Day 1: Course Overview and Introduction

CSEE 4119
Computer Networks
Ethan Katz-Bassett

COLUMBIA UNIVERSITY
IN THE CITY OF NEW YORK

Sept 6 admin

- Masks ***required***, over nose and mouth
- Attendance & participation ***not*** required
- If you are not feeling well or were exposed to COVID, please stay home
- Videos of lectures available
  (live Zoom potentially available, but no live Q&A)

- Get book: Kurose/Ross 8th edition
  - See syllabus for some options
- Get & read syllabus and course policies: definitive version linked from Courseworks
- Reminder: Sign up for Ed Discussion & CourseWorks (if you weren't automatically added)

Why study computer networking?

- *Possible reasons:*
  - –

Why study computer networking?

- Networking is ubiquitous
  - We use the Internet nearly continuously, in many ways

Key networking challenge (class will come back to this):
How to support diverse and changing use cases?

- Pandemic highlights Internet as critical infrastructure
  - Many people around the world depend on it for work, school, entertainment, socializing
    - A key role in enabling stay-at-home orders and distancing

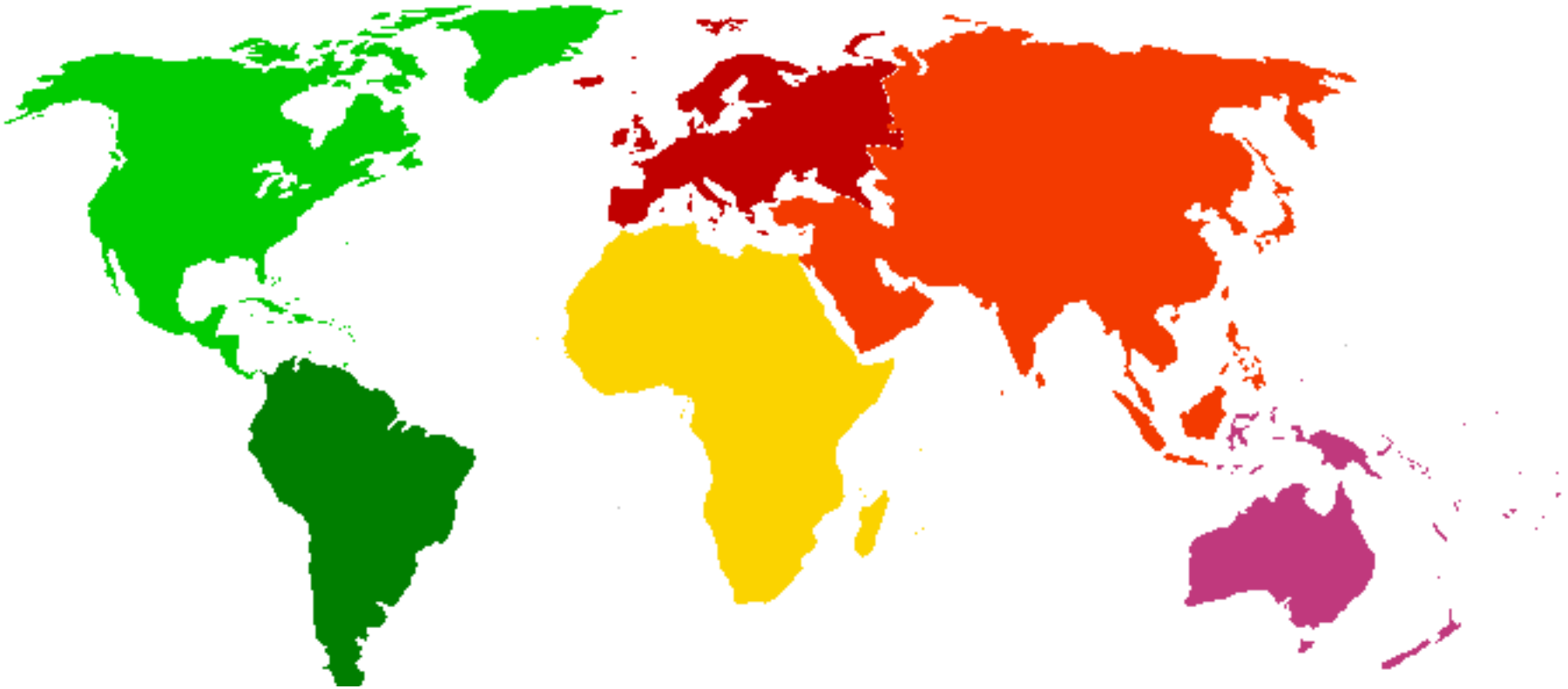
Key networking challenge (class will come back to this):
How to provide reliable service in dynamic environment?

  - We have used it to stream our classes

Key networking challenge (class will come back to this):
How to provide near-real-time interactive content?

Remote learning relies on Internet

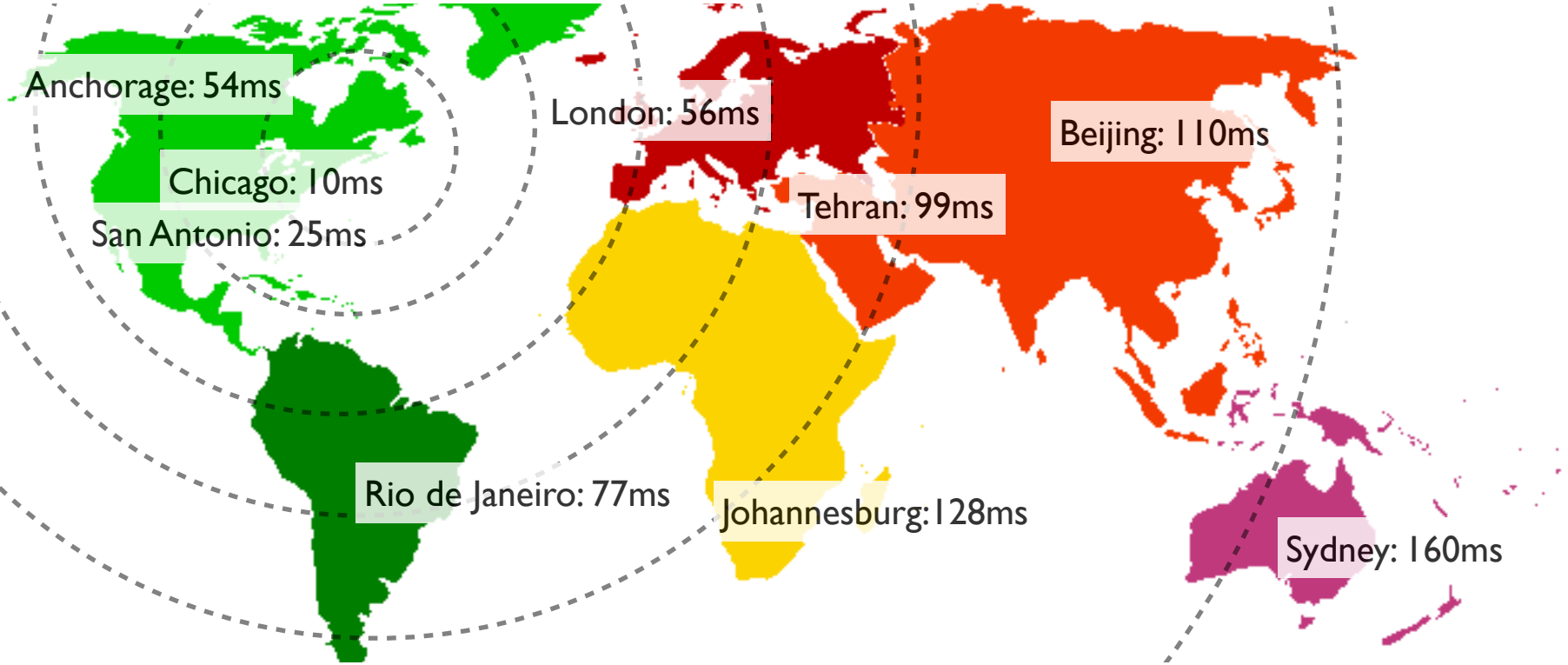
- During pandemic, students attend classes from locations around the world



- Zoom has to stream the video to all these locations:
  - Within 150 milliseconds (or conversations feel unnatural)
  - At least 1.5 Mbps (recommended for Zoom)

Video travels in cables around world

- Speed of light (SoL) in fiberoptic cable: 200 km / ms
- Minimum latency from NYC and back:



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  - Within 150 milliseconds (or conversations feel unnatural)

Network challenge: *How to communicate globally (with little overhead over SoL)?*

What is Ethan's Internet speed?

