Networking Trends 2025



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Audio/Video recordings of this class lecture are available at:

http://www.cse.wustl.edu/~jain/CSE5700-25/

Student Questions

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Overview

1. Why worry about the trends?
2. How to find the trends?
3. What are current trends?

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Selecting the Right Field

- An important question for **students**, academics, entrepreneurs, and companies
- Goal: To impact
- Follow the **paradigm shifts**:
  - 1980: Ethernet
  - 1990: ATM Networks
  - 2000: Optical Networks
  - 2005: Wireless Networks
  - 2008: Next Generation Internet/SDN
  - …
  - 2025: Whatever is being **hyped** this year?



Industries adapt by necessity.
Academics continue to develop deeper expertise in what they already know.

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Sources of Trends

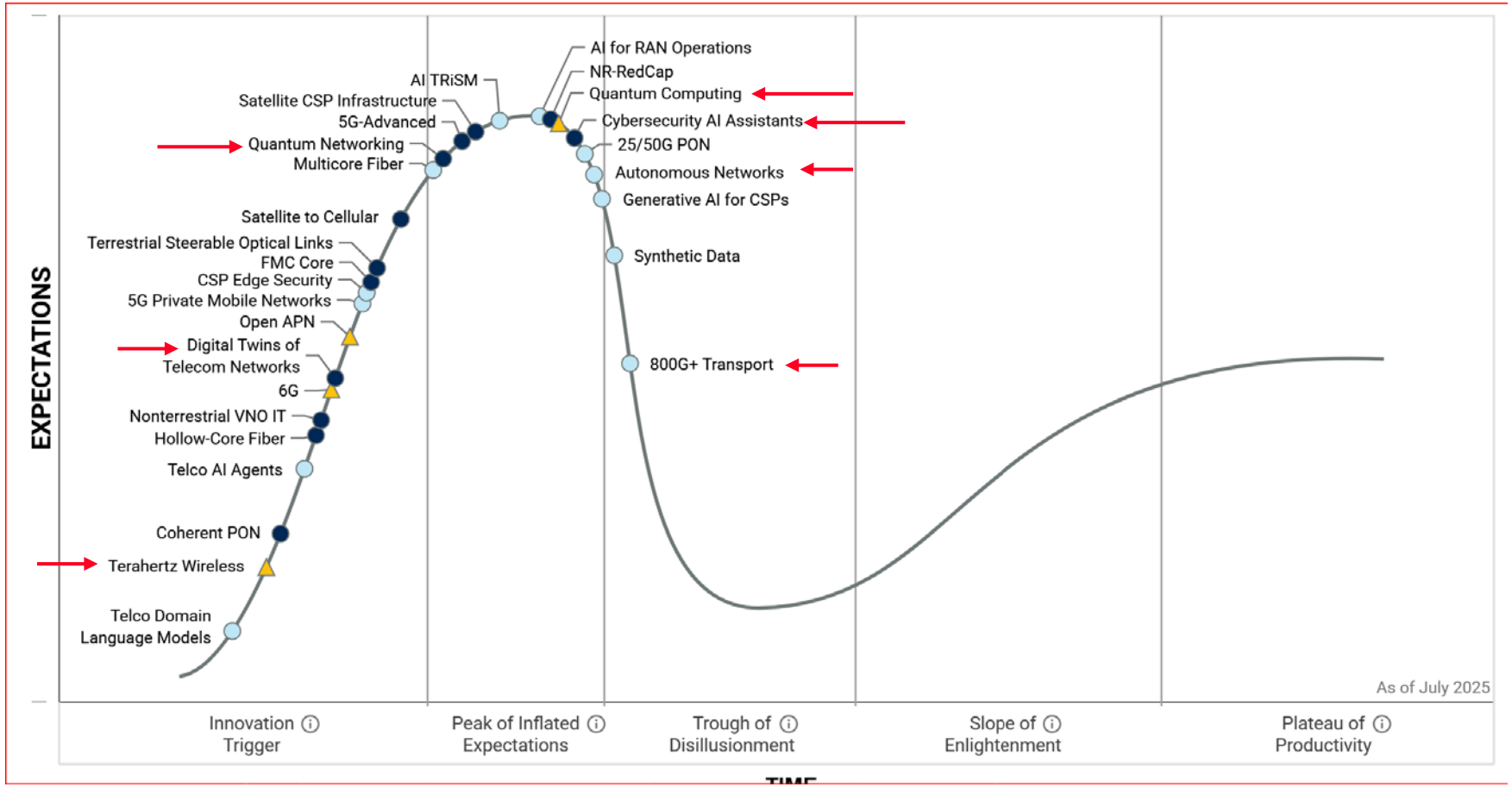
1. Industry analytics companies like Gartner

   ⇒ Venture capital investments
2. Standards Organizations Activities:
   1. IEEE: Layer 2
   2. IETF: Layer 3 and above
   3. ITU: Carriers
   4. 3GPP: 3G, 4G, 5G, 6G, …
3. NSF funding areas
4. Leading companies' white papers: Cisco
5. Google searches by people all over the world

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Gartner's Emerging Technology in the Communications Industry Hype Cycle 2025



Ref: P. Kjeldsen, P. Liu, S. Fabre, "Hype Cycle for Emerging Technologies in Communications Industry, 2025," Gartner ID G00826997, 21 July 2025 (Available by subscription).

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- Many of these (i.e., digital twins) are at very different maturity levels I think based on how different researchers have worked on them (or even industry). The key question here is how academic researchers decide which to adopt early and which to wait for. Or, this list is being made in the opposite direction, like Gartner created the list based on what academic researchers were working on?

They do both a literature survey and an industry survey.

