NIMBIX Informatics Xcelerated

The Effects of Clouds & Accelerators on the HPC Production Process

Presentation for Society of High Performance Computing Professionals

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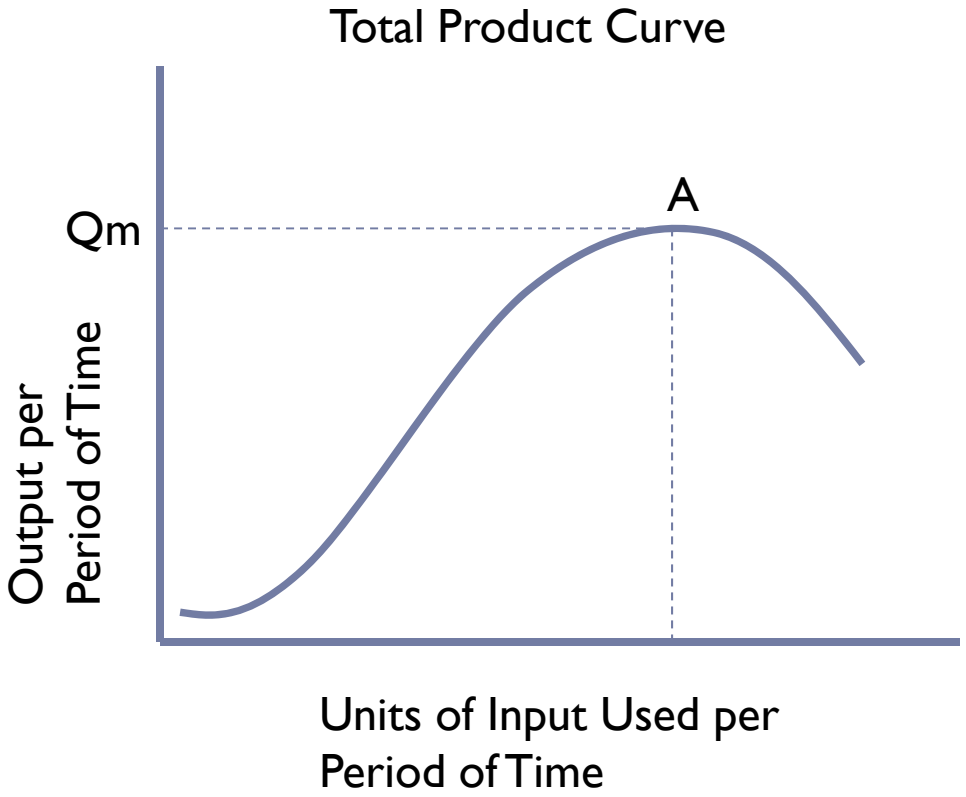
Topic Outline

- Definition Production Process
- Production Inputs in HPC Datacenters
- Accelerators
- Cloud
- Barriers to Adoption
- Conclusion

Production

- The economic process of converting inputs to outputs
- Production uses resources to produce goods for exchange
- Measured as the rate of output per period of time

