

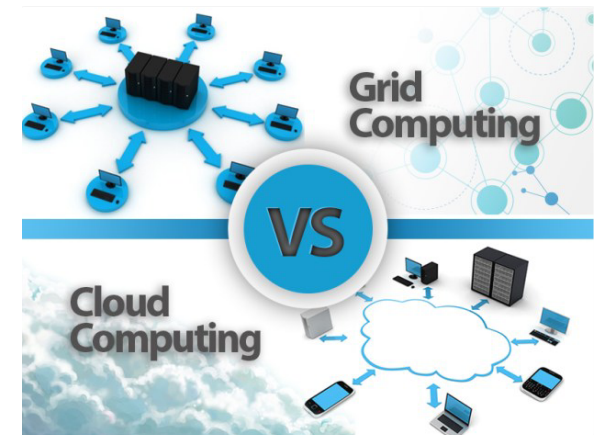
# Emerging Trends in the Economics of Cloud Computing



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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

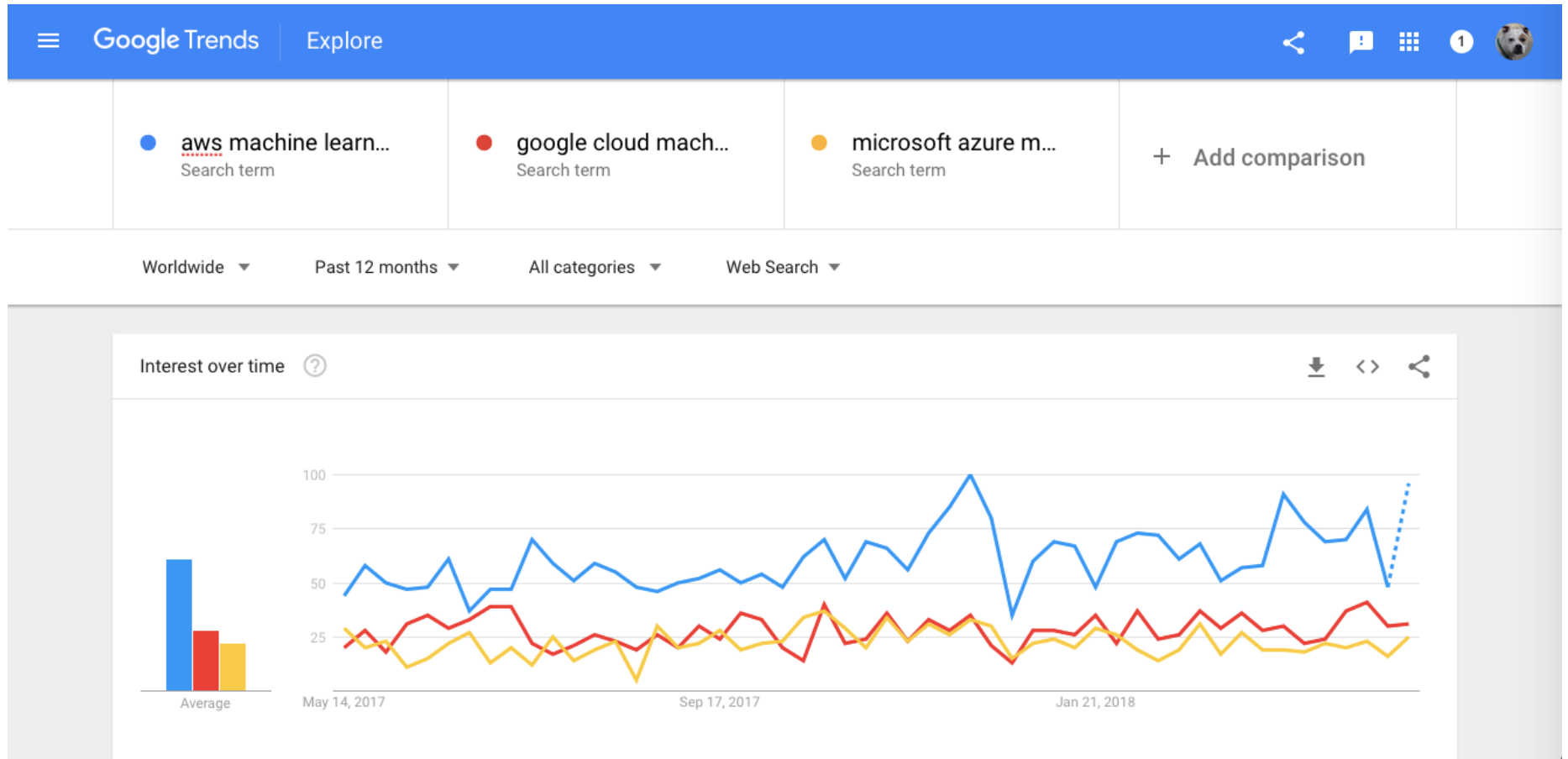
# Service Specialization

- 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

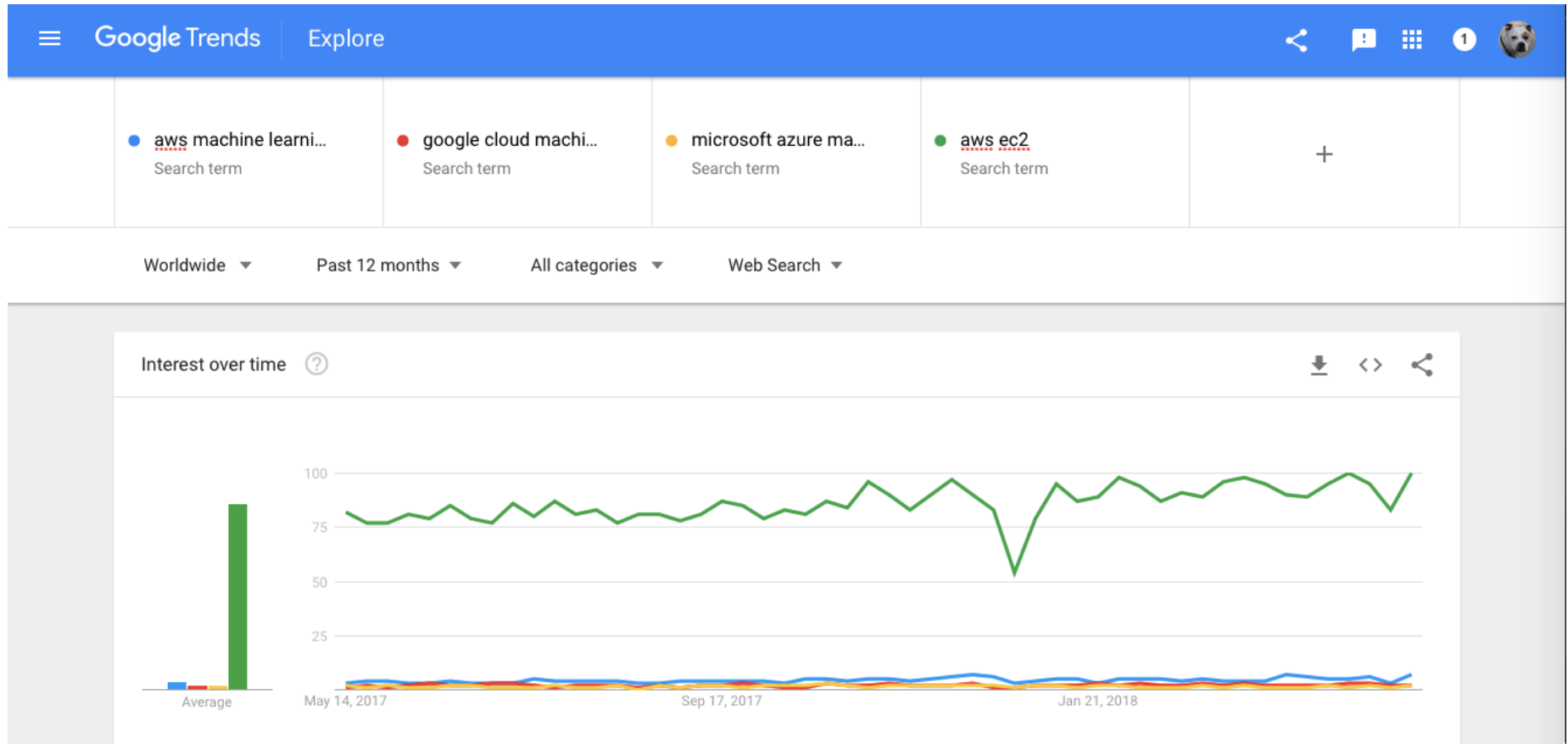
- Service specialization is moving the cloud ecosystem away from general-purpose hosting and toward SaaS

# Cloud Success is Slow

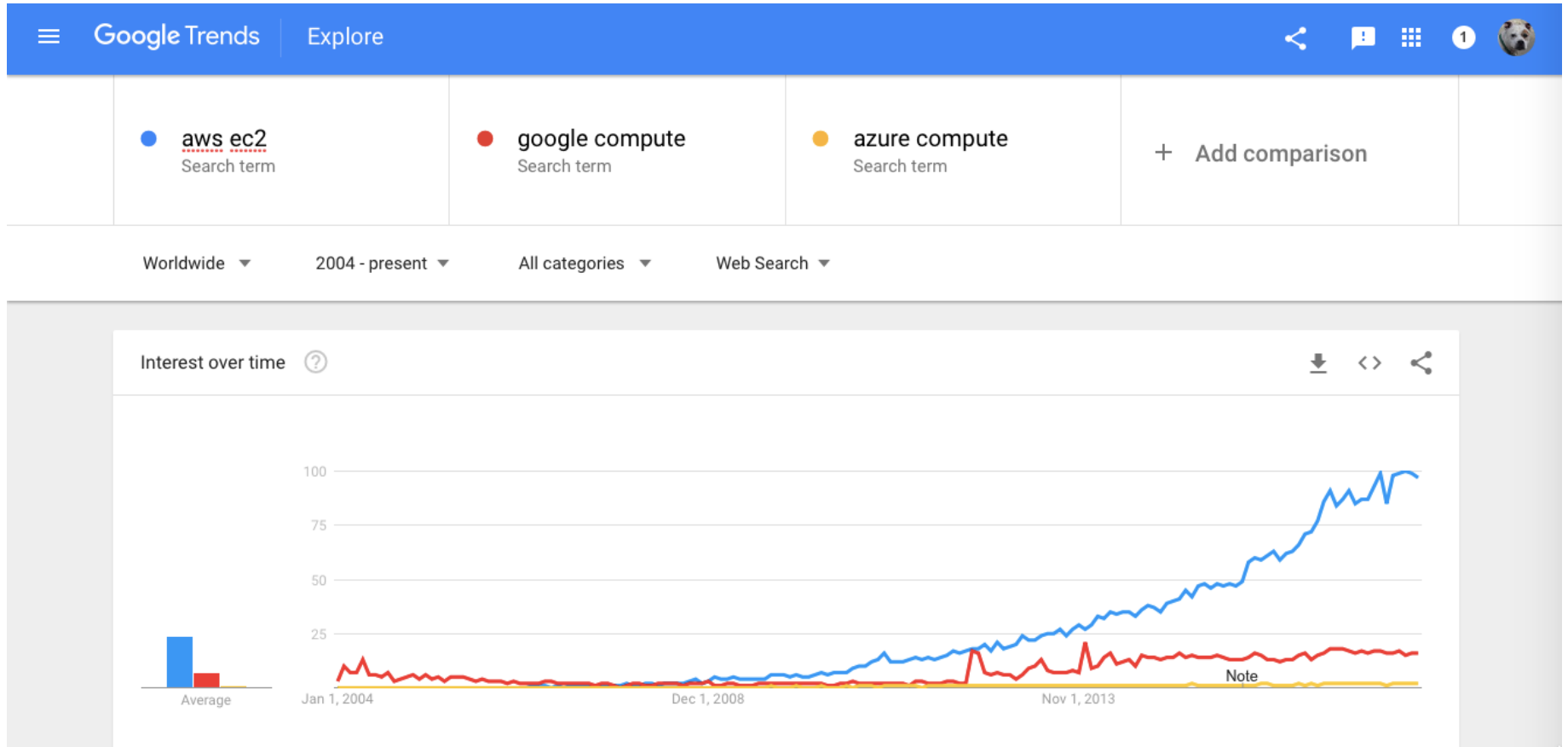