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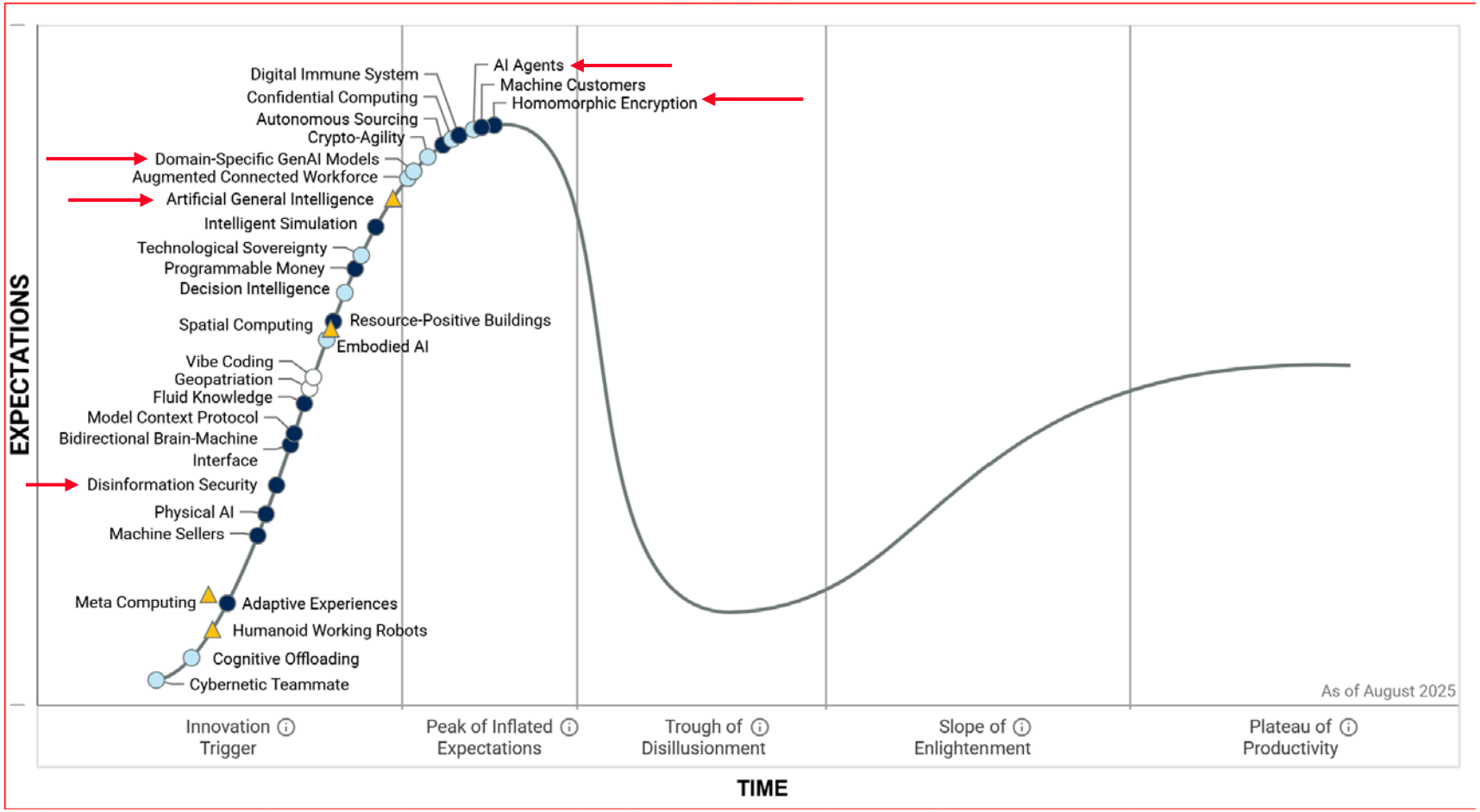
Emerging Communications Technologies

- Hollow-core fiber: Light travels faster than in single-mode fibers
- Non-terrestrial VNO IT: Virtual Network Operators for LEO
- Digital Twins: Digital simulations of components and systems
- Open All-photonic Networks (APN): Dynamically create connections between endpoints.
- Carrier Service Providers (CSP) Edge Security
- Fixed Mobile Convergence (FMC) Core: Fiber to the home and 5G combination
- AI Trust, Risk, and Security Management (TRISM)
- New-Radio Reduced Capability (NR-RedCap) for IoT

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Gartner's Emerging Technology Hype Cycle 2025

