Efficiency of International Standard Serial Number Code as an Error Correcting Scheme

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To cite this article:
David Muriuki Gikunju, Peter Waweru Kamaku, Augustus Wali Nzomo. Efficiency of International Standard Serial Number Code as an Error Correcting Scheme. Pure and Applied Mathematics Journal. Vol. 10, No. 1, 2021, pp. 1-8. doi: 10.11648/j.pamj.20211001.11

Received: November 6, 2021; Accepted: December 20, 2021; Published: February 28, 2021

Abstract: Error correcting coding is an effective technique of detecting and correcting errors which may occur due to environmental interference or physical defects such as human errors in the communication channels. The International Standard Serial Number code is internationally used for identifying the title of serial publications. This paper analyzes the efficiency of the international standard serial number code as an error correcting scheme. Moreover, the paper explores on the factors which affect the efficiency of any error correcting scheme. The study utilizes weight checksum technique to detect and correct error(s) in a code word. It is clear that ISSN code is not an efficient error coding scheme. ISSN code is only reliable in error detection. ISSN code can detect any error in the code iff the weight checksum equation does not hold. However, the code does not detect silent errors. The study develops a new efficient and robust modified ISSN code that is efficient in error detection and correction capabilities. The code has dual mechanism for error detection and correction in a code word. If the weight checksum equation does not hold and secondly, if the conditions for the generating equation do not hold. Modified ISSN code can detect and correct silent errors in a code word. Modified ISSN code is an efficient error coding scheme for it is efficient in error detection and correction capabilities.

Keywords: ISSN, Modified ISSN, Efficient, Error, Coding, Scheme

1. Introduction

Different communication channels have different error correcting coding schemes depending on the types of errors expected in a particular communication channel. An effective error coding requires an efficient scheme which is selected based on the characteristics of the specific communication channel.

1.1. Factors Affecting the Efficiency of an Error Coding Scheme

1.1.1. Durability of the Entire Error Coding Scheme

Durability of error coding scheme depends on the duration of time the entire coding system can stay before being exhausted. An efficient error coding scheme should last for a long period of time. The dictionary of the coding scheme should be large enough to be used for a longer period in its utilization.

1.1.2. Precision of Code Words in an Error Coding Scheme

The total number of digits in a code word in an efficient coding scheme should not be too large so as to lose its immediate utilization. A good \((n, q)\) error correcting code should have a considerable length \(n\) for fast transmission of messages and large field \(q\) to ensure wide transmission of a variety of information (to ensure big dictionary). The code words of the coding scheme should have little similarities to each other. A good \((n, q)\) error correcting code should have a well define field \(q\) to ensure precision in its usage. The length of all code words should be same.

1.1.3. Reliability in Utilization of the Error Coding Scheme

The primary principle of an error coding scheme is to assist the receiver of a message to get the true information intended
by the sender, therefore, an efficient error coding scheme
should guarantee high probability of accuracy of the messages
received by the receiver. An error coding scheme can only
guarantee a high probability of accuracy of the message if
and only if it can be able to detect and correct error(s) which
may occur. An efficient error coding scheme should, therefore,
detect and correct all errors that may occur from the original
message.

1.2. Efficiency of the ISSN Code in Error Detection and
Correction

1.2.1. Durability of the ISSN Code

The International Standard Serial Number (ISSN) is a code
that is internationally accepted for identifying the title of
serial publications. From ISSN network statistics by January
2019, more than 2.5 million ISSNs had been issued. The
number increases by approximately 60,000 to 70,000 ISSNs
annually. However, about 130,000 ISSN codes are changed
and corrected annually. ISSN is only associated with the title
of the publication. Therefore in case a publication is modified
appropriately, a new ISSN has to be assigned. This means
that if a publication title changes ten times the same publication
has to be assigned ten new ISSN. It is clearly evident that the
number of ISSN codes changed and corrected is about double the
number of ISSN increase per year.

