Apple: Business Overview

June 2024

AMERICAS SEGMENT

FY2023 Revenue: $162.6 Billion

EUROPE SEGMENT

(includes Africa, Middle East & India)

FY2023 Revenue: $94.3 Billion

GREATER CHINA SEGMENT

FY2023 Revenue: $72.6 Billion

JAPAN SEGMENT

FY2023 Revenue: $24.3 Billion

REST OF ASIA SEGMENT

FY2023 Revenue: $29.6 Billion

PRODUCT AND SERVICE OFFERINGS

Products
(FY2023 Revenue: $298.1 Billion)

iPhone
(FY2023 Revenue: $200.6 Billion)

iPhone

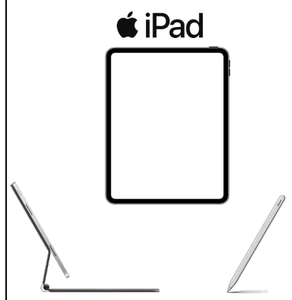
Mac
(FY2023 Revenue: $29.4 Billion)

MacBook

iMac

iPad
(FY2023 Revenue: $28.3Billion)

iPad



Wearables & Home Accessories
(FY2023 Revenue: $39.8 Billion)

AirPods

tv

WATCH

beats by dr.dre

Vision Pro

HomePod

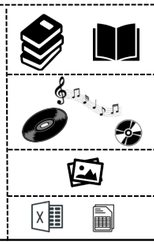
Services
(FY2023 Revenue: $85.2 Billion)

Advertising Services

Search Ads

Cloud Services

iCloud



Apple Care

AppleCare+

Digital Content

Arcade

Fitness+

Music

News+

tv+

Payment Services

Card

Pay

Pay Later
(to be discontinued)

Apple Ecosystem

Apple Inc.
One Apple Park Way
Cupertino, California 95014
Phone: (408) 996-1010 ; Website: www.apple.com

Outside Relationships

Regulators | Capital | Suppliers | Customers

U.S. Regulation

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

U.S. Patent and Trademark Office (USPTO); U.S. Copyright Office; and ICANN (patent, copyright, trademark, service mark, and domain name registrations and renewals; safe harbor against copyright liability for linking, caching, hosting third-party content)

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

U.S. Internal Revenue Service (IRS) and State Tax Authorities (regulation of corporate income taxes, indirect taxes such as excise/duty and sales/use taxes, payroll taxes, and withholding taxes)

U.S. Department of Justice (DOJ) and Federal Trade Commission (FTC) (DOJ/FTC enforcement of antitrust laws; FTC enforcement of, and investigations under, fair trade and consumer protection laws; DOJ enforcement of laws regarding data privacy foreign corrupt practices; advertising and sales; FTC prohibition of unfair or deceptive practices or claims in advertising)

U.S. Department of the Treasury (FinCen "know your customer" data collection requirements / anti-money laundering regulation; OFAC restricted party transactions regulation; and Treasury economic sanctions)

U.S. Customs and Border Protection (CPB) (regulation of imports of raw materials, supplies and intermediate and finished goods; customs duties administration)

U.S. Dept of Commerce (DOC), including Bureau of Industry and Security (BIS) Export Administration (EA) (DOC tariffs and trade barriers; BIS regulation of export of intermediate and finished goods, raw materials, and supplies, information handling; EA export licenses)

Consumer Protection (CPSC) (regulation of distribution of certain material to children and collection of information from minors; product defects protection)

Capital

- Public Debt Holders and Qualified Institutional Buyers — Bond Financing
- Hedge Counterparties — Foreign Exchange and Interest Rate Derivatives Contracts
- Commercial Paper Dealers and Lenders — Working Capital Financing
- Bank — Environmental, IP, Labor, Trad, Tax, and Consumer Safety, Business, and Antitrust Regulation

Suppliers

- Filmed Entertainment Content Producers and Partners — Licenses to Distribute Digital Entertainment Content
- Major League Soccer (MLS) (in 2022, MLS granted an exclusive 10-year, $2.5 billion license to Apple to distribute games) — License to Distribute All Major League Soccer Games Globally (via Apple TV+ Major League Soccer Subscription Streaming Service)
- Major League Baseball (in 2022, MLB granted Apple a 7-year license to broadcast games for US$85 million per year ($595 million total), including an annual $55 million rights fee and $30 million for Apple advertising.) — License to Distribute Major League Baseball Games Globally (via Apple TV+ Subscription Streaming Service on Friday Nights)

Digital Rights Management and Security Solutions

IP and Software Applications Licenses (Apple Receives a 30% Commission on App Sales and In-App Purchases)

iPhone, MacBook, Mac, and Tablet Sales (via Retail and Online Stores and Apple's Direct Sales Force)

Third Party IP and Software Developers
- Software Applications and Service Developers
- Intellectual Property Owners

Selected Suppliers

Electronic and Other Components
- Murata (ceramic capacitors)
- TDK (next generation small solid-state batteries made of all-ceramic material, using oxide-based solid electrolytes and lithium alloy anodes, to be use in wearable devices – e.g., wireless earphones, smartwatches, Air Tag tracking devices)

Consumer Markets for Mobile Phones, Computers, and Tablets

via Direct Sales Channels (37% of Sales)
- Individual Consumers
- Education Institutions
- Governments
- Large Enterprises
- Small and Mid-Sized Businesses

via Indirect Sales Channels (63% of Sales)
- Cellular Network Carriers (44% of Apple accounts receivable)
- Retailers
- Wholesalers
- Resellers (for large corporations and enterprises, small ssall businesses , and governments)

Customers

Hardware Components Supply and Assembly Services

Retail Consumers (Watch Wearers, TV Viewers, Music Listeners, and Headphone Users)

Wearables, Homes and Accessories Sales

Advertisers and Website Publishers (Universities, Small, Medium, and Large Businesses, Government Agencies, Political Campaigns)

Advertising Sales

Fee-Based Apple Care Phone Support and Repair Services

Apple Device Owners

Fee-Based Sales of Cloud Storage (Apple operates 10 data centers globally; by contrast, Microsoft Azure runs 300 data centers)

Digital Content Consumers

Commission-Based Digital Content Sales for Downloading

Readers, Applications and Entertainment Consumers (App Store, iTunes, Apple Books)

Subscription Based Digital Content Streaming Services

News, Entertainment, Fitness Consumers, and Gamers (Apple Music, Apple TV+, Apple News+, Apple Fitness+, Apple Arcade)

June 2024

Apple Inc. (a California corporation)

Debt Structure

Debt: $106.6B @ 9/30/23 | **Credit Ratings** (Senior Unsecured Debt): Moody's: AAA; S&P: AA+

Working Capital

Commercial Paper Program: Outstanding: $6.0B Avg. Rate: 5.28%

Other Debt/Segment Debt

2024-2062 Notes: $101.3B @ 0.00% to 4.65%

2026-2053 Notes: $5.2B @ 4.04% to 4.88%

Brand History

Apple Logo Through the Years

(1976–1977) | (1977–1995) | (1995–1998) | (1999 – 2001) | (2001 – 2007) | (2007 – 2015) | (2015 – Present)

Equity Structure

Equity

2023 Share Repurchase Program Authorized: $90 Billion Remaining: $74.1 Billