searching such as in information retrieval, text mining, Quran memorizing and interpretation.

4.3. Verses Conversion

Verses conversion depends on the previous section which is word conversion. The simple verse represented on hexadecimal is the first verse in the Quran بسم الله الرحمن الرحيم which is repeated 114 times; if we compare the size of the verse Bismillah Alrahman Alrahim (بسم الله الرحمن الرحيم) will be 23 bytes compared to 4 bytes of FDFD hexadecimal representation, indicating storage size reduction.

Next, the case study of this research was the second chapter of the Al-Quran which was Surah Al-Baqarah ((البقرة)) which contains 26249 letters, 2279 unique words, 6140 words, 286 verses besides surah Al-Fatiha. Table 1 shows the Quran Surah Statistics (QSS) effectively made up 36 rows showing the Arabic printable letters, and 114 columns for all thesauruses. The rest of the rows or columns show computed cumulative statistics. The acronym WWR stands for Words without Repetition or unique words where the alphabets are ordered in accordance to the Unicode standard as shown in Table 1.

Table 1: Quran surat statistics (QSS) [1]

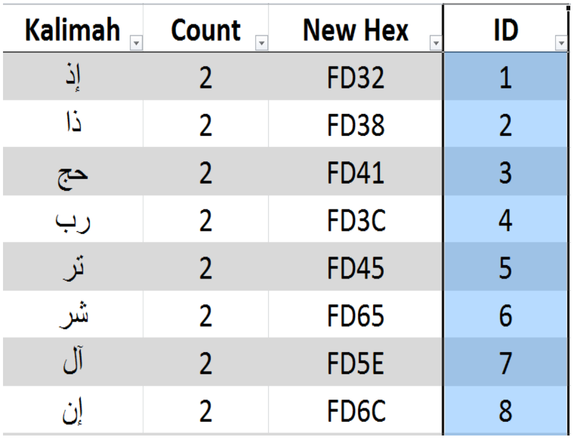


				الفاتحة	البقرة	آل عمران	النساء
Letter	Rank	Total	%	1	2	3	4
ء	29	1578	0.48	0	125	68	71
آ	30	1511	0.46	0	126	74	64
أ	13	9119	2.76	1	657	359	433
ؤ	36	673	0.20	0	47	39	55
إ	18	5108	1.54	2	389	221	248
ئ	34	1182	0.36	0	94	64	54
ا	1	43542	13.17	23	3544	2005	2263
ب	9	11491	3.47	4	918	574	478
ة	24	2344	0.71	0	216	100	116
ت	10	10520	3.18	3	970	557	561
ث	31	1414	0.43	0	128	52	75
ج	21	3317	1.00	0	200	93	136
ح	20	4140	1.25	5	328	171	196
خ	23	2497	0.76	0	191	104	128
د	17	5991	1.81	4	458	252	301
ذ	19	4932	1.49	1	330	218	181
ر	8	12403	3.75	8	874	508	489
ز	28	1599	0.48	0	107	67	51
س	16	6012	1.82	3	451	227	306
ش	25	2124	0.64	0	168	86	82
ص	26	2072	0.63	2	155	88	122
ض	27	1686	0.51	2	133	66	101
ط	32	1273	0.38	2	99	50	65
ظ	35	853	0.26	0	62	36	45
ع	12	9405	2.84	6	797	383	404
غ	33	1221	0.37	2	75	62	62
ف	14	8747	2.64	0	751	396	503
ق	15	7034	2.13	1	553	306	255
ك	11	10497	3.17	3	832	485	582
ل	2	38191	11.55	22	3201	1892	1962
م	4	26735	8.08	15	2192	1246	1303
ن	3	27270	8.25	11	2019	1232	1334
ه	7	14850	4.49	5	1197	664	767
و	5	24813	7.50	4	2058	1147	1297
ى	22	2592	0.78	0	208	95	119
ي	6	21973	6.64	14	1596	998	1123
Letters		330709		143	26249	14985	16332
WWR		14870		26	2279	1469	1513
Words		77797		29	6140	3501	3763
Verses		6236		7	286	200	176

