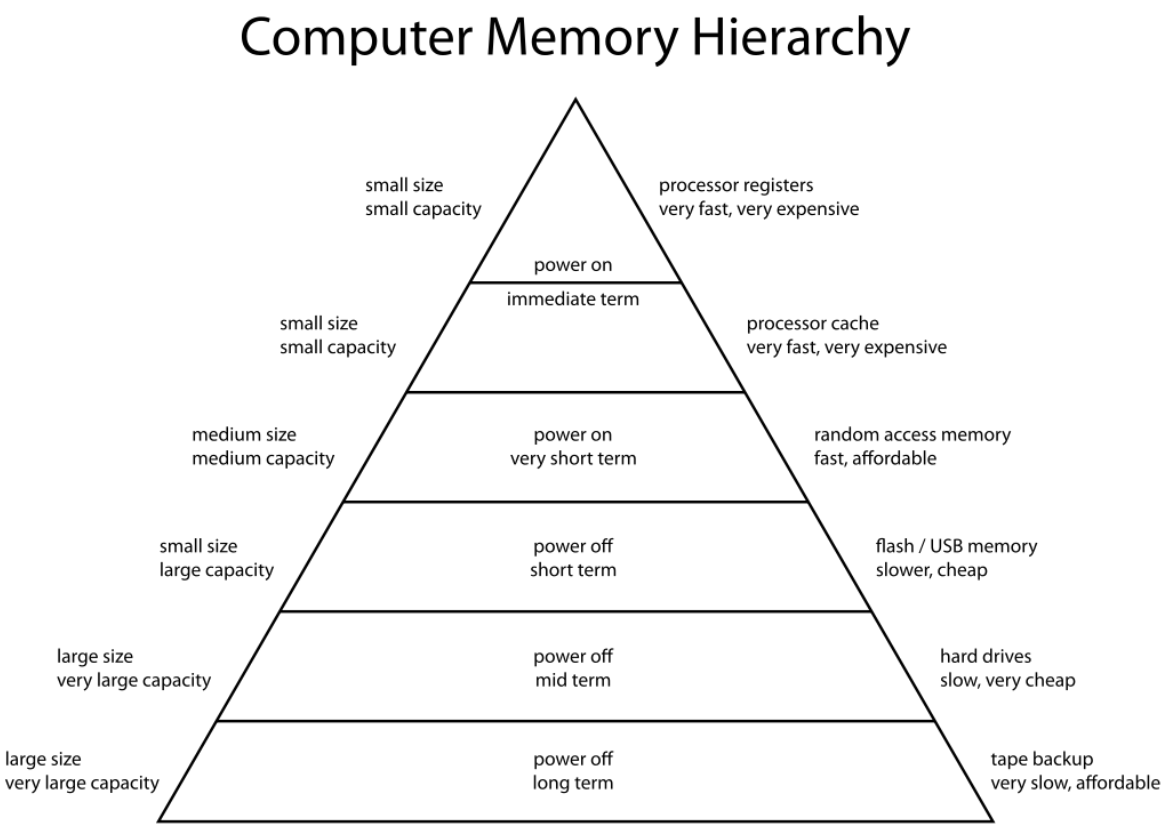
1. More on memory
    a. Characteristics of memory systems
        i. Physical type
            1. Need two well-defined states in the medium to differentiate 0 and 1
            2. Semiconductor – flip-flops, capacitors, so on
            3. Magnetic surface – stored using magnetism (like hard drives)
            4. Optical – CDs, Blu-ray, and the like
        ii. Volatility
            1. Non-volatile – retains information when power is off (hard drives)
            2. Volatile – loses information when power is cut (registers, flip flops, RAM)
        iii. Location – internal (RAM) or external (USB hard drive)
        iv. Capacity – number of bytes, number of words
        v. Units of transfer – larger memory devices tend to have larger units of transfer
        vi. Access methods
            1. Sequential – linear search to pass through intermediate records
                a. O(n) to find a piece of data
                b. Tape drives are sequential
            2. Direct access – reach general vicinity (via tracks), then sequentially to exact sector
                a. O(n/tracks + sectors)
                b. Hard drives do this
            3. Random access – each addressable location has a unique, physically wired-in addressing mechanism
                a. O(1) to access that piece
                b. RAM (hence the name)
            4. Associative – ask for a piece of data, rather than the address
                a. O(1) to ask if memory contains value 1234
                b. Memory looks at everything in parallel to determine address
                c. Content Addressable Memory (CAM)
        vii. Performance
            1. Access time – time it takes to do a read or write
            2. Cycle time – in RAM, access time + extra time to reset circuit/memory
                a. Must get ready again to access another value
            3. Transfer rate – rate at which data can be transferred in and out of memory
        viii. Erasability
            1. Some memories are non-erasable, hence the term read-only memory (ROM)
            2. Otherwise, most memories we encounter are erasable

2. Memory hierarchy
    a. Shows trade-offs between quantity, speed, and cost
    b. Image below taken from Wikipedia



    c. Forms a pyramid
        i. At the top, costliest and smallest memories like registers and cache
            1. However, they are extremely quick to access
        ii. At the bottom, cheapest and largest memories like hard drives and tape
            1. Extremely slow to access, especially tape
    d. Key to success of the hierarchy
        i. As we move down the pyramid, we want to access the lower things less
        ii. Dependent on the idea of *locality*
    e. Locality types
        i. Temporal locality – if we accessed something previously, we're probably going to access it again soon
            1. Imagine an array
            2. We're probably going to go through it multiple times
        ii. Spatial locality – if we access something, odds are we're going to access something near it
            1. Imagine an array again
            2. If we touch the first element, we're probably going to access the second and third ones as well
    f. Locality is the key behind why caches work so well