Networking challenge: *How to provide ever-increasing speeds for richer apps?*

200 Mbps: Ethan's home

25 Mbps: Netflix Ultra HD

1.5 Mbps: Zoom recommended

600 kbps Zoom min

14.4 kbps: Ethan's 1991 Internet

With Ethan's 1991 speed:

- 2% Zoom minimum, 1% Zoom recommended
- 1.5 minutes to download syllabus
- 30 minutes to download a song
- 2 hour movie:
  - 12 days for standard definition (SD)
  - More than a month for HD
  - 3 months for 4K Ultra HD

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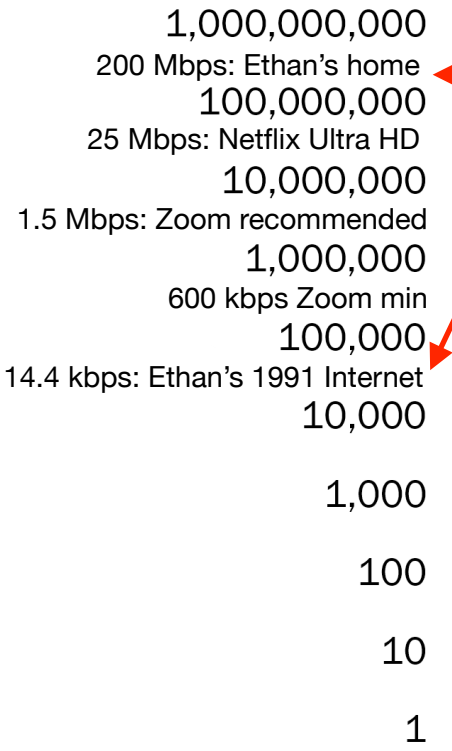

Ethan's Internet speed increased 17,000x in 29 years

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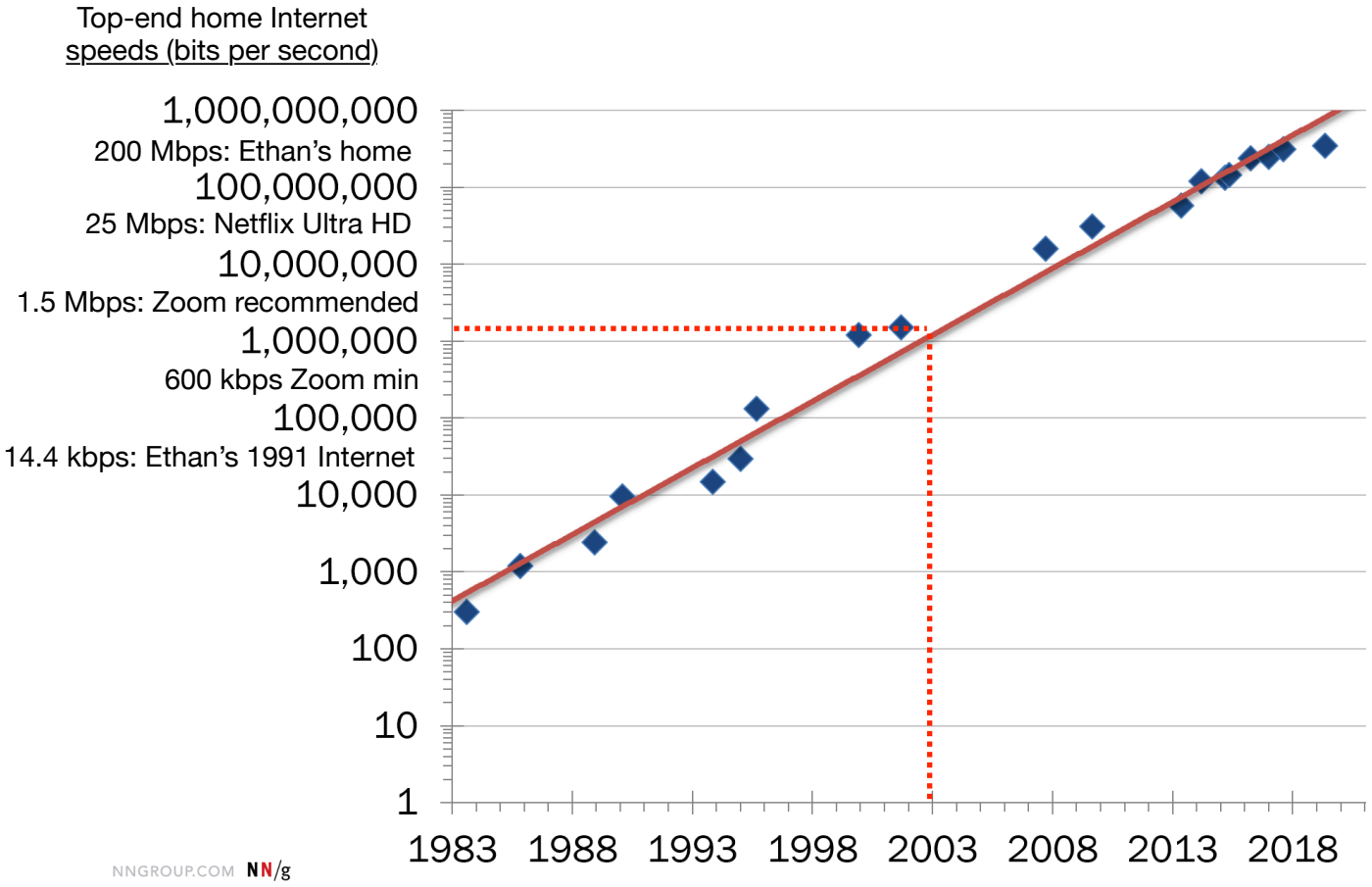
Some Internet history



- Ethan's Internet speed increased 17,000x in 29 years
- Nielsen's law: Top user speed grows by 50% per year
  - model: top Internet speed increased 127,000x in 29 years

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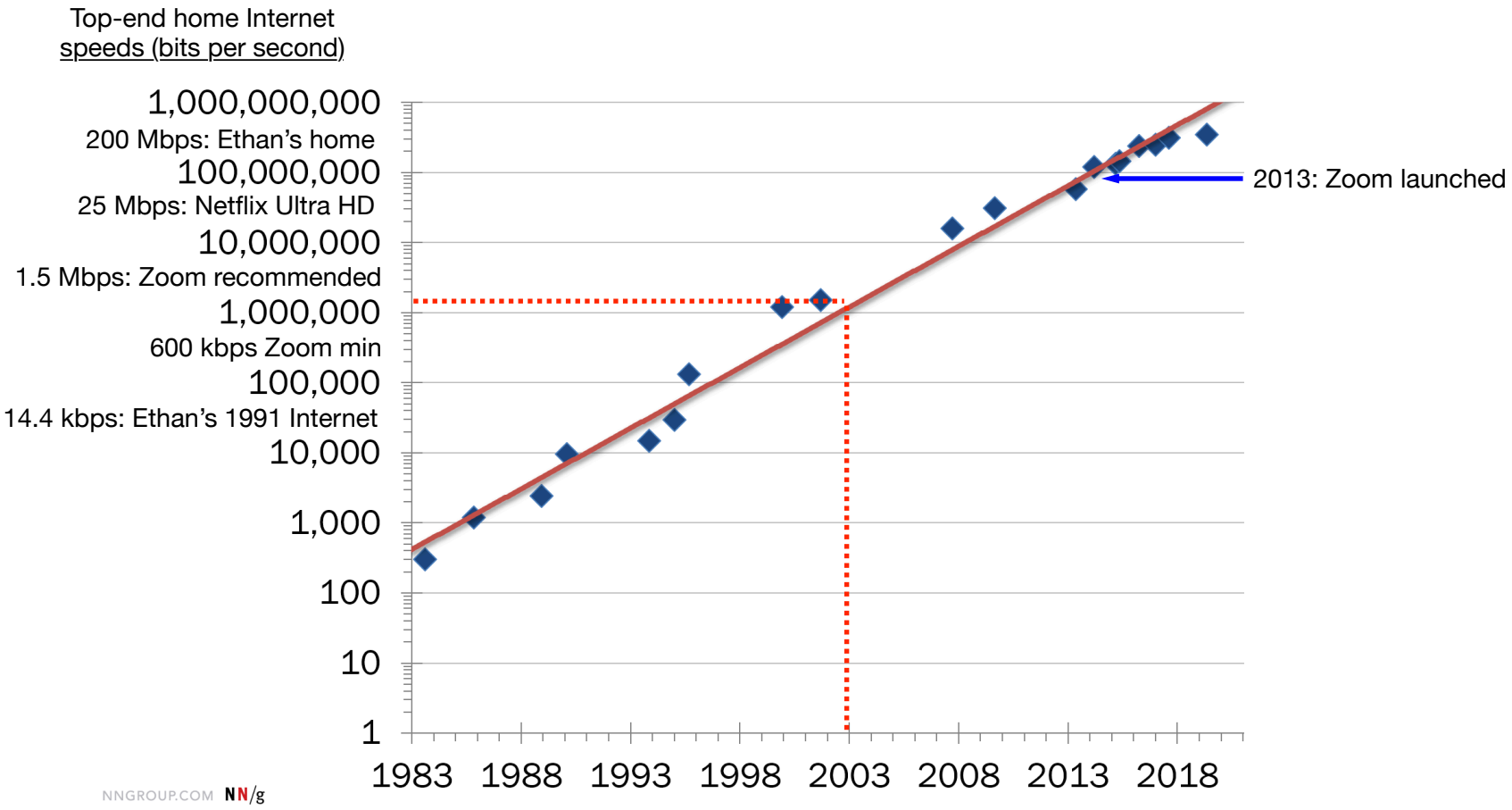

