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**Economic Commission for Europe****Inland Transport Committee****Working Party on Rail Transport****Group of Experts on Permanent Identification of Railway Rolling Stock****First session**

Geneva, 2–4 September 2020

Item 5 of the provisional agenda

**Development of the Unique Rail Vehicle Identification System****Introduction to the Luhn Algorithm****Submitted by Rail Working Group\*****I. Introduction**

1. The Luhn Algorithm is named after its German creator, the computer science researcher Mr. Hans Peter Luhn. It is a simple check digit formula used very widely to validate ID numbers. Its proven scope of applications is very broad:<sup>1</sup>

- Credit card numbers
  - Including VISA, AMEX, Mastercard, Diners Club, etc.
- US National Provider IDs, issued to healthcare providers
- Canadian + Greek social insurance numbers
- Israeli + South African national ID numbers
- Survey codes appearing on receipts of major restaurant chains
  - Including McDonalds, Taco Bell, etc.

2. The algorithm is in the public domain and is specified in ISO/IEC 7812. Unlike more sophisticated, proprietary security techniques, the Luhn Algorithm's purpose is not to guard against malicious hackers. Instead, the Luhn Algorithm is employed as a simple method to distinguish valid numbers from invalid ones, such as those corrupted by typos.

**II. How does it work?**

3. Take the number 12345674; let us assume it is a valid credit card number. The final digit (4) is a kind of control key (also called check digit) to analyse the integrity of the

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\* This document was scheduled for publication after the standard publication date owing to circumstances beyond the submitter's control.

<sup>1</sup> [www.geeksforgeeks.org/luhn-algorithm/](http://www.geeksforgeeks.org/luhn-algorithm/).

remaining digits. If two of the initial numbers (for example, producing 1324567 instead of 1234567) are scrambled and entered into the Luhn Algorithm, a result other than 4 will be generated, proving the invalidity of the number.

### III. A closer look at the maths behind these validity checks

4. The Luhn Algorithm starts at the end of the number, from the last right digit to the first left digit. One must multiply by 2 all digits of even rank, going from left to right as aforementioned. If the double of a digit is equal or superior to 10, replace it by the sum of its digits. Then find the sum  $s$  of all digits found. The control digit  $c$  is equal to  $c = (10 - (s \bmod 10) \bmod 10)$ . (A friendly reminder: mod refers to the modulo operation. Modulo is the name of the calculus of the remainder in the Euclidean division. The modulo calculator returns the rest of the integer division.)

### IV. Using the formula<sup>2</sup>

5. A concrete example using the formula:
- The number 853X, please find the check digit X.
  - Take the digit 3, double it,  $3 * 2 = 6$ .
  - Take the digit 5, do not multiply by 2.
  - Take the 8, multiply by 2:  $8 * 2 = 16$  and due to it being greater than 10, find the sum of its digits:  $1 + 6 = 7$
  - The sum  $s$  is  $6 + 5 + 7 = 18$ . As  $18 \bmod 10 = 8$ , the final calculation yields
  - $c = (10 - 8 \bmod 10) = (10 - 8) = 2$
  - 2 is the check digit and 8532 is therefore valid according to Luhn

Here is a table to further visualize this example:

8	5	3	0
$8 * 2 = 16$	Stays 5	$3 * 2 = 6$	Stays 0
$1 + 6 = 7$	5	6	0
$s = 7$	+5	+6	+0 = 18
			$c = 10 - ((18 \bmod 10) \bmod 10)$
			$c = 10 - (8 \bmod 10)$
			$c = 10 - 8$
			$c = 2$

### V. Conclusion

6. The Luhn Algorithm is an effective, publicly available means of checking the validity of numbers. It cannot guard against malicious attacks, nor is it used by banks to calculate their Card Validation Codes. Furthermore, the Luhn Algorithm cannot check the validity of dates on cards<sup>3</sup>.

7. The Luhn algorithm will however detect any single-digit error, as well as almost all transpositions of adjacent digits. It does however have some flaws:

<sup>2</sup> [www.dcode.fr/luhn-algorithm](http://www.dcode.fr/luhn-algorithm).

<sup>3</sup> [www.investopedia.com/terms/l/luhn-algorithm.asp](http://www.investopedia.com/terms/l/luhn-algorithm.asp).

(a) It will not detect transposition of the two-digit sequence 09 to 90 (or vice versa); <sup>4</sup>

(b) It will detect most of the possible twin errors (but it will not detect 22 ↔ 55, 33 ↔ 66 or 44 ↔ 77). <sup>5</sup>

8. More complex and secure algorithms (ex. Verhoeff Algorithm) exist but their commercial use is comparatively quite limited; they simply lack the convenience (especially from a computing and management perspective) of the Luhn Algorithm, which as demonstrated above, can be employed with mere pen-and-paper and can offer solutions to all sorts of issuers of important numbers.

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<sup>4</sup> <https://planetcalc.com/2464/>.

<sup>5</sup> Kamaku and Wachira, Twin Error Detection in Luhn's Algorithm (2015).