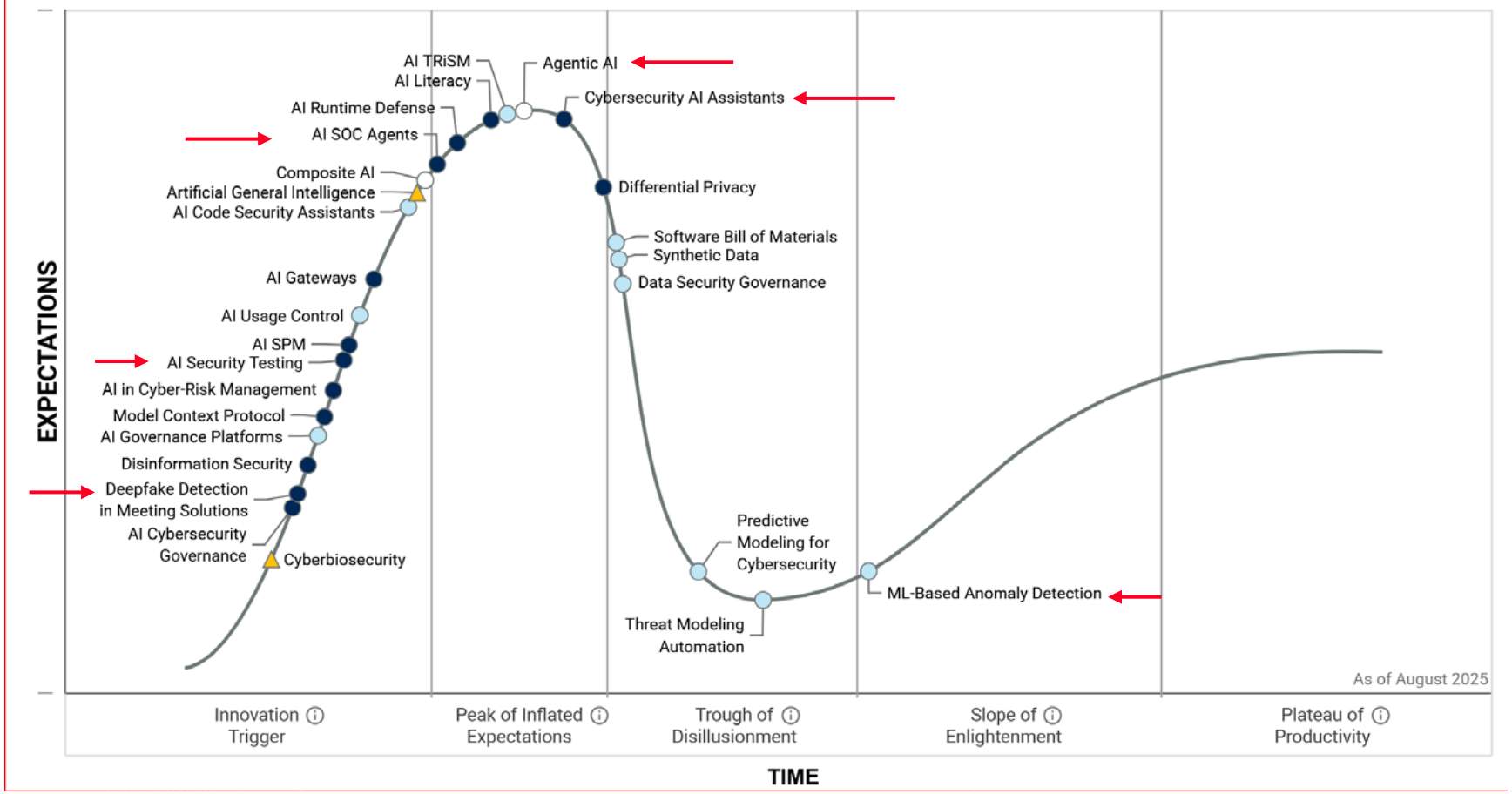


Ref: C. Stephan, J. Wong, M. Resnick, "Hype Cycle for Emerging Technologies, 2025," Gartner ID G00824262, 5 August 2025 (Available by subscription).

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Gartner's AI and Cybersecurity Hype Cycle 2025



Ref: J. D'Hoinne, M. Acosta, J. Murphy, "Hype Cycle for AI and Cybersecurity, 2025," Gartner ID G00829144, 7 Aug 2025 (Available by subscription).

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IEEE 802 LAN/MAN Standards

- Security
- Optical Automotive Ethernet
- Time Sensitive Networking
- 200, 400, 800, and 1600 Gbps PHY
- Backplane Ethernet

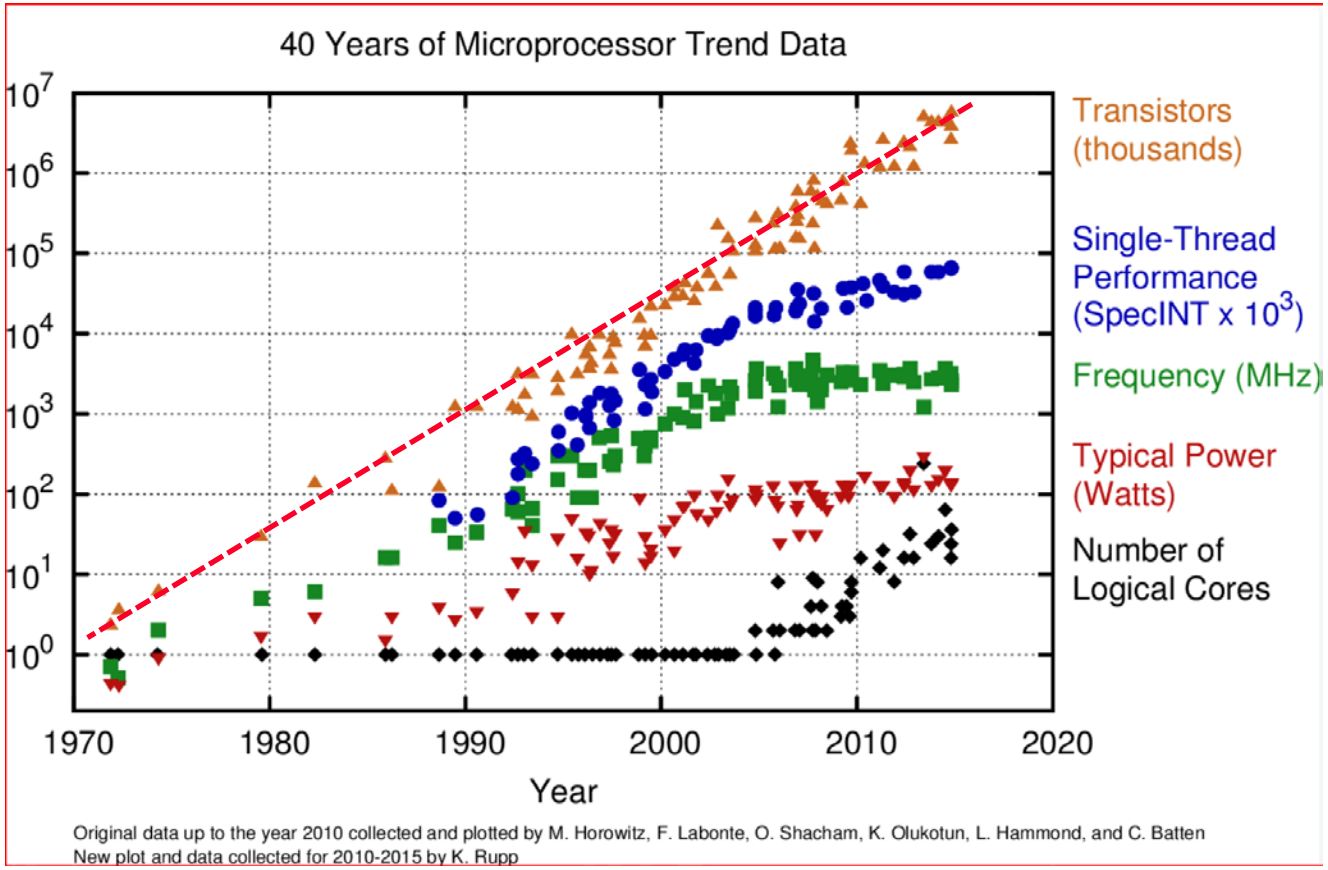
Ref: https://www.ieee802.org/3/

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Processor Growth: Moore's Law

- Garden Moore, Director of R&D, Fairchild Semiconductor
  1965: Transistor density doubling every two years

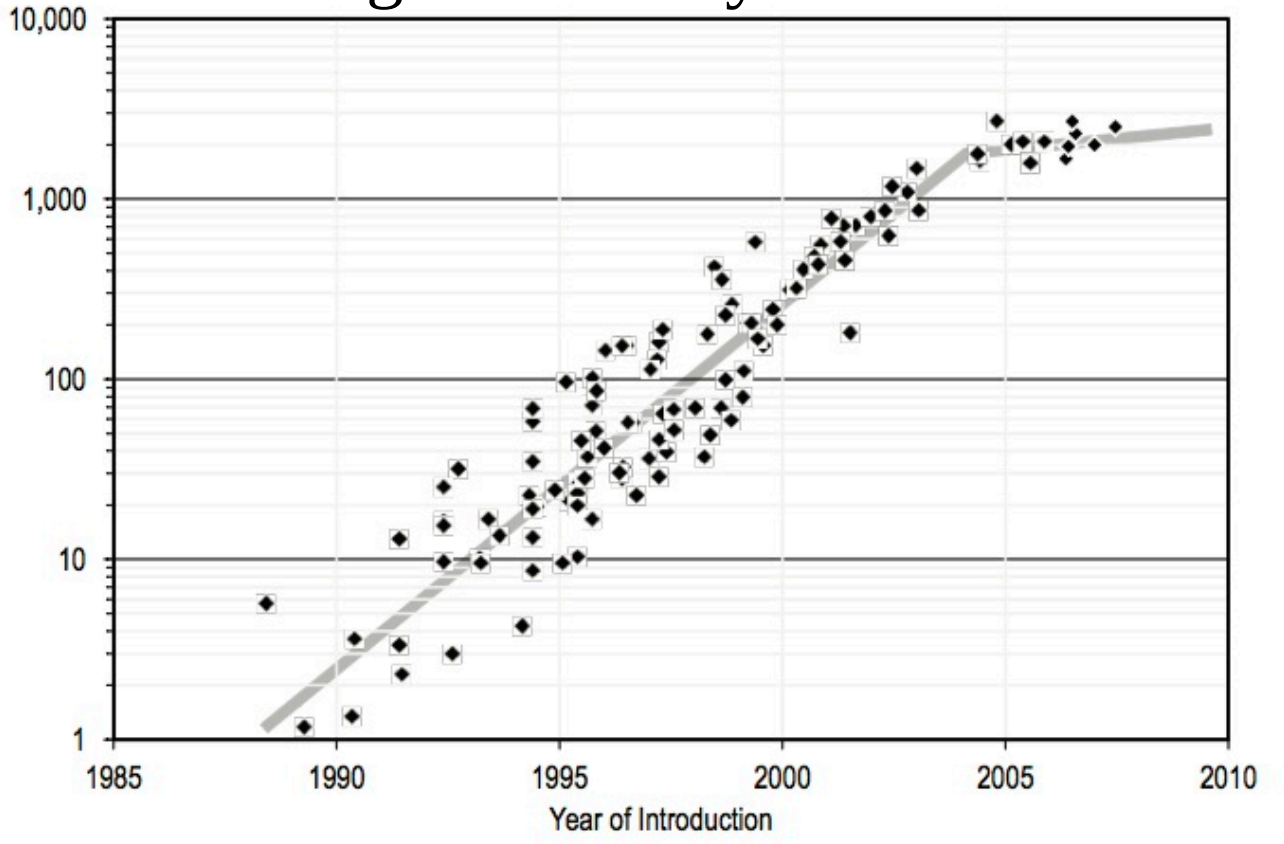


Ref: https://www.karlrupp.net/2015/06/40-years-of-microprocessor-trend-data/

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Will Moore's Law Continue?

- A debate has begun… It may have broken down in 2004…



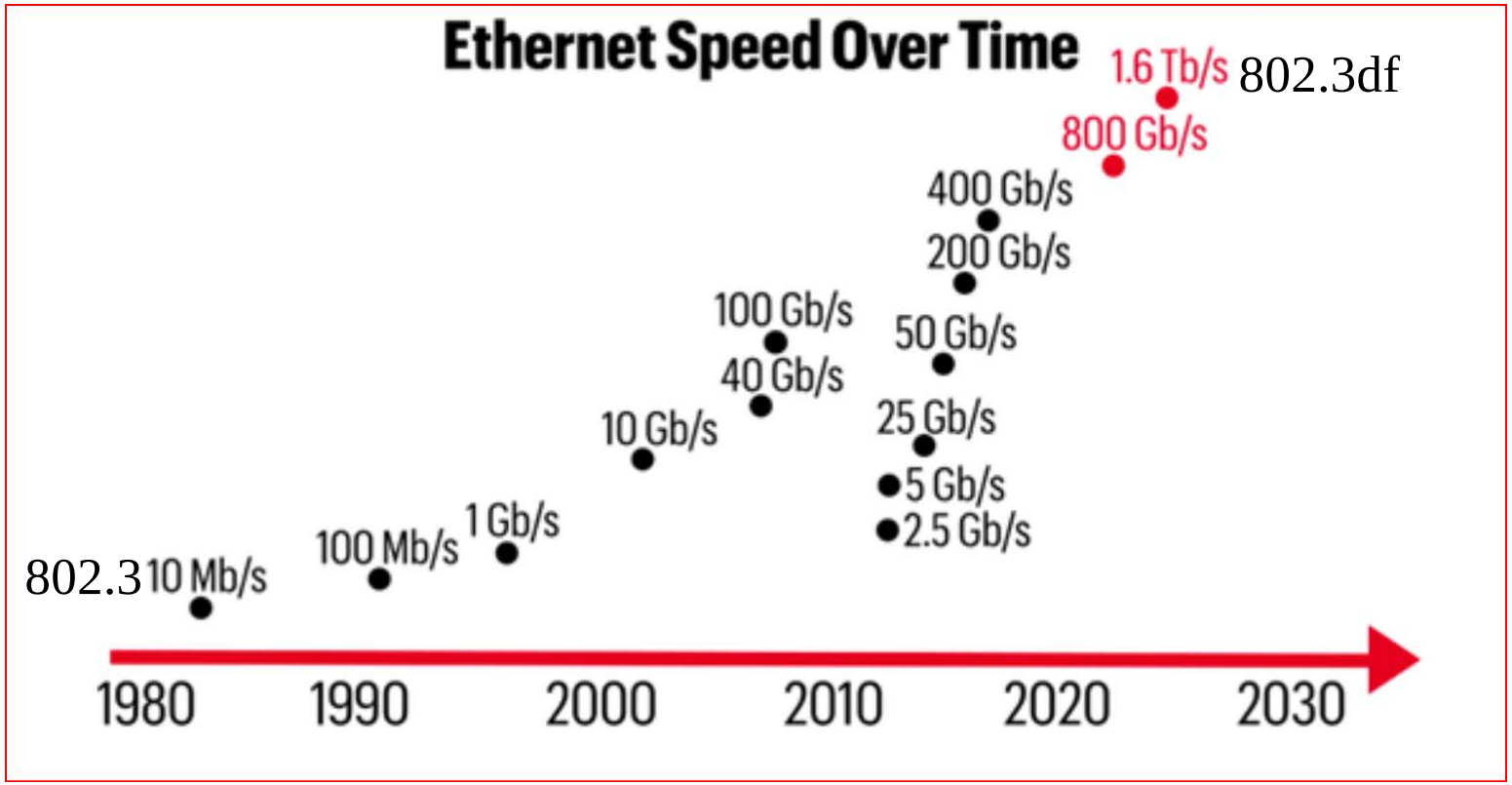
Ref: R. Jones, "Economics after Moore's Law," Soft Machines, July 21, 2107, http://www.softmachines.org/wordpress/?p=2097

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Ethernet Speeds

- IEEE Standards Nominal speeds

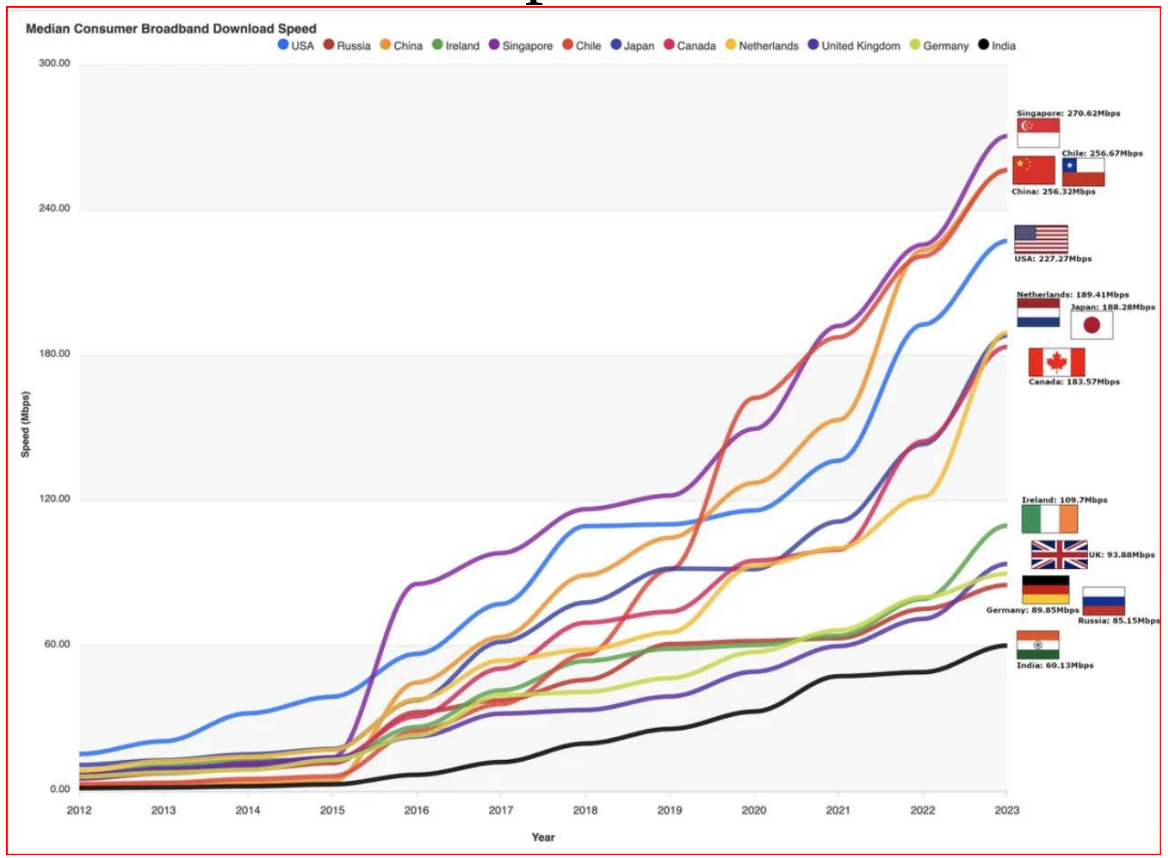


Ref: https://semiengineering.com/the-vital-role-of-1-6t-networking-in-emerging-technology/

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Consumer Download Speeds

- IEEE Standards Nominal speeds



Ref: https://www.reddit.com/r/dataisbeautiful/comments/1aun28g/oc_median_consumer_internet_download_speeds_from/

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Internet Engineering Task Force (IETF)

- Automated Network Management
- The Internet of Things
- New Transport Technology
- Security and Privacy
- Energy Efficient Internet
- Fine-Grained Access Control in public and private clouds

- Internet Research Task Force (IRTF): Research part of IETF

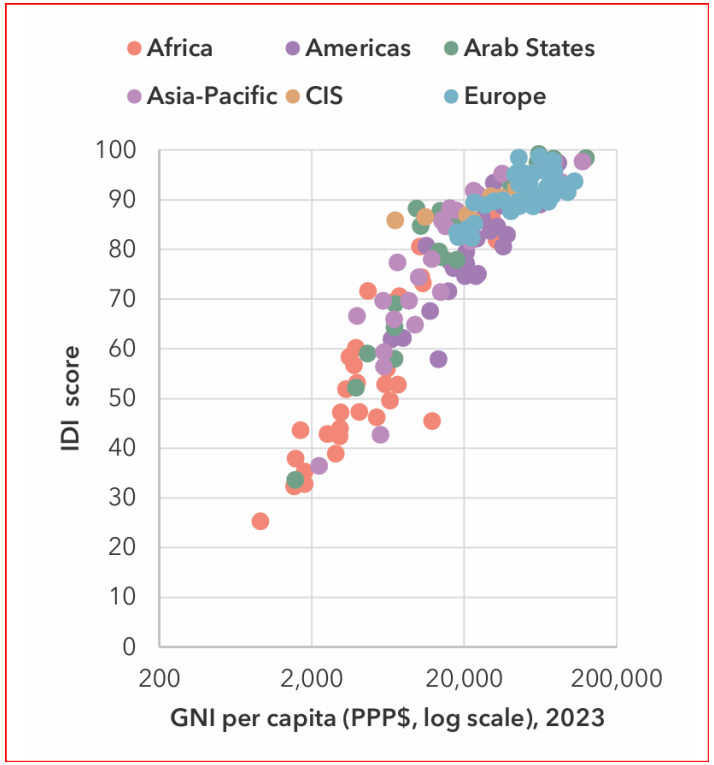
Ref: https://www.ietf.org/meeting/125/

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ITU ICT Development Index 2025