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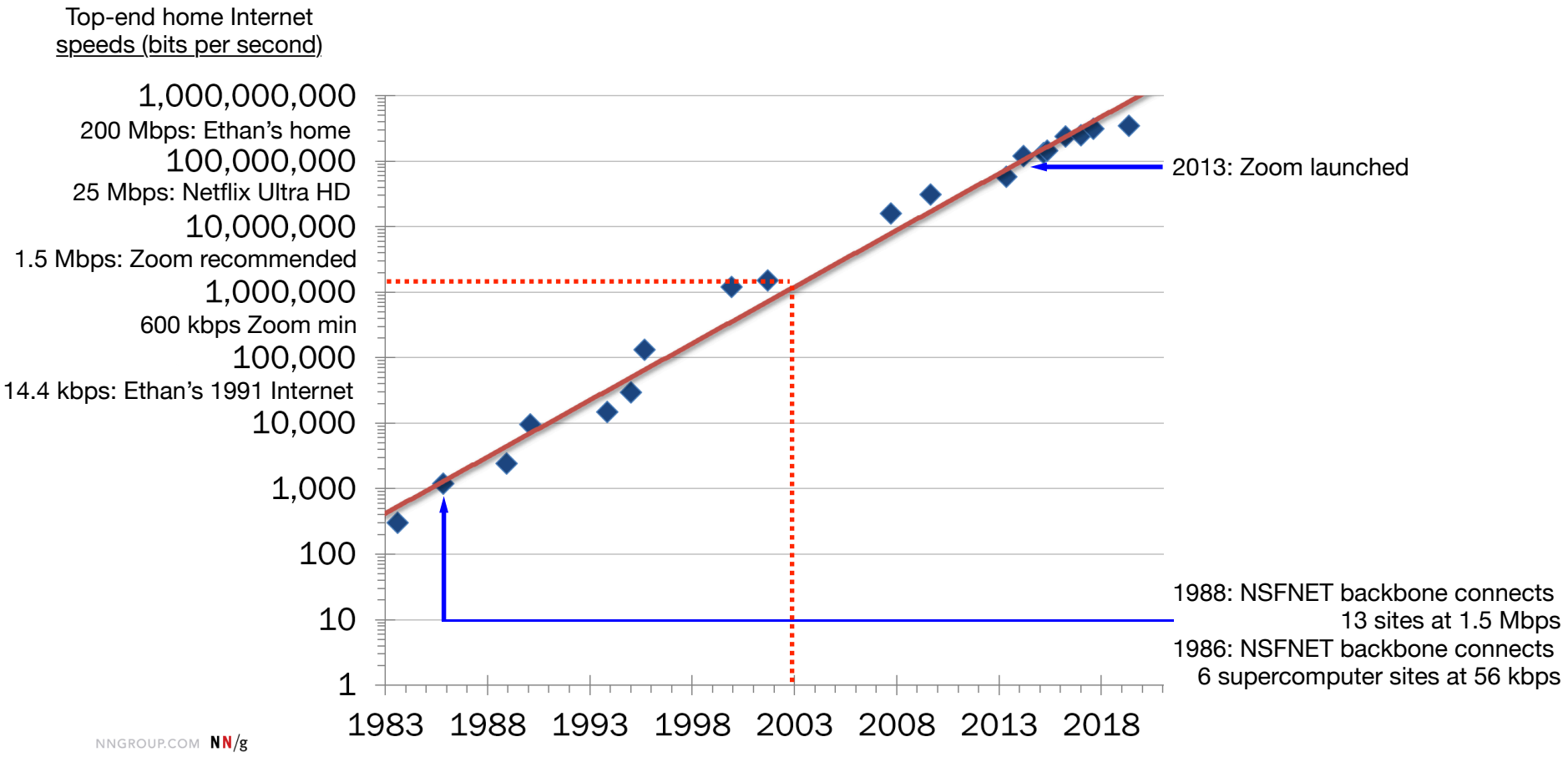
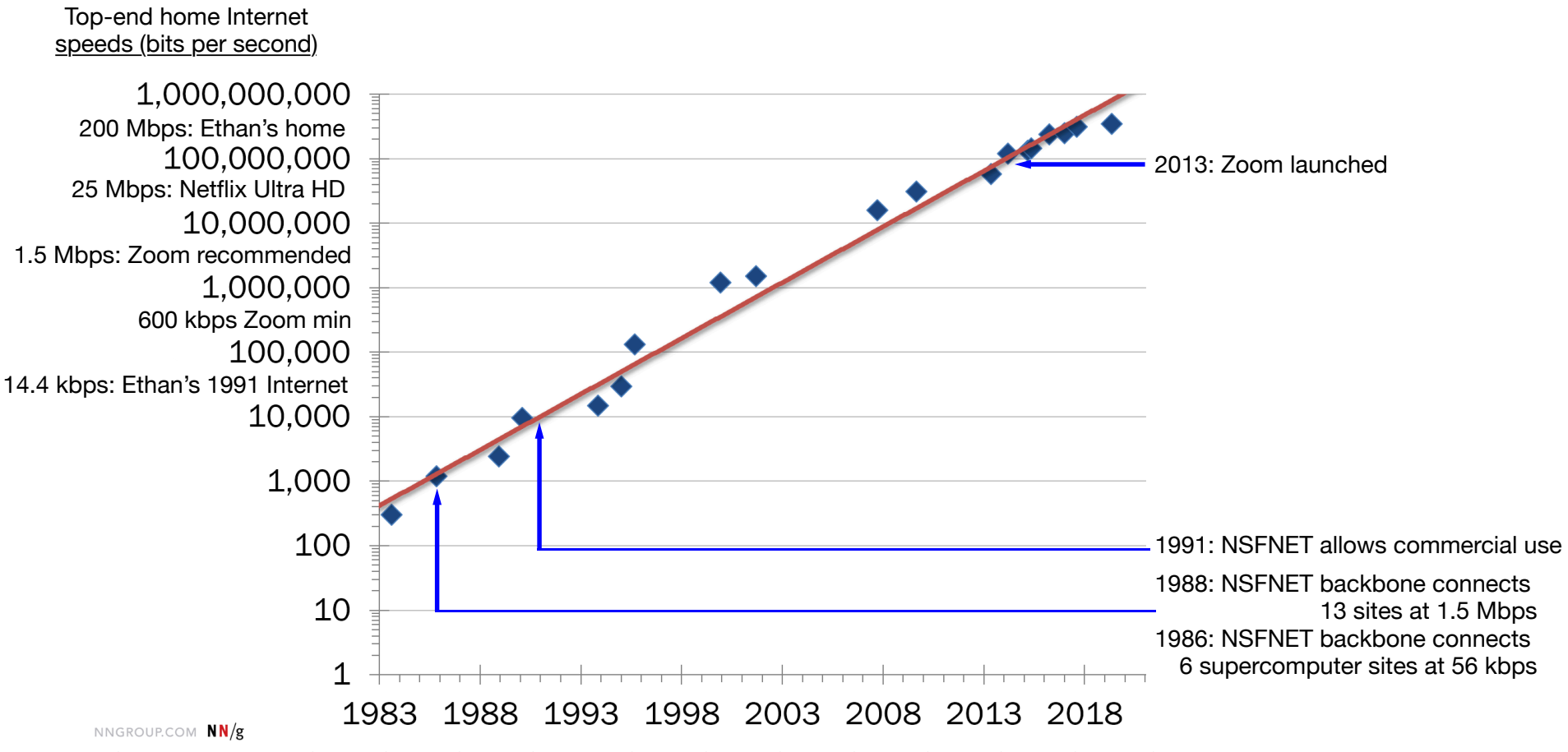


- NSFNET: backbone networks in US that developed into Internet
  - 1988: new NSFNET backbone is 1.5 Mbps…shared by all users
  - 2003: individual homes can get 1.5 Mbps

Some Internet history



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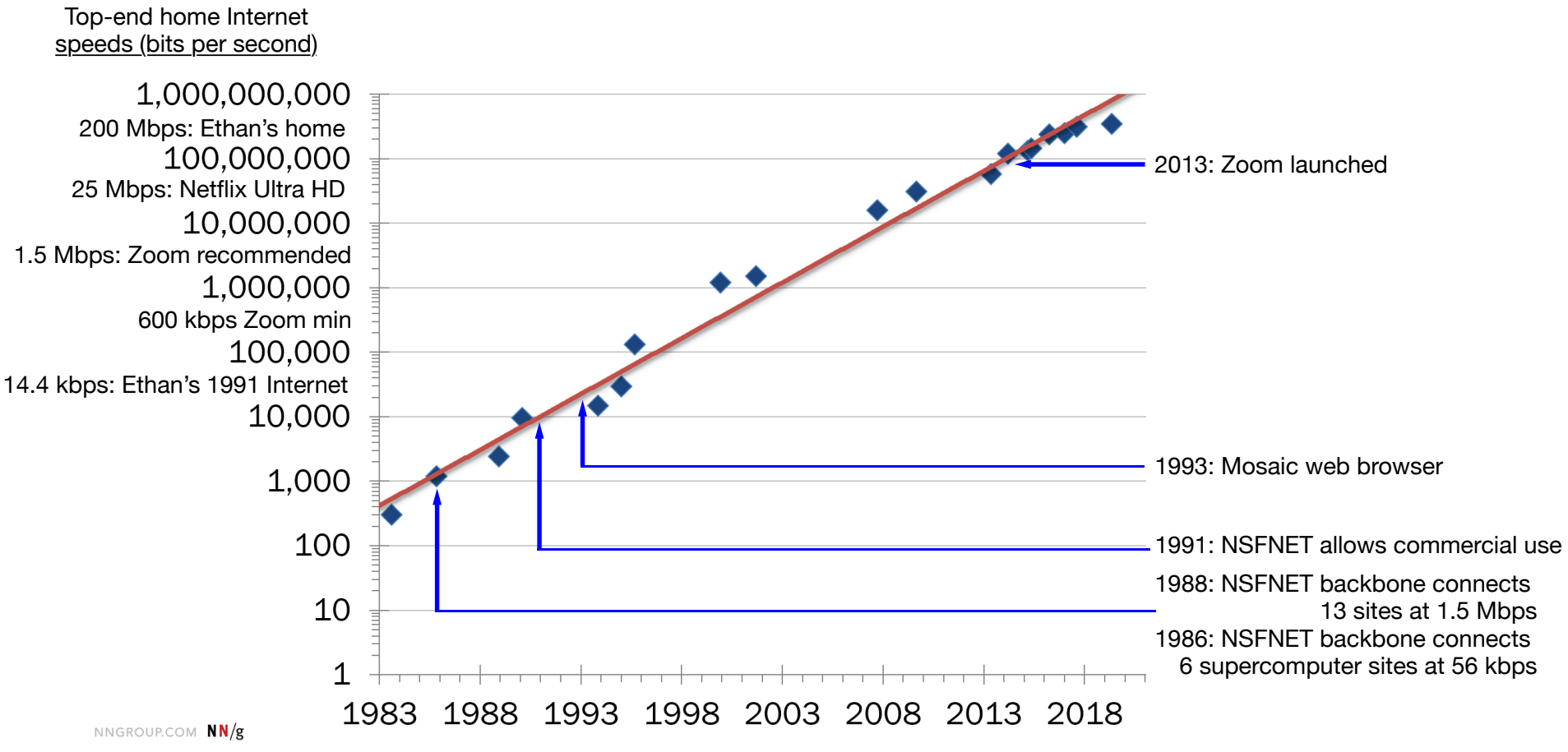

