Alphabet

Alphabet Ecosystem

May 2024

GOOGLE SERVICES SEGMENT

FY2023 Revenues: $272.5 Billion

Google Services includes products and services such as ads, Android, Chrome, devices, Google Maps, Google Play, Search, and YouTube. Google Services generates revenues primarily from advertising; fees received for consumer subscription-based products such as YouTube TV, YouTube Music and Premium, and NFL Sunday Ticket; the sale of apps and in-app purchases and devices. Google generates revenue from sales of (1) hardware devices, app sales, and YouTube subscriptions, and (2) advertising displayed on Google Search, Google Network, and YouTube platforms.

Google

Google Subscriptions, Platforms and Devices

android, chrome, fitbit, Google Photos, Pixel, Nest, Gmail, waze, Google Maps, YouTube, Docs, Sheets, Slides

Google Advertising

YouTube Ads

YouTube

Google Network

Google AdSense, AdMob, Google Ad Manager

Google Search

Google

GOOGLE CLOUD SEGMENT

FY2023 Revenues: $33.1 Billion

Google Cloud offers enterprise customers a variety of consumption-based and subscription-based on demand cloud infrastructure and technology services (e.g., compute, storage, database, analytics, machine learning, and artificial intelligence) through (1) the Google Cloud Platform and (2) Google Workspace communication and collaboration tools. Google Cloud is the third largest cloud provider in the world, with an 11% share of the global cloud infrastructure services market.

Google Cloud

Google Cloud

Google Workspace

Google Cloud

Google Workspace

OTHER BETS SEGMENT

FY2023 Revenues: $1.5 Billion

Other Bets (or "moonshots") are technology-driven and problem-oriented developmental projects that are embedded in multiple operating segments that are not individually material and have the goal to become thriving, successful businesses. Revenues are generated primarily from the sale of health care related services and internet services.

Self-Driving Vehicles

WAYMO

Delivery Drones

Wing

Precision Healthcare Delivery

verily

Drugs for Age-Related Diseases

Salt-Base Energy Storage

MALTA

Artificial Intelligence
(includes AI chatbot and drug development)

Google DeepMind, Gemini, Isomorphic Labs

Quantum Computing
(for drug discovery)

SANDBOXAQ™

Sensors for Sustainable Agriculture and Oceans

mineral, Google Tidal

Electric Grid Virtualization

tapestry

Home Geothermal Energy Solutions

Dandelion

High-Speed Broadband Services

GFiber

Growth Equity and Venture Capital Funds

CapitalG, GV

Alphabet

Alphabet Ecosystem

Alphabet, Inc.
1600 Amphitheatre Parkway
Mountain View, CA 94043
Phone: (650) 253-0000; www.abc.xyz

Outside Relationships

Regulators

Subjects of U.S. and Foreign Regulation

Data Protection, Consumer Protection, e-Commerce, Advertising

U.S. Department of Justice (DOJ), Federal Trade Commission (FTC)
(**DOJ/FTC:** enforcement of antitrust and fair trade laws; **FTC:** enforcement of consumer protection laws and prohibition of unfair or deceptive practices or claims in advertising; **DOJ:** enforcement of foreign corrupt practices and anti-bribery laws)

U.S. Consumer Product Safety Commission (CSPC)
(regulation regarding product safety, distribution of certain material to children and collection of information from minors; product defects protection)

Billing and E-commerce
(regulatory proposals regarding Google Play billing policies)

Communications and Content

U.S. Federal Communications Commission (FCC)
(regulation of TV, satellite, radio, wire, and cable communications, including multi-channel video programing distributors of media, TV, film and digital content; and regulation regarding broadband access, fair competition, radio secrecy, homeland security, and public safety)

General

U.S. Department of Labor (DOL)
(**DOL:** regulation of work practices, wage and overtime record-keeping; **EEOC:** enforcement of anti-discriminatory laws in hiring, workplace practices and civil rights; **OSHA:** workplace health and safety, and serious injury reporting)

U.S. Department of Commerce (including Bureau of Industry and Security)
(regulation regarding export and import controls and licenses, tariffs and trade barriers)

U.S. Environmental Protection Agency (EPA)
(regulation of discharges, leaks, emissions, disposals, storage of particulate matter, hazardous waste, and toxic substances in the water, air and soil; Superfund cleanup requirement for contamination)

U.S. Department of the Treasury
(restricted party transactions and improper payments, and economic sanctions; regulation of money laundering)

Foreign

Data Protection Agencies
(personal data protection regulation)

Foreign Ownership and Investment
(regulation of foreign investments in critical industries of host nations)

Anti-Corruption
(prohibition on bribes and other payments to foreign government officials)

Capital

Public Debt Holders

Commercial Banks (Lead Bank: Bank of America)

Suppliers

Alphabet Worker's Union
(represents 800 out of 182,000 full-time employees, temporary employees, vendors, and contractors)

Key Categories of Supply

- Chemicals and Manufacturing Restricted Substances
- Solar Panels and Components
- Transportation Services (shipping, trucking, and railroads)
- Property Owners (warehouses and data centers)
- Data Center Equipment (servers, microprocessors, networking equipment—cables, adaptors, switches, routers, sensors, and connectors, graphics processing units, including with AI technologies, and data center software)
- Packaging Materials (plastics, cardboard)
- Metals (aluminum, steel, precious minerals)
- Software Applications and Service Developers
- Intellectual Property Owners
- Tele-communications (voice and data networks, mobile device and wireless networks and software development services, collaboration tools, and wireless telecom products)
- Electronic Components
- Batteries

Customers

Google OS Licensee, Subscription, and Device Customers

Operating Systems Licensees

- Multinational Original Equipment Manufacturers and Other Android Operating System Licensees
- Automotive OEMs

Subscriptions

- Smartphone, Tablet, Desktop, and Laptop Computer Users
- Auto Owners
- TV Watchers
- Game Players
- Video, Music, TV, and Other Content Consumers

Device Sales

- Individual Consumers

Business Regulation
Bond Financing
Working Capital Financing
Labor Union Representation and Collective Bargaining Services

Licenses to Use Various Iterations of the Android Open-Source Project Operating System, Google Mobile Services, Google Play Store, and Android Trademarks and Brands

Supplies of (1) Electronic Components, Datacenter Equipment, Hardware Supplies, Metals, Chemicals, and Packaging Materials, (2) Assembly, Manufacturing, Transportation, Telecom, and Software Development Services, and (3) User-Generated Content to YouTube Platforms

Android Automotive Infotainment Operating System and Google Automotive Services Licenses

Consumer Sales of (1) Cloud Storage (via Subscription), (2) Productivity, Mail, Calendar, Messaging, Map/Navigation, Music, Photo, and Other Applications and Services (via Downloads and/or Subscription), (3) Video Games (via Purchase and Download) and In-App Purchases, and (4) YouTube Music, YouTube Premium, and YouTube TV Streaming (via Subscription or a Free, Ad-Based Service)

Sales of Hardware (Fitbit Wearable Devices, Google Nest Home Products, Pixel Smartphones, and)

Alphabet Inc. (a Delaware corporation)

Debt Structure

Debt ($14.701 Billion @ 12/31/23) | Credit Ratings: S&P: AA+, Moody's: Aa2

Commercial Paper Program:	2024 – 2028 Revolving Credit Facilities	2024-2060 Notes: $13.0B @ 0.45% - 3.38%
Available: $10.B Outstanding: $0	Available: $10.0B Outstanding: $0	

Logo History

Corporate Brands

1997-1997	1997	1997-1999	1999-2010
Google	Google	Google!	Google
2010-2013	**2013 - 2015**	**2015 - Present**	**2015 - Present**
Google	Google	Google	Alphabet

Equity Structure

Share Capital and Repurchases

Preferred Stock	Class A and C Stock Repurchase Program	Class C Capital Stock	Class B Common Stock	Class A Common Stock
Authorized: 100M Shares Outstanding: 0 Shares Record Holders: None	Authorized: $70.0B (Class A + Class C) Remaining: $36.3B Expiration: None	(No Vote) Authorized: 60.0B Shares Outstanding: 5.671B Shares Record Holders: 1,757	(10 Votes; Convertible at Any Time at the Option of the Shareholder and Automatically Upon Sale or Transfer to Class A Common Stock) Authorized: 60.0B Shares Outstanding: 869M Shares Record Holders: ~59 (Founders/Insiders)	(1 Vote) Authorized: 180.0B Shares Outstanding: 5.893B Shares Record Holders: 7,305

Governance

Board of Directors

Larry Page (E)	L. John Doerr (L)	**Committees** Audit and Compliance (A) Leadership Development, Inclusion, & Compensation (L) Nominating and Corporate Governance (N) Executive (E)
Sergey Brin (E)	Roger W. Ferguson Jr. (A)	
Sundar Pichai (E)	Robin L. Washington (L)	
John L. Hennessy (N)	K. Ram Shriram (L)	
Frances H. Arnold (N)	R. Martin Chavez (A)	

Executive Team

CEO: Sundar Pichai	CEO, Google Cloud: Thomas Kurian	SVP Devices and Services: Rick Osterloh
President, Chief Investment Officer (and outgoing-CFO) Alphabet and Google: Ruth M. Porat (with oversight of Other Bets)	President, Global Affairs, Chief Legal Officer and Secretary Alphabet and Google: Kent Walker	SVP, Knowledge and Information Google (Google Search, Assistant, Geo, Ads, Commerce and Payment Products): Prabhakar Raghavan
SVP, Chief Business Officer, Google: Philipp Schindler	SVP, Platforms and Ecosystems: Hiroshi Lockheimer	

Business Relations

Global and Regional Sales Activities for Google and YouTube

Global, Technical, and Consumer Support and Operations

Key Product Area Partnerships

Key Product Area Development Teams

People Operations

- Workforce Strategy
- Talent Acquisition and Development
- Specialized Services (Temporary Staffing Agencies, Café Operations, Content Moderation, Customer Support, Physical Security)
- Compensation and Benefits
- Immigration
- Employee and Works Council Relations
- Diversity, Equity, and Inclusion
- Culture and Employee Engagement

Products

- Google Search
- Assistant
- Geo
- Ads
- Commerce
- Payments

Supply Chain

- Third Party Manufacturing
- Procurement
- Semiconductor Chip Production
- Supplier Relations

Finance

- Finance
- Accounting
- Treasury
- Tax
- Financial Reporting
- Financial Planning & Analysis
- Risk Management
- Internal Audit
- Business Operations
- Rea Estate and Workplace Services

Corporate Matters

Information

- Business Applications and Software Licenses
- IT Infrastructure and Networking Equipment
- Machine Learning
- Analytics
- Software Development
- E Commerce Platforms
- Artificial Intelligence (responsible AI, AI infrastructure, data science, contact center, Gemini generative AI)

Legal

- Content Policy
- Legal Operations
- Litigation Management
- Employment Law Matters
- IP Management
- Responsible Innovation
- Government Affairs
- Corporate Governance and Secretarial Matters
- Philanthropy

Operations

Google Services

2023 Revenues: $272.543 Billion (88.7%)

Google Services includes products and services such as ads, Android, Chrome, devices, Google Maps, Google Play, Search, and YouTube. Google Services generates revenues primarily from advertising; fees received for consumer subscription-based products such as YouTube TV, YouTube Music and Premium, and NFL Sunday Ticket; the sale of apps and in-app purchases and devices. Google generates revenue from sales of (1) hardware devices, app sales, and YouTube subscriptions, and (2) advertising displayed on Google Search, Google Network, and YouTube platforms.

Google Subscriptions, Platforms, and Devices ($29.055 Billion)

Android, Androidtv, Android Auto
Operating system designed primarily for touchscreen mobile devices (smartphones/tablets), TVs, and vehicles.

Chrome
Operating system designed primarily for the Chromebook; it uses the Google Chrome web browser as its principal user interface.

Google Play
Online store on Android and digital distribution service for 2.5+ billion monthly users across 190+ markets worldwide.

Google Photos
A consumer photo application for mobile and web that enables users to store, share, automatically back up, organize, and edit digital photos.

Google Maps
A web service providing detailed information about geographical regions and sites worldwide, including conventional roadmaps with aerial and satellite views.

Google Drive
A free service allowing users to store and access files online and to access free web-based applications for creating documents, spreadsheets, and presentations.

Gmail
A free web-based email service that provides users with 15GB of storage for messages and the ability to search for specific messages and automatically organizes related messages into a conversational thread.

YouTube Subscription
A free and subscription website service that enables users to create, upload, watch, and share videos online.

Other Applications
Google's other well-known applications and platforms for language translation, digital payments, navigation and imagery, and health.

Pixel Devices
Smartphone with android O/S and Google's Tensor chip.

Nest Devices
Smart speakers enabling voice commands for virtual assistance; also includes WiFi devices, door locks / cameras, and thermostats.

Fitbit Devices
Wearable smart watches, pedometers, and physical fitness monitors.

Chromecast Device
Internet content streaming device for TV/audio systems plus operating system for TV sets.

Google Advertising ($224.473 Billion)

YouTube Ads ($29.243 Billion)

- YouTube: YouTube video sharing and social media platform
- YouTube Kids: Video hosting app and website for children
- Music: Song and music video streaming service
- Shorts: Short-form (<60 seconds) version of YouTube
- YouTubeTV: Television streaming service

Google Network ($32.780 Billion)

- AdMob: Free platform that enables developers to earn money by displaying targeted in-app ads alongside their app content on mobile devices
- Google AdSense: Advertisers compete for space on websites to publish their ads targeted to the site content and audience maintained by Google. Site owner and Google generate revenue on a per-click/per-impression basis
- Google Ad Manager: Online ad exchange allowing site owner to (1) manage inventory of ads and audiences those ads serve, (2) check the performance of ads, (3) manage the buying/selling of ads by other networks

Google Search and Other ($162.450 Billion)

- Google: Google's proprietary search properties
- Ask, Lycos, dogpile: third-party partners using Google as default search engine
- Google Maps, YouTube: internal partners using Google as default search engine

Google Services Competition

O/S	Hardware	Digital Video	Video Sharing	Search	Advertising	E-Commerce
Microsoft amazon	DELL Microsoft HUAWEI SAMSUNG	amazon prime video NETFLIX hulu tv+ Disney+ pedcock	Instagram TikTok	Yandex Bai du NAVER yahoo!	Meta amazon Microsoft Alibaba.com	Walmart+ prime ebay Alibaba.com

Google Cloud

2023 Revenues: $33.088 Billion (10.8%)

Google Cloud offers enterprise customers a variety of consumption-based and subscription-based on demand cloud infrastructure and technology services (e.g., compute, storage, database, analytics, machine learning, and artificial intelligence) through (1) the Google Cloud Platform and (2) Google Workspace communication and collaboration tools. Google Cloud is the third largest cloud provider in the world, with an 11% share of the global cloud infrastructure services market.

Infrastructure

Data centers power Google's cloud infrastructure, cloud services and innovation engines, including its flagship Google Cloud Platform. Google Cloud has been investing heavily in new AI and generative AI products that rely on and are powered by data centers. Google's data centers power the company's global 40 Cloud Regions and 121 Cloud Zones available in over 200 countries and territories. Google's data center footprint also has 187 network edge locations.

AI-Optimized Infrastructure
(provides open, reliable, and scalable compute, networking, and storage to enable customers to (1) run workloads anywhere, (2) migrate and modernize IT systems, and (3) train and serve various types of AI models.)

Cybersecurity
(helps customers detect, protect, and respond cybersecurity threats. AI integrated to further strengthen security outcomes, detect cyber threats to investigate, identify attack paths, and accelerate resolution of cybersecurity threats.)

Database and Analytics
(provides a variety of different types of databases — relational, key-value, inmemory — to store and manage data for different types of applications. Google Data Cloud also unifies data lakes, data warehouses, data governance, and advanced machine learning into a single platform that can analyze data across any cloud.)

AI Platform & Duet AI
(The Vertex AI platform enables developers to train, tune, augment, and deploy applications using generative AI models and Enterprise Search and Conversations services. Duet AI for Google Cloud provides pre-packaged AI agents that assist developers to write, test, document, and operate software.)

Business Units

Google Cloud

Industry Solutions
(retail, consumer packaged goods, manufacturing, automotive, supply chain / logistics, energy, healthcare and life sciences, media / entertainment, games, telecom, financial services)

Infrastructure Modernization
(active assist, migrations of applications and data centers, backup disaster recovery, Rapid Storage, compute, storage, performance, connectivity, mainframe modernization, observability, SRE, Red Hat and Windows on Google Cloud, virtual desktops)

Jump Start Deployments
(Cymbal bank website, Boot-Balanced virtual machines, large documents summaries, AI/ML image processing, Java application, three-tier web app, ecommerce web app, analytics lakehouse, data warehouse using Bigquery)

Security
(security foundation, analytics, operations, and resilience framework, web app / API protection, risk/compliance as code, software supply chain security)

Digital Transformation
(operational efficiency, health-care industry systems, in-house development, innovations)

APIs and Applications
(new business channels using APIs, open banking APIs, unlocking legacy applications using APIs)

Data Cloud
(AI, database, smart analytics solutions)

Government and Public Sector Solutions
(state, local, and federal government, cybersecurity, education, technology, Canada public sector, Department of Defense, and Google Workspace for Government)

Smart Analytics
(data warehouse and lake modernization, Spark on Google Cloud, stream analytics, business intelligence, data science, marketing analytics, geospatial analytics and AI, datastore, centric framework)

Application Modernization
(CAMP, modernizations of traditional applications and software delivery, migrations from PaaS and quantitative, DevOps best practices, SRE principles, day 2 operations for GKE, Anthos and optimizations of GKE, run applications at the Edge, distributed, hybrid, multi-cloud, serverless, API management)

Databases
(games, migrations of databases and Oracle workloads to Google Cloud, modernization, database portfolio, SQL server on Google Cloud, open source databases)

Productivity/Collaboration
(Google Workspace, Chrome enterprise, cloud identity search)

Startups and Small and Medium-Sized Businesses
(Google Cloud for Web3, signing solutions, startup program SaaS)

Artificial Intelligence
(contact center AI, document AI, product discovery, duet AI)

Google Workspace

Google Workspace and Duet AI in Google Workspace (1) provide easy-to-use, secure communication and collaboration tools, including apps like Gmail, Docs, Drive, Calendar, and Meet, (2) enable secure hybrid and remote work, boosting productivity and collaboration and (3) in the case of Duet AI, write, organize, visualize, accelerate workflows, and have richer meetings.

Applications

- Gmail: Business Email
- Calendar: Shared calendars
- Drive: Cloud Storage
- Meet: Video / voice conferencing
- Docs: Word processing
- Sheets: Spread-sheets
- Slides: Presentation builder
- Chat: Messaging for teams
- Forms: Create surveys / forms
- Sites: Create team sites
- Keep: Note taking service
- Apps Script: Create custom apps

Security and Management

- Admin: Manage Google Workspace for organization
- Endpoint: Manage past Workspace tools, screenshots, account wipes
- Vault: Data retention and e-discovery
- Work Insights: Data on app use, work patterns, collaboration

Cloud Competition

Cloud Infrastructure
aws, Alibaba Cloud, Microsoft Azure, ORACLE Cloud Infrastructure, IBM Cloud

Cloud-Based Apps
aws, salesforce, ORACLE, SAP, slack, Office 365, ZOOM

Other Bets

2023 Revenues: 1.527 Billion (0.5%)

Other Bets (or "moonshots") are technology-driven and problem-oriented developmental projects that are embedded in multiple operating segments that are not individually material and have the goal to become thriving, successful businesses. Revenues are generated primarily from the sale of health care related services and internet services.

Transportation and Logistics

Waymo
Self-driving cars in San Francisco, Phoenix, and Los Angeles (applied for)

Wing
Delivery drones

Taara
Internet service delivery via laser beams

Health and Life Sciences

Verily
Healthcare and disease prevention research and precision care delivery

Calico
Drugs for age-related diseases

Urban Innovation and Infrastructure

Malta
Salt-based and grid-scale energy storage technology that stores electricity from renewable energy sources

Artificial Intelligence, Robotics, and Connectivity

Google DeepMind
AI and machine learning, including the Gemini AI chat bot and drug developer Isomorphic Labs

Chronicle
Cybersecurity intelligence and analytics platform

SandboxAQ
Quantum computing technology partnership with Nvidia to pursue drug discovery projects

Sustainable Agriculture and Environment

Tidal
Underwater camera system and machine perception to save the oceans

Mineral
AI sensors, robotics, other big data analysis tools used to support sustainable agriculture

Communications and Data

Chorus
Logistics/supply chain sensor technology, software and machine learning tools

Tapestry
Electric grid virtualization

Home and Energy Solutions

Dandelion
Home geothermal energy solutions

GFiber
High-speed broadband fiberoptic internet business in 15 cities

Educational and Business Services

Capital G
Growth equity investment fund

Google Ventures
Venture capital for diverse startups

Competition

Artificial Intelligence	Investment Funds	Internet Services	Life Sciences / Health
(Google DeepMind) OpenAI Copilot ANTHROPIC LLaMA by Meta	(Capital G, Google Ventures) SoftBank TIGERGLOBAL PERSHING SEQUOIA	(Google Fiber) LUMEN AT&T verizon xfinity	(Verily, Calico) evolent HUMA

Outside Relationships

Customers

Segment Customers

- Individuals (autonomous vehicle rideshare passengers)
- Retailers (drone delivery)
- Healthcare Industry and Employers (precision health services and stop-loss insurance)
- Electric Power Market, (long-duration energy storage)
- Researchers (application of AI tools to drug discovery, cyber security, etc.)
- Agricultural Market (ag-tech services)
- Supply Chain Industry (supply chain Sensor tech services)
- Residential Housing and Commercial Real Estate Market (geothermal heating and cooling pumps)
- Individual Consumers at Home (high-speed internet service)

Suppliers

Professional and Support Services Firms

Professional

- Ernst & Young (audit services)
- WPP GroupM / Essence Digital (advertising services, including generative AI-driven marketing collaboration)
- Paul Weiss; Williams & Connolly (DOJ/anti-trust litigation services)
- Wilson Sonsini (free speech and anti-trust litigation services)
- Key Lobbying Firms (Cornerstone Government Affairs, Crossroads Strategies, Fulcrum Public Affairs, Holland & Night, S-3 Group)

Support

- Café Operators
- Customer Support Services
- Content Moderation Monitors
- Temporary Staffing Agencies
- Physical Security Services Firms

Key Other Bets Collaborators

- Nvidia (investment in Google SandboxAQ)
- Silver Lake, Temsek Fund (investment in Verily)
- Eli Lilly, Novartis (research collaborations with Isomorphic Labs)
- AbbVie (therapy discovery and development with Calico for patients with amyotrophic lateral sclerosis (ALS) and neuro degenerative disorders)
- Uber (partnership to give riders the option of a fully autonomous ride in Phoenix)

Capital

Significant Shareholders

Class A Common (1 vote per share)

- Vanguard Group (6.97%)
- BlackRock (6.03%)
- State Street Corp (3.23%)
- Fidelity Management & Research (1.99%)
- Geode Capital Management (1.69%)
- Institutional Ownership: 62.07%

Class B Common (10 votes per share)

- Larry Paige (44.1%)
- Sergey Brin (41.8%)
- Eric E. Schmidt (6.9%)
- L. John Doerr (2.5%)

Class C Common (no vote)

- Vanguard Group (8.41%), BlackRock (7.06%), FMR (3.87%), State Street (3.79%)

Key Company Data (as of December 31, 2023)

Overview: Mountainview, California-based Alphabet Inc. is a collection of businesses, the largest of which is information technology juggernaut Google. Known as a pioneer in AI-development and internet search, Google generates revenues by (1) delivering online advertising on its Google search properties, (2) cloud-based solutions that provide enterprise customers with infrastructure and platform services as well as communication and collaboration tools, (3) sales of Chrome-based computers, Pixel mobile phones, Fitbit personal fitness devices, Nest smart home devices, apps, and digital and physical merchandise via in-app purchases, (4) licensing of mobile phone, computer, and vehicle infotainment operating systems, and (5) fees for subscription-based services, such as the YouTube platform.

Share Data

NASDAQ Ticker Symbol: Class A - "GOOGL" Class B – Not Traded Class C – "GOOG"

Share Price (as of 5/17/24): Class A: $176.06 Class C: $177.29 (although lacking the right to vote, Class C shares are usually more expensive to buy than Class A shares; because Alphabet only repurchases Class C shares, Class C shares have more demand)

Earnings Per Share (Trailing 12 Months): $5.79

Forward Annual Dividend: none

Market Capitalization: $2.182T (5/17/2024)

Resources

Employees: 182,502 (66% in the U.S., 17% in Norway, 9% in Canada, 8% in Other Global Locations)

Headquarters: Mountain View, CA

Countries with Operations and Activities: 13

Financial Highlights

Statement of Income

- Revenues: $307.394B
- Cost of Revenues Sold: $133.332B
- Gross Profit: (43.4% Margin)
- Operating Expenses: $89.8B
- Operating Income: $84.293B
- Net Earnings: $73.794B

Balance Sheet

- Total Assets: $402.392B
- Total Liabilities: $119.013B
- Long-Term Debt: $13.253B
- Equity: $283.379B

Cash Flow

- From Operations: $91.652B
- Used in Investing: $(27.063)B
- Used in Financing: $(72.093)B

Financial Returns

- Return on Equity: 26.04%

Key Developments

AI Innovation: Google is advancing AI to organize information more effectively and make it universally accessible, enhancing user interaction with tools like the search engine and "Circle to Search." These innovations support intuitive, multimodal interactions across various formats, driving both technological and practical applications.

Regulators

Securities Regulators

U.S. Securities and Exchange Commission
(regulation of offers and sales securities, material event disclosure and financial reporting requirements; recordkeeping requirements under anti-bribery law)

NASDAQ Global Select Market
(listing, maintenance and corporate accountability rules)

Securities Law Regulation and Sock Listing Requirements
Equity Capital
Dividends and Common Stock Repurchases
Professional and Support Services

Sales of Other Bets Products and Services

Partnerships, Collaborations, and Co-investment Arrangements in Support of Alphabet's Other Bets

Sales of Ad Space on YouTube Music, TV Programming and Other Video Content

(1) Google Ads Sales of Click-Driver Advertising and Data Analytics Services and (2) Publisher Sales of Advertising on Their Websites

Google Web Search Services

Sales of Google Search Advertising and Data Analytics Services

Licenses of Google Search Engine (Under Preferred/Default Search Engine or Operating System Agreements)

Sales of Google Cloud Platform Services (Fees for Infrastructure, Platform, and Other Services)

Sales of Google Workspace Cloud-Based Communication and Collaboration Tools (Gmail, Docs, Drive, Calendar, and Meet)

Google Advertising Customers (YouTube Ads, Network Ads, Search)

Advertisers (businesses, organizations, universities, and political campaigns)

Colleges and Universities; Small, Medium, and Large Businesses; Civic, Charitable, and Non-Governmental Organizations; Political Campaigns; Sole Proprietorships; Business Enterprises, Organizations, Political Campaigns, Universities, and Individuals

Google Cloud Customers (Cloud Platform, Workspace)

Small and Medium-sized Businesses; Large Enterprises; Retailers; U.S. Government; Business Enterprises (digital workplace productivity tools for their workforces)

Amazon Web Services, Microsoft Azure and Google Cloud collectively now account for more than 50 percent of the world's largest data centers across the globe as the three companies continue to spend billions each year on building and expanding their global data center footprint to accommodate the high demand for cloud services.

Mobile Device Makers

Smartphone and Computer OEMs

Apple ($208(year to be the default search engine on Apple devices)

Google pays distribution partners to make available Google's search access points and services. Distribution partners include browser providers, mobile carriers, original equipment manufacturers, and software developers.

Siemens Energy Ventures, Alfa Laval, Breakthrough Energy Ventures, Proman, Chevron Technology Ventures, and Piva Capital
(selected investors in Malta long-duration energy storage business)

European Bioinformatics Institute
(partnership with Google DeepMind to create AlphaFold database/AI system which provides open access to 200M+ protein structure predictions to accelerate Scientific research and drug discovery)

EMBL-EBI

Technical Services
(consulting, engineering, contract manufacturing, fiber optic network construction, and installation services)

Content Creators
(the YouTube platform relies on user generated content; creators must have 1,000 subscribers and 4,000 watch hours in the past year to earn revenue from Google, with RPM rates, or revenue per mille, believed to range from between $1.61 and $29.30 per 1,000 views.

Google works with more than 500 suppliers worldwide to manufacture hardware components for its datacenters, consumer devices, and other related products.

May 2024

Overview of the Information Technology Industry: Framework (with Google)

May 2024

Data Activities

A UPSTREAM: DATA PRODUCTION

The Promise of Data. Many experts believe data (and particularly big data) hold the key to the future because of their ability to reveal patterns and connections that significantly improve lives from secure self-driving cars to more effective pharmaceutical treatments to more reliable weather forecasts enabling farmers to get better yields or predicting drought conditions. To understand how to harness the benefits of data, the starting point is to understand what data are, who generates data, and who collects data.

Data Creation. Data volumes have skyrocketed. From 2010 to 2020, the amount of data created, captured, copied, and consumed in the world increased from 1.2 trillion gigabytes to 59 trillion gigabytes, an almost 5,000% rate of growth! IBM estimates there are 2.9 million emails sent every second, 375 megabytes of data consumed by households daily, 20 hours of video uploaded to YouTube every minute, 24 petabytes of data processed per day by Google, and 73 products ordered on Amazon per second. More data was generated in the last two years than in the entire human history before that. The total amount of data created, captured, copied, and consumed globally is forecast to increase rapidly, reaching 180 zettabytes in 2025. We are swimming in a world of data.

Data Creators. Every individual, business, and government agency anywhere generates data:

- Each second of each day, individuals generate data. On Google alone, people submit 40,000 search queries per second, which amounts to 1.2 trillion searches yearly! Each minute, 300 new hours of video show up on YouTube. That's why there are more than 1 billion gigabytes (1 exabyte) of data on Google's servers! People share more than 100 terabytes of data on Facebook daily. Every minute, users send 31 million messages and view 2.7 million videos. Smart devices (for example, fitness trackers, sensors, and Amazon Echo) produce 5 quintillion bytes of data daily.
- Every business generates data (a) through its internal support functions (e.g., human resources, procurement, legal, accounting, R&D, sales and marketing) that tends to be similar across all business sectors and (b) arising from operations that are unique to its business sector (i.e., the products and services the company sells), such as healthcare (health insights, data on the effectiveness of different drug treatments, and improvements in emergency room care), banking (customer account balances, and loan delinquencies), entertainment media (the TV shows subscribers watched during peak viewing hours), retail (customer profiles and purchase histories and habits), energy and utility industries (sensors indicating turbine and engine performance), construction (building construction sequencing, and subcontractor scheduling), and transportation (train conditions and fuel consumption).
- In the U.S., the federal government is perhaps the most prolific generator of data, including weather, employment, and economic statistics, surveillance footage of foreign troop movements, the flight paths of asteroids and comets, the amount of government student loans outstanding, and data on the incidence of disease.

Data Collection. Although individuals, businesses and government agencies generate data for themselves (original data generation), each data generator is involved in collecting data from the other data generators, which itself is a form of data generation (secondary data generation). For example, a business will collect personal data from its customers in order to establish an online banking account, the government will request data from a pharmaceutical company to determine whether to grant approval for a new drug, and individuals will collect data from the government or a business in order to initiate litigation.

B MIDSTREAM: DATA STORAGE & PROCESSING

Storage. Once generated, data will be stored until needed:

- On disks embedded in stationary and mobile computing devices (e.g., desktop and laptop computers, tablets, smartphones, digital assistants, wearables/watches, and fitness trackers);
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Computing (i.e., Analyzing and Processing). Over 99% of collected data never gets used or analyzed. Despite this tremendous waste of data, data that are ultimately used will be processed into more valuable products for their owners, such as:

- Individuals, a photo collection or recommended music playlist, healthy diet plan, or exercise regime for individuals; and
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C DOWNSTREAM: DATA CONSUMPTION

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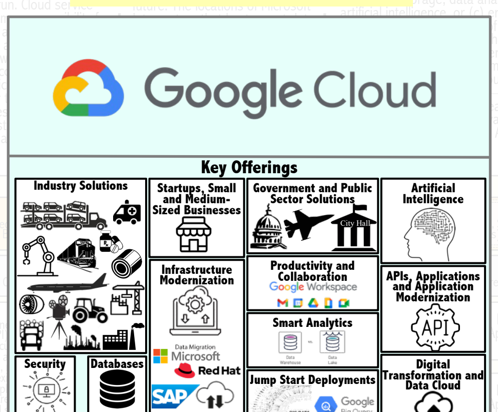
Data Generation, Computing and Consumption

INDIVIDUAL DATA GENERATION

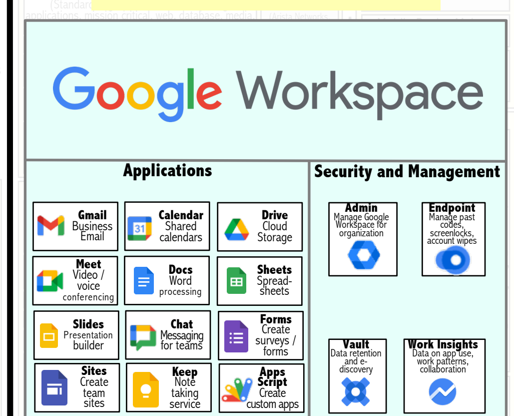
BUSINESS DATA GENERATION

GOVERNMENT DATA GENERATION

CLOUD COMPUTING

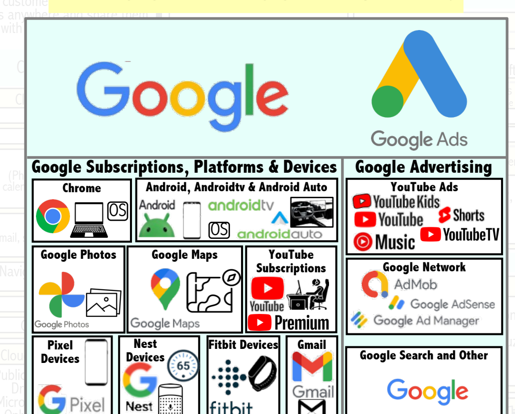


OFFICE COMPUTING



EDGE COMPUT-ING

PERSONAL COMPUTING



DATA USAGE

THE SIZE OF DATA

Data Transmission

A Data Transmission from Upstream Sector →

D Connecting Streams: Data Transport

Upstream to Midstream to Downstream

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BROADBAND / INTERNET TRANSMISSION

← Data Transmission to Midstream Sector B1

B2 Refined Data Transmission from Midstream Sector →

ELECTROMAGNETIC SPECTRUM TRANSMISSION

← Refined Data Transmission to Downstream Sector C1

C2 Modified Data Transmission from Downstream Sector (Restarts the Transmission Cycle A) →

Overview of the Information Technology Industry: Overview (with Google)

May 2024

Data Activities

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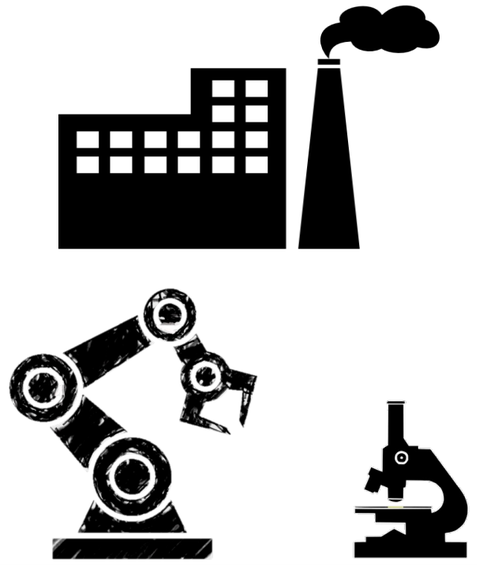
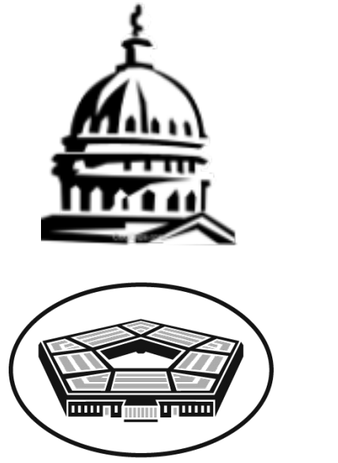
Data Generation, Computing and Consumption

INDIVIDUAL DATA GENERATION

BUSINESS DATA GENERATION



GOVERNMENT DATA GENERATION



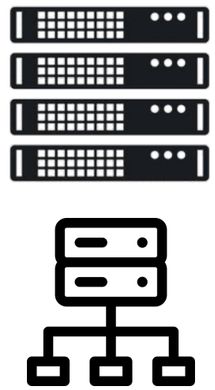
ENTERPRISE COMPUTING

CLOUD COMPUTING

Cloud Data Center

OFFICE COMPUTING

On-Premises Data Center



EDGE COMPUTING

PERSONAL COMPUTING

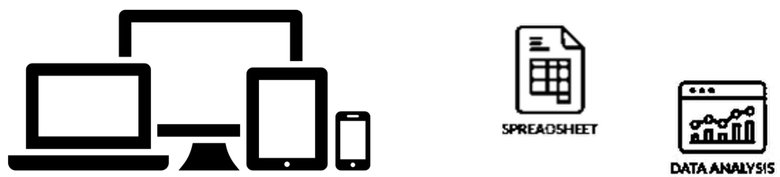
PERSONAL COMPUTING IN THE CLOUD

PERSONAL COMPUTING ON DEVICE

Devices

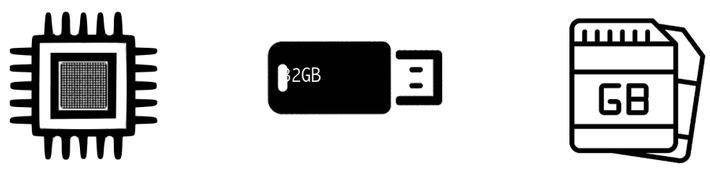
Personal Applications

Cloud, Data Center and Business Applications



DATA USAGE

THE SIZE OF DATA



Data Transmission

A — Data Transmission from Upstream Sector

D — Connecting Streams: Data Transport

Upstream to Midstream to Downstream

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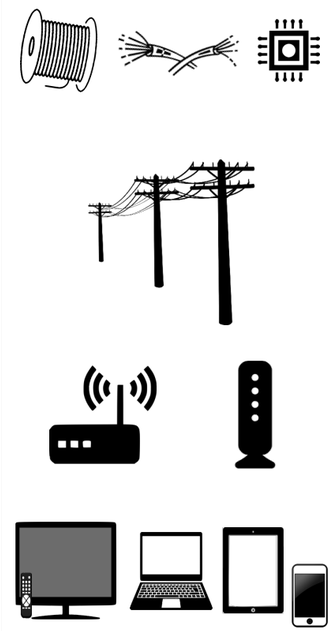


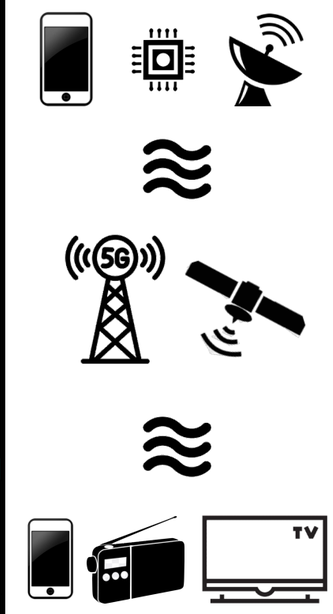
B1 — Data Transmission to Midstream Sector

B2 — Refined Data Transmission from Midstream Sector

C1 — Refined Data Transmission to Downstream Sector

C2 — Modified Data Transmission from Downstream Sector (Restarts the Transmission Cycle A)

ELECTROMAGNETIC SPECTRUM TRANSMISSION



Overview of the Information Technology Industry: Key Players

May 2024

Data Activities

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BUSINESS DATA GENERATION

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ENTERPRISE COMPUTING

CLOUD COMPUTING

Hyperscale Data Center/Cloud Service Providers

aws, Microsoft Azure, Google Cloud, ORACLE Cloud Infrastructure, Alibaba Cloud

Cloud, Data Center and Business Applications Developers

IBM, Microsoft, zendesk, aws, DocuSign, Adobe, SAP, zoom, salesforce, Google Cloud, intuit quickbooks, ORACLE, THE APACHE SOFTWARE FOUNDATION, ADP

OFFICE COMPUTING

Server OEMs

Hewlett Packard Enterprise, NetApp, DELL Technologies, IBM, Lenovo, citrix

Networking Equipment OEMs

Hewlett Packard Enterprise JUNIPER NETWORKS, DELL Technologies, cisco, HPE aruba networking, paloalto NETWORKS, ARISTA, FORTINET, LIGHTSTREAM, HUAWEI, Extreme networks

EDGE COMPUTING

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PERSONAL COMPUTING

PERSONAL COMPUTING IN THE CLOUD

amazon drive, iCloud, Drive, OneDrive, facebook

PERSONAL COMPUTING ON DEVICE

Device Makers

SAMSUNG, SONY, SHARP, LG, amazon, TOSHIBA, mi, xiaomi, hp, Lenovo, acer, HUAWEI, Google

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DATA USAGE

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AT&T, verizon, T-Mobile, uscellular

Data Transmission to Midstream Sector (B1)

Refined Data Transmission from Midstream Sector (B2)

Refined Data Transmission to Downstream Sector (C1)

Modified Data Transmission from Downstream Sector (Restarts the Transmission Cycle at A) (C2)

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A UPSTREAM: DATA PRODUCTION

The Promise of Data. Many experts believe data (and particularly big data) hold the key to the future because of their ability to reveal patterns and connections that significantly improve lives from secure self-driving cars to more effective pharmaceutical treatments to more reliable weather forecasts enabling farmers to get better yields or predicting drought conditions. To understand how to harness the benefits of data, the starting point is to understand what data are, who generates data, and who collects data.

