Technical Challenges of Cloud Computing

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Beyond the Genome
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Data Challenges

- HiSeq 2000: ~ 200 Gbp / 8 day run
  - ~200GB compressed (gzip) : ~303KB/s
    - Total Volume: Sequences, QV, Read Ids

~42 DVDs / run

- 200 GB Transfer Time [75% efficiency]:
  - Cable/Fios: 10 Mbit/s [.94 MB/s] = 61 hrs
  - CSHL: 100 Mbit/s [9.4 MB/s] = 6 hrs
  - USB 2.0: 480 Mbit/s [45 MB/s] = 76 min
  - LAN: 1 Gbit/s [96 MB/s] = 36 min

- Crossbow:
  - 106 GB, 1007 fq.gz files
    - Many small files, easier to parallelize/recover/verify
  - EBI – Amazon (US East) in 75min [~24MB/s]
    - Parallel transfer:
      - 40 simultaneous FTPs
      - Very late at night
      - Saturated- no benefit using more

Data Solutions

- Reduce volume to transfer
  - Compressed fastq files or binary encoding
  - Short read ids
  - Semantic reductions:
    - Don't send/store uninformative sequences?
    - Store compressed de Bruijn Graph?

5:1
compression

- Make best use of existing connections
  - Parallel FTP, TCP Window Size, Aspera
  - Wanted: S3/Hadoop transfer with recovery & MD5

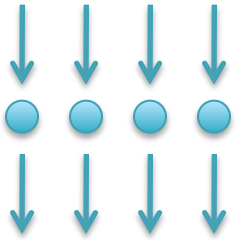
- Establish new connections
  - Upgrade to Gigabit+ Internet
    - > $100k / year
  - Sneakernet solutions
    - Reduced fee for AWS Import/Export
  - Ship DNA to sequencing centers colocated with cloud
    - Complete Genomics, BGI

NYC – LA
@ 37 Tbit/s

Cloud Programming Models

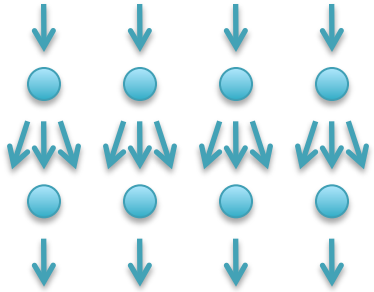
Batch computing: Condor, Grid Engine, Amazon SQS

- Programming Model: Relatively easy, but restricted
- Challenges: Scheduling, Load Balancing, Fault Tolerance
- Resources: Sufficient local memory & cores, fast file system



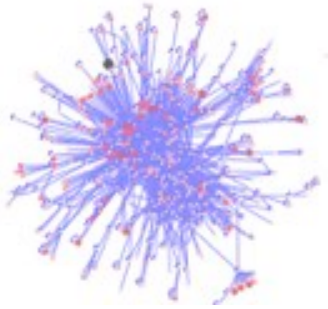
Loosely coupled: Hadoop, Dryad, Amazon EMR

- Programming Model: More complicated, more expressive
- Challenges: Parallel Communication
- Resources: 4+ cores, 1 TB / core disk, 4 GB / core RAM
  - Cloudera Recommendations: http://bit.ly/bj2lec



Tightly coupled: MPI, Pregel, Hadoop

- Programming Model: Most complicated, most expressive
- Challenges: Parallel Algorithms
- Resources: High Bandwidth, low latency interconnects
  - Amazon Cloud Compute Instance Type



Cloud Programming Challenges

- Distributed computing challenges
  - Foreign/restricted programming model
  - Distributed debugging
  - Input/output formats, compressed formats
  - Distributing files to hundreds of nodes
- Parallel Algorithms Challenges
  - Amdahl's Law & Load Balance
    - Speedup is never as good as you want
  - Graph searching is notoriously difficult & slow
    - Emerging models (Pregel) look promising
- Shared environment dumping the queue
  - Schedule job on "broken" machine
    - (<1GB disk free, no free RAM, etc)
    - Job crashes right away -> No jobs running -> repeat
  - Virtualization protects users from each other

Institutionalization

- Usability & Support
  - Documentation and Predictability
  - User Handholding
- Policy
  - Privacy, Security
  - IRB/HIPPA for patient/sensitive data
- Accountability
  - Who is on the line for making it all work?
  - Maintaining continuity is hard