Additionally, the entire ISSN coding scheme has a relatively
small dictionary. The dictionary of 10,000,000 code words
and currently more than 2.5 million ISSNs has been issued
by January 2019. This implies that with about 70,000 code
words issued per year and 130,000 ISSN codes changes and
correction annually, the remaining ISSN code words can last
for maximum of 35 years. With high number of publications
increase, currently ISSN coding scheme is not durable.

1.2.2. Precision of the ISSN Code Words

ISSN code is computed modulo 11, therefore the code is a
finite field. ISSN code being a finite field of order 11, each
element of the code word is supposed to be chosen from the
set \( F_{11} = \{0, 1, 2, ..., 9, 10\} \) but the element 10 has two digits
1 and 0, therefore, not applicable as an element of the code
word. However, in the case when the check digit is 10, an
alphabetic letter is used. An alphabetic letter is used to ensure
that the length of the ISSN codes remains eight. The usage of
the alphabetic letter only in the check digit but not in an
element of the entire code word makes the ISSN code to loss
its brevity and precision. ISSN uses numeric digits except in
check digit where alphabetic digit is used. Therefore, there
is a lot of similarities of the elements from one code word to
another.

1.2.3. Reliability in the Utilization of the ISSN Code Words

From the properties of ISSN code [12], it is clear that the
following deductions hold;

1. ISSN code can detect any error in a code word if and only
if the weight check sum equation does not hold.
2. ISSN code can detect and correct all single error in a code
word if and if the position of the error is known.
3. ISSN can detect and correct all transposition errors in a
code word even if the position of errors is unknown.
4. ISSN can detect and correct all double errors in a code
word if and only if the position of errors is known.
5. ISSN cannot detect and correct silent error(s) in a code
word.
6. ISSN code cannot correct jump transpose error, double
error, jump twin error, phonetic error, twin error, omission,
and insertion error in a code word.

Corollary 1.1. ISSN code is not an efficient error coding
scheme.

Proof. It is clear that ISSN code is neither durable nor
precise error correcting scheme. Moreover, it is clear that ISSN
is not reliable in error correction for it only corrects a single
error and a transposition error in a code word. Therefore, ISSN
code is not efficient in error correction.

2. Modified ISSN Code

The Modified ISSN code is developed and generated by
the use of functions, permutations and the properties of the
existing ISSN code. The code is developed on the basis of
a good communication channel and an efficient error coding
scheme.

2.1. Development and generation of modified ISSN

1. The Modified ISSN code is an alphanumerical code, that
is, it is made of alphabetical digits and numerical digits.
2. The Modified ISSN code is a finite field of order 31
where each digit is chosen from the set \( F_{31} \). The set \( F_{31} \)
is the set \( Z_{31} = \{0, 1, 2, ..., 30\} \) . Each code word of
the modified ISSN code has a length of 8 digits, where
each digit chosen from the set \( F_{31} \). Alphabetical digit
O and I are omitted, for O resembles numerical digit
0 and I resembles 1 hence to avoid confusion. Thus
the set \( F_{31} = \{0, 1, 2, ..., 8, 9, A, B, C, ..., U, V, W\} \)
without alphabetical digits I and O. The main
reason of using alphabetical digits is to replace two
digits numerical digits hence avoiding confusing and
enhancing preciseness.
3. The elements in each code word is generated by
the generating equation defined by \( x_{i+1} = 3x_i + 5 \mod{31}, \ i = 1, 2, ..., 6 \) except the last digit of the
code word. The last digit of code word is the check
digit hence is computed. The first term(digit) of the
generating equation is chosen randomly from the \( F_{31} \approx
Z_{31} \).
4. It is not a must for the generating equation defined by
\( x_{i+1} = 3x_i + 5 \mod{31}, \ i = 1, 2, ..., 6 \) to start at the
beginning of a code word. The sequence generated by
of the generating equation can also be terminated in a
code word. In the case where the sequence is terminated,
digit 0 is inserted after the last digit of the terminated
sequence and before the first digit of the other generating
example. The first term(digit) of the other generating equation is also chosen randomly from the $F_{31} \cong \mathbb{Z}_{31}$.
5. The digit 0 does not have to necessarily be used when a sequence generated by the generating equation has been terminated, it may be used as an element of the code word itself. That is, digit 0 may be generated by the generating equation or may be at the beginning of the generating equation. In this case, digit 0 acts as a neutral digit. This implies that the generated sequence does not necessarily terminate once there is a digit 0.
6. In the case where the generating equation does not start at the beginning of a code word, the first digit of sequence is repeated from the beginning of a code word until where the start digit of the generating equation starts. Moreover, it is not a must for the generating equation to start at the beginning immediately after digit 0 in case the generated sequence had been terminated.

