MSc Artificial Intelligence – e-Portfolio Artefact

Module: Module 1 – Launch into Computing
Unit: Unit 2 – Logical Foundations of Computing
Activity Type: Discussion Activity

Title: Boolean Logic Applications and Logic Circuit Design

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Introduction

This artefact presents my Unit 2 learning activity on Boolean logic and its practical applications in computing systems. The activity consists of two tasks: analysing real-world applications of Boolean logic and designing a logical circuit with a truth table.

Task 1: Boolean Logic in Real-World Systems

Boolean Logic in Real-World Systems Boolean logic forms the fundamental decision-making framework upon which modern computing systems operate. By representing information through binary states (true/false, 1/0), Boolean algebra enables machines to evaluate conditions and execute structured instructions efficiently. Rather than remaining a purely mathematical abstraction, Boolean logic functions as the operational core of both software systems and hardware architectures (Mano and Ciletti, 2018). Its ability to reduce complexity into binary logic allows large-scale digital systems to perform reliable and scalable computation.

To illustrate its practical significance, this report examines two real-world applications: search engines at the software level and Central Processing Units (CPUs) at the hardware level. These examples demonstrate how Boolean logic operates consistently across different layers of computing systems.

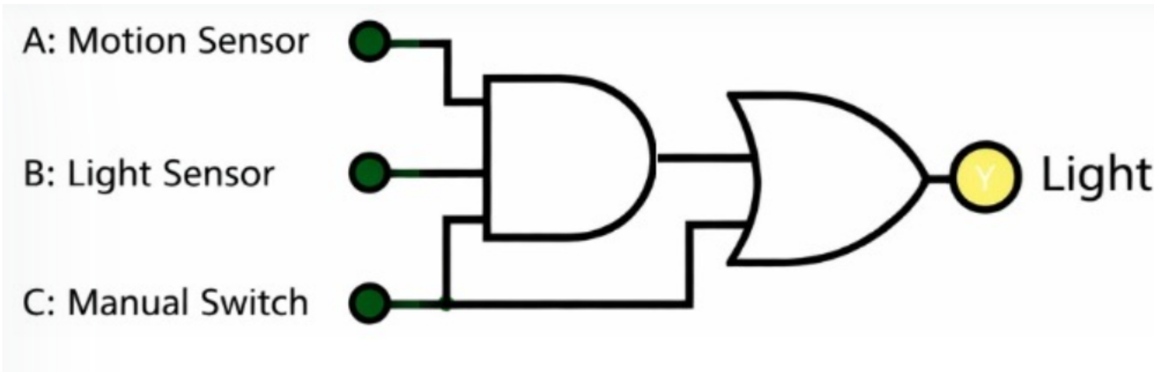
In search engines, Boolean operators such as AND, OR, and NOT structure the way queries are processed. When users input multiple keywords, the system evaluates logical relationships between those terms to determine which indexed documents satisfy the specified criteria. For example, combining keywords using AND narrows result to records containing both terms, while OR broadens the search to include either term. The NOT operator excludes unwanted results. This structured logical evaluation enables efficient retrieval from vast digital repositories and reflects how Boolean expressions underpin large-scale information retrieval systems (Brin and Page, 1998). From a systems perspective, this highlights how abstract logical rules directly shape everyday digital interactions.

At the hardware level, Boolean logic is physically implemented within digital circuits through logic gates constructed from transistors. Gates such as AND, OR, NAND, and NOR combine to form integrated circuits that define the architecture of CPUs. The Arithmetic Logic Unit (ALU) performs calculations and comparisons by coordinating sequences of Boolean operations. Even complex processor instructions ultimately resolve into simple binary decisions. This demonstrates that Boolean algebra is materially embedded within silicon-based technologies that power modern computation (Harris and Harris, 2021).

Reflecting on these applications, it becomes clear that Boolean logic is not confined to theoretical mathematics; it serves as the unifying mechanism linking software functionality and hardware execution. Understanding this relationship reinforces why Boolean logic remains central to the design, efficiency, and reliability of contemporary computing systems.

Task 2: Logic Circuit Design – Smart Room Lighting Control System

Smart Room Lighting Control System



Truth Table:

A- Motion	B- Dark	C- Manual	Y - Light ON
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

This circuit represents a smart room lighting control system. It uses three inputs:

- **A – Motion Sensor**
- **B – Light Sensor (Dark Detection)**
- **C – Manual Switch**

The circuit is designed so that the light turns ON only when certain conditions are met.

First, inputs A (motion detected) and B (dark room) are connected to an AND gate. This means the output of the AND gate becomes 1 only when both motion

is detected, and the room is dark. If either condition is false, the AND output remains 0.

The output of the AND gate is then connected to an OR gate, together with input C (manual switch). The OR gate allows the light to turn ON if either:

- **Motion is detected AND the room is dark,**
  OR
- **The manual switch is pressed.**

This means the manual switch acts as an override. Even if no motion is detected or the room is not dark, pressing the switch will still turn the light ON.

The final output Y (Light) represents the lighting system. The Boolean expression of this circuit is:

$Y=(A \cdot B)+C$

This design demonstrates how Boolean logic enables automated and user-controlled decision-making in smart home systems.

References

Brin, S. and Page, L. (1998) ‘The anatomy of a large-scale hypertextual Web search engine’, *Computer Networks and ISDN Systems*, 30(1–7), pp. 107–117.

Harris, D.M. and Harris, S.L. (2021) *Digital Design and Computer Architecture*. 3rd edn. Burlington: Morgan Kaufmann.

Mano, M.M. and Ciletti, M.D. (2018) *Digital Design*. 6th edn. Harlow: Pearson.