Data Creation. Data volumes have skyrocketed. From 2010 to 2020, the amount of data created, captured, copied, and consumed in the world increased from 1.2 trillion gigabytes to 59 trillion gigabytes, an almost 5,000% rate of growth. IBM estimates there are 2.9 million emails sent every second, 375 megabytes of data consumed by households daily, 20 hours of video uploaded to YouTube every minute, 24 petabytes of data processed per day by Google, and 73 products ordered on Amazon per second. More data was generated in the last two years than in the entire human history before that. The total amount of data created, captured, copied, and consumed globally is forecast to increase rapidly, reaching 180 zettabytes in 2025. We are swimming in a world of data.

Data Creators. Every individual, business, and government agency anywhere generates data:

- Each second of each day, individuals generate data. On Google alone, people submit 40,000 search queries per second, which amounts to 1.2 trillion searches yearly! Each minute, 300 new hours of video show up on YouTube. That's why there are more than 1 billion gigabytes (1 exabyte) of data on Google's servers! People share more than 100 terabytes of data on Facebook daily. Every minute, users send 31 million messages and view 2.7 million videos. Smart devices (for example, fitness trackers, sensors, and Amazon Echo) produce 5 quintillion bytes of data daily.
- Every business generates data (a) through its internal support functions (e.g., human resources, procurement, legal, accounting, R&D, sales and marketing) that tends to be similar across all business sectors and (b) arising from operations that are unique to its business sector (i.e., the products and services the company sells), such as healthcare (health insights, data on the effectiveness of different drug treatments, and improvements in emergency room care), banking (customer account balances, and loan delinquencies), entertainment media (the TV shows subscribers watched during peak viewing hours), retail (customer profiles and purchase histories and habits), energy and utility industries (sensors indicating turbine and engine performance), construction (building construction sequencing, and subcontractor scheduling), and transportation (train conditions and fuel consumption).
- In the U.S., the federal government is perhaps the most prolific generator of data, including weather, employment, and economic statistics, surveillance footage of foreign troop movements, the flight paths of asteroids and comets, and the incidence of disease.

Data Collection. Although individuals, businesses and government agencies generate data for themselves (original data generation), each data generator is involved in the collection of data from the other data generators, which itself is a form of data generation (secondary data generation). For example, a business will collect personal data from its customers in order to establish an online banking account, the government will request data from a pharmaceutical company to determine whether to grant approval for a new drug, and individuals will collect data from the government or a business in order to initiate litigation.

B MIDSTREAM: DATA STORAGE & PROCESSING

Storage. Once generated, data will be stored until needed:

- On disks embedded in stationary and mobile computing devices (e.g., desktop and laptop computers, tablets, smartphones, digital assistants, wearables/watches, and fitness trackers);
- In data centers operated by government agencies and business enterprises; or
- In the cloud (i.e., mega-data centers operated by cloud service providers). Surprisingly, only a small percentage of newly created data (2%) is kept. Nonetheless, in line with the rapid growth of the data volume, the installed base of storage capacity is forecast to increase at a compound annual growth rate of 19.2%.

Computing (i.e., Analyzing and Processing). Over 99% of collected data never gets used or analyzed. Despite this tremendous waste of data, data that are ultimately used will be processed into more valuable products for their owners, such as:

- Individuals, a photo collection or recommended music playlist, healthy diet plan, or exercise regime for individuals; and
- Businesses, insights on how to increase productivity and reduce costs, when to repair equipment, what goods to produce (and the price to sell them), or whether fraud may be occurring.

Applications. Big data is only as useful as the ability to read it. Therefore, data generators and collectors need tools to analyze and read the data. Businesses use tools to extract data from business systems and integrate it into a repository, such as a data warehouse. Once in the warehouse, the data can be analyzed. Analytical tools range from spreadsheets with statistical functions to enterprise resource planning systems (ERP), customer relations management programs (CRM), payroll tools, and operational systems.

Edge to Core to Cloud. The applications can be located:

- On-device (i.e., on the same computing device where the data are stored);
- On-premises (i.e., in a data center maintained by an enterprise at a central or core location);
- At the edge (i.e., at the location near where the data are generated);
- In the cloud (i.e., a data center operated by a cloud service provider, where over 30% of all stored data is uploaded); or
- Any combination of the above. Because the data landscape is more dispersed than ever, the modern organization requires IT solutions that capture and analyze data as they move from "edge to core to cloud."

Artificial Intelligence. The phenomenon of artificial intelligence (AI) refers to the development and deployment of computer systems and algorithms that can perform complex tasks typically requiring human intelligence. Today, the amount of data that is generated, by both humans and machines, far outpaces humans' ability to absorb, interpret, and make complex decisions based on that data. As a result, users of data are increasingly relying on AI for complex decision making. Specific applications of AI include expert systems, natural language processing, image recognition, speech recognition, content generation, and machine vision.

High-Performance Computing. Industry standard servers have been the backbone for multi-workload computing. However, with the explosion of data the desire to apply AI software and algorithms to the data, high-performance computing has become essential for compute-intensive workloads, such as AI (including machine learning and deep learning), data analytics, graphics and scientific computing, across hyperscale, cloud, enterprise, public sector, and edge data centers. Increasingly, the modern server is equipped to handle high-performance computing (HPC), processing data and performing complex calculations at high speeds. To put it into perspective, a laptop or desktop with a 3 GHz processor can perform 3 billion calculations per second. While that is much faster than any human can achieve, it pales in comparison to HPC solutions that can perform quadrillions of calculations per second. These HPC environments incorporate a suite of products, including AI technologies to train algorithms on large data sets that (2) learn patterns and make predictions or decisions without being explicitly programmed (machine learning) and (2) employ neural networks with multiple layers to handle complex tasks such as image recognition, natural language processing, and speech recognition (deep learning).

C DOWNSTREAM: DATA CONSUMPTION

Receipt and Consumption. Once refined data are received, government agencies, enterprises and individuals will consume the data in one or more forms. They can:

- let the data sit on their device unopened,
- delete the data from their device (e.g., junk mail, remove duplicate images and media)
- consume it, and then:
  - Delete the data, or
  - Store the data on the device, or
- work on the data, which restarts the data cycle of generation, processing, transmission, and consumption.

Internet Users. The global population is 7.9 billion people. There are over 5.47 billion active internet users, so they account for approximately 66% of the entire world's population. This also means that 2.7 billion people have no internet access. Approximately 7.5 billion people are projected to use the internet by 2030 when 500 billion devices will be connected to the internet.

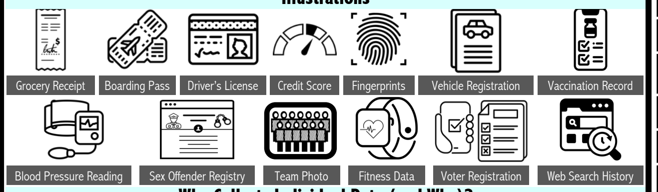
Data Generation, Computing and Consumption

1 INDIVIDUAL DATA GENERATION

Individuals as Data Generators. People generate over five quintillion bytes of data each day via (1) web searches (5 billion each day), (2) uploading content such as photos, videos and messages on social media (e.g., 300 million daily photo uploads), (3) email communications (294 billion emails per day), and (4) other means such as connected cars, IoT devices, and smartphone gaming and other apps)

- Photos, Videos (Family, baby, friends, wedding, family reunions, vacations, holidays, and other special occasions)
- Personal Health Data (Blood pressure data, sleep, heart rate data, medical history, blood test data, vaccinations, allergies, health insurance, height, weight)
- Internet Data (Browser web search history (porn, amazon.com, YouTube, and entertainment websites visited), account passwords, purchase history)
- Consumer Spending Data (In-store and online spending on goods and services, product and service complaints)
- Auto Data (Driving history, traffic violation/tickets, auto insurance, driving video footage, speed data, vehicle ID and other information, accident history, gas consumption, property value)
- Food/Beverage Data (Food purchases, food preferences, food allergies, grocery lists, recipes)
- Communications (Text messages, emails, phone call data, voice mail)
- Financial and Tax Data (Bank account, tax return, cash deposits, credit score, investment portfolio, budgets, home & auto loans and insurance, life insurance policy, account passwords, credit card usage)
- Art (Music, writings, drawings)
- Entertainment Data (TV viewing and streaming history, TV recorder, gaming, attendance at sporting event and concerts)
- Exercise Data (Heart rate/workout data, steps, calories consumed)
- Home Data (Home address, electricity and gas consumption, property value, school district, zoning, home mortgage, home insurance)
- Personal/Legal Data (Address books, contacts, birth dates, social security number, birth certificates, fingerprints, passwords, arrest/conviction history)
- Location Data (Personal location, device location, family tracking, movement tracking)

Illustrations



Who Collects Individual Data (and Why?)

