

LIC25_PCOM7E July 2025 B -> Logic Circuit Design: Practical Implementation of Boolean Algebra -> Task A – Boolean Logic in Modern Computing: Applications in Bing Search and CPU Circuits

by Jens Kolby - Thursday, 7 August 2025, 4:13 PM

Boolean Logic Gates: The Foundation of Modern Digital Technology

Boolean Logic, invented by British mathematician George Boole (1815-1864), is a fundamental principle in computer science, enabling modern computing systems to process information through binary decisions represented as true (1) or false (0) (ScienceDirect, 2024, sec. 2.3.1). Its significance extends beyond classical computing technologies. Logic gates are even utilized at the molecular level, where DNA-based logic systems can process information within living cells and can identify signatures for various cancer types (Zadegan et al., 2015). However, Boolean logic has natural limitations. While being deterministic, it ensures predictability and stability, it struggles to model vague or uncertain information. In such cases, fuzzy logic offers a suitable alternative. It allows intermediate truth values between 0 and 1, enabling more nuanced reasoning (Ghahnavieh et al., 2024). The following sections demonstrate how Boolean logic is applied in real-world computing in the Bing search engine and in CPU operations.

How Bing Implements Boolean Logic to Support Search Engine Optimisation (SEO)

According to Microsoft (n.d.), Bing applies Boolean logic using a specific set of syntactic rules. Search terms are combined using AND logic by default; however, users can refine their results with explicit operators, such as OR and NOT, which must be written in uppercase to function correctly. Bing evaluates these operators according to a hierarchy, from highest to lowest precedence:

Operator Precedence in Bing:

1. () – parentheses
2. "" – quotation marks
3. NOT / –
4. AND / &
5. OR / |

CPU Operations and Boolean Logic

CPUs are constructed from logic gates, including AND, OR, and NOT. According to Tanenbaum and Austin (2013, pp. 147-152), transistors are used to build these gates that interpret voltage levels as binary values, enabling CPUs to perform Boolean operations at the circuit level. These operations are essential for executing conditional logic and control flow within modern processors.

Conclusion

Boolean logic is the backbone of digital systems. Despite its limitations in modelling uncertainty, it enables predictable and logical processing in computing systems. In the future, Boolean logic will increasingly be combined with AI and Natural Language Processing (NLP), allowing for more advanced, flexible, and accurate interpretation of user inputs. CPUs will continue to rely on Boolean logic to control flow and execute operations. Quantum computing is a developing field that may enhance, rather than replace, traditional Boolean logic circuits. However, that discussion is beyond the scope of this report.

References

Microsoft (n.d.) Advanced search options. Microsoft Support. Available at: <https://support.microsoft.com/en-us/topic/advanced-search-options-b92e25f1-0085-4271-bdf9-14aaea720930> (Accessed: 7 August 2025).

ScienceDirect (2024) Boolean Logic. Available at: <https://www.sciencedirect.com/topics/computer-science/boolean-logic> (Accessed: 6 August 2025).

Tanenbaum, A.S. and Austin, T. (2013) Structured Computer Organization. 6th edn. Harlow: Pearson, pp. 147–150.

Zadegan, R.M., Jepsen, M.D.E., Hildebrandt, L.L., Birkedal, V. and Kjems, J. (2015) 'Construction of a fuzzy and Boolean logic gates based on DNA', *Small* (Weinheim an der Bergstrasse, Germany), 11(15), pp. 1811–1817. doi:10.1002/smll.201402755.

Ziaei Ghahnavieh, M., Habibi Manesh, E. and Sheikhmoradi, L. (2024) 'Comparative comparison of fuzzy logic and classical logic', *International Journal of Nonlinear Analysis and Applications*, 15(4), pp. 440–451. Available at: https://ijnaa.semnan.ac.ir/article_8836_4cd4db2344517ba2f1fa587bfd1a07d5.pdf (Accessed: 6 August 2025).