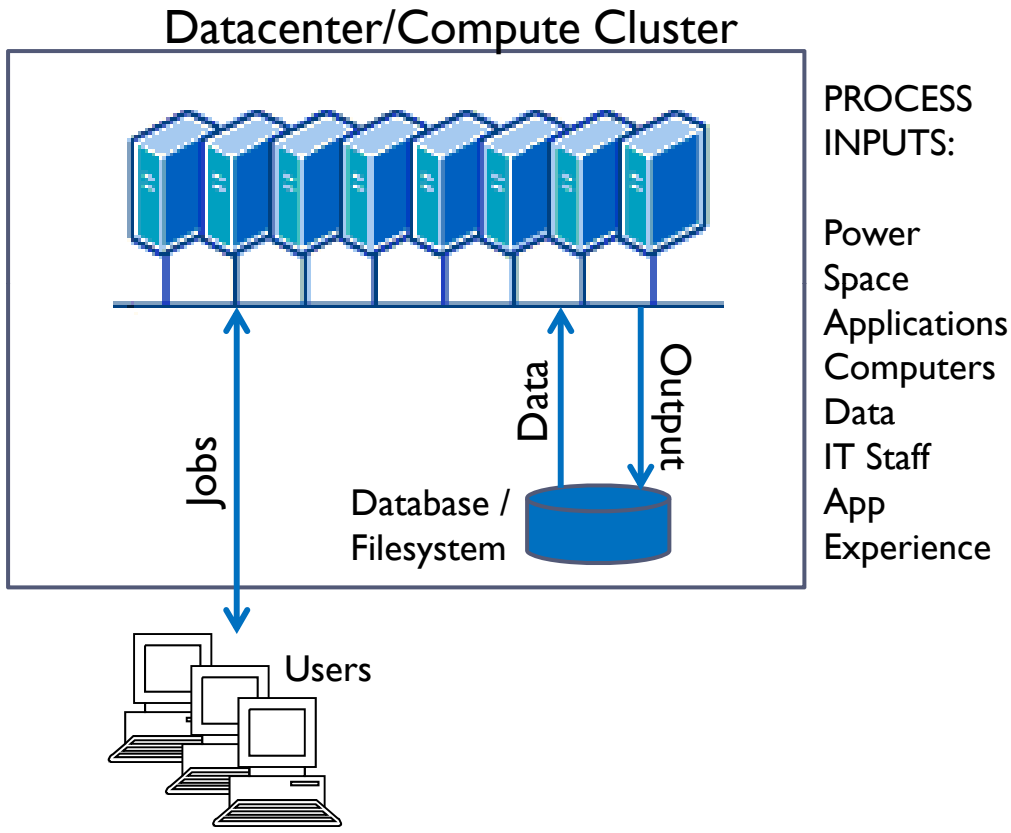


Factors of Production

- Resources used in the production process
  - In economics: Land, Labor, Capital Stock, Human Capital
- Fixed Factors of Production – Factors that are not easily changed over the short run
- Variable Factors of Production – Factors whose usage rate can be changed easily
  - Over the long run, all factors can be changed

The HPC Production Process

- Methods of combining inputs: Technology
- What are process goals? Reduce Costs? Increase productivity? Increase throughput?
- Assumption – In HPC implementations, many factors are fixed over the short run

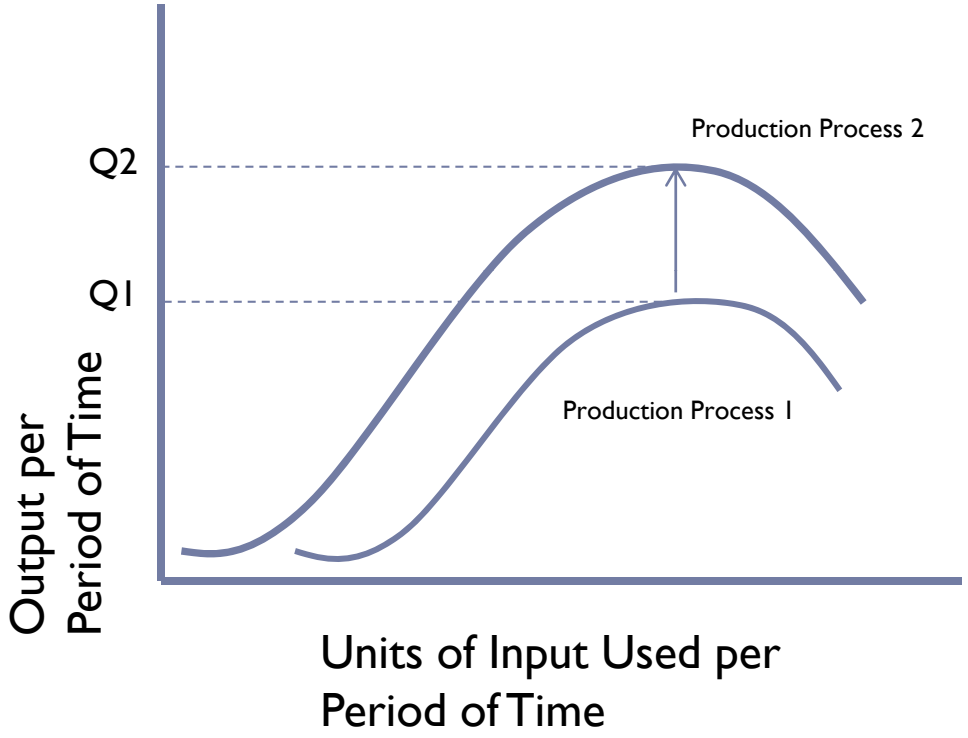


HPC Production Process Inputs

- Applications (Machinery)
  - Technology Costs: Internal Development / Licensed
- Computer Systems (Machinery)
- Data (Raw Material)
  - Workload Inputs
- Datacenter space (Land)
- HPC/Application Expertise (Human Capital)
- IT Staff (Labor)
- Power (Raw Material)