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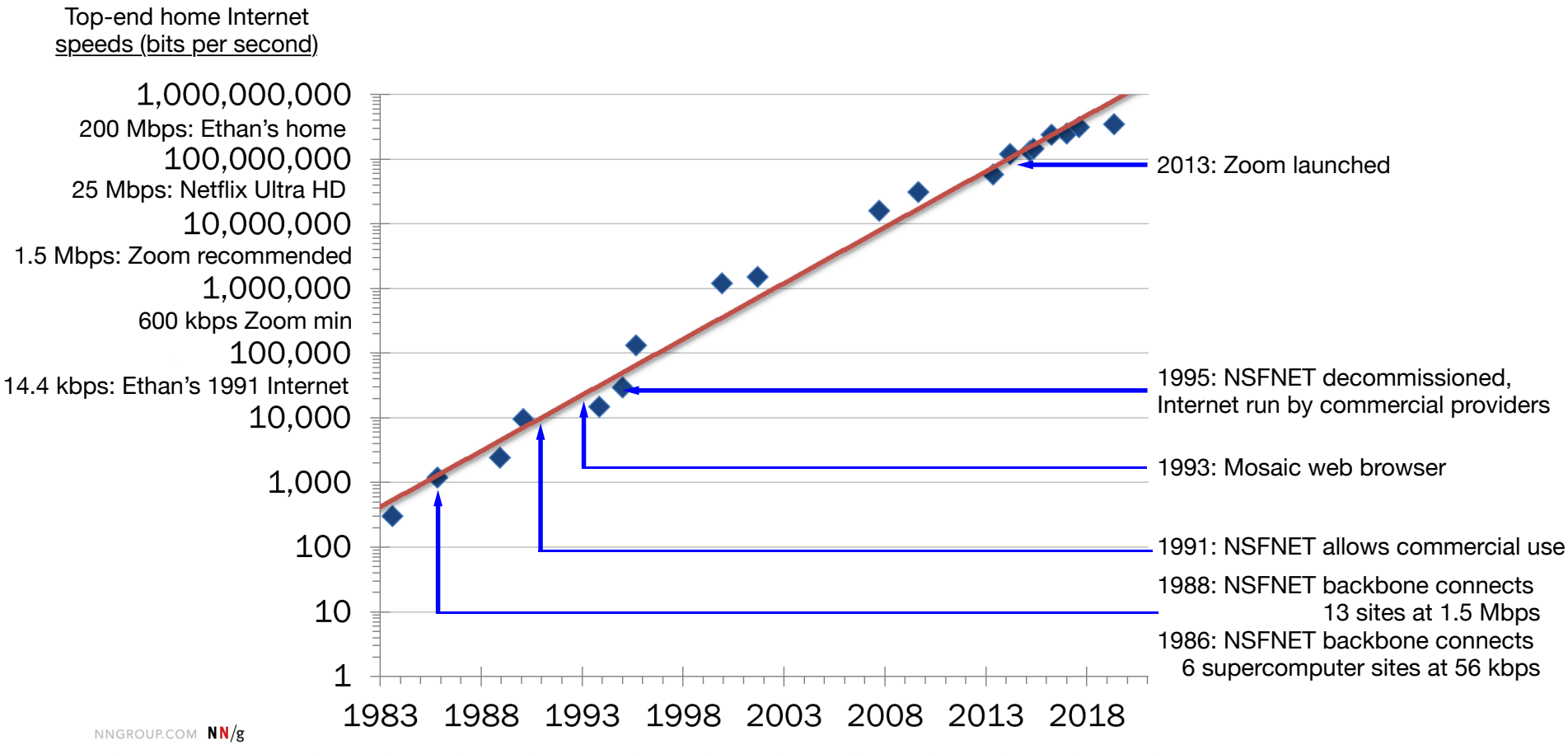

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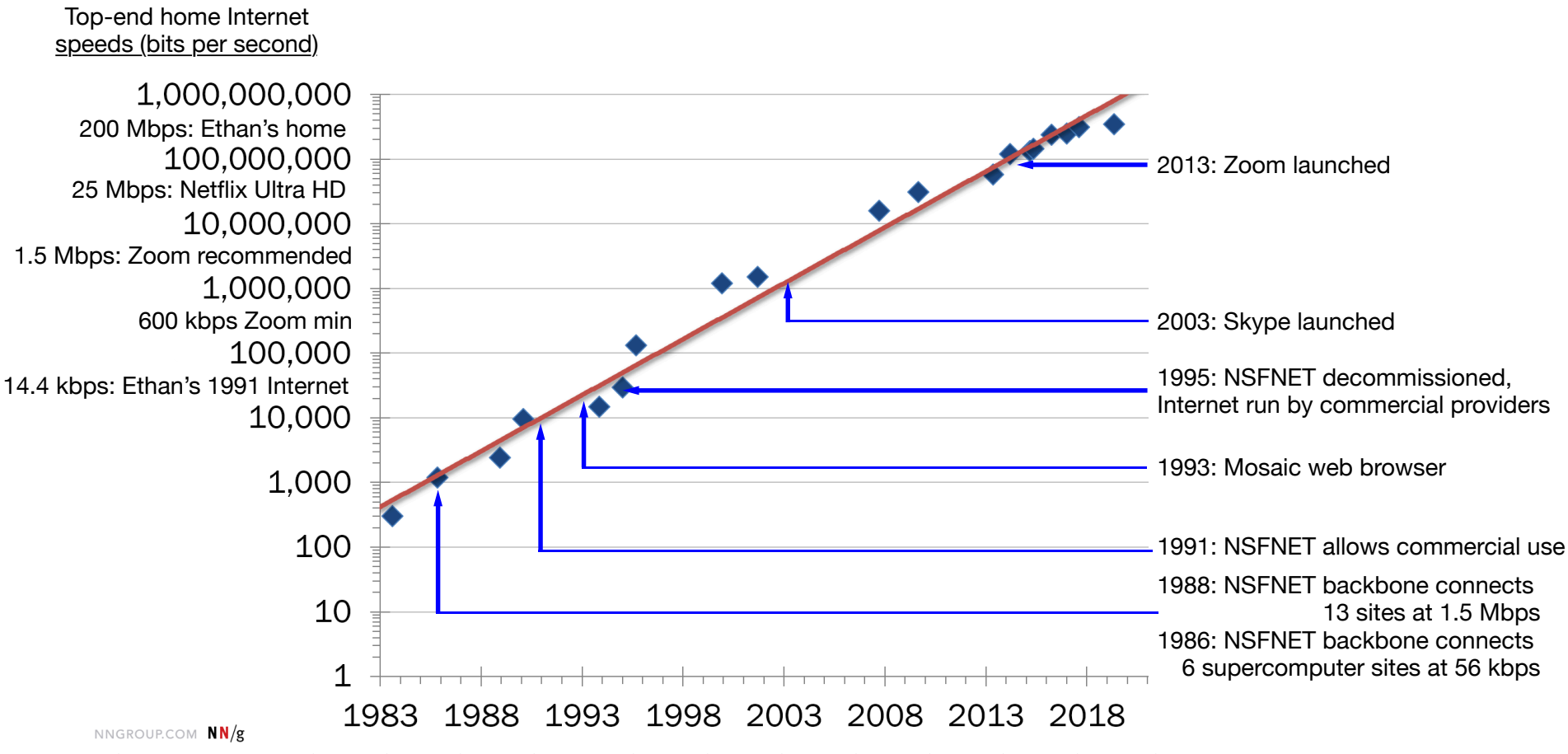