Information and Communication Technologies (ICT)
ICT Development Index (IDI) = Level of connectivity



Ref: https://www.itu.int/pub/D-IND-ICT_MDD-2025-1

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Federal Research Funding

- Networking and Information Technology Research and Development (NITRD)
  - Group of 15 Federal agencies: NSF, NIH, NASA, DOE, DARPA, ONR, …
  - Recommends a supplement to the president's annual budget
- Large-scale Networking
- Advanced Wireless R&D
- Artificial Intelligence
- Computing-Enabled Human Interaction, Communication, and Augmentation
- Computer-Enabled Networked Physical Systems
- Cyber Security and Privacy

Ref: NITRD, "NITRD and NAIIO Supplement to the Present's FY2025 Budget," November 2024, 60 pp., https://www.nitrd.gov/pubs/FY2025-NITRD-NAIIO-Supplement.pdf

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Cisco Annual Internet Report (2018-2023)

Updated in 2020. Now 5 years old. By 2023:

- 5.3 Billion Internet Users = 2/3 of the world population
- 29.3 billion Internet devices = 3.6 networked devices per person
- 50% of network connections will be Machine-to-Machine (M2M) = IoT
- 50% of M2M connections will be home applications. Others are cars, industrial.
- 70% of the global population will have mobile connectivity
- Cisco also has reports on AI readiness and Cybersecurity Readiness (See references)

Ref: https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.pdf

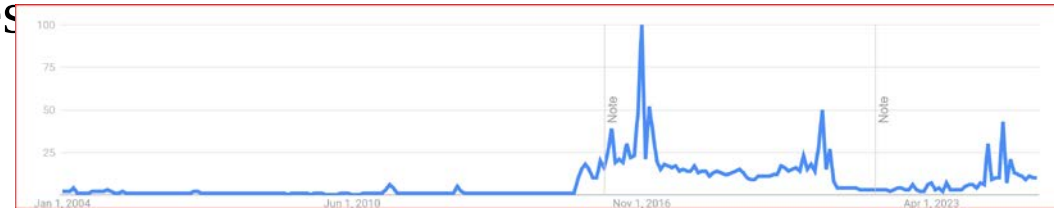
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What is Google Trends?

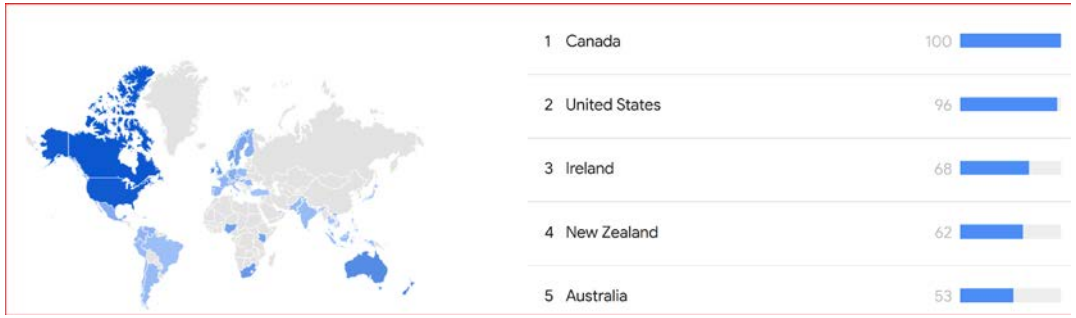
- A time series graph of the number of searches on any term of your choice
- Scaled to 100%. 100=Maximum over time
- Includes geographical distribution of those searches
- Includes major news items
- Example: "Donald Trump" Popular in Canada

Interest Over Time



Jan 1, 2004 Nov 2, 2016 Nov 2, 2024

Interest By Region

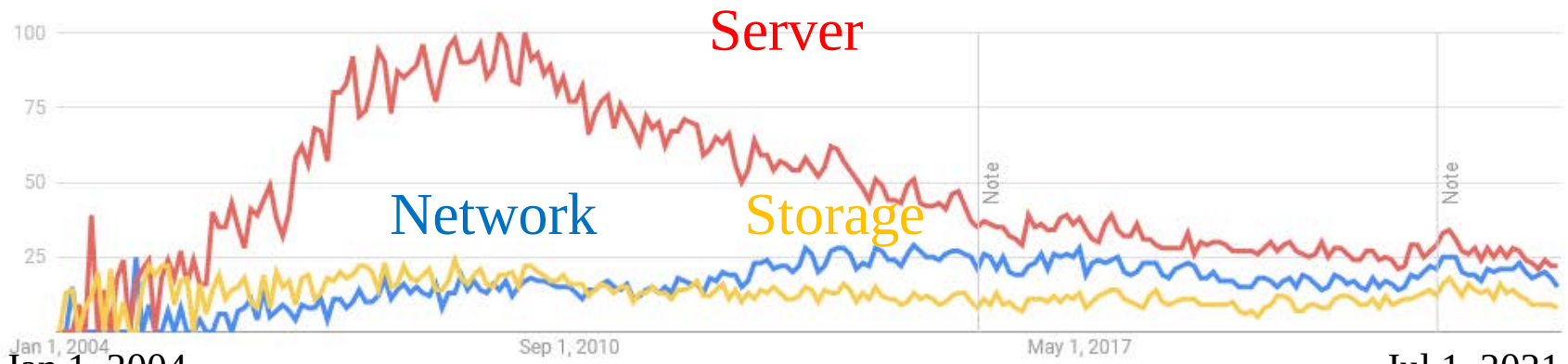


Ref: https://trends.google.com/trends/explore?date=all&q=Donald%20Trump&hl=en

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Virtualization: Google Trends