Examples of modified ISSN code;

1 8 V W 2 B 7 N
B B B B B 7 R 0
S M 0 V W 2 B 3

Where

Table 1. Elements of modified ISSN code.

|   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 |
| A | B | C | D | E | F | G | H | I |
| L | M | N | O | P | Q | R | S | T |
| V | W | X | Y | Z |   |   |   |   |

2.2. Number of Code Words in Modified ISSN Code

Proposition 2.1. Modified ISSN code has a dictionary of upper bound of 28, 644, 217.

Proof. The Modified ISSN code is finite field of order 31 where each digit is chosen from the set $F_{31} \cong \mathbb{Z}_{31}$. Each code word of the modified ISSN code has a length of 8 symbols, where each symbol is chosen from the set $F_{31}$. Moreover, the eighth digit of the modified ISSN code is the check digit which is computed on the basis of weight checksum equation. The elements in each code word is generated by the generating equation defined by $x_{i+1} = 3x_i + 5 (mod 31)$ for $i = 1, 2, 3, ..., 6$. It is not a must for the generating formula for the generation of the elements of a code word to start at the begin of the code word. Total numbers of the code words depends on the generating equation and digit 0 for the termination of the generated sequence. Digit 0 for the termination of the generating equation can occur from the second digit of a code word to the seventh digit of a code word. There are 31 ways of choosing the first digit of a code word, two ways of choosing the second digit, that is, through generating equation or repetition if generating equation does not start in the beginning of a code word. From the third digit to the seventh digit there are three ways of choosing each digit. There is only one way of choosing the eighth digit for it is computed to satisfy the weight checksum equation. Moreover, if there is a digit 0 in second digit, there are 31 ways of choosing the third digit, similar to the fourth digit until the seventh digit. Therefore there are $31 \times 2 \times 3^5$ or $31^6$ ways of choosing a code word, hence the dictionary of the modified ISSN code is 15066 + 28, 620, 151 = 28, 644, 217.

2.3. Calculation of the Check Digit in a Modified ISSN Code Word

Let the code word for modified ISSN be $X = x_1, x_2, ..., x_7$ without the check digit. To compute the check digit, $x_8$, since the code word digits $x_1, x_2, ..., x_7$ are known, calculate $\sum_{i=1}^{7} jx_i$. Let $\xi = \sum_{i=1}^{7} jx_i$ then $x_8 + \xi \equiv 0 (mod 31)$. Now since 0 is additive identity of $\mathbb{Z}_n$, therefore $x_8$ is the additive inverse of $\xi (mod 31)$. Thus $x_8 \equiv -\xi (mod 31)$.

Example 2.1. Calculate $x_8$ for the ISSN code word 1 8 V W 2 B 7 $x_8$. To compute $x_8$, calculate $\xi = \sum_{i=1}^{7} jx_i$. In the case where the generating equation does not start after digit 0, the first digit of the new sequence is repeated after digit 0 until where the start digit of generating equation starts.

7. ISSN codes are only associated with the title of a publication, in case changes and corrections are made to the title of a publication, the code word will have an extra digit called a blind digit. A blind digit is separated from the check digit by a hyphen. A blind digit does not affect the weight check sum of the entire code word. It is given depending on the number of changes made in the title of a publication. Importance of the blind digit is to help to know the number of times the changes and corrections have been made to a title of a publication.

8. The eight digits of the modified ISSN code must satisfy $\sum_{i=1}^{8} jx_i \equiv 0 (mod 31)$. 


The code word has to satisfy the checksum weight equation
\[ \sum_{i=1}^{7} jx_i = 443 \equiv 9 \pmod{31}. \]
Hence \( x_8 = 9^{-1} \equiv 22 \pmod{31} \).