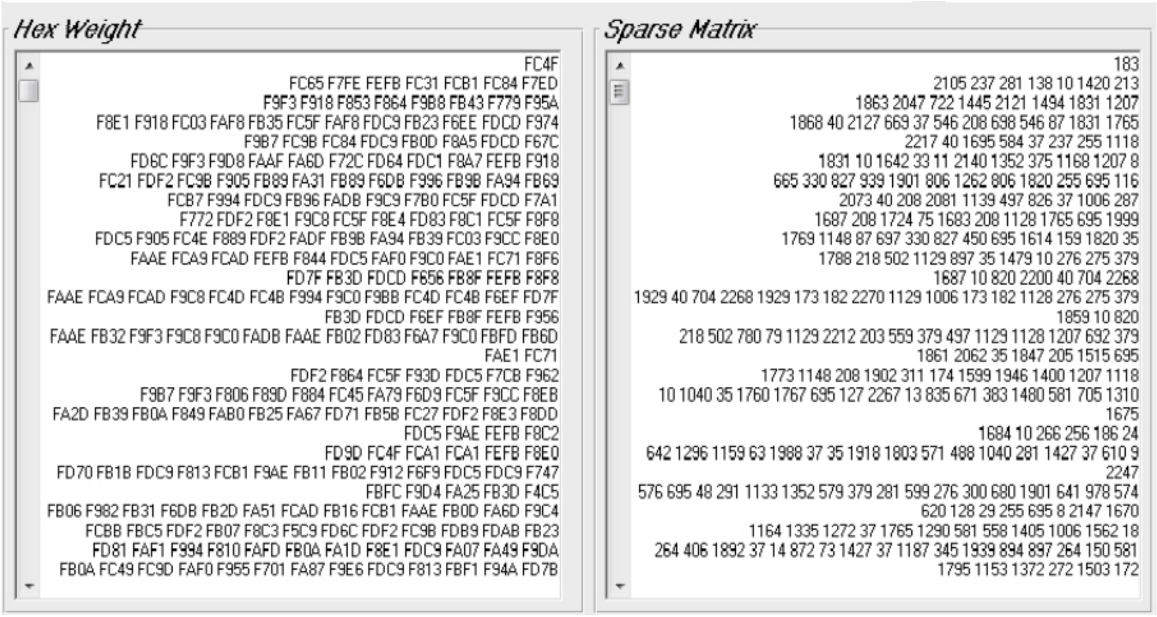
4.4. Sparse Matrix and Double off Set Indexing

Sparse matrix is the solution for words that has same hexadecimal representation by giving each word a unique ID to avoid duplication. This conversion is represented on a Lookup Table shown in Table 2. The conversion is represented with three columns; the first column contains the word in Arabic or Kalimah, the second column contains a counter that counts the number of each repeated word, the third column contains a hexadecimal representation for each word and the last column contains an ID. The storage of words being optimized through the use of one memory space for that particular word rather than one memory space for each Arabic character in the words of the Quran. Then, a sparse matrix will be constructed to encode to the display of Arab characters in Surah Al-Baqarah ((البقرة)) as shown in Figure 5. Here, the reduction of the storage was 25.00%.

Table 2: Lookup Table Represent Surat Al-Baqarah ((البقرة))



Kalimah	Count	New Hex	ID
إذ	2	FD32	1
ذا	2	FD38	2
حج	2	FD41	3
رب	2	FD3C	4
تر	2	FD45	5
شر	2	FD65	6
آل	2	FD5E	7
إن	2	FD6C	8



```
                                                                   FC4F
                                   FC65 F7FE FEFB FC31 FCB1 FC84 F7ED
                              F9F3 F918 F853 F864 F9B8 FB43 F779 F95A
    F8E1 F918 FC03 FAF8 FB35 FC5F FAF8 FDC9 FB23 F6EE FDCD F974
                         F9B7 FC9B FC84 FDC9 FB0D F8A5 FDCD F67C
              FD6C F9F3 F9D8 FAAF FA6D F72C FD64 FDC1 F8A7 FEFB F918
    FC21 FDF2 FC9B F905 FB89 FA31 FB89 F6DB F996 FB9B FA94 FB69
                  FCB7 F994 FDC9 FB96 FADB F9C9 F7B0 FC5F FDCD F7A1
                   F772 FDF2 F8E1 F9C8 FC5F F8E4 FD83 F8C1 FC5F F8F8
    FDC5 F905 FC4E F889 FDF2 FADF FB9B FA94 FB39 FC03 F9CC F8E0
         FAAE FCA9 FCAD FEFB F844 FDC5 FAF0 F9C0 FAE1 FC71 F8F6
                              FD7F FB3D FDCD F656 FB8F FEFB F8F8
FAAE FCA9 FCAD F9C8 FC4D FC4B F994 F9C0 F9BB FC4D FC4B F6EF FD7F
                                  FB3D FDCD F6EF FB8F FEFB F956
FAAE FB32 F9F3 F9C8 F9C0 FADB FAAE FB02 FD83 F6A7 F9C0 FBFD FB6D
                                                          FAE1 FC71
                              FDF2 F864 FC5F F93D FDC5 F7CB F962
           F9B7 F9F3 F806 F89D F884 FC45 FA79 F6D9 FC5F F9CC F8EB
FA2D FB39 FB0A F849 FAB0 FB25 FA67 FD71 FB5B FC27 FDF2 F8E3 F8DD
                                            FDC5 F9AE FEFB F8C2
                                  FD9D FC4F FCA1 FCA1 FEFB F8E0
 FD70 FB1B FDC9 F813 FCB1 F9AE FB11 FB02 F912 F6F9 FDC5 FDC9 F747
                                       FBFC F9D4 FA25 FB3D F4C5
FB06 F982 FB31 F6DB FB2D FA51 FCAD FB16 FCB1 FAAE FB0D FA6D F9C4
    FCBB FBC5 FDF2 FB07 F8C3 F5C9 FD6C FDF2 FC9B FDB9 FDAB FB23
     FD81 FAF1 F994 F810 FAFD FB0A FA1D F8E1 FDC9 FA07 FA49 F9DA
 FB0A FC49 FC9D FAF0 F955 F701 FA87 F9E6 FDC9 F813 FBF1 F94A FD7B
```