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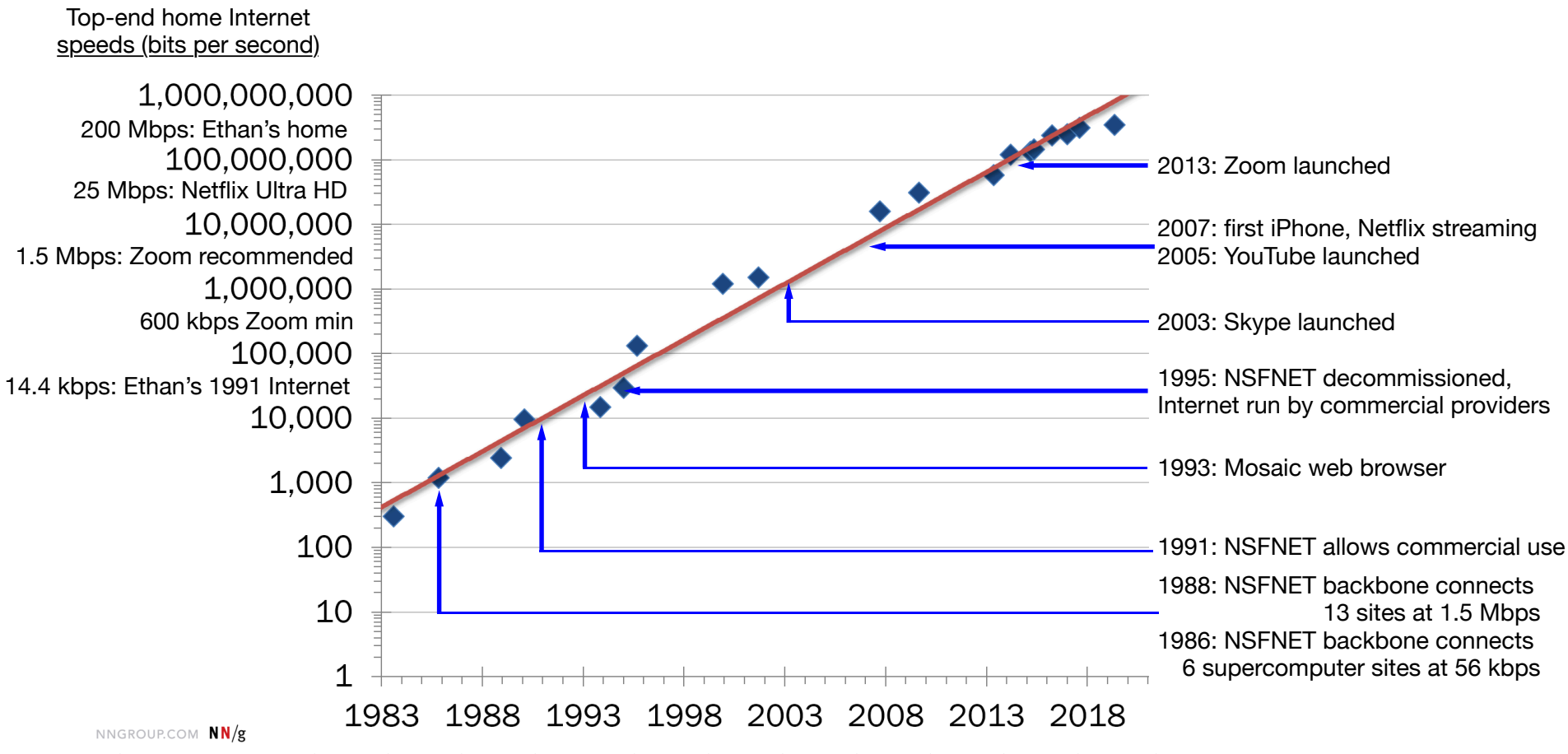

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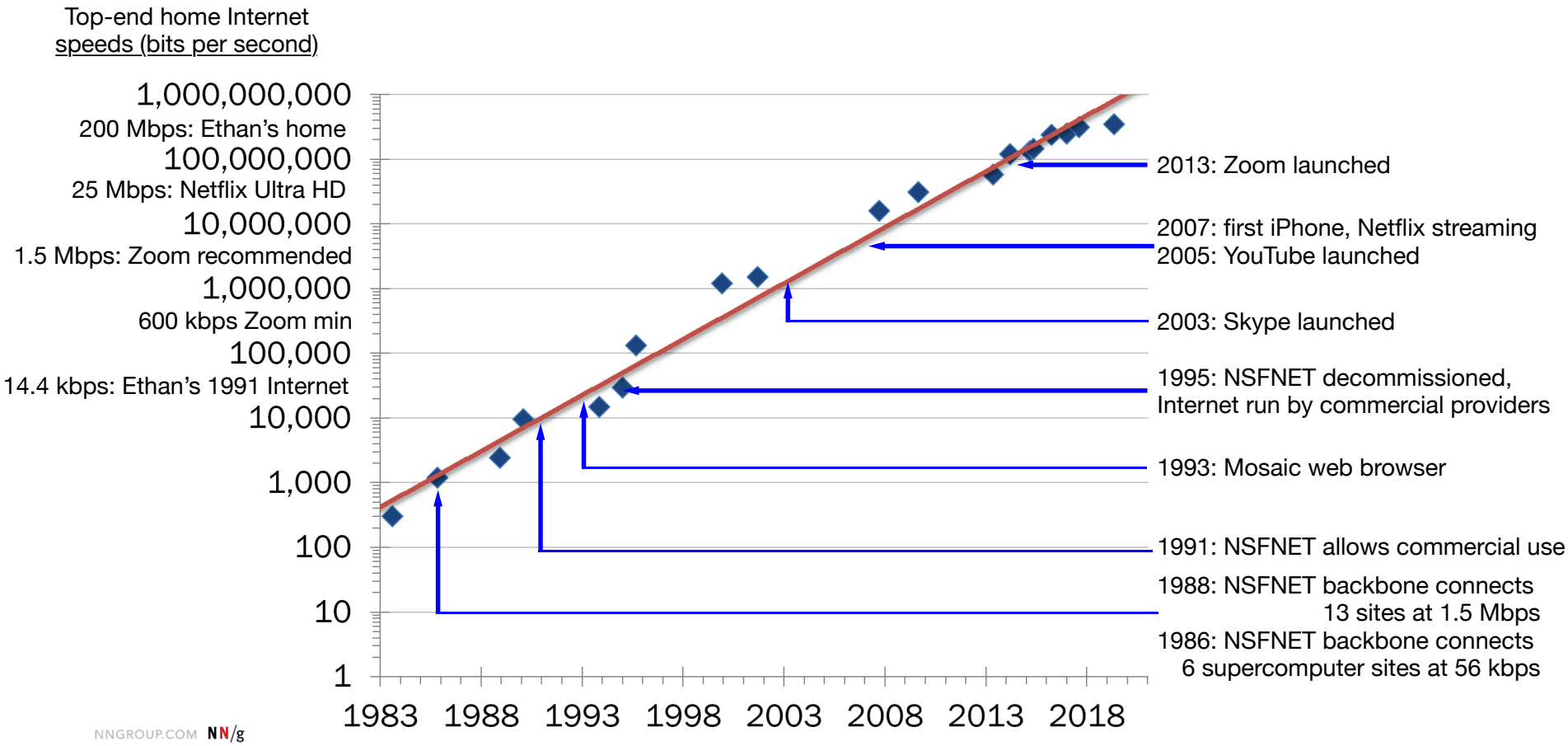
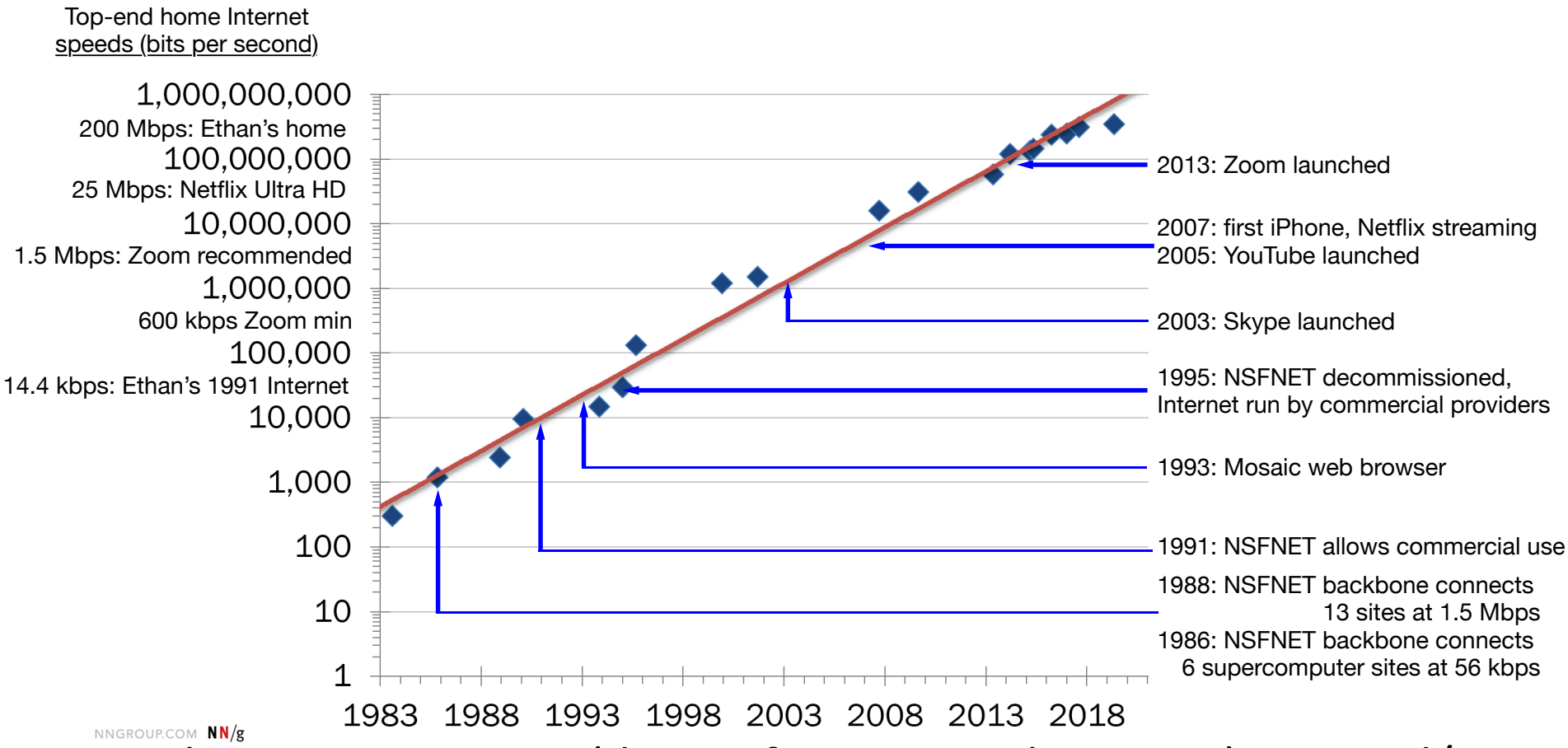


