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Word count: 749

This report summaries my experience with raspberry pi focusing on system bus architecture, assembly language and the UNIX file system.

In 1936, the Turing machine was the first abstract model of a computer, using a tape divided into sequential squares containing both data and instructions. Each square is either blank, 0 or, 1. The machine reads the square and then, following a pre-coded instruction set, can either write to square or move the tape left/right. Once all the movements and writing is completed, the machine enters a halt state.

In Von Neumann architecture data and instructions are interspersed within main memory. Whereas in Harvard architecture separate buses are used for data and instructions resulting in efficient pipelining. Most modern computers utilise von Neumann architecture whereas portable computers such as the raspberry pi and Arduino may utilise the Harvard architecture for increased efficiency

Theoretical computing, based on Turing’s work using true and false predicated logic, involves objectively solving problems using logic and mathematics. This is now mechanically implemented using silicon chips. Through photolithography, it is possible to etch a silicon wafer using a photomask and UV light.

Computers generally use the binary (base 2) system. Binary addition, performed using hardware, follows simple binary rules with carry bits (flag). Subtraction is performed by converting one number to its negative value using 2s complement, adding the numbers as above. Multiplication and division is achieved using logical shifts. The overflow and carry flags are monitored to avoid mathematical errors. The ALU, within the CPU, directly performs logical operations such as AND, OR, XOR etc.

The CPU is responsible for repeatedly fetching, decoding and executing instructions. The instruction pointer holds the address for the next instruction to be fetched. This is copied to the memory address register (MAR). The control unit then sends a signal via control bus. The data in memory location is transferred to the memory data register (MDR) and copied to the instruction register. The program counter is incremented. The control unit then decodes the instruction. Finally, the instruction is executed using the ALU, accumulator etc.

The ARM architecture used in the raspberry pi allows for smaller compiled code compared to the x86 used in modern computers. ARM has more registers and a reduced instruction set computer (RISC). Because of RISC, each instruction runs in a single cycle. In ARM arithmetic operations are performed using only the processor and registers e.g. two registers would be required to compute addition or subtraction. The arm architecture is more energy-efficient and results in less heat dispersion. The x86 architecture is intel’s closed sourced complex instruction set computer (CISC), this has fewer registers, direct access to memory locations and a larger variable-length instruction set thus reducing compiler complexity. X86 CPUs are generally larger in size, less power efficient and produce more heat.

The Unix file system, which is a part of the Unix operating system, utilizes graph theory in which trees are used to organize files in a hierarchical order in which files are accessed through one root tree. Devices such as a USB stick or SD card exist within a single file system, this is different to windows which creates a new tree for each additional device. Some files on the UNIX system may contain information such as previous inputs that can be accessed through arrow keys and prediction based on recent lines or console outputs. Unix is also open source thus allowing changes to conceptual features of the file system.

The X86 system bus consists of an address, control and data bus. A bus transfers data/information between components in a computer. The data and control buses are bi-directional while the address bus, responsible for addressing memory is uni-directional

The control bus sends timing specific signals to the CPU allowing it to sync with its own fetch-decode-execute cycle. The raspberry pi is SOC (system on chip) with ARM architecture which is largely based on the Harvard architecture in which the data and instruction are stored separately requiring two separate busses. This results in better pipelining as both can be fetched simultaneously.

This differs from modern computers using von Newman architecture where instructions are routed on a single bus. i.e., one system bus containing, data, address and control bus. The raspberry pi probably has separate buses for instructions, instruction address, data, data address and i/o. The system bus in the pi is likely between the peripheral bridge and the CPU. Where as in X86 its between CPU and RAM.