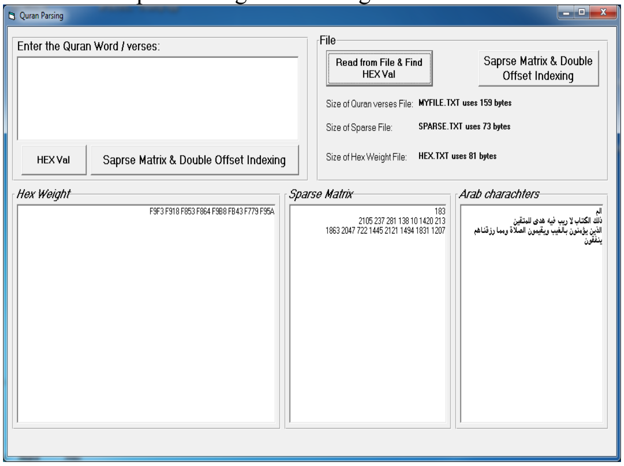
```
                                                              183
                                 2105 237 281 138 10 1420 213
                        1863 2047 722 1445 2121 1494 1831 1207
            1868 40 2127 669 37 546 208 698 546 87 1831 1765
                              2217 40 1695 584 37 237 255 1118
                  1831 10 1642 33 11 2140 1352 375 1168 1207 8
          665 330 827 939 1901 806 1262 806 1820 255 695 116
                   2073 40 208 2081 1139 497 826 37 1006 287
              1687 208 1724 75 1683 208 1128 1765 695 1999
           1769 1148 87 697 330 827 450 695 1614 159 1820 35
              1788 218 502 1129 897 35 1479 10 276 275 379
                                1687 10 820 2200 40 704 2268
1929 40 704 2268 1929 173 182 2270 1129 1006 173 182 1128 276 275 379
                                                  1859 10 820
    218 502 780 79 1129 2212 203 559 379 497 1129 1128 1207 692 379
                                1861 2062 35 1847 205 1515 695
          1773 1148 208 1902 311 174 1599 1946 1400 1207 1118
  10 1040 35 1760 1767 695 127 2267 13 835 671 383 1480 581 705 1310
                                                             1675
                                         1684 10 266 256 186 24
  642 1296 1159 63 1988 37 35 1918 1803 571 488 1040 281 1427 37 610 9
                                                             2247
 576 695 48 291 1133 1352 579 379 281 599 276 300 680 1901 641 978 574
                                620 128 29 255 695 8 2147 1670
         1164 1335 1272 37 1765 1290 581 558 1405 1006 1562 18
  264 406 1892 37 14 872 73 1427 37 1187 345 1939 894 897 264 150 581
                                     1795 1153 1372 272 1503 172
```

Fig. 5: Sparse Matrix Represent Arabic Characters for Surat Al-Baqarah

5. Implementation

This section discusses the implementation process of DQM from the first step until evaluation; developing a DQM prototype application involves combining and chaining many components, not all components will need to be executed on every system run. Instances containing the Quranic letters and words must be represented in Hexadecimal. Basically, the implementation process of the proposed system features three major processes which are: (1) letters conversion to hexadecimal, (2) word conversion to hexadecimal, and (3) sparse matrix with double offset indexing.

This Quranic Code will be done on three levels; character or letter, word, and verse level. Character level will be translated using UTF-8 character encoding for each of the Arabic characters in the Quran which is the basis of DQM, and compute the word representation in hexadecimal, followed by the verses. The algorithm was implemented using Visual studio and Java server as depicted in Figure 6 showing the main interface.


