Introduction to Multimedia Technology (MM301)

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Lempel Ziv Encoding

- It is dictionary-based encoding
- Around 1977, Abraham Lempel and Jacob Ziv developed the Lempe l-Ziv class of adaptive dictionary data compression techniques. Also known as LZ-77 coding then LZ-78

- Lempel–Ziv–Welch (LZW) is a universal lossless data compression algorithm created by Abraham Lempel, Jacob Ziv, an d Terry Welch. It was published by Welch in 1984

- It was the algorithm of the widely used Unix file compression utilit y compress, and is used in the GIF image format.

Lempel Ziv Encoding

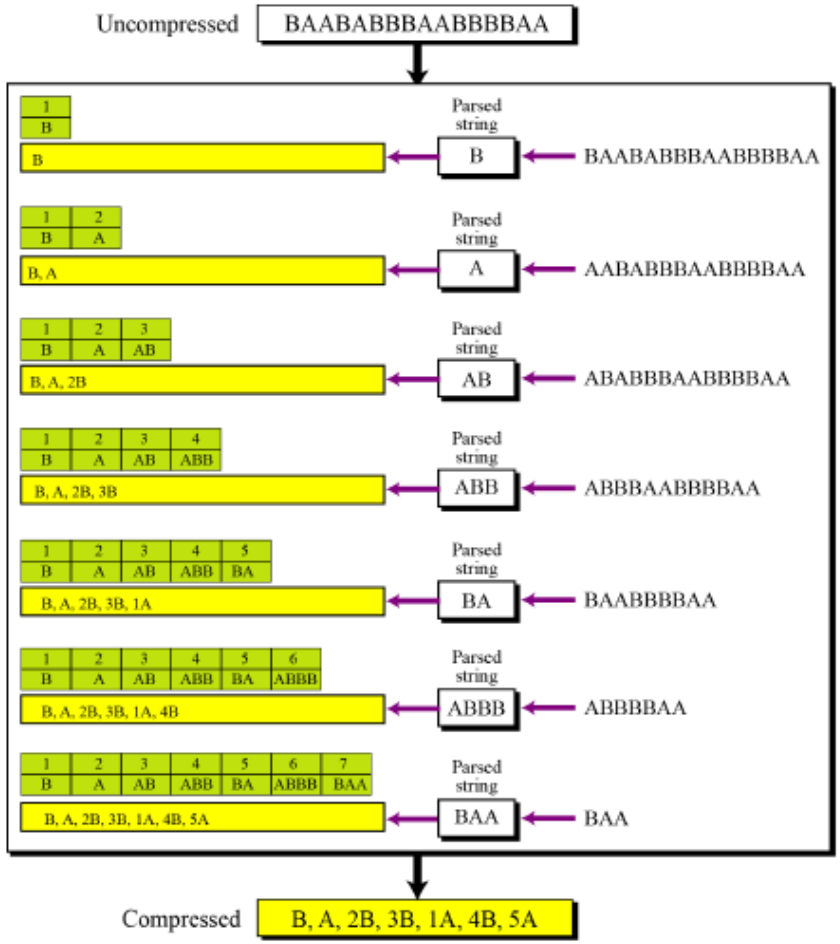
- Basic idea:
  - Create a dictionary(a table) of strings used during communication.
  - If both sender and receiver have a copy of the dictionary, then previously-encountered strings can be substituted by their index in the dictionary.