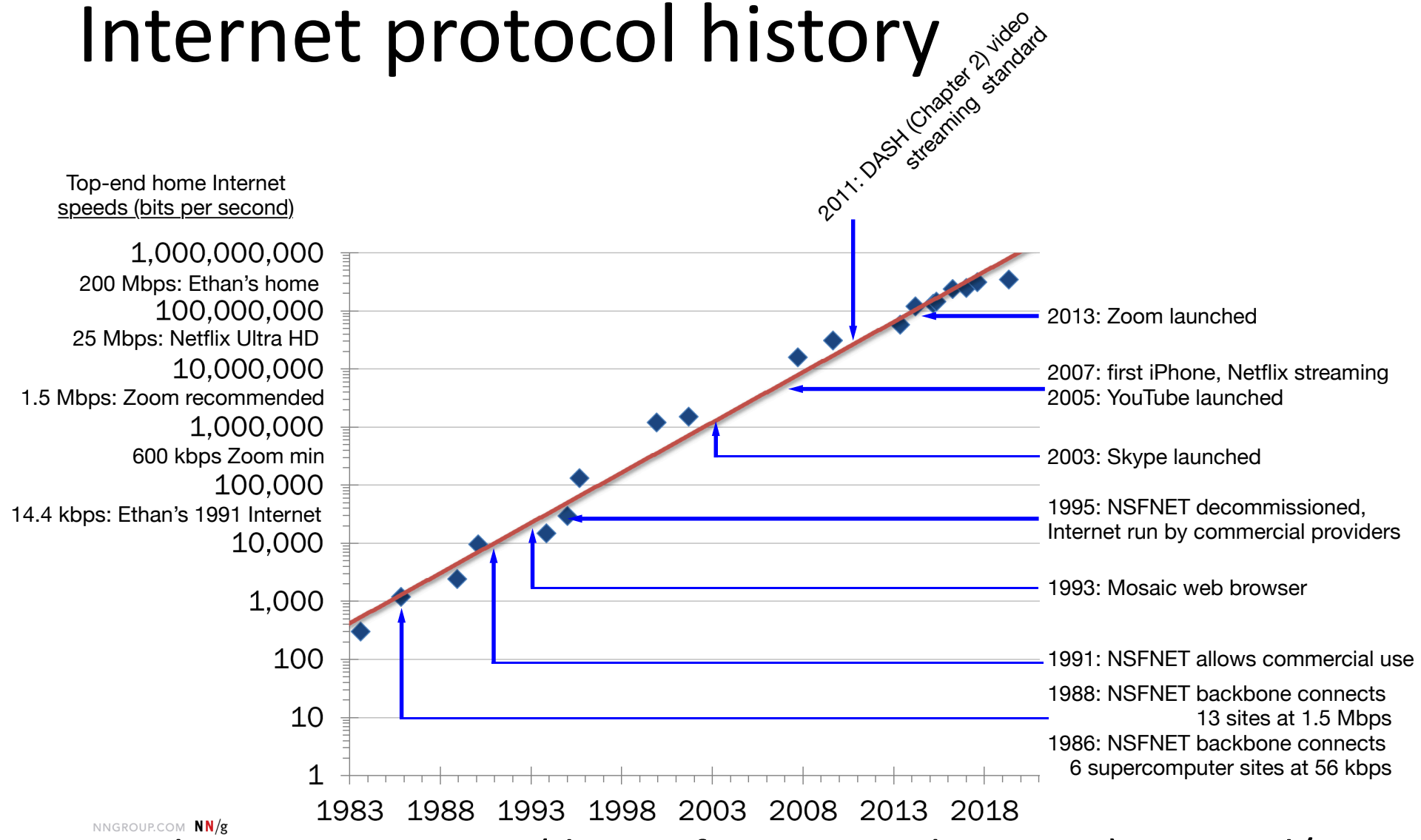
- Huge changes since 1995 (dawn of commercial Internet):
  - 25,000x increase in access speeds
  - 0.04% of world online -> 62% of world online
  - New use cases: mobile, streaming, interactive, …

Internet protocol history



- Huge changes since 1995 (dawn of commercial Internet) in speed/use
- What about its design?
  - Design defined by protocols (we'll discuss exactly what that means later)

Internet protocol history



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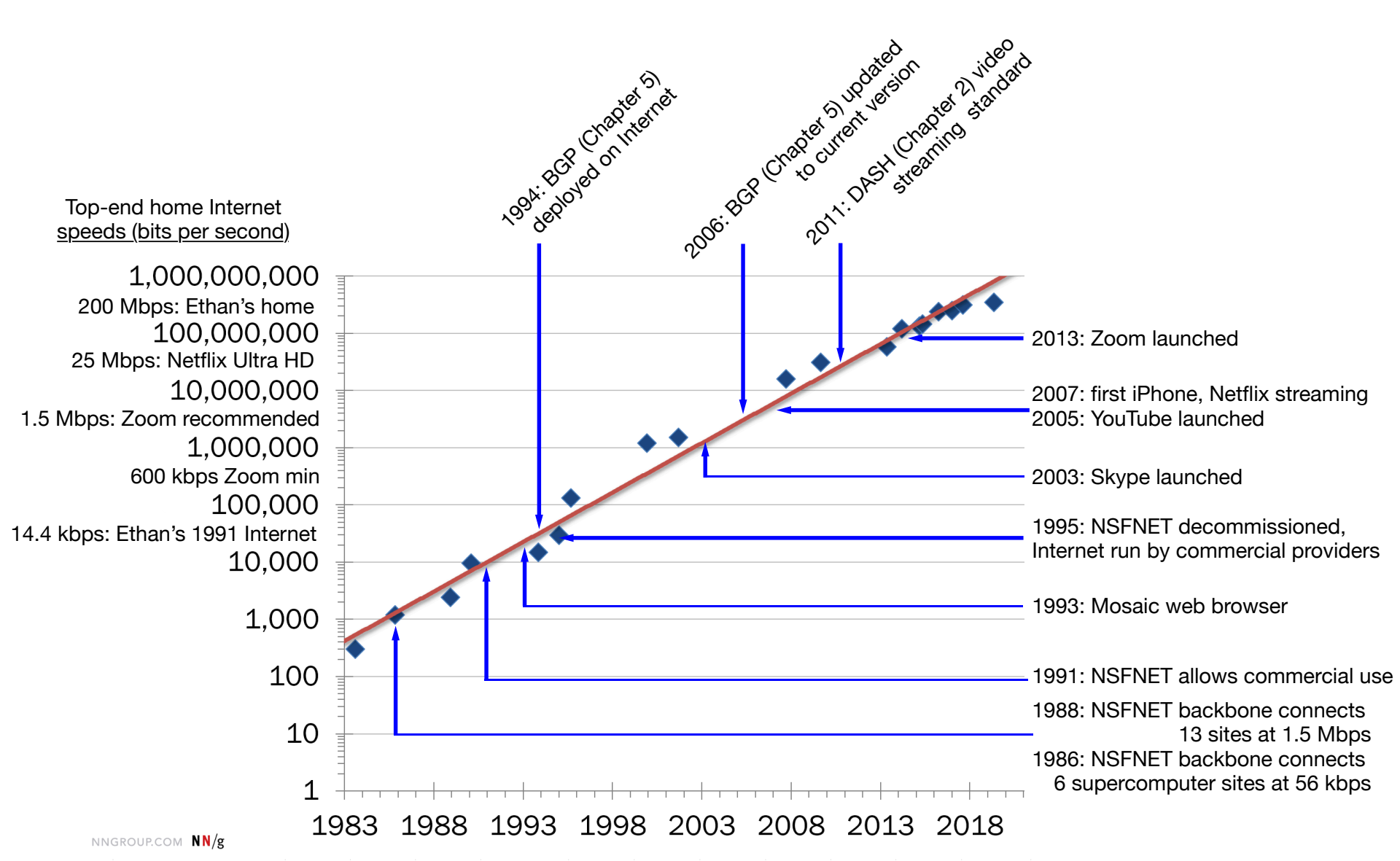
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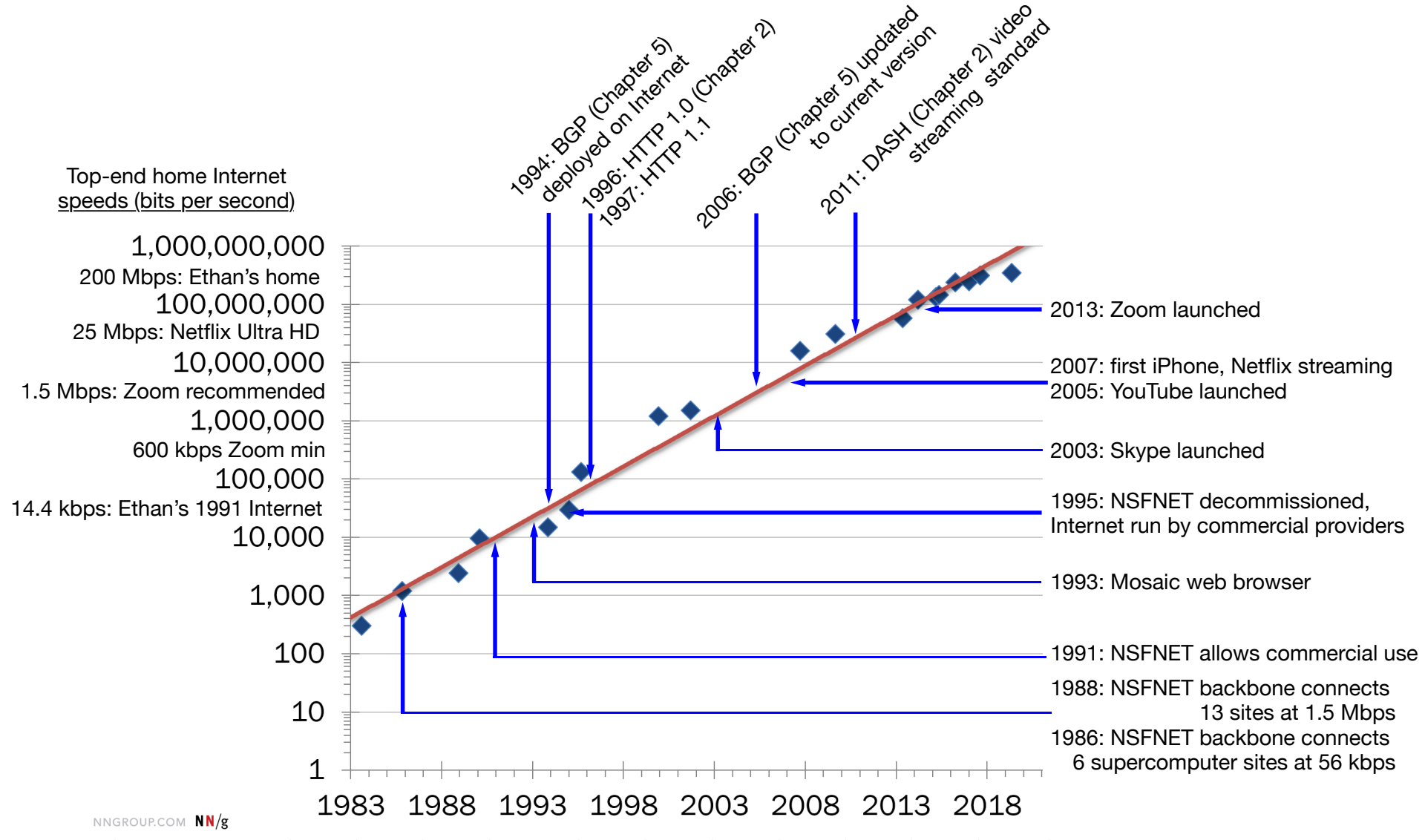
2013: Zoom launched
2007: first iPhone, Netflix streaming
2005: YouTube launched
2003: Skype launched
1995: NSFNET decommissioned, Internet run by commercial providers
1993: Mosaic web browser
1991: NSFNET allows commercial use
1988: NSFNET backbone connects 13 sites at 1.5 Mbps
1986: NSFNET backbone connects 6 supercomputer sites at 56 kbps
NNGROUP.COM NN/g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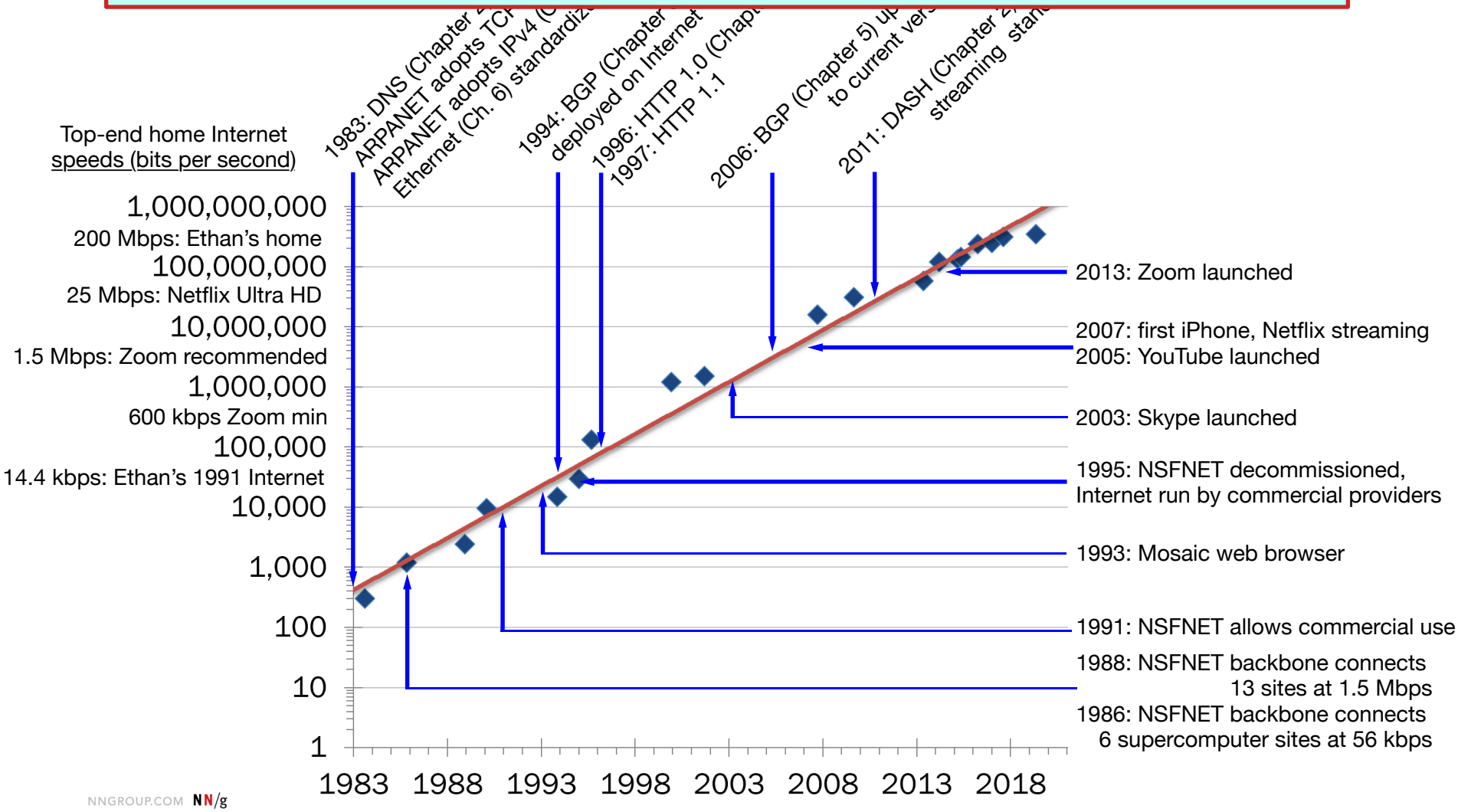
Networking challenge: *How to design for (unknown) growth/change?*