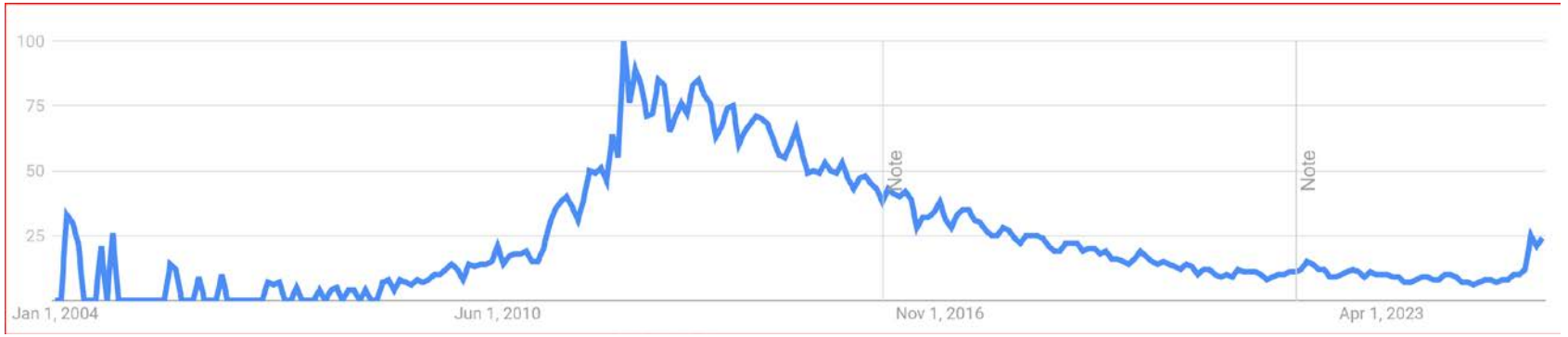
Jan 1, 2004 Jul 1, 2021

- Virtualization
  - Server
  - Network
  - Storage
- Increasing curiosity about network virtualization

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OpenFlow: Google Trends



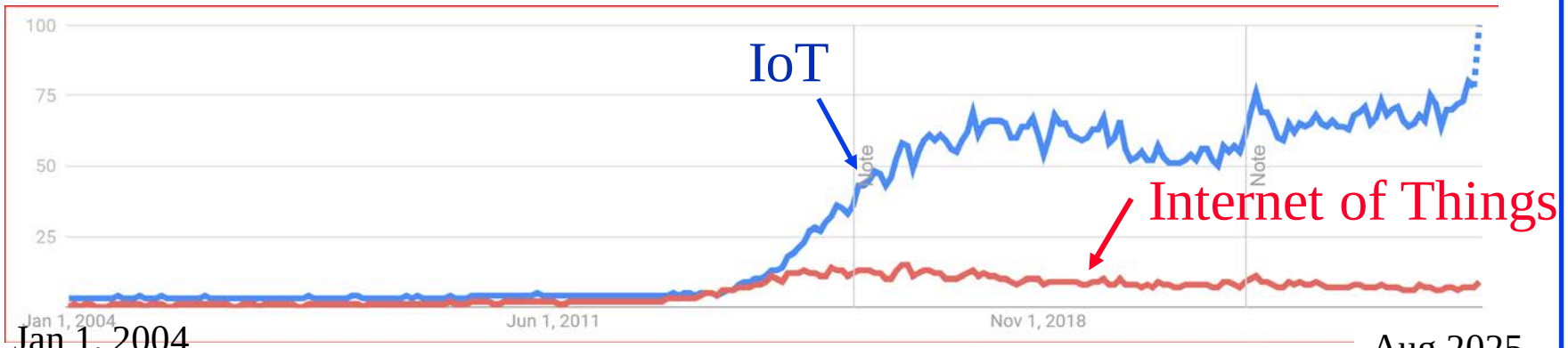
Jan 1, 2004

May 25

- Started 2004
- Past the peak
  (Everyone who needs to know knows)
- Peak at Open Networking Summit (April/May 2012)
- High interest in China, Taiwan, South Korea, Japan

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IoT: Google Trends



Jan 1, 2004

Aug 2025

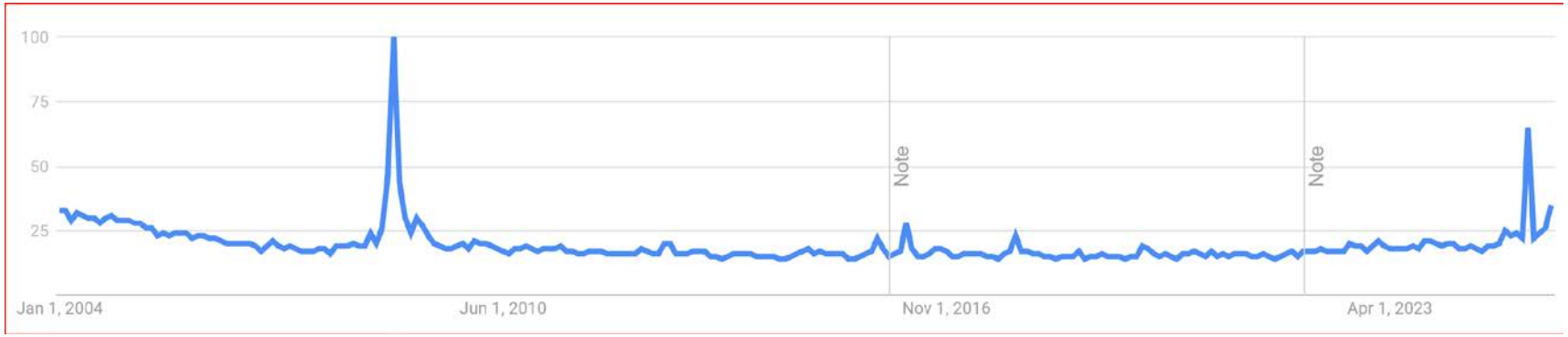
- Knee around 2014
- High interest all around the world



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Quantum



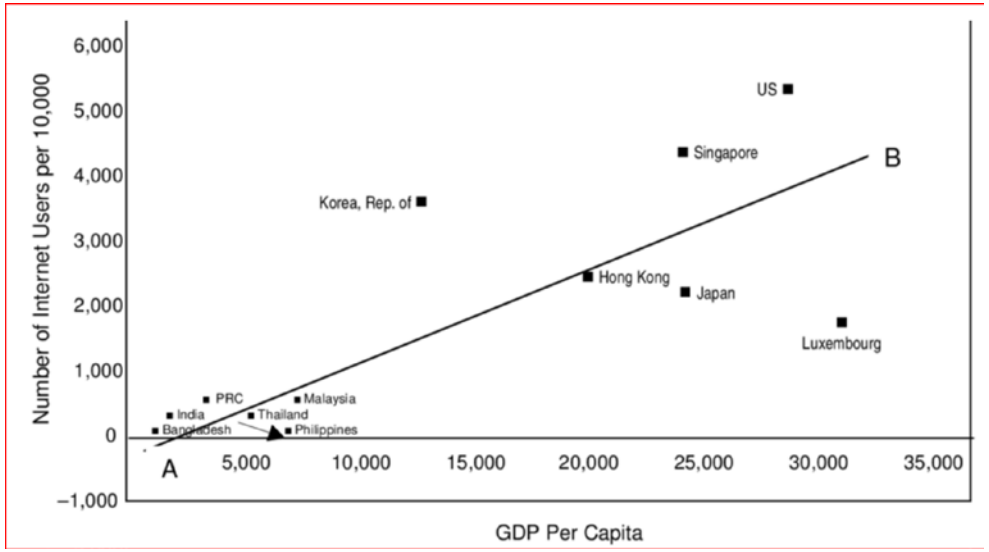
Jan 2004 Nov 2008 Mar 2025

- Has been around for quite some time
- Public interest is up and down
- Expected to go up with US research funding