Lempel Ziv Compression

- Have 2 phases:
  - Building an indexed dictionary
  - Compressing a string of symbols
- Algorithm:
  - Extract the smallest substring that cannot be found in the remai ning uncompressed string.
  - Store that substring in the dictionary as a new entry and assign i t an index value
  - Substring is replaced with the index found in the dictionary
  - Insert the index and the last character of the substring into the compressed string

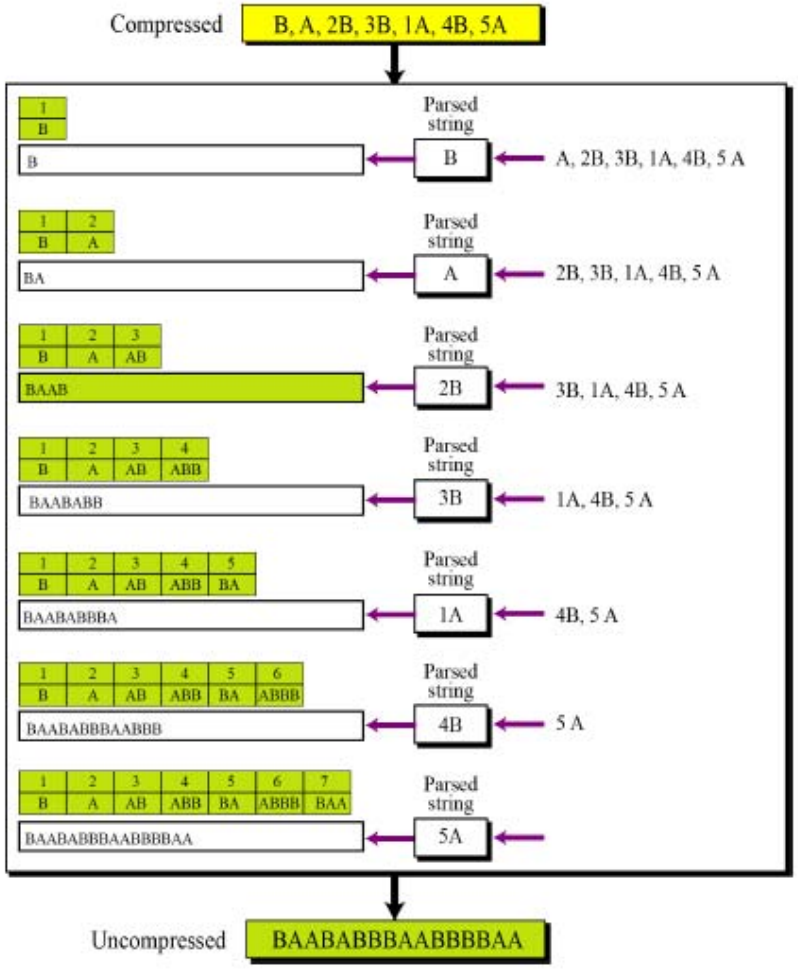
Lempel Ziv Compression

- Compression example:



Lempel Ziv Decompression

- It's just the inverse of compression process



LZW Compression

- As mentioned earlier, static coding schemes require some knowledge about the data before encoding takes place.
- Universal coding schemes, like LZW, do not require advance knowledge and can build such knowledge on-the-fly.
- Example: ASCII codes
  - Codes 0-255 in the code table are always assigned to represent single bytes from the input file.
- As the encoding continues, LZW identifies repeated sequences in the data, and adds them to the code table.
- Decoding is achieved by taking each code from the compressed file, and translating it through the code table to find what character or characters it represents.

LZW Encoding Algorithm

```
1   Initialize table with single character strings
2    Current= first input character
3    WHILE not end of input stream
{
4        Next = next input character
5            IF (C + N is in the dictionary table)
             {
6                 { current = C + N}
7        ELSE
8                {output the code for current
9         add C+N to the dictionary table
10         C = N }
           }
11       END WHILE
}
12   output code for C
```

Example 1: Compression using LZW

Example 1: Use the LZW algorithm to compress the string

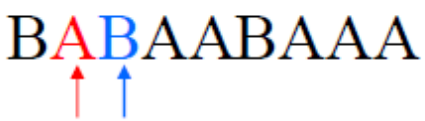
BABAABAAA

Example 1: LZW Compression Step 1

BABAABAAA

Current	Next	Output	Add to dictionary
B 66	A 65	B 66	BA 256

Example 1: LZW Compression Step 2



Current	Next	Output	Add to dictionary
B 66	A 65	B 66	BA 256
A 65	B 66	A 65	AB 257