3. Error Detection in Modified ISSN Code

Modified ISSN code is an improved error coding scheme in terms of error detection and correction capabilities. Let \( X = x_1, x_2, ..., x_8 \) be the code word for modified ISSN, then the weight checksum is computed
\[ \sum_{i=1}^{8} jx_i \equiv 0 \pmod{31}. \]
If \( \sum_{i=1}^{8} jx_i \equiv 0 \pmod{31} \) then the code has detected error(s). Moreover, let the code word for modified ISSN be \( X = x_1, x_2, ..., x_8 \), then \( x_2 = (3x_1 + 5) \pmod{31}, x_3 = (3x_2 + 5) \pmod{31}, ..., x_7 = (3x_6 + 5) \pmod{31} \). If \( x_i \neq (3x_{i-1} + 5) \pmod{31}, i = 2, 3, ..., 7 \) then the code has detected error(s). An ISSN code word has a length of only eight digits unless there is change of the title of the publication where the code word has nine digits, therefore, if the code has a length of more or less than eight then there is an error.

Remark 3.1. if \( x_i \neq (3x_{i-1} + 5) \pmod{31}, i = 2, 3, ..., 7 \) does not necessarily indicate an error in the code word for there are two occasions where \( x_i \neq (3x_{i-1} + 5) \pmod{31}, i = 2, 3, ..., 7 \) will occur but no error has occurred in the code word:

a. In case there is a digit 0 indicating the termination of the generating equation \( x_{i+1} = 3x_i + 5 \pmod{31}, i = 1, 2, ..., 6 \)

b. In case there is repetition of a digit indicating that the generating equation \( x_{i+1} = 3x_i + 5 \pmod{31}, i = 1, 2, ..., 6 \) has not begun in the beginning of the code word or after digit 0 when there is termination of the generating equation.

The code word has to satisfy the checksum weight equation
\[ \sum_{i=1}^{8} jx_i \equiv 0 \pmod{31}. \]

3.1. Single Error Detection in a Modified ISSN Code Word

Proposition 3.1. The Modified ISSN code detects any single error in the Modified ISSN code word.

Proof. Suppose \( X = x_1, x_2, ..., x_8 \) is the modified ISSN code word and \( Y = x_1, x_2, ..., x_{\tau-1}, y_\tau, x_{\tau+1}, ..., x_8 \) with \( y_\tau = x_\tau + \alpha \equiv 0 \pmod{31} \) is the modified ISSN code word with a single error that has occurred in digit \( x_\tau, 1 \leq \tau \leq 8 \). Then
\[
\left( \sum_{j=9-i}^{8} jy_j \right) + \left( \sum_{j=9-i}^{8} jx_j \right) + (9 - \tau) \alpha \equiv 0 \pmod{31}
\]

Moreover, \( y_\tau \neq (3x_{\tau-1} + 5) \pmod{31} \). Therefore the single error is detected.

Proposition 3.2. The Modified ISSN code detects silent error in a code word.

Proof. Suppose a single error has occurred in a modified ISSN code word but \( \sum_{j=9-i}^{8} jx_j \equiv 0 \pmod{31} \). Then if \( Y = x_1, x_2, ..., x_{\tau-1}, y_\tau, x_{\tau+1}, ..., x_8 \) with \( y_\tau = x_\tau + \alpha \equiv 0 \pmod{31} \) is the modified ISSN code word with a single error that has the position \( x_\tau \) then
\[
\left( \sum_{j=9-i}^{8} jy_j \right) + (9 - \tau) \alpha \equiv 0 \pmod{31}
\]

This implies that either \( 9 - \tau \) or \( \alpha \) is a multiple of 31 or 0. Since \( 9 - \tau \) cannot be a multiple of 31 or 0 for \( 1 \leq \tau \leq 8 \) hence \( \alpha = 0 \) and no error. However, there is a single error in the code word then there exist a digit of the code word \( x_i \neq (3x_{i-1} + 5) \pmod{31} \). Therefore \( x_\tau \neq (3x_{\tau-1} + 5) \pmod{31} \) and hence the silent error detected. Conversely, Suppose a single error has occurred in modified ISSN code but \( x_i = (3x_{i-1} + 5) \pmod{31} \) for \( i = 2, 3, ..., 7 \) then \( \sum_{j=9-i}^{8} jx_j \neq 0 \pmod{31} \) then the silent error is detected.