Government
- Raise Revenue (Tax returns / collections, funding allocations)
- Address Disputes (Workplace, road conditions, zoning, lawsuits, discovery)
- Make Determinations (Professional licenses/certifications, sex offender registry, voter registration, driver's license, vehicle registration)
- Provide Domestic Security (Law enforcement, crime prevention, terrorist tracking, investigations, background checks, security clearances, surveillance)
- Protect Environment and Consumers (Product investigations, clinical drug trials, environmental and consumer product safety regulation)
- Ensure Public Health (Vaccine development, drug allocations, public alerts, research, product recalls)
- Allocate Services (Census insights & demographics)

Businesses
- Develop Products/Advertising (Consumer analytics/preferences, telemetrics, pricing strategy, diagnosis, research)
- Handle Disputes (Legal proceedings and discovery)
- Hacking (Ransom)
- Order Supplies (Restocking)
- Build Employment Relationships (Application, drug tests, background checks)
- Submit Government Reports (Taxes, legal reporting, subpoena response)
- Process Card Payments (Credit, charge, debit processing)

Individuals
- Build Relationships (Friendships and social networking)
- Handle Disputes (Legal proceedings and discovery)

2 BUSINESS DATA GENERATION

Business Sectors. Businesses are among the largest data generators and processors. Every company generates data (a) through its internal support functions that tends to be similar across all business sectors (e.g., HR data) and (b) arising from its business operations that are unique to its business sector (i.e., the products and services the company sells).

Internal Support Data. Internal support data that are similar from one organization to another include human resources, environmental, health and safety, financial performance, customer relations, periodic sales, the company's annual plan and budget, contract management, and supply chain and procurement data. Because of these similarities, companies are able to select from several commonly used or standard business software applications to effectively manage information and produce the information, results, and insights required to manage the business effectively.

- Internal Human Resources (Personal employee data, compensation data, performance reviews, job postings/applications, diversity statistics)
- Internal Sales (Sales data, stock-keeping units, customs duties, customer lists, trade classifications, pricing, marketing programs)
- Internal Employee Safety (Death, serious injury reports, days away from work)
- Internal Finance (Financial performance, debt, cash, tax and accounting positions, investments, budget/annual plan, audit reports)
- Internal Supply Chain (Sourcing, logistics, inventory levels, warehousing)
- Internal Research and Development (Product / process innovation, quality, testing, IP records)
- Internal Tech (Data centers, business software application licenses / subscriptions, IT infrastructure and devices, cloud computing)
- Internal Legal (Regulatory filings, lawsuit filings and discovery, transactional due diligence, contracts, lobbying records, documents)

Product and Service-Specific Data. Product and service-specific data are unique to a business sector and relate to the goods and services made and sold by a company's operations (e.g., film and TV production, natural gas and petroleum products pipeline transportation, credit card payments processing, airline flight reservations, plant-based protein production, cold rolled stainless steel sheet production, data from a legal discovery process, etc.). Homegrown or customized applications may be required to manage and process forms of product and service-specific data.

- Utility Service (Gas, Electric, Telecom, Water) (Account information, consumption data, payment history)
- General Industrials (Machine performance, capacity, utilization, downtime)
- Financial Services (Banking and Insurance) (Checking accounts, credit history, loan data, credit cards data)
- Building and Construction (Housing demand data, homeowner profiles, blueprints)
- Defense (Intelligence, surveillance, weapons performance)
- Transportation (Navigation, traffic, repair and maintenance logs, weather data)
- Health (Patient diagnoses, medical records, drug clinical trial data)
- Social Media (Analytics, user insights, algorithms, advertising records)
- Other Industries (Education, food, energy, technology, professional services, entertainment, consumer staples, cloud computing/storage)

Who Collects Business Data (and Why)?

Government
- Raise Revenue (Tax returns, withholdings)
- Address Disputes
- Submit Govt. Reports
- Provide Domestic Security (Law enforcement, crime prevention, terrorist tracking, investigations, security clearances, surveillance)
- Protect Environment, Consumers, Public Health (Product investigations/recalls, clinical drug trials, environmental and consumer product safety regulation)
- Make Determinations (Approvals, licenses, permits, and registrations)

Businesses
- Develop Products/Advertising (Consumer preferences, pricing strategy, research)
- Process Payments (Credit, charge, debit)
- Handle Disputes (Legal proceedings, discovery)
- Order Supplies
- Build Business Relationships (Registration, due diligence, credit evaluation)
- Submit Government Reports/Taxes

Individuals
- Build Relationships (Job search, personal investing)
- Handle Disputes (Legal proceedings and discovery)

3 GOVERNMENT DATA GENERATION

U.S. Government is Prolific Data Generator. The government (consisting of the federal, 50 state, and over 30,000 local governments) is a prolific generator and collector of data needed to provide for the safety and welfare of U.S. citizens and matters of public interest, such as enforcing criminal and disclosure laws, evaluating trademark and patent applications, providing national security and border control, administering voter registration and social security benefits, tracking census data, and forecasting weather.

- Agriculture (Meat inspections, farm subsidies, low-income food assistance)
- Justice (Law/drug enforcement, antitrust reviews, prison management)
- Commerce (Census, exports, IP, weather, climate)
- Labor (Wage/hour and injury reports, discrimination/labor complaints)
- Communications (Spectrum allocation, broadcast licenses, complaints)
- Museums (Museum collection, preservation, and research data)
- Consumer Product Safety (Safety standards, complaint tracking, research, investigations)
- Postal (Routes, addresses, postal codes, rates, vehicle fleet data)
- Defense (Military forces, intelligence, defense systems, weapons)
- Public Health (Biomedical research, disease prevention, food, drug and medical device approvals, Medicare/Medicaid)
- Education (Sponsored universities, low-income district aid, student loans)
- Social Security (Tax ID numbers, retirement, disability and survivor benefits)
- Election (Voter data, campaign fundraising and reports)
- State (Arms control, diplomatic missions, foreign aid, human rights)
- Energy (Research, nuclear stockpile, wholesale energy transmission)
- Transportation (Statistics, safety data, fuel economy, licensing, investigations, infrastructure development/maintenance)
- Environmental Protection (Permits, pollution levels, superfund clean-up, investigations)
- Homeland Security (Disaster aid, immigration, transport security, border control)
- Treasury and Securities Markets (Public company reporting, broker-dealer/commodity trader regulation, bank examinations, depositor insurance, prohibited party lists, tax collections, Treasury securities, statistics)
- Housing (Statistics, mortgages, housing assistance)
- Interior (Indian affair, wildlife, national parks/monuments, mining leases)
- Veterans (Healthcare, rehabilitation, disability benefits, and burial data)

Mission Critical Data Requires the Highest Level of Security. Whereas individuals tend to generate data that are personal in nature (i.e., not considered "mission critical"), "off-the-shelf" applications will do for most types of personal computing. If an individual loses data, a nuisance is created, but that's about as far as it goes (except in the case of identity and financial theft). As a result, individuals do not regard data security as high a priority as does government. By contrast, the government and the people who work for it are far flung and generate vast amounts of unique data requiring specialized applications. Because data are vital for the government to perform its core functions, its focus on secure computing is overwhelming.

Who Collects Government Data (and Why)?

Government
- Collect Intra-Government Data (Hearings/investigations, subpoenas, policy making, Budgeting, funding allocation to states/localities)
- Collect Inter-Government Data (Foreign government data collections from homeland government—confirm compliance with treaties, trade and defense agreements with allies, hacking, terrorism, national security/surveillance of foreign governments and officials, understand military and weapons capability)

Businesses
- Forecast Business (Economic, consumption and price data and trends)
- Provide Cloud-Based Business Software
- Hacking (Ransom)
- Establish Relationships (Registration)
- Order Supplies (Restocking)
- Submit Government Reports (Taxes returns, financial and regulatory reporting)
- Handle Disputes (Discovery, legal proceedings)
- Process Card Payments (Credit, charge, debit processing)

Individuals
- Build Relationships (Job search)
- Information Gathering
- Handle Disputes (Legal proceedings and discovery)

ENTERPRISE COMPUTING

CLOUD COMPUTING

4 Public

The public cloud is defined as computing resources and services (e.g., servers, consumer and business applications, and storage) offered by a cloud service provider over the public Internet to anyone who wants to use or purchase them. Cloud service providers (typically one of the Big Tech companies, such as Amazon Web Services, Alphabet's Google Cloud, and Microsoft Azure) provide their infrastructure (IaaS or Infrastructure as a Service), their cloud-based platforms (PaaS or Platform as a Service), their applications (SaaS or Software as a Service), and/or storage services for free (for a minimal level of service), for a fixed fee, or on an on-demand basis, allowing customers to pay only per usage for the central processing unit (CPU) cycles, storage, or bandwidth they consume. Cloud services give users access to computing tools without the overhead of physical infrastructure. The cloud service provider owns and administers the data centers where customers' workloads run. Cloud service providers assume responsibility for all hardware and infrastructure maintenance and provide high-bandwidth network connectivity to ensure rapid access to applications and data. Public clouds can also be deployed faster than an enterprise's own on-premises infrastructures and with an almost infinitely scalable platform.

5 Private

While a public cloud encompasses infrastructure, platforms, software, and storage services offered by a cloud service provider over the public internet to anyone who wants to buy them, private cloud services are offered over the internet (or over a private internal network) to only select users (such as U.S. Customs and Border Protection), not the general public.

Government Private Cloud. The federal government is one of the largest buyers of private cloud services. These services enable government agencies (and contractors supporting the government) to move more sensitive workloads securely into the cloud, modernize their technology, and save time and resources while meeting critical mission needs. Microsoft Azure, one of a handful of authorized private cloud service providers to the government, operates over 200 data centers in 34 countries. The company plans to build 50 to 100 new data centers across the globe each year for the foreseeable future. The locations of Microsoft data centers that host secret data for the U.S. government are classified.

Top Government Cloud Services Customers
U.S. Cabinet Departments (Health and Human Services, Veteran Affairs, Commerce, Energy, Homeland Security, Defense, Treasury, Justice)

6 Hybrid and Multi-Cloud

Hybrid Cloud. Most companies move into the cloud incrementally, putting some of their workloads on a public cloud or small-scale private cloud to gauge the experience before taking the plunge, while relying on their own data centers to handle the bulk of their workloads. Others more committed to the cloud may store sensitive financial or customer information on a private cloud and use the public cloud to run their enterprise resource planning applications. In either scenario, these companies are operating in the hybrid cloud--a mixed computing, storage, and services environment made up of on-premises computing, private cloud, and public cloud services, with orchestration among them.