- Huge changes since 1995 (dawn of commercial Internet)…
- …but basic protocols defining Internet are nearly unchanged

Why study computer networking?

- Networking is ubiquitous.

  Innovations we use daily:
  - the Internet
  - the World Wide Web
  - Wi-Fi
  - Cell/LTE networks
  - Facetime / YouTube / Netflix
  - social networks: Facebook/Instagram

  • Challenges that remain:
  - Security
  - Reliable service in dynamic settings
  - Rich near-real time interactive content, AR/VR
  - Supporting underserved areas
  - Critical services

  Networking challenge: *How to support diverse and ever-changing use cases?*

  – We are using it right now to stream this class

  Networking challenge: *How to provide near-real-time interactive content?*

  – What has changed since you first used the Internet?

- Most current use cases didn't exist when Internet was designed. What principles/practices supported growth?

What we will study

- Application layer
  - How to build applications that span multiple computers and use Internet to communicate
  - How common Internet applications work (web, video, DNS,…)
- Transport layer
  - How to deliver messages across Internet, including:
    - Establishing communication between computers
    - Reliably delivering messages
    - Avoiding congestion despite many uncoordinated senders
- Network layer: How to steer data from source to destination
- Link layer: How to transfer data between direct neighbors, wired and wireless
- (soon, we'll discuss why we call these layers)

How we will study networking

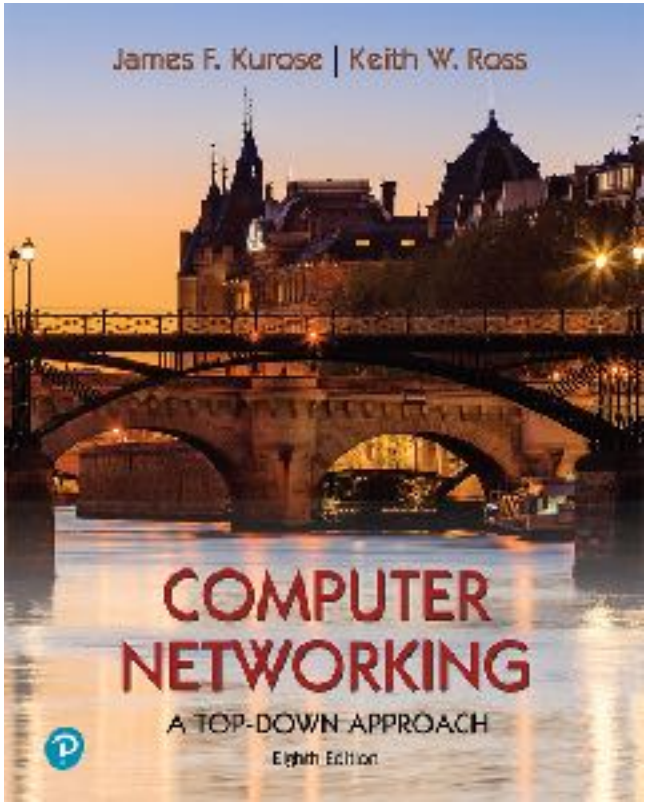
- Classroom time is primarily lecture-based
  - But please ask lots of questions
  - And join professor/TA office hours (we will survey for timezones and preferences once enrollment stabilizes)
- Your course work (we'll discuss more shortly)
  - Projects when you build a working internet and application
  - Written homeworks to reinforce material
  - Midterm/final
- Class closely follows book (we'll discuss more shortly)

Projects

- Build working networks/networked applications
  - Learn by doing
  - See the concepts in action
- Project 1: Build a video proxy that adapts video bitrate based on network conditions
  - Actually watch the video in a real web browser!
  - Learn network socket programming, writing client-side and server-side code
- Project 2: Build a working internet
  - Student is network operator, configures one network
  - Class-wide hackathon to interconnect to form a working internet
- Intermediate milestones to keep you on track

Why this book?