Example 1: LZW Compression Step 3

BABAABAAA

Current	Next	Output	Add to dictionary
B 66	A 65	B 66	BA 256
A 65	B 66	A 65	AB 257
B 66	A 65	"BA" is in the dictionary! check if "BAA" is	
BA 256	A 65	BA 256	BAA 258

BABAABAAA

Example 1: LZW Compression Step 4

BABAABAAA

Current	Next	Output	Add to dictionary
B 66	A 65	B 66	BA 256
A 65	B 66	A 65	AB 257
B 66	A 65	"BA" is in the dictionary! check if "BAA" is	
BA 256	A 65	BA 256	BAA 258
A 65	B 66	"AB" is in the dictionary! check if "ABA" is	
AB 257	A 65	AB 257	ABA 259

BABAABAAA

Example 1: LZW Compression Step 5

BABAABAAA

Current	Next	Output	Add to dictionary
B 66	A 65	B 66	BA 256
A 65	B 66	A 65	AB 257
B 66	A 65	"BA" is in the dictionary! check if "BAA" is	
BA 256	A 65	BA 256	BAA 258
A 65	B 66	"AB" is in the dictionary! check if "ABA" is	
AB 257	A 65	AB 257	ABA 259
A 65	A 65	A 65	A A 260

Example 1: LZW Compression Step 6

BABAABAAA

Current	Next	Output	Add to dictionary
B 66	A 65	B 66	BA 256
A 65	B 66	A 65	AB 257
B 66	A 65	"BA" is in the dictionary! check if "BAA" is	
BA 256	A 65	BA 256	BAA 258
A 65	B 66	"AB" is in the dictionary! check if "ABA" is	
AB 257	A 65	AB 257	ABA 259
A 65	A 65	A 65	A A 260
A 65	A 65	"AA" is in the dictionary	
A A 260	-	A A 260	-

BABAABAAA

Example 1: LZW Compression (Final result)

Current	Next	Output	Add to dictionary
B 66	A 65	B 66	BA 256
A 65	B 66	A 65	AB 257
BA 256	A 65	BA 256	BAA 258
AB 257	A 65	AB 257	ABA 259
A 65	A 65	A 65	A A 260
A A 260	-	A A 260	-

OUTPUT 66 65 256 257 65 260

LZW Decompression

- The LZW decompressor creates the same dictionary table during decompression.
- The dictionary table is updated for each character in the input stream, except the first one.
- Decoding achieved by reading codes and translating them through the code table being built.

Example 1: LZW Compression (Final result)

- Input size before compression: 9 X 8 = 72 (8 bits every symbol)
- Output size after compression 6 X 9 = 54 (9 bits every symbol)
- Which means the output is 75% of what is used to be

LZW Decompression Algorithm

```
1   Initialize table with single character strings
2   OLD = first input code
3   output translation of OLD
4   WHILE not end of input stream
5      NEW = next input code
6      IF NEW is not in the dictionary table
7            S = translation of OLD
8            S = S + C
9      ELSE
10           S = translation of NEW
11     output S
12     C = first character of S
13     OLD + C to the dictionary table
14     OLD = NEW
15  END WHILE
```

Example 2: LZW Decompression

Example 2: Use LZW to decompress the output sequence of Example 1:

<66><65><256><257><65><260>.

Example 1: LZW Decompression

Encoded String <66><65><256><257><65><260>.

Current	Output	Add to dictionary
66	66	
65	65	66 65 (256)
256	66 65	65 66 (257)
257	65 66	66 65 65 (258)
65	65	65 66 65 (259)
260	65 65	

Decompression <B><A><BA><AB><A><AA>.

LZW: Some Notes

- This algorithm compresses repetitive sequences of data well.

- Advantages of LZW over Huffman:
  - LZW requires no prior information about the input data stream.
  - LZW can compress the input stream in one single pass.
  - Another advantage of LZW its simplicity, allowing fast execution.

Thanks