Emerging Trends in the Economics of Cloud Computing

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My background

• Large-scale HPC and Grid computing

• Open source private clouds

• NSF federated cloud infrastructure => Aristotle

• Sustainability, cloud computing, and IoT

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Four New Functionalities

- Functions as a Service (FaaS)
- Container orchestration
- AI and Machine Learning
- IoT
Cloud Service Catalogs are Expanding

- **AWS**: ~ 150 (added 25 in the last 6 months)
- **Azure**: ~ 220
- **GCP**: ~ 50

**Caveats (and there are a lot)**
- *Unscientific* (I counted from the product pages)
- Some services have many subservices (e.g. EC2)
  - Philosophical difference about what is a service

- If each service has an API, then to use “all” of the “Big 3” cloud requires on the order of 400 different APIs
  - Probably a wildly conservative estimate
  - Doesn’t count Oracle or IBM
  - Lots of redundancy, little compatibility
Emerging Trend #1

- The cloud is becoming more heterogeneous to use as a unifying paradigm.
  - Service proliferation + lack of API and semantic interoperability
Service Specialization

• In the beginning...Google App Engine, S3, and EC2
  – Infrastructure access to hosted applications
• Since then...moving up the stack
• For Example: Machine Learning and AI
• Frameworks
  – Azure Machine Learning Studio
  – Google Machine Learning Engine
  – AWS ML
• Specific ML/AI problems
  – Text-to-speech, speech-to-text, image recognition, video tagging, chatbots, sentiment analysis
Emerging Trend #2

- Service specialization is moving the cloud ecosystem away from general-purpose hosting and toward SaaS
Cloud Success is Slow
Really Slow
But trending upward nicely
Open Source is not slow
Sometimes really not slow
But not always lasting
Emerging Trend #3

• Open source is the gateway drug for cloud services
  – Open source is a “hits business”
  – Cloud is “sticky” and constantly trending upward
Predictions for the Future

• The public clouds will cannibalize other cloud-based businesses
  – Proliferation of SaaS, the ability to integrate within a cloud, lack of interoperability between clouds

• Cloud providers will become the primary curators of open source
  – Generate hits and then offer “servicized” versions in the cloud
  – The more complicated the technology, the better
  – Google will do this first and Amazon will do this last

• Next disruption: free IoT
  – First to come up with the “Google search box” for IoT will lead the generation of the next set of emerging trends