| | |
|---|---|
| Size of facility (critical load watts) | 8,000,000 |
| Average power usage (%) | 80% |
| Power usage effectiveness | 1.45 |
| Cost of power ($/kWh) | $0.07 |
| % Power and cooling infrastructure (% of total facility cost) | 82% |
| **CAPEX for facility (not including IT equipment)** | **$88,000,000** |
| Number of servers | 45,978 |
| Cost/server | $1450 |
| **CAPEX for servers** | **$66,700,000** |
| Number of rack switches | 1150 |
| Cost/rack switch | $4800 |
| Number of array switches | 22 |
| Cost/array switch | $300,000 |
| Number of layer 3 switches | 2 |
| Cost/layer 3 switch | $500,000 |
| Number of border routers | 2 |
| Cost/border router | $144,800 |
| **CAPEX for networking gear** | **$12,810,000** |
| **Total CAPEX for WSC** | **$167,510,000** |
| Server amortization time | 3 years |
| Networking amortization time | 4 years |
| Facilities amortization time | 10 years |
| Annual cost of money | 5% |

*Reference for case study data*

**1.)**

[A]

20% more expensive than the original cost of $1450 per server, which would be $1740 per server. The number of faster servers needed for the same utilization is 45978/1.1 = 41799

$$Cost\ of\ faster\ servers = number\ of\ servers \times cost\ per\ server\ for\ faster\ servers$$
$$= 41799 \times \$1740 = \$72,730,260$$

$$New\ WSC\ CAPEX = 88000000 + 72730260 + 12810000 = \$173,540,260$$

[B]

Assuming the servers use 15% more power, and the baseline use is 165 W, new server use is 165*1.15 = 190 W. Network load is 377,795 W.

$$Critical\ Load = Number\ of\ Servers \times Watts\ per\ Server + Network\ Load$$
$$= 41799 \times 190\,W + 377795 = 7941810 + 377795$$
$$= 8,319,605\,W$$
$$OPEX = \$493,153$$

**2.)**

[A]

$$100\% \times 45978\ servers \times 100\%\ power = 75\% \times N\ servers \times 60\%\ power$$
$$45978 = 0.75 \times N \times 0.6$$
$$N = 45978/(0.75 \times 0.6) \approx 102,172\ servers$$

∴The server operator would need approximately 102,172 servers running at medium performance to achieve the same level of performance as all servers running at full performance.

**3.)**

[A]

Dataset = 300 Gb    Network bandwidth = 1 Gb/s

Map rate = 10 s/Gb    Reduce rate = 20 s/Gb

Disk bandwidth = 200 Mb/s; 300 Gb * 0.2 Gb = 60 Gb

30% of data read from remote nodes

60 Gb * 0.3 = 18 Gb read remotely; 42 Gb read from disk

$$Local\ Data\ Access\ Time = \frac{42\ Gb}{200\ Mb/s} = 210\ s$$

60 Gb * 20 s/Gb = 1200 s to reduce

$Expected\ Execution\ Time = ((180 + 210) \times 2 + 600 + 1200) = 2508\ s$

<u>1000 Nodes:</u>

300 Gb/1000 = 300 Mb per node

300 Mb * 0.3 = 90 Mb read remotely; 210 Mb read locally

$Network = \frac{90\ Mb}{100\ Mb/s} = 0.9\ s$    $Disk = \frac{210\ Mb}{200\ Mb/s} = 1.05\ s$

$Map\ Time = \frac{300\ Mb}{10\ s/Mb} = 3\ s$    $Reduce\ Time = \frac{300\ Mb}{20\ s/Mb} = 6\ s$

Main bottleneck is the reduce step, and data transfer is the other.

∴Communication occurs locally in a rack; bottlenecks are the same for every node size.