Multi-Cloud. In a multi-cloud environment, enterprise use more than one cloud platform that each delivers a specific application. Governments and enterprises use multiple cloud vendors so they can choose IT services from various companies to (a) avoid being locked in to one vendor that might raise prices, (b) use what they perceive as the best-in-class capabilities from a particular cloud service provider, including those related to cloud storage, data analytics or artificial intelligence, or (c) ensure they have a backup in the event of an outage at a cloud service provider. The downside of this approach is "interoperability"—i.e., not have having a platform or process in place to integrate various cloud services into a usable format—but many tools and systems to deal with interoperability issues are available from companies such as IBM and Accenture.

7 Cloud Computing Services

- SaaS (Cloud Hosted Applications; See Below)
- PaaS (Development Tools, Database Management, Business Analytics, Operating Systems)
- IaaS (Servers and Storage, Networking Firewalls, Security, Data Center Physical Plant/Buildings)

Cloud Service Providers (Alibaba Cloud Computing, Amazon Web Services, Microsoft Azure, Google Cloud, Oracle Cloud Infrastructure)

Cloud Hosted Applications (AI and machine learning, altered and virtual reality, application integration, application programming interface (API) management, blockchain, computing, containers/Kubernetes, content delivery, cost management, customer engagement, data analytics, developer tools, end user computing, game tech, healthcare and life sciences, hybrid and multi-cloud, internet of things (IoT), management and governance, media services, migration and transfer, mobile, networking, operations, platform for modernizing existing apps and building new apps, quantum technologies, robotics, satellite, security, identity and compliance, serverless computing, SQL database, storage, stream/batch processing analytics, Tableau software and other big data warehouse optimization applications (reading unstructured, semi-structured and structured data for insights, business intelligence, price optimization, recommendation engines, preventive maintenance and support))

App Developers (Adobe, AWS, Box, DocuSign, GitHub, Microsoft Azure, Apache, Alibaba Cloud, Google Cloud, IBM Software, McAfee, Zoom, Zendesk)

Personal Applications (See 20)

Business Applications (See 13)

OFFICE COMPUTING

8 Data Center

The data center centralizes a business enterprise's shared IT operations for the purpose of storing, backing up and recovering, managing, processing, and disseminating data and applications. It consists of (a) building or facility large enough to house energy-consuming IT equipment in a climate-controlled environment, (b) equipment and software to run IT operations and store data and applications ("core components" include servers, storage systems, networking infrastructure such as hubs, switches, routers, bridges, gateways, multiplexers, transceivers, and information security elements such as firewalls, VPN gateways, and intrusion detection systems), (c) support infrastructure (i.e., equipment contributing to securely sustaining the highest IT system availability and reliability possible—99.671%-99.995% availability) such as uninterruptible power sources, environmental control systems, and physical security systems, and (d) operations staff to monitor and maintain the IT and infrastructure equipment on a 24/7 basis. Because they house the organization's most critical asset (data), data centers are crucial for daily operations and business continuity of an enterprise and are viewed as top priorities. There are 7+ million data centers worldwide. Due to the public cloud, modern data center infrastructures have evolved from on-premises physical servers to virtualized platforms that support applications and workloads across multi-cloud environments.

9 On Work Device

On work device computing is the act of processing, analyzing and storing data on a personal computing device, such as a desktop, laptop, tablet, or smartphone. Although computing is mostly done through applications posted in a data center or public cloud, many data processing actions can be done entirely within the work device.

10 Key Data Center Equipment Categories

- Servers (Standard, high-performance computing, applications, mission critical, web, database, media, and email servers)
- Security (Firewalls)
- Application Delivery Controllers (Load Balancer)
- Storage Arrays (Primary, Data, and Unstructured Data Storage)
- Networking Equipment (Wired and wireless local area network (LAN)—WIFI access points, switches, routers, sensors, and related software; and software-defined wide area network (WAN))

Device Makers (Arista Networks, Cisco Systems, Citrix, Dell Technologies, Extreme Networks, HPE, IBM Systems Hardware, Juniper Networks, Lenovo, Microsoft Servers, Net App)

11 Computing Devices

- Stationary (Desktop computers, workstations, thin clients, desk phones/land lines, printers, copy machines, and virtual machine wear and tools—keyboard, video, mouse (KVM), and virtual machines on a person computer)
- Mobile (Laptop computers, smart phones and tablets)
- Both Categories (Apple, Dell Technologies, HP, Huawei, Lenovo, LG, Samsung)
- Mobile Device Makers (Motorola, Oppo, Xiaomi)
- Stationary Device Makers (Acer, ASUS, Fujitsu, Dell Technologies-VMware, Sharp, Sony, Toshiba)

12 Key Data Center Applications Categories

- Middleware (Open application programming interface software that bridges an operating system and the applications running on it)
- Big Data, Machine Learning, AI (Algorithms)
- Real-time Data Collection
- Workload Optimization
- Data Storage, Management, Backup & Recovery
- Data Center Performance Monitoring (Data center device discovery, rack and floor space planning management, chilled water system, connectivity analysis, capacity utilization, network downtime, energy cost and utilization, tracking for physical, virtual, and cloud-assets, open application programing interface (API) to enable two business application to communicate, temperature management, and KPI tracking)

App Developers (Adobe Systems, Apache, Cisco Systems, HPE, IBM Software, Microsoft Servers, Oracle, Schneider Electric)

13 Business Applications

Software Categories (Accounting, Billing, Business Intelligence/Data Visualization, Business Messaging, Business Process and Automation, Contract Management, Customer Relationship Management, Document Storage, Electronic Signatures, Enterprise Resource Planning, Expense Reports, High Volume E-Commerce / Payments, HR Management, Marketing Automation, Payroll, Productivity, Project Management, Procurement and Supply Chain Management, Purchase Order and Inventory Management, R&D Lab Management, Virtual Meeting)

Software Developers (ADP, Alphabet/Google, Cisco Systems, DropBox, Microsoft, Oracle, QuickBooks, Salesforce, SAP, Zoho)

14 EDGE COMPUTING

Edge computing is the practice of capturing, storing, processing, and analyzing data near the client (i.e., where the data is generated, such a personal computing device) instead of in a centralized data-processing warehouse. At the edge of any network, there are opportunities for positioning servers, processors, and data storage arrays as close as possible to those who can make best use of them. Where a business enterprise can reduce the distances, the speed of electrons being essentially constant, it can minimize latency (i.e., lag or delays in communication over a network). A network designed to be used at the edge leverages this minimal distance to expedite service and generate value. Essentially, edge computing works by pushing data, applications and computing power away from the centralized network to, and running workloads at, its extremes. In technical terms, it is referred to as a "distributed IT network architecture" that enables mobile computing for data produced locally. By contrast, massive amounts of centralized data often mean more risk, increased time spent sorting through less helpful data in the data center or cloud, and a heavier investment in enterprise security. Edge computing takes some pressure off data centers by processing and storing data at a local server or device level.

15 Edge Computing

Devices
- Edge Computing Servers
- Edge Data Center
- IoT Hardware/Connected Home Products

Selected Makers: AdLink, AWS, Cisco Systems, Dell Technologies, Edge Intelligence, Equinix, Google Cloud, Hewlett Packard Enterprise, Huawei, IBM Distributed Infrastructure, Intel, Oracle, SAP

PERSONAL COMPUTING

16 PERSONAL COMPUTING IN THE CLOUD

When a customer uses a cloud-based application (e.g., a document storage application such as Dropbox), the customer is allotted a certain amount of storage space in an online server known as "the public cloud." These servers are owned by cloud service providers (e.g., Amazon Web Services, Google Cloud Platform, and Microsoft Azure). Though small by comparison, companies like Dropbox also function as a cloud service provider for users of its application. After the customer installs the Dropbox app on a personal computing device, any files that the customer stores locally on the device will be copied to the Dropbox server as well. If the customer make changes to these files in one place, updates are automatically mirrored everywhere. By synchronizing Dropbox files locally and online, the customer can access these files anywhere and share them with others more easily.

17 Cloud Providers

Cloud Applications
- File Backup
- File Sharing
- Cloud Storage (Photos, music, contacts, calendars, mail, documents, eBooks, games)
- Productivity (Email, spreadsheets, documents, presentations)
- Navigation and Location Services
- Social Media
- Online Shopping

Cloud Service Providers: Publicly Available: Amazon Drive, Google Drive, Microsoft OneDrive Users Only: Apple iCloud and Facebook

18 PERSONAL COMPUTING ON DEVICE

Personal computing is the act of processing, analyzing, and storing data on a personal computing device (i.e., a device designed for only one person to use at a time). Although computing is often done through applications hosted in the public cloud, many data processing actions can be done entirely within the personal computer. Personal computers fall into several categories, differentiated by their size: desktop computers, laptops, smartphones, and tablets. A desktop computer is designed for desk use and is seldom moved. Its essential components consist of (a) external parts such as a keyboard, a mouse, and a monitor and (b) internal parts, including the central processor (the brain), memory, and storage. Desktop computers are on the expensive end of the cost spectrum and tend to be more powerful than their smaller relatives, can run a variety of applications, and can be enhanced with additional storage drives and memory. A laptop, or notebook, is portable and designed to fold up like a notebook for carrying and storage. It includes a built-in screen, keyboard, and pointing device (instead of a mouse). Laptops can run most software applications, and are more expensive than tablets and smartphones, but they are not customizable or upgradable. A tablet is a portable computer consisting of a touch-sensitive screen mounted on a plastic frame with a small computer components inside. It has no physical keyboard or pointing device, but a software-based keyboard appears on-screen when needed. Though convenient because of their portability, tablets have limited memory and storage and can run desktop computer applications. A smartphone is a mobile phone that has a touch-sensitive screen and can run applications (e.g., music and photo organizers, games, and a navigation program) but lacks power and is not customizable.

19 Personal Computing Devices

Devices
- Smart Phones
- Tablets
- Printers
- Gaming Consoles (PlayStation, Xbox)
- Wearables (Smart watches, fitness trackers)
- Laptops
- Desktops
- Digital Assistants (Amazon Alexa)

Selected Makers
- Integrated Manufacturers: Apple, Amazon, Alphabet/Google, Microsoft
- Operating System Developers: Licensors to OEMs: Google, Microsoft; For Internal Use: Amazon, Apple
- Original Equipment Manufacturers: Acer, Apple, Asus, Dell Technologies, Fujitsu, HP, Huawei, Lenovo, LG, Samsung, Sharp, Sony, Toshiba, Xiaomi

20 Key Applications

Categories: Calendar Service, Dictionary, eBooks Storage and Organization, Language Translation, Games Storage and Organization, Music Storage and Organization, Navigation/Maps, Photos Storage and Organization, Productivity, Social Media, Web Search

Selected Developers: Activision Blizzard, Amazon, Apple, EA Sports, Eleks, GeekyAnts Intellectsoft, Intuz, Openxcell, Tencent, Willowtree, YML

21 DATA USAGE

Mobile Data. Mobile data (also called "wireless" or "cellular" data) is the distribution of digital data through a wireless network and is how a person gets online when they are not on a wired or a wireless Wi-Fi connection. It is an invisible connection usually to a satellite or a nearby cell tower that allows people to visit websites and use apps on their mobile device.

