B. Readability

As humans are best at seeing patterns and deviations from common patterns, a purely positional representation of numerals could be too monotonous and could weaken the recognition of digits in long numbers. To make the digits more distinguishable, different shapes for the digits were developed. After analyzing decimal digits, the following features were considered for making the shapes of numerals and ligatures more distinct:

1. Sharp edges/rounded edges of corners,
2. Straight/curved lines,
3. Rectangular/sloped lines,
4. Prolonged shapes (slight subscript/superscript) of numerals.

For example, the proposed digit for 15 can be written with the following shapes: 'E', 'Ɛ' or '€'. Each of them has the same "topology" (i.e. placement of lines that depict bits), but each has a different graphical shape. In our proposal, rules for shape deviation is also applied positionally in a systematic manner.

Figure 7. Examples of shape deviations for various digits in the proposed base-256 digit set

VII. COMPARISON OF NUMERAL SYSTEMS

Table 1 shows a comparison of the various proposals mentioned in *Section II* according to the qualities defined in *Section III*. In order to keep the comparison brief, we include only two of the Supplemented Digit sets in the comparison — Standard Hexadecimal and MEJD's symbols — because we find none of the other sets to be noticeably better than both of these sets.

TABLE I. COMPARISON OF QUALITIES OF PROPOSED NUMERALS

Symbol Set	MNE	STR	LIG	AMB	DSP	BIN	0	1	TRN	Score
Standard Hexadecimal '0'-'9' 'A'-'F'		✓		✓	✓		✓	✓		**5**
Martin 1968	✓					✓			✓	**3**
Laponte 1969	✓	✓		✓		✓	✓	✓		**6**
MEJD 2009	✓			✓			✓	✓		**4**
Cumings 2009	✓	✓		✓	✓	✓	✓	✓		**7**
Hexy Digits 2011	✓			✓		✓	✓	✓		**5**
Trismarck 2012					✓	✓				**2**
Vītoliņš 2015	✓	✓	✓		✓	✓	✓		✓	**7**
Vītoliņš and Cumings 2017	✓	✓	✓	✓	✓	✓	✓		✓	**8**

Of course, some qualities may be more important than others, and some sets may have qualities in differing degrees. For instance, *Martin 1968* is best for translation to and from binary, because of its strong positional principles. *Laponte 1969* is good for handwriting and unambiguous strokes, but its numerals poorly present bits. No digits except those *Vītoliņš 2015* can be used in joined ligatures to create base-256 digits, either because the digits are "too dense" for larger values (e.g. *Martin 1968*) or they become indistinct because of their shape.

VIII. IMPLEMENTATION OF PROPOSED NUMERALS

Hexadecimal numerals are often used in computing to represent the contents of computer memory. In fact, one tool used frequently by computer programmers is a *hex editor:* a software application that enables its user to view the full contents of a file, byte-by-byte, as a series of hexadecimal symbols, and make precise changes to the file's contents by typing hexadecimal symbols. The digits proposed in this paper have already been implemented in custom-built fonts and integrated into two hex editors:

1. As a plugin for Notepad++ which is a popular text editor
2. As a plugin for Eclipse , which is a popular IDE

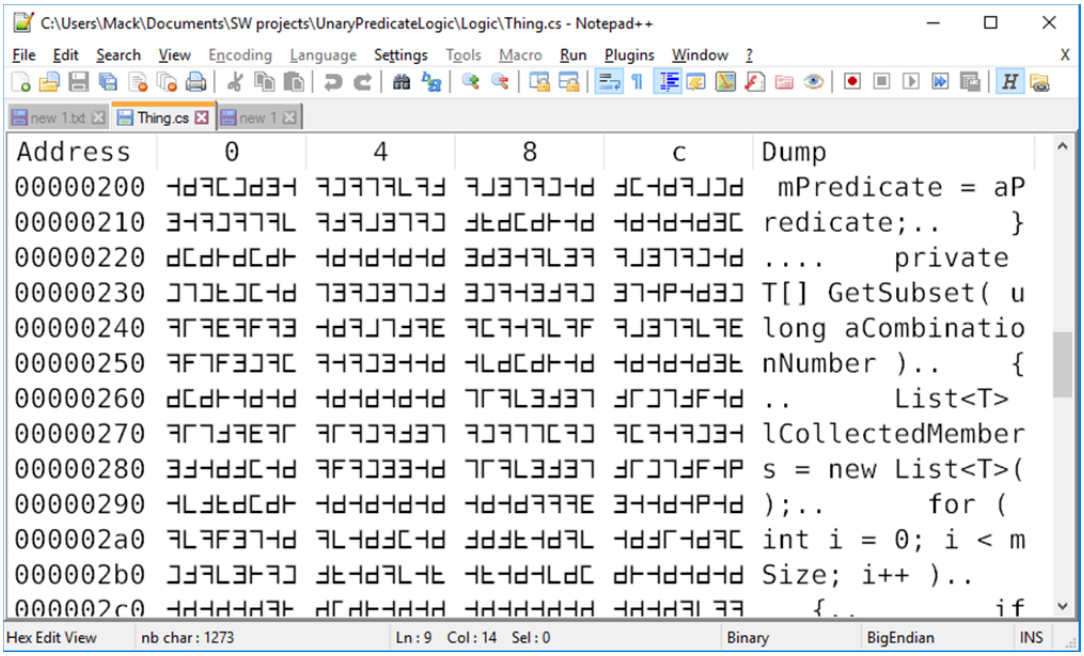

Figure 8. Screenshot of an "Alternative Hexadecimal Editor" with proposed numerals in Notepad++

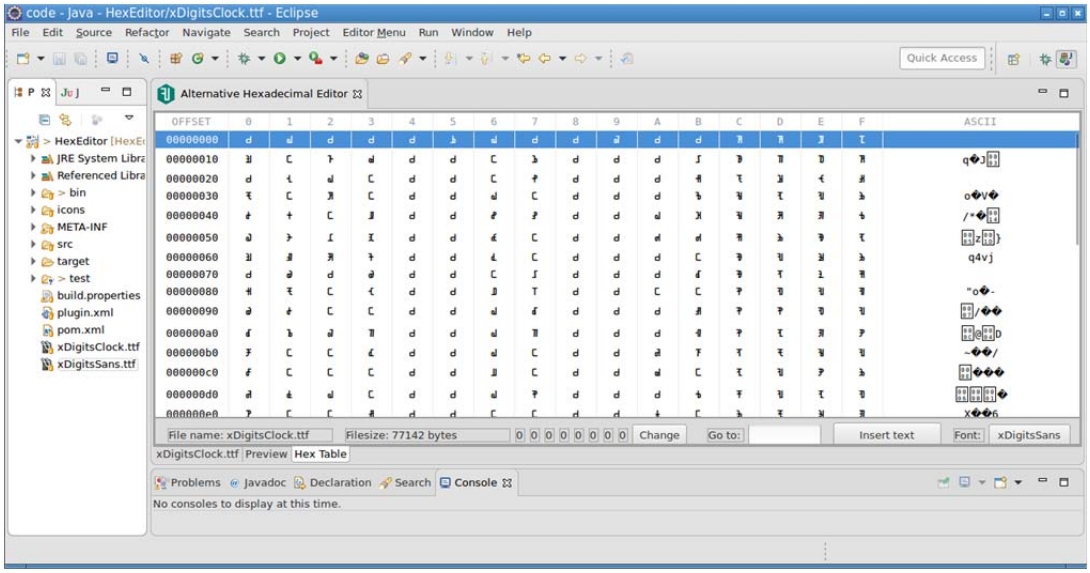

Figure 9. Screenshot of an "Alternative Hexadecimal Editor" with proposed numerals in Eclipse

IX. CONCLUSION AND FUTURE WORK

Our proposed hexadecimal numerals provide a good balance of binary encoding, simplicity, redundancy, readability and writeability. The binary-encoding scheme, with the reasonable exceptions for 0 and 8, allows to the digits to be joined together in "ligatures" and represent the value of an 8-bit byte with a single digit.

Future work is necessary in the area of usability. It should be investigated what the best approach is to make the exact shape of the symbols not only distinct but also ergonomic. This system of numerals should be popularized in computer science studies and applied fields.

Names of proposed numerals could also be binary-encoding, such as what was proposed by Robert Laponte [3]: Ho, Ha, He, Hi, Bo, Ba, Be, Bi, Ko, Ka, Ke, Ki, Do, Da, De, Di. For base-256 digits names are joined in two syllable words such as: Hoha, Hehi, Boba, Bebi, Koka, Keki, Doda, Dedi. It should be investigated which consonant-vowel pairs are the most international and allows adding suffixes for names for languages with inflexions.

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[2] B. A. Martin, "Letters to the editor: On binary notation", Communications of the ACM, Volume 11 Issue 10, Oct. 1968, Page 658.
[3] Brevet d'invention n° 1.569.028, Procédé de codification de l'information, Robert Jean Lapointe, demandé le 28 mars 1968, délivré le 21 avril 1969.