Proposition 3.3. The Modified ISSN code corrects the single errors in a code word.

Proof. Suppose \( X = x_1, x_2, ..., x_8 \) is the modified ISSN code word and \( Y = x_1, x_2, ..., x_{\tau-1}, y_\tau, x_{\tau+1}, ..., x_8 \) with \( y_\tau = x_\tau + \alpha \equiv 0 \pmod{31} \) is the modified ISSN code word with a single error that has occurred in digit \( y_\tau, 1 \leq \tau \leq 8 \). The most important thing is the code detect the position of the digit with error. From second digit to the second last digit of the code word is generated by the generating equation \( x_{\tau+1} = 3x_\tau + 5 \pmod{31} \) unless there is a repetition of digits or digit 0 indicating termination of the generating equation. By use of the generating equation \( x_{\tau+1} = 3x_\tau + 5 \pmod{31} \) the digit \( y_\tau = x_\tau + \alpha \equiv 0 \pmod{31} \) is the modified ISSN code word with a single error that has occurred in digit \( y_\tau, 1 \leq \tau \leq 8 \). The position of \( y_\tau \) is detected, the error is corrected by the computing \( y_\tau = (3x_{\tau-1} + 5) \pmod{31} \) and \( y_\tau = \left( \frac{x_{\tau-1} + 5}{3} \right) \pmod{31} \). In case \( x_{\tau+1} \leq 5 \) or \( x_{\tau+1} - 5 \) is not divisible by 3 then
\[
3y_\tau \equiv x_{\tau+1} - 5 \pmod{31}
\]
\[3^{-1} y_\tau = 3^{-1} \times ((x_{\tau+1} - 5) \pmod{31})
\]
\( y_\tau = 21 \times ((x_{\tau+1} - 5) \pmod{31}) \)

when \( x_{\tau+1} < 5 \)
\[y_\tau = 21 \times ((31 + (x_{\tau+1} - 5)) \pmod{31}) \]

Then the weight checksum equation
\[ \sum_{i=1}^{8} jx_i \equiv 0 \pmod{31} \]
0 \pmod{31} is tested whether it holds. Additionally, when the error has been detected and the position of the error is known. Then the error can be corrected by

\[
(9 - \tau) y_r \equiv - \left( \sum_{i=1}^{8} \sum_{j=9-i \neq \tau} j x_i \right) \pmod{31}
\]

\[
y_r = (9 - \tau)^{-1} \times \left( \sum_{i=1}^{8} \sum_{j=9-i \neq \tau} j x_i \right) \pmod{31}
\]

Since \( y_r = x_\tau + \alpha, \alpha = 0 \) hence \( y_r = x_\tau \) yielding the original modified ISSN code word \( X = x_1, x_2, ..., x_8 \).

**Example 3.1.** Let \( 1 \ 8 \ V \ W \ 2 \ B \ 7 \ N \) be the modified ISSN code word and \( 1 \ 8 \ V \ W \ C \ B \ 7 \ N \) be the modified ISSN code word with a single error at \( x_8 \). By

\[
\sum_{i=1}^{8} j x_i \neq 0 \pmod{31}
\]

\[
505 \neq 0 \pmod{31}
\]

\[
9 \neq 0 \pmod{31}
\]

therefore the single error is detected. By use of the generating equation \( x_{i+1} = (3x_i + 5) \pmod{31} \) the position of the error is found. The error is at \( x_3 \) for

\[
C = 12 \neq (3W + 5) \pmod{31}
\]

\[
12 = 95 \pmod{31}
\]

the error is corrected by the computing \( y_r = (3x_\tau + 5) \pmod{31} \) and \( y_r = \left( \frac{x_\tau + 5}{3} \right) \pmod{31} \)

\[
x_5 = (3x_4 + 5) \Rightarrow x_5 = (3V + 5) \pmod{31}
\]

\[
x_5 = (90 + 5) \pmod{31}
\]

\[
x_5 = 2 \text{ and}
\]

\[
x_5 = \left( \frac{B - 5}{3} \right) \pmod{31}
\]

\[
x_5 = \left( \frac{11 - 5}{3} \right) \pmod{31}
\]

\[
x_5 = 2
\]