Mobile is not Wi-Fi. Data transmission by mobile is fundamentally different from Wi-Fi. With Wi-Fi, there is a data connection (cable, fiber, or ethernet) to a local hub or modem and then to a Wi-Fi router for transmission. The transmission signal is localized (say, in a house or cafe) and only available if the user is within close range (say 100 feet or 30 meters) of the router itself. Mobile or cell phone data, by contrast, does not require the user to be tethered to a local router.

Mobile Data Consumption. Most often, mobile data is used up in one of three ways:
(1) Emails, texts, and direct messages all use mobile data. Emails with high-resolution photos attached will take a lot of data, while a short text saying "I'm here" won't take much at all.
(2) Web browsing or surfing the Web on mobile devices takes up a lot of data because webpages tend to have large images or videos. But a lot of this browsing data is used up by ads and unseen trackers. Blocking this data not only removes unwanted clutter, but also can save phone data.
(3) Apps are likely the biggest data. Any app that needs to connect to the Web to update, refresh, or download will use cell data, including all social media and streaming apps (e.g., Facebook, X (formerly Twitter), Spotify, and Netflix) will quietly eat up your data.

Top Application Categories by Data Consumption	
High-Definition Video Streaming (Netflix, Disney+, Prime Video, YouTube)	900 MB/hr
Video Conferencing (Zoom, FaceTime, Skype, Teams)	480 MB/hr
Standard-Definition Video Streaming (Netflix, Disney+, Prime Video, YouTube)	240 MB/hr
Social Media (Facebook, Instagram, Snapchat, Tik Tok)	80-840 MB/hr
Online Interactive Gaming (Steam, Origin, Roblox, PlayStation)	60 MB/hr
Web Browsing	60 MB/hr
Music Streaming (Spotify, Apple Music, SoundCloud)	30 MB/hr
GPS and Ridesharing (Google Maps, Waze, Apple Maps, DiDi, Uber, Lyft)	

22 THE SIZE OF DATA

The size of data is measured in bytes. Bytes are used to determine (a) the amount of computer storage consumed by data and (b) the volume of information that is sent over the internet in a given amount of time. For example, the average American uses about 7 gigabytes (GB) of mobile data per month. Most internet service providers (ISPs) will charge fees to users of their internet networks based on the number of bytes transmitted by the user. Most internet users have heard of kilobytes, megabytes, gigabytes, or even terabytes—everyday amounts of data that represent the sizes of, say, an email attachment, two hours of Netflix TV content streaming, or an entire photo library stored in Amazon Photos. However, because because the entire digital universe is expected to reach 180 zettabytes (ZB) by 2025, a 410% increase from the current size of 44 ZB, internet users will need need to learn the measures of larger data sizes.

Symbol	Unit	Value	Size (in bytes)	Examples
b	bit	0 or 1	1/8 of a byte	The smallest unit of data that a computer uses to represent a binary decision (1 or 0), such as yes or no
B	bytes	8 bits	1 byte	One B is equal to a single text character (e.g., "w"), and 10 bytes would equal a word
KB	kilobytes	1,000 bytes	1,000 bytes	One KB is equal to a sentence, and 100 KBs would equal an entire page
MB	megabytes	$1{,}000^2$ bytes	1,000,000 bytes	A 500-page e-book; 1 song download equals 2 to 5 MBs
GB	gigabytes	$1{,}000^3$ bytes	1,000,000,000 bytes	7 minutes of video
TB	terabytes	$1{,}000^4$ bytes	1,000,000,000,000 bytes	130,000 photos
PB	petabytes	$1{,}000^5$ bytes	1,000,000,000,000,000 bytes	20 million file cabinets
EB	exabytes	$1{,}000^6$ bytes	1,000,000,000,000,000,000 bytes	How much data each person on Earth produces per year
ZB	zettabytes	$1{,}000^7$ bytes	1,000,000,000,000,000,000,000 bytes	As much information as there are grains of sand on all the world's beaches
YB	yottabytes	$1{,}000^8$ bytes	1,000,000,000,000,000,000,000,000 bytes	As much information as there are atoms in 7,000 human bodies

Because data is growing faster than anticipated, it won't be long until we use a brontobyte (BB or 1,000 YBs), geopbyte (GPB or 1,000 BBs), or saganbyte (1,000 GPBs).

Data Transmission from Upstream Sector A

Data Transmission to Midstream Sector B1

Refined Data Transmission from Midstream Sector B2

Refined Data Transmission to Downstream Sector C1

Modified Data Transmission from Downstream Sector (Restarts the Transmission Cycle A) C2

Data Transmission

D Connecting Streams: Data Transport

23 Upstream to Midstream to Downstream

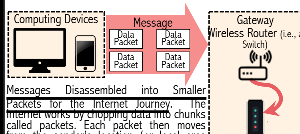
Round-Trip Process. Raw, unprocessed data will be transported from an individual's device (whether acting alone or for a business or government entity) to a data center, private cloud or public cloud and back again as refined data. This cycle is essentially a "round-trip" process, where data is effectively mined, shipped, refined, and shipped again. Although the round-trip process typically occurs in the blink of an eye, the transport of data (as with any shipping process that involves logistics) takes time.

24 Modes of Transmission

Data Transmission. Data (called messages) will be transported by its sender to a recipient via:
- the internet; or
- radio wave transmission.

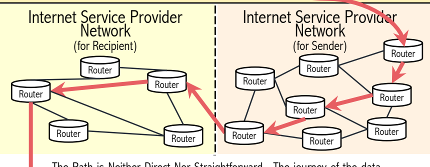
The Internet. The internet is a worldwide computer network (owned and operated by internet service providers (ISPs)) that transmits a variety of data and media across interconnected devices. Data are transmitted (on demand in the case of streaming services or online purchases) along the interconnected fiber optic cable networks owned by various ISPs to (1) the consumers' wired device or (2) to a local area network where data flows through a data connection (cable, fiber, or ethernet) to a local hub or modem and then to a Wi-Fi router for transmission to the consumer's wireless device.

Sender's Location (i.e., Local Area Network or LAN for Individuals and Wide Area Network or WAN for Enterprises)



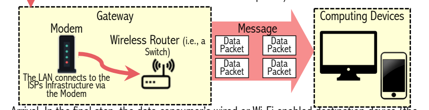
Messages Disassembled into Smaller Packets for the Internet Journey. The internet works by chopping data into chunks called packets. Each packet then moves from the sender's location (or local area network or LAN) to the network of a local internet service provider (ISP), where it will move rapidly through the internet in a series of steps (or hops).

Next Stop: Long-Haul Transmission by ISP. The next hop delivers the sender's data packets to a long-haul ISP, one of the telecommunications giants that transport data (at the speed of light) on their networks of fiber-optic cable and routers spanning the globe. ISPs offer the sender access to their networks for a fee based on connection speeds and bandwidth levels.



The Path is Neither Direct Nor Straightforward. The journey of the data packets often takes several more paths, which are plotted out one by one by the routers in the ISP's network (in accordance with a so-called "Border Gateway Protocol" or BGP), as the data packets moves across the Internet. For the system to work properly, the information shared among routers cannot contain lies or errors that might cause a data packet to go off track – or get lost altogether.

Recipient's Location (i.e., Local Area Network or LAN for Individuals and Wide Area Network or WAN for Enterprises)

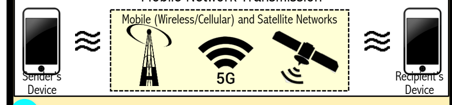


Arrival. In the final step, the data consumer's wired or Wi-Fi enabled destination device (the recipient's personal computer, tablet or smartphone) reassembles all the sender's data packets into a coherent message. A separate message goes back through the network to the sender confirming successful delivery.

25 Radio Spectrum

Electromagnetic Spectrum Radiation. The electromagnetic spectrum includes all forms of electromagnetic radiation, such as radio waves, infrared radiation, visible light, ultraviolet radiation, X-rays, and gamma rays. The spectrum encompasses a wide range of electromagnetic frequencies (from "extremely low frequencies" to extremely high frequencies) used for wireless communication. To transmit and receive cellular signals, devices use antennas designed for specific frequency ranges. For example, when a device transmits a radio signal (e.g., a radio wave produced by an alternating current in an antenna), it emits electromagnetic waves that spread out until they encounter a receiving device tuned to the same frequency. These waves can be be modulated with information (such as sound or data) by varying their amplitude (AM) or frequency (FM). The receiving device then converts the waves back into the original sound or data. To prevent interference caused when multiple devices that share the same frequency range disrupt one another's communications, the Federal Communications Commission (FCC) allocates different portions of the electromagnetic spectrum for specific uses (e.g., FM radio, AM radio, TV broadcasts, mobile networks, satellite communications, Wi-Fi, and radar).

Mobile Network Transmission



26 Transmission Networks

Transmission Network Owners. The U.S. internet landscape features miles of fiber-optic cable that connects the country to the world. While many owners of the largest fragments of these networks are well-known (AT&T, Comcast, Verizon), other less-well-known owners also play a vital role (e.g., Lumen Technologies and Cox Communications). There are over 2,500 internet service providers in the U.S., but nearly one-half provide wired connections, and only a few offer complete coverage across the entire country.

Data Transportation Services
- Wireless/Mobility Service (Wireless Voice, Data, Text and Public Safety Services)
- Wireless and Wireless-Enabled Products (Handsets, Wireless-Enabled Computers, Wireless Data Cards, Accessories)
- Wireline Service/ Broadband Connectivity (Internet Service via DSL, High-Speed, Fiber-Optic, and Copper-Based Networks)

Telecom Service Providers (Alphabet / Google FiberAT&T, Charter Communications Spectrum, Comcast Xfinity, Cox Communications, Lumen, Optimum, T-Mobile, US Cellular, Verizon)