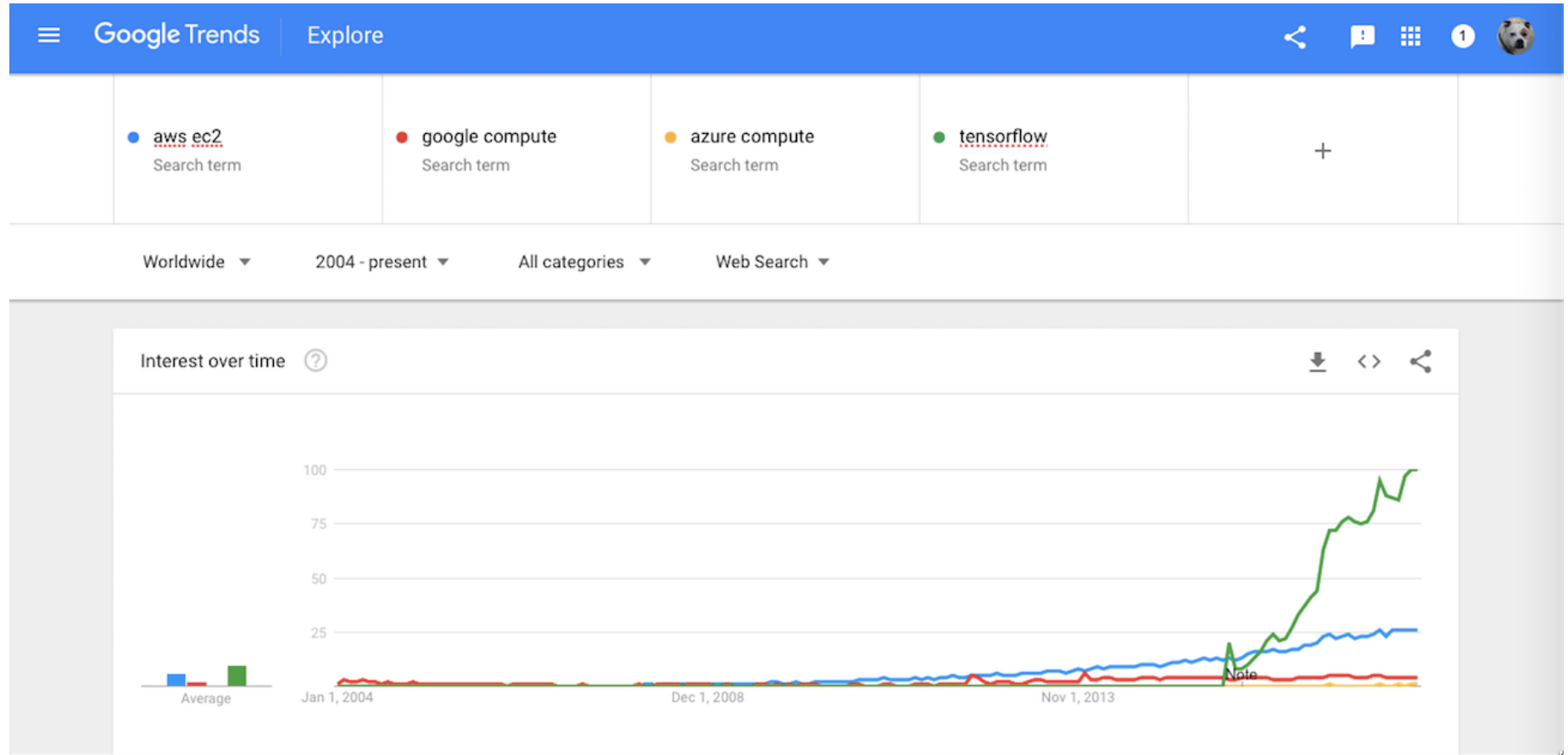
# Really Slow



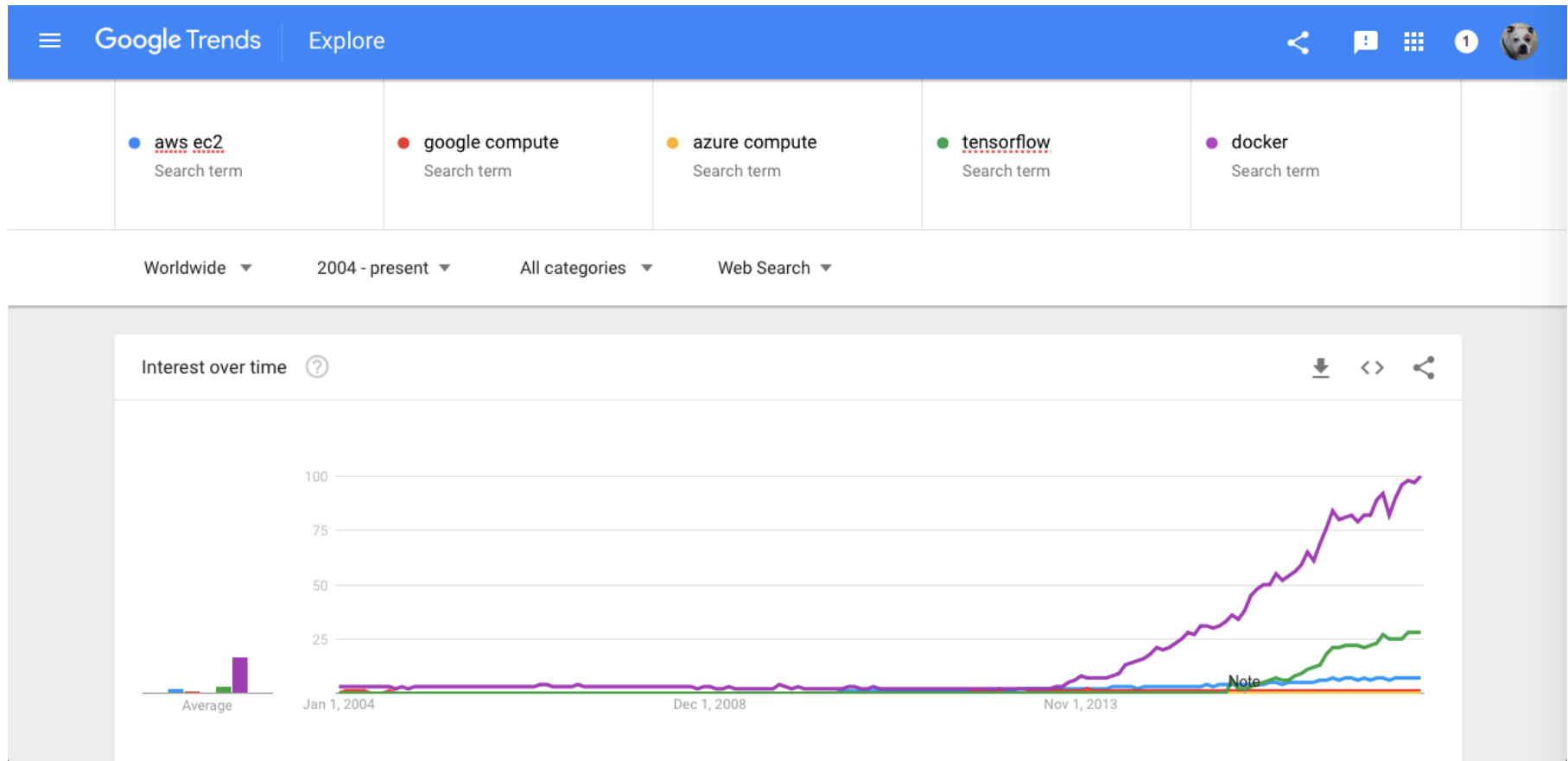