- *Who is this?*
  - Jim Kurose
  - Professor at UMass
- *Who is this?*
  - Keith Ross
  - Dean at NYU Shanghai
  - Professor at NYU (Brooklyn campus)

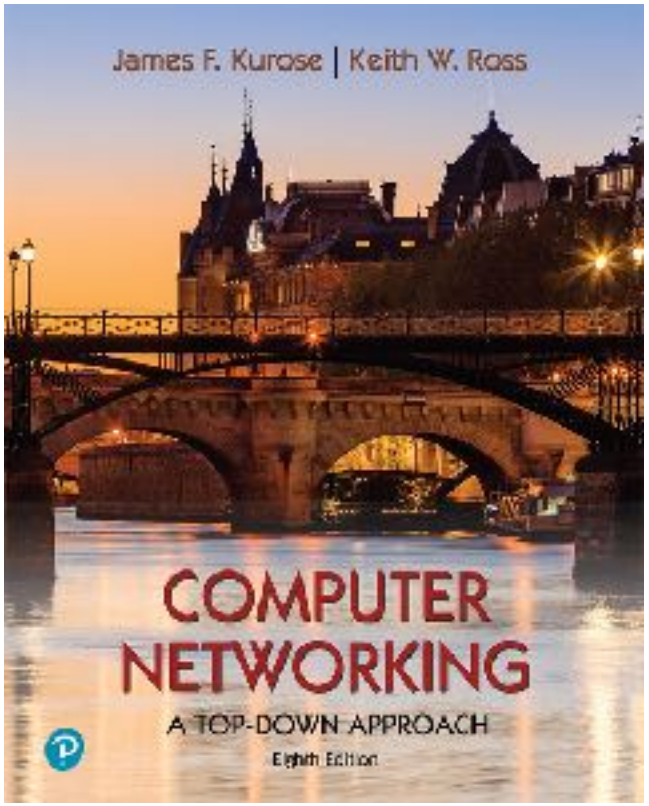


- *What do you have in common w/ Kurose & Ross?*
  - All about networking!
  - They went to Columbia!
- *What do I have in common with Kurose?*
  - All about networking!
  - My parents shop at same grocery as him

Computer Networking
A Top-Down Approach
8th edition
Jim Kurose, Keith Ross
Pearson, 2020

Why this book?

- Authors went to Columbia!
- Focuses on the Internet
  - Relatable
  - Internet design supported tremendous growth and change…how?
    - Principles and practice
- A top-down approach
  - Networking traditionally taught bottom up
    - Physical layer up towards applications
  - Top-down: applications down to physical
  - How do Internet applications we use work?
    - What is needed to support use cases?
    - Goal of network is to support applications
  - Many major changes at application layer



Computer Networking A Top-Down Approach
8th edition
Jim Kurose, Keith Ross
Pearson, 2020

What we will cover

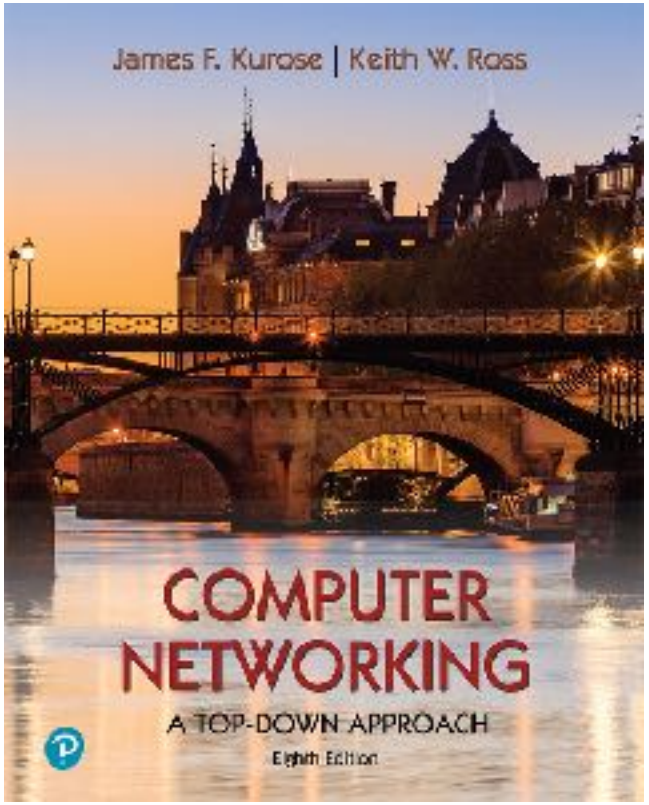
Chapters 1-6

1. Computer Networks and the Internet
2. Application Layer
3. Transport Layer
4. Network Layer: Data Plane

   (SDN is approach to separate data and control planes)
5. Network Layer: Control Plane
6. Link Layer: Links, Access Networks, LANs

If time allows, one of Chapters 7-9

7. Wireless and Mobile Networks
8. Security in Computer Networks
9. Multimedia Networking



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What do my students and I work on?

Chapters 1-6

1. Computer Networks and the Internet
2. Application Layer

We built system that controls which Microsoft servers to direct users to, speeding up user performance in some countries by 50%.

3. Transport Layer

We redesigned how Google servers recovery from packet loss, speeding up user performance by 23% on average.

4. Network Layer: Data Plane

We solved "the number one plague" of Internet troubleshooting and helped deploy our solution at Google.

5. Network Layer: Control Plane

We designed and built the system Facebook uses to select which routes to use to direct traffic to its 2 billion users.

6. Link Layer: Links, Access Networks, LANs

We developed a scheme for managing traffic in cable networks to improve video performance. We're talking to major cable companies.

Who's Who

- Professor:
  Ethan Katz-Bassett. Office hour: Mondays 2-3pm, CEPSR 817
  chance this will change
- TAs:
  - **Abhilash Venkatesh**
  - **Jennifer Wang**
  - **Rohan Kumar Sachdeva**
  - **Sebastian Manuel Hereu**
  - **Shuyue Yu**
  - **Xiangcong Kong**
  - **Yunfan Zhang**
  - **maybe more to come**

- We will have office hours most days of the week, at various times. Schedule to be announced.
- See next slide for details on how to contact us

Contacting us

- Please follow this order of preference to help us best reply in a timely manner and serve the full class:
  1. Use Ed Discussion unless there is a specific reason you cannot.
     a. Unless explicitly private (e.g., about your grade), please make it visible to your classmates. Fine to make it anonymous to classmates.
     b. If private, send to professor and all TAs.
  2. If you can't use Ed Discussion, email the appropriate list:
     - csee4119f22-instructor@googlegroups.com (TAs and professor)
     - csee4119f22-ta@googlegroups.com (TAs)
  3. If you can't email the list, email professor or individual TA
     - e-mail: ethan@ee.columbia.edu

       Please put [csee4119] as a prefix in the subject of all email to me (or I will miss the email and not reply).

       Please only email me if Ed Discussion is not an option.

Resources

- **main course pages are Ed Discussion and CourseWorks**
  - **you must join both**
  - **whenever I say Piazza, I mean Ed Discussion**
  - place for course announcements & course materials (HW, etc) (currently: syllabus and course description)
  - where you can ask questions of instructors
  - https://courseworks2.columbia.edu/courses/157112
  - where you submit assignments and get grades
  - includes a link to class Ed Discussion
- Make sure you are on Ed Discussion and CourseWorks and receive announcements from them
- Links to Ed Discussion and CourseWorks in syllabus: http://www.columbia.edu/~ebk2141/teaching/4119.html

Lectures

- Attend in person and ask questions
- Join Zoom live, but no live Q&A
- Videos will be made available on CourseWorks, under "Video Library"

Admin Highlights

- much more detail on *syllabus on CourseWorks*
  - *everyone should read this to get all the details*
  - *I will try to let you know when there are important updates to it, but my homepage and CourseWorks always link to most recent version*
- grading policy:
  - 50%: Assignments:
    - 33%: 2 projects (1 programming, 1 network configuration)
    - 17%: written homeworks covering chapters 1-5 (maybe 6)
  - 50%: Exams (more details on next slide):
    - 15%: Midterm.
    - 35%: Final. Cumulative.
- late policy:
  - Each day (24-hour period) or partial day late incurs a 20% penalty
  - 4 slip days. To request, you must add a CourseWorks comment to your assignment submission **after** submitting (but within 12 hours). See syllabus for request format. Can be used on HW or projects.
  - A slip day can only be used atomically.
- *no* make-up exams or assignments, *no* extra credit

Exams (and hackathon)

- Exams are closed book/notes. Final is cumulative.
- Midterm: in class, tentatively November 3
- In-class hackathon: tentatively November 22
- Final: registrar schedules,
  tentatively Tues. Dec. 20 or Thurs. Dec. 22.
  1:10-4:00pm*
- no make up dates (so plan ahead)
- *If you can't make those days, please postpone taking the class.*
- *If you have a medical emergency, contact me ASAP.*

Prerequisites

- Comfort with basic probability
  - No need for a full/particular class
- Programming fluency
  - 1st project requires programming in Python
  - We will cover network socket programming in class, but you are expected to know/pick up basic Python (including basic threading) on your own
    - If you know (Java/C++/Ruby/etc) and are willing to put in some effort to translate what you know to Python, it should be fine
- Able to navigate Linux environment
  - Either already experienced or willing to teach self

Academic Integrity

- Plagiarism and cheating are taken **very seriously**
  - ***0 for the assignment, possibly F for the course***
  - ***Every incident reported to Dean of Students***
  - (homework, program, exam, etc.)
- For homeworks, you can discuss general ideas, but every answer must be done separately and in your own words
- Programs must be your own code and will be automatically checked
- Read the full policy on the syllabus (and links from it)
- **any questions?** Ask me
  - **"I didn't know" is not acceptable**

Uploading course materials to sites such as CourseHero, Chegg or Github is academic misconduct at Columbia (see pg 10 of Columbia guide).