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Internet and GDP

- Internet users from countries with higher GDP are more likely to search for future topics than about the past.
- Economic indicators are correlated to on-lin behavior.



Ref: Quibria, M. & Tschang, Ted. (2001). Information and communication Technology and Poverty: An Asian Perspective. University Library of Munich, Germany, MPRA Paper, Available on ResearchGate.net

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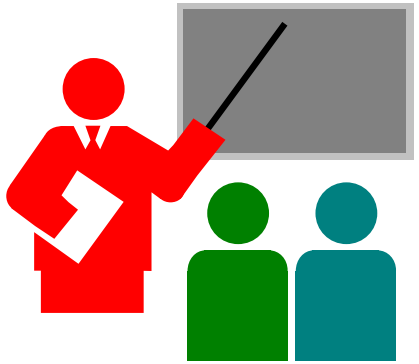
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Other Recent Developments

- Bio-Inspired Protocols: Swarm Routing
- AI agents stack with protocol layers
- Zero Trust Architecture with protocol enforcement points
- Post-Quantum Transport Layer Security (TLS)
- Multipath TCP
- Quick UDP Internet Connection (QUIC) transport protocol
- Intent-Based Networking
- IPv6+ and Recursive Internet Architecture (RINA)

Student Questions

Summary



1. Five sources of Trends: Analytic Reports (Gartner), Standards (IEEE, IETF, ITU), US Government Funding, Industry (Cisco), and Google.
2. All of these are highly correlated.
   (Does Gartner look at Google trends before publishing their graphs? It would be unwise not to.)
3. All forecasting is based on the past ⇒ Continuous.
   Real future is invented ⇒ Discontinuous
4. Short-term forecasts are OK. Long-term is always way off.
5. Most successful people are those who look ahead and adapt

Student Questions

Homework 2

- See Canvas. You will need to answer questions after downloading a Gartner report, an IEEE Standard, and an IETF RFC.

Student Questions

Reading List

Required Reading:

1. P. Kjeldsen, P. Liu, S. Fabre, "Hype Cycle for Emerging Technologies in Communications Industry, 2025," Gartner ID G00826997, 21 July 2025 (via one.WUSTL for our students only)
2. Cisco, "Cisco Annual Internet Report (2018–2023)," March 2020, https://www.cisco.com/c/en/us/solutions/collateral/executive-perspectives/annual-internet-report/white-paper-c11-741490.html

Not Required:

1. 2025 Cisco Cybersecurity Readiness Index, https://newsroom.cisco.com/c/dam/r/newsroom/en/us/interactive/cybersecurity-readiness-index/2025/documents/2025_Cisco_Cybersecurity_Readiness_Index.pdf
2. Cisco AI Readiness Index, 2024, https://www.cisco.com/c/dam/m/en_us/solutions/ai/readiness-index/2024-m11/documents/cisco-ai-readiness-index.pdf

Student Questions

Acronyms

- 3GPP Third Generation Parternetship Project
- AI Artificial Intelligence
- APN All-photonic Networks
- ATM Asynchronous Transfer Mode
- CSE Computer Science and Engineering
- CSP Carrier Service Providers
- DARPA Defense Advanced Research Project Agency
- RedCap Reduce Capacity
- DOE Department of Energy
- FMC Fixed Mobile Convergence
- GDP Gross Domestic Product
- ICT Information and Communications Technology
- ID Identity

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Acronyms (Cont)

- IEEE Institution of Electrical and Electronic Engineers
- IETF Internet Engineering Task Force
- IoT Internet of Things
- IPv6 Internet Protocol Version 6
- IRTF Internet Research Task Force
- IT I nformation Technology
- ITU International Telecommunications Union
- LAN Local Area Networks
- LEO Low Earth Orbit
- MAN Metropolitan Area Network
- MO Missouri
- NASA National Aeronautics and Space Administration
- NIH National Institute of Health

Student Questions

Acronyms (Cont)

NITRD	Networking and Information Technology Research and Development
NR	New-Radio
NSF	National Science Foundation
OK	Okay
ONR	Office of Naval Research
PHY	Physical Layer
PON	Passive Optical Network
QUIC	Quick UDP Internet Connections
RFC	Request for Comments
RINA	Recursive Internet Architecture (RINA)
SDN	Software Defined Networks

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Acronyms (Cont)

- TCP Transport Control Protocol
- TLS Transport Layer Security
- TRISM Trust Risk, and Security Management
- UDP User Datagram Protocol
- US United States
- VNO Virtual Network Operators
- WUSTL Washington University in Saint Louis

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http://www.cse.wustl.edu/~jain/cse5700-25/m_02trn.htm

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Related Modules



CSE 567: The Art of Computer Systems Performance Analysis
https://www.youtube.com/playlist?list=PLjGG94etKypJEKjNAa1n_1X0bWWNyZcof

CSE473S: Introduction to Computer Networks (Fall 2011),
https://www.youtube.com/playlist?list=PLjGG94etKypJWOSPMh8Azcgy5e_10TiDw





CSE 570: Recent Advances in Networking (Spring 2013)
https://www.youtube.com/playlist?list=PLjGG94etKypLHyBN8mOgwJLHD2FFIMGq5

CSE571S: Network Security (Spring 2011),
https://www.youtube.com/playlist?list=PLjGG94etKypKvzfVtutHcPFJXumyyg93u





Video Podcasts of Prof. Raj Jain's Lectures,
https://www.youtube.com/channel/UCN4-5wzNP9-ruOzQMs-8NUw

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