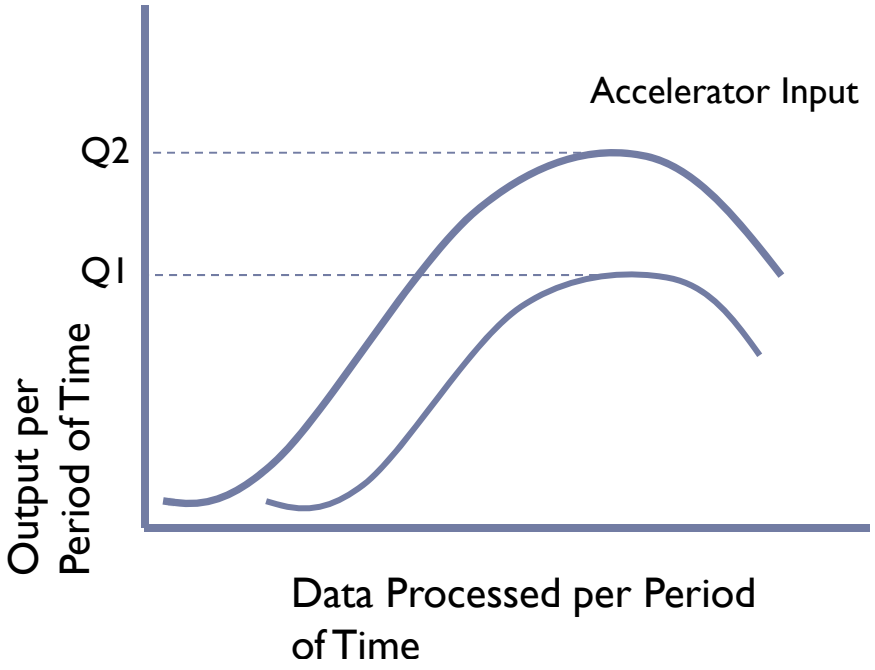
The Challenge of Increasing Production Output

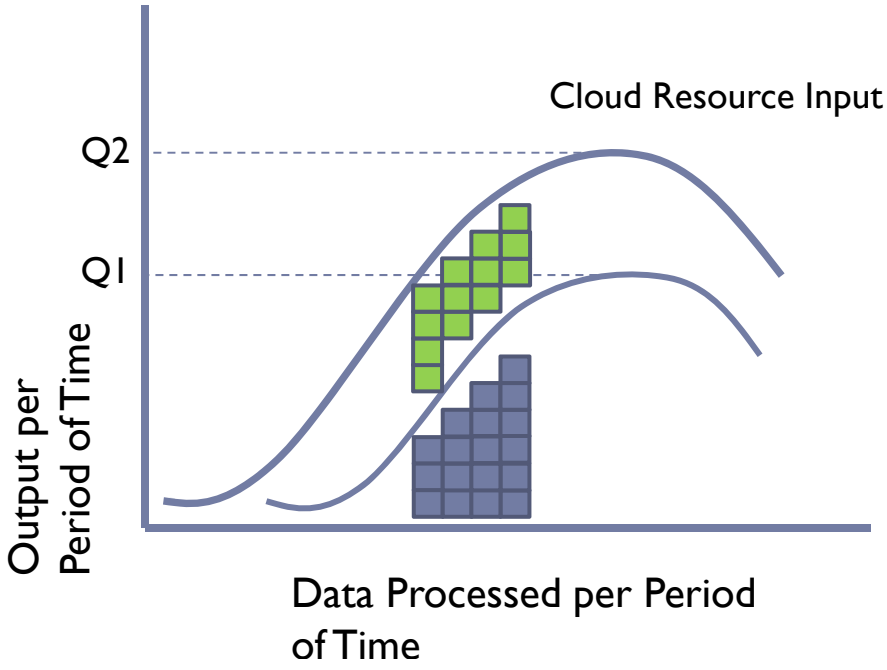
- Scale-out requires investment in:
  - Datacenter/Colo Space
  - Capital Equipment
  - Power/Cooling
- Deployment of new technologies
  - New Algorithms
  - Application Investment
  - Network Infrastructure
  - Computer Architecture