Hence the error is corrected.

**Remark 3.2.** The Modified ISSN is more efficient in single error detection and correction than ISSN code.

### 3.2. Transposition Error Detection and Correction in a Modified ISSN Code Word

**Proposition 3.4.** The Modified ISSN code detects all transposition error in a code word.

**Proof.** Suppose \( X = x_i, i = 1, 2, ..., 8 \) is the modified ISSN code word and \( Y = x_1, x_2, ..., x_\beta, x_\tau, ..., x_8 \) with \( x_\tau \) and \( x_\beta \) be exchanged digits of the modified ISSN code word. Then

\[
(\sum_{i=1}^{8} j y_i) \pmod{31}
\]

\[
(\sum_{i=1}^{8} j x_i) + (\tau - \beta) x_\tau + (\beta - \tau) x_\beta \neq 0 \pmod{31}
\]

\[
(\tau - \beta)(x_\tau - x_\beta) \neq 0 \pmod{31}
\]

provided \( \tau \neq \beta \) and \( x_\tau \neq x_\beta \). Therefore, transposition error of digits \( x_\tau \) and \( x_\beta \) is detected.

**Corollary 3.1.** The Modified ISSN code corrects all transposition errors in the code word.

**Proof.** From the above prove (detection of transpose error) it is clear that

\[
x_1 = (3x_{i-1} + 5) \pmod{31} \quad i = 2, 3, ..., 7
\]

\[
x_\beta = (3x_\tau + 5) \pmod{31}
\]

\[
x_\tau = \left( \frac{x_\beta - 5}{3} \right) \pmod{31}
\]

Thus implying there is a transpose error which can be corrected by exchanging the digits \( x_\tau \) and \( x_\beta \).

**Example 3.2.** Let \( 1 \ 8 \ V \ W \ 2 \ B \ 7 \ N \) be the modified ISSN code word and \( 1 \ 8 \ V \ W \ B \ 2 \ 7 \ N \) be the modified ISSN code word with adjacent transposed error at \( x_5 \) and \( x_6 \). Consider the new modified ISSN code word \( 1 \ 8 \ V \ W \ B \ 2 \ 7 \ N \), the weight checksum equation \( \sum_{i=1}^{8} j x_i \neq 0 \pmod{31} \).

\[
(5 - 6)(11 - 2) = -9 \neq 0 \pmod{31}
\]

Moreover, \( 2 \neq (3 \times 11 + 5) \pmod{31} \) for \( (3 \times 11 + 5) \pmod{31} = 38 \pmod{31} = 7 \) and \( 11 \neq (\frac{5 - 2}{3}) \pmod{31} \) but \( 11 = (2 \times 3 + 5) \pmod{31} \) and \( 2 = (\frac{11 - 5}{3}) \). Hence the transposed error detected. Since the transposed error is detected the code can be corrected by transposing the digits yielding \( 1 \ 8 \ V \ W \ 2 \ B \ 7 \ N \) by which the weight checksum equation holds. Hence the error
corrected.