# But trending upward nicely



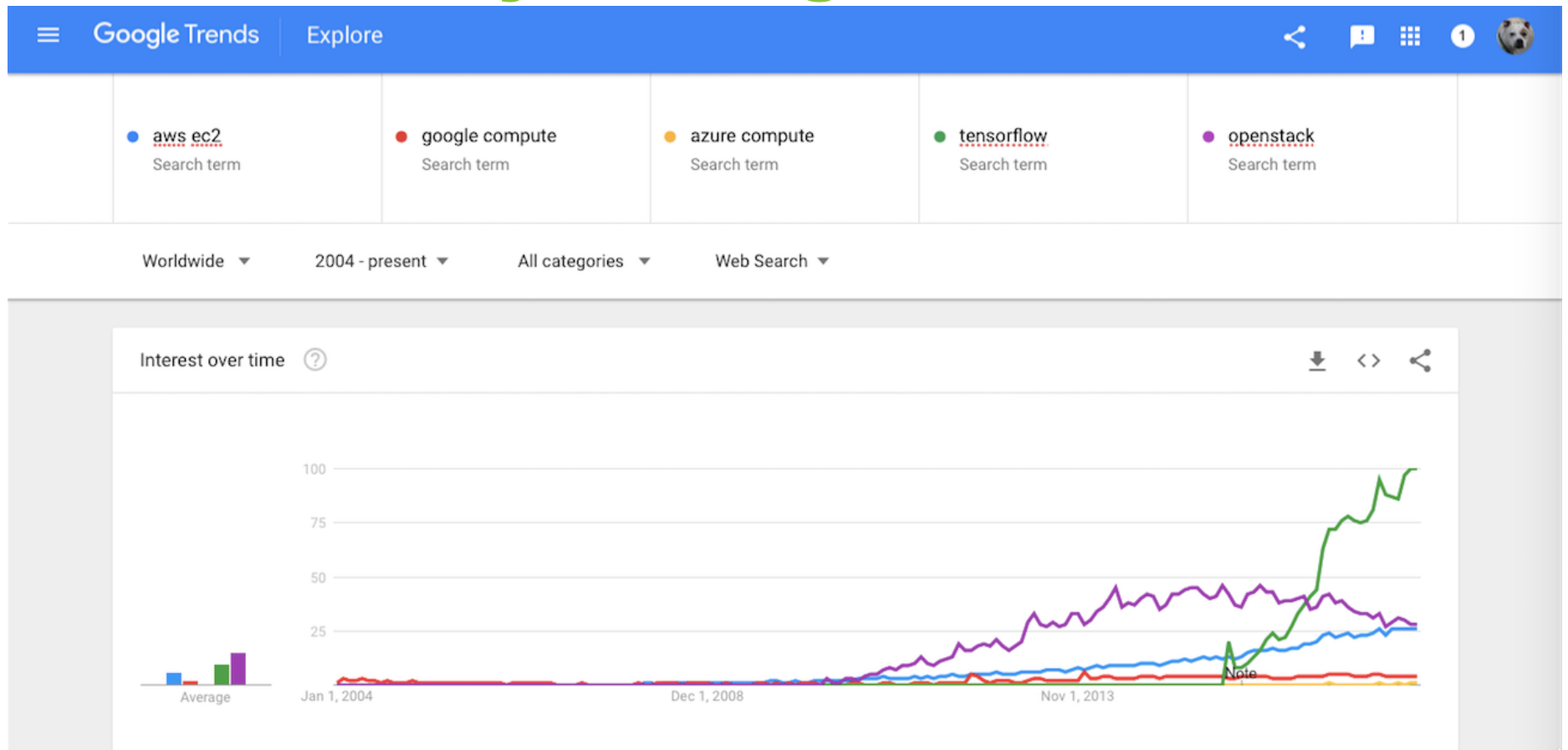
# Open Source is not slow



# 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