Accelerators & Cloud Resources as Inputs

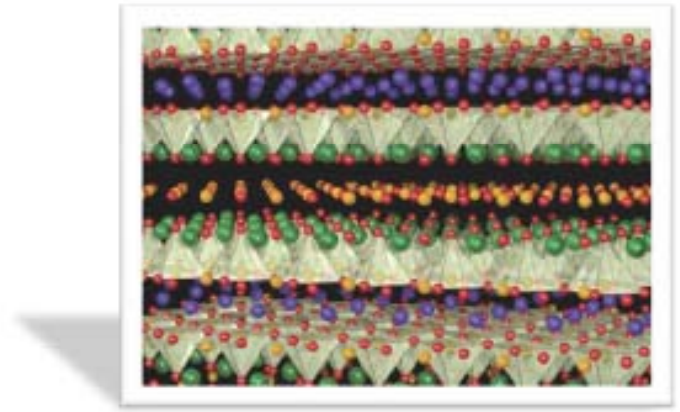
- Assumptions:
  - Accelerated platforms reduce runtimes
  - Bandwidth sufficient for data transport to cloud resources
- Additional Input Cost Considerations
  - Lower energy requirements & less physical space

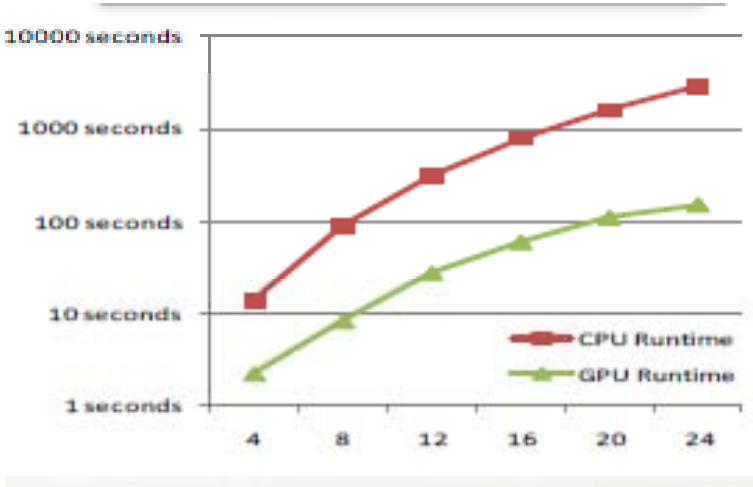




Accelerator Technology Decreases Runtimes

- Quantum Monte Carlo simulation
  - High-temperature superconductivity and other materials science
  - 2008 Gordon Bell Prize
- GPU acceleration speedup of 19x in main QMC Update routine
  - Single precision for CPU and GPU
  - Required detailed accuracy study and mixed precision port of app
- Full parallel app is 5x faster, start to finish on a GPU-enabled cluster on Tesla T10