**Remark 3.3.** The Modified ISSN is more efficient in transpose error detection and correction than ISSN code.

### 3.3. Jump Transposition Error Detection and Correction in Modified ISSN Code

**Proposition 3.5.** The Modified ISSN code detects all jump transposition error in a code word.

**Proof.** Suppose that \( X = x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8 \) is a modified ISSN code word and \( Y = x_1, x_2, x_3, x_4, x_3, x_6, x_7, x_8 \) be modified ISSN code word with jump transposition error. The check sum of \( X \) and \( Y \) are \( 8x_1 + 7x_2 + 6x_3 + 5x_4 + 4x_5 + 3x_6 + 2x_7 + x_8 \) and \( 8x_1 + 7x_2 + 6x_3 + 5x_4 + 4x_3 + 3x_6 + 2x_7 + x_8 \) respectively. Assume that \( X \) and \( Y \) are multiple of 31 that is both are \( \sum_{i=1}^{8} jx_i \equiv 0 \mod(31) \). Consider \( X - Y \).

After cancellation

\[
X - Y = 6x_3 - 6x_5 + 4x_5 - 4x_3
= 2x_3 - 2x_5 = 2(x_3 - x_5).
\]

Since \( x_3 - x_5 \) is \( -30 \leq x_3 - x_5 \leq 30 \). The only multiple of 31 between \(-30 \) and 30 is zero. Therefore \( x_3 - x_5 = 0 \), then \( x_3 = x_5 \) meaning no error has occurred. This is a contradiction. Alternatively, suppose that \( X = x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8 \) is a modified ISSN code word and \( Y = x_1, x_2, x_3, x_4, x_3, x_6, x_7, x_8 \) be the modified ISSN code word with jump transposition error. Consider \( Y = x_1, x_2, x_3, x_4, x_3, x_6, x_7, x_8 \) then the error can be detected by \( x_4 \neq (3x_5 + 5) \mod(31) \) and \( x_4 \neq (\tau x_5) \mod(31) \) but \( x_4 \equiv (3x_5 + 5) \mod(31) \) and \( x_4 \equiv (\tau x_5) \mod(31) \). Hence jump transposition error detected.

**Corollary 3.2.** The Modified ISSN code corrects all jump transposition error in a code word.

**Proof.** It is clear that once the jump transposition error has been detected can be corrected. Suppose that \( X = x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8 \) is a modified ISSN code word and \( Y = x_1, x_2, x_3, x_4, x_3, x_6, x_7, x_8 \) be the modified ISSN code word with jump transposition error. Consider \( Y = x_1, x_2, x_3, x_4, x_3, x_6, x_7, x_8 \) once the error is detected by \( x_4 \neq (3x_5 + 5) \mod(31) \) but \( x_4 = (3x_3 + 3) \mod(31) \). This implies that the error can be corrected by transposing \( x_3 \) and \( x_5 \) and then test whether the weight checksum equation holds and the generating equation \( x_1 = (3x_{i-1} + 5) \mod(31) \) \( i = 2, 3, ..., 7 \) holds.

**Example 3.3.** Let 1 8 V W 2 B 7 N be the modified ISSN code word and 1 8 V W 2 B 7 N be the modified ISSN code word with jump transposed error at \( x_3 \) and \( x_5 \) The error is detected by the fact that \( x_4 \neq (3x_5 + 5) \mod(31) \), and \( x_4 \neq (\tau x_5) \mod(31) \) but \( x_4 = (3x_3 + 5) \mod(31) \) and \( x_4 = (\tau x_5) \mod(31) \) therefore the jump transposition error can be corrected by exchanging \( x_3 \) and \( x_5 \) yielding 1 8 V W 2 B 7 N in which both \( x_i = (3x_{i-1} + 5) \mod(31) \) \( i = 2, 3, ..., 7 \) and \( \sum_{i=1}^{8} jx_i \equiv 0 \mod(31) \) hold.

### 3.4. Double Error Detection and Correction in Modified ISSN Code

**Proposition 3.6.** The Modified ISSN code detects and corrects all double error in the code word.

**Proof.** Suppose \( Y = x_1, i = 1, 2, ..., 8 \) be the modified ISSN code word and \( Y = x_1, x_2, ..., x_{i-1}, x_r, x_\beta, x_{\beta+1}, ..., x_8 \) be the modified ISSN code word with double error in digit \( x_r \) and \( x_\beta \). Without loss of generality \( Y = \sum_{i=1}^{8} jx_i \equiv 0 \mod(31) \) and error detected in the code word \( Y \). Suppose there is no error in the \( Y \) then \( Y = \sum_{i=1}^{8} jx_i \equiv 0 \mod(31) \) and \( x_i = (3x_{i-1} + 5) \mod(31) i = 2, 3, ..., 7 \) but this not the case. Since there is an error in \( Y \), the double error is detected by

