Anatomy of a Data Center

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Commodity CPU:
Xeon E5-2440: 6/12 cores
Xeon Gold 6148: 20/40 cores

Server:
Multiple sockets,
RAM, disks

Rack:
16-64 servers +
top-of-rack switch

Cluster:
Multiple racks + cluster switch

Data Center:
>100,000 servers

[Google Data Center, Eemshaven, Netherlands]

Fault Tolerance

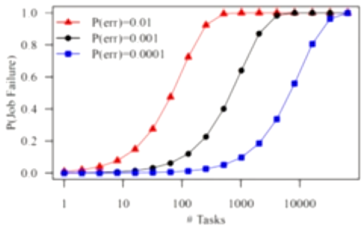
- **Yearly Data Center Failures**
  - ~0.5 overheating (power down most machines in <5 mins, ~1-2 days)
  - ~1 PDU failure (~500-1000 machines suddenly disappear, ~6 hrs)
  - ~1 rack-move (plenty of warning, ~500-1000 machines powered down, ~6 hrs)
  - ~1 network rewiring (rolling ~5% of machines down over 2-day span)
  - ~20 rack failures (40-80 machines instantly disappear, 1-6 hrs)
  - ~5 racks go wonky (40-80 machines see 50% packet loss)
  - ~8 network maintenances (~30-minute random connectivity losses)
  - ~12 router reloads (takes out DNS and external vIPs for a couple minutes)
  - ~3 router failures (immediately pull traffic for an hour)
  - ~dozens of minor 30-second blips for dns
  - ~1000 individual machine failures (2-4% failure rate, at least twice)
  - ~thousands of hard drive failures (1-5% of all disks will die)

Other Common Issues

- **Configuration issues**, partial SW updates
- **Transient errors:** no space left on device,

Recap: Error Rates at Scale

- Cost-effective commodity hardware
- Error rate increases with increasing scale
- Fault Tolerance for distributed/cloud storage and data analysis



Cost-effective Fault Tolerance

- BASE (basically available, soft state, eventua
- Effective techniques
  - ECC (error correction codes), CRC (cyclic
  - **Resilient storage:** replication/erasure co
  - **Resilient compute:** task re-execution / s

Cost-effective Fault Tolerance