Quran Parsing
Enter the Quran Word / verses:
File
Read from File & Find HEX Val
Saprse Matrix & Double Offset Indexing
HEX Val
Saprse Matrix & Double Offset Indexing
Hex Weight
Sparse Matrix
Arab charachters

Size of Quran verses File: MYFILE.TXT uses 159 bytes

Size of Sparse File: SPARSE.TXT uses 73 bytes

Size of Hex Weight File: HEX.TXT uses 81 bytes

```
F9F3 F918 F853 F864 F9B8 FB43 F779 F95A
```

```
                               183
      2105 237 281 138 10 1420 213
1863 2047 722 1445 2121 1494 1831 1207
```

الم
ذلك الكتاب لا ريب فيه هدى للمتقين
الذين يؤمنون بالغيب ويقيمون الصلاة ومما رزقناهم
ينفقون

Fig. 6: Main interface of DQM.

In the DQM application, the algorithm can be applied directly by entering any Arabic or Quranic letter, word or verse, then retrieve the hexadecimal weight of the entered characters. Next, generate the sparse matrix and compare the size byte.

6. Evaluation

The main factor in the evaluation process is the solution quality, which is measured by comparing the size of a file before and after applying DQM algorithm. For example, the word Al-Rahim(الرحيم), Qadeer(قدير), and the first verse in the Quran which is *Bismillah Al-Rahman Al-Rahim* (بسم الله الرحمن الرحيم), the hexadecimal representation was computed to be 5F893, 3FB22 and FDFD respectively which yield about 58.33%, 37.50%, 82.60% reduction.

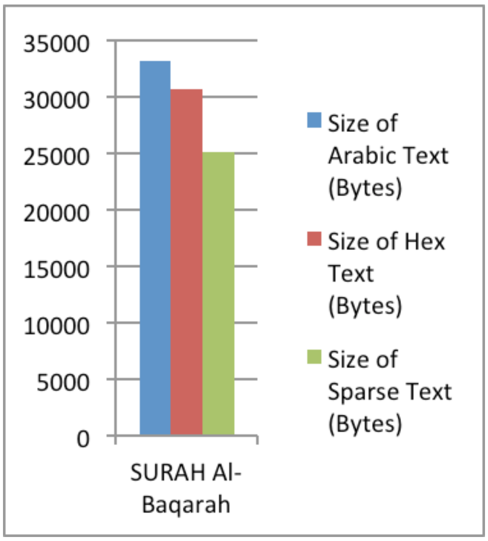


Fig. 7: Size comparison between Arabic text, Hex text and sparse text for Surah Al-Baqarah.

The first verse in the Al-Quran بسم الله الرحمن الرحيم is repeated 114 times. Therefore, if we compare the size of the verse Bismillah Al-Rahman Al-Rahim (بسم الله الرحمن الرحيم) will be 23 bytes instead of 4 bytes of FDFD hexadecimal representation. Imagine the reduction when repeated 114 times, the reduction will be of 2622 bytes compared to 456 bytes after applying the conversion algorithm which equal to 82.60%. For surah Al-Baqarah, the reduction on the storage size was 25.00%; and Al-Fatiha was 47.89%. Table 3 summarizes the comparison for all above mentioned words, verses, in addition to surah Al-Baqarah and Al-Fatiha. Figure 7 depicts the size comparison between arabic text, hex text and sparse text for surah Al-Baqarah.

Table 3: Summary of the comparison.

Word/ Verse/ Surah	Number of Words	Repeated Words	Size of Arabic Text (Bytes)	Size of Hex Text (Bytes)	Size of Sparse Text (Bytes)	Occurrence in the Quran (Freq.)	Total Size Reduction (%)
Alrahim الرحيم	1	0	12	5	9	148	58.33
Qadeer قدير	1	0	7	5	4	45	37.50
Besm Ellah Alrahman Alrahim بسم الله الرحمن الرحيم	4	0	23	4	4	114	82.60
Surah Al-Fatiha الفاتحة	29	3	159	149	85	1	47.89
Surah Al-Baqarah البقرة	2210	649	33199	30652	25149	1	25

7. Conclusion

In this paper, a new Digital Quran Model was proposed using Hexadecimal representation for storage optimization. Sparse matrix with double offset indexing use for handling words and verses duplications reduces the storage at 82.60% for the first verse in the Quran *Bismillah Al-Rahman Al-Rahim*, 25% for surah Al-Baqarah and 47.89% for Al-Fatiha. Thus, DQM is able to handle duplications and optimize the memory space. The approach can be extended to other non-Roman characters such as to serve information retrieval for non-English text (e.g. Hindi, Chinese, Japanese, etc.) categorized in unicode standards.

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