\[
x_\beta \neq (3x_r + 5) \mod(31)
\]
\[
x_r \neq (\tau x_\beta - 5) \mod(31)
\]

moreover,

\[
x_r \neq (3x_{r-1} + 5) \mod(31)
\]
\[
x_\beta \neq (\tau x_{\beta+1} - 5) \mod(31)
\]

but the rest \( x_i = (3x_{i-1} + 5) \mod(31) \) holds. Since \( x_{r-1} = (3x_r + 5) \mod(31) \) and \( x_{\beta+1} = (\tau x_\beta - 5) \mod(31) \), the twin error in \( Y \) is corrected by making \( x_r = (3x_{r-1} + 5) \mod(31) \) and \( x_\beta = (\tau x_{\beta+1} - 5) \mod(31) \) then test whether the weight checksum equation holds.

**Example 3.4.** Let 1 8 V W 2 B 7 N be the modified ISSN code word and 1 8 V 5 C B 7 N be the modified ISSN code word with double error at \( x_3 \) and \( x_4 \). Since the weight checksum equation does not hold, the error is detected in the code word. The double error is detected by

\[
C \neq (3x_5 + 5) \mod(31)
\]
\[
5 \neq \left(\frac{C - 5}{3}\right) \mod(31)
\]
\[
5 \neq (3x + 5) \mod(31)
\]

and

\[
C \neq \left(\frac{B - 5}{3}\right) \mod(31)
\]
\[
12 \neq \left(\frac{11 - 5}{3}\right) \mod(31)
\]

Since

\[
V \equiv (3x + 5) \mod(31)
\]
\[
29 \equiv (3x + 5) \mod(31)
\]
and

\[ B = \left(\frac{7 - 5}{3}\right) (mod\ 31) \]
\[ 11 = 3^{-1} \times 2 \ (mod\ 31) \]
\[ 11 = 21 \times 2 \ (mod\ 31) \]
\[ 11 = 42 \ (mod\ 31) \]

then

\[ x_\tau = (3 \times V + 5) \ (mod\ 31) \]
\[ x_\tau = (3 \times 29 + 5) \ (mod\ 31) \]
\[ x_\tau = 30 = W \]

and

\[ x_\beta = \left(\frac{B - 5}{3}\right) (mod\ 31) \]
\[ x_\beta = \left(\frac{11 - 5}{3}\right) (mod\ 31) \]
\[ x_\beta = 2 \]

Therefore the code has detected and corrected double errors in the code word.

4. Efficiency of the Modified ISSN in Error Detection and Correction

**Proposition 4.1.** Modified ISSN code is an efficient error coding scheme.

**Proof.** Without loss of generality, modified ISSN code is efficient in error detection and correction. Moreover, modified ISSN has a blind digit which shows the number of corrections and modification done of the title of publication. ISSN coding scheme is only associated with the title of the publication. Therefore in case a publication is modified appreciably, only the blind digit changes. This means that if a publication is modified ten times the modified ISSN code shows that the title of the publication has being changed ten times. Moreover, modified ISSN code is a finite field where its elements are precisely selected and therefore an efficient coding scheme.

5. Conclusion

The study has shown that ISSN code is not an efficient error coding scheme. ISSN code is only efficient in error detection for it only reliable in error detection. ISSN code can detect any error in the code if the weight checksum equation does not hold. However, the code does not detect silent errors. Modified ISSN code is efficient in error detection and correction capabilities. The code has dual mechanism of detection of errors in a code word. First, if the weight checksum equation does hold and secondly, if the generating equation does not hold. Modified ISSN code can detect and correct silent error in a code word. Modified ISSN code is an efficient error coding scheme for it is efficient in error detection and correction capabilities. Moreover, the code has a relatively big dictionary.

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