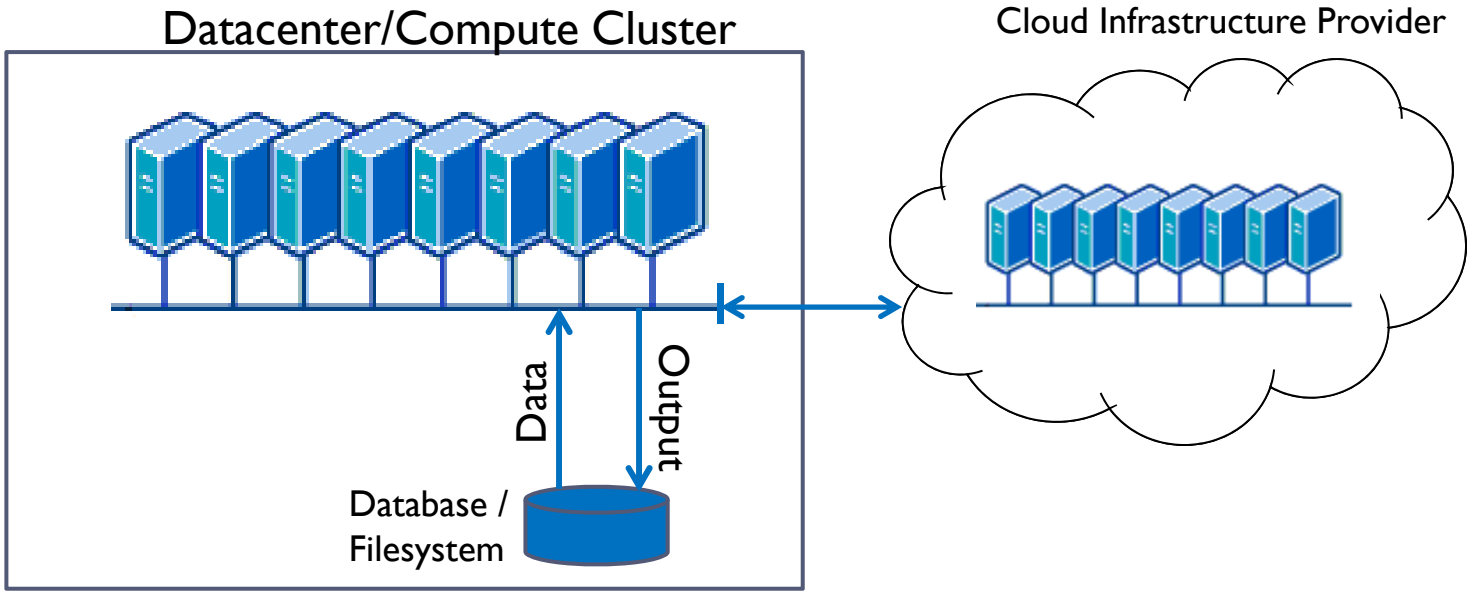




GPU study: J.S. Meredith, G. Alvarez, T.A. Maier, T.C. Schulthess, J.S. Vetter, "Accuracy and Performance of Graphics Processors: A Quantum Monte Carlo Application Case Study", *Parallel Comput., 35(3):151-63, 2009.*
Accuracy study: G. Alvarez, M.S. Summers, D.E. Maxwell, M. Eisenbach, J.S. Meredith, J. M. Larkin, J. Levesque, T. A. Maier, P.R.C. Kent, E.F. D'Azevedo, T.C. Schulthess, "New algorithm to enable 400+ TFlop/s sustained performance in simulations of disorder effects in high-Tc superconductors", SuperComputing, 2008. [*Gordon Bell Prize winner*]

Cloud Technology Impacts Short-Run Fixed Factors

- Scenario: Requirement for workload volume exceeds maximum compute capacity
  - Datacenter and computer infrastructure a "fixed input" in the short run
- External cloud resources become option for extending compute capacity



Barriers to Adoption

- Availability of accelerated application source code
  - Requires additional investment in code development or application acquisition
- Capital for accelerator hardware
  - Assessing technology risk / cost
- Data transport costs & bandwidth constraints in/out of datacenter
- Data security
- Workload management / scheduling
  - Difficult for both heterogeneous HW and cloud implementations

Overcoming Barriers

- Cloud / on-demand business models may enable experimentation with processes
  - Lower the risk to evaluate state of the art hardware
  - Help develop appropriate security measures
  - Smooth out infrastructure investment
  - Benchmark alternative technologies
- New tools for heterogeneous computing rapidly evolving
- Creative carrier solutions may overcome bandwidth constraints?

Evaluating Process Inputs

- HPC Production Process: Quantum Monte Carlo Simulation, QMC Update Routine

	CPU / Single Machine	CPU+GPU / Single Machine	Internal + External Cloud
Qmax (results/ hour)	1	19	Q_{USER}
Equipment	a_1	a_2	0
Depreciation	b_1	b_2	0
Power/Cooling/Rent	c_1	c_2	0
Other Variable Rate	0	0	d_3
Cost / Result	r_1	r_2	r_3

- Build functions to evaluate process solutions or combinations of inputs

Conclusion & Summary

- Applying economic principles provides insights on evaluating HPC processing options
- Each HPC production process is unique
  - Business needs should drive definition of process
- Accelerators & cloud resources most certainly impact a production process
- Technology adoption rates will vary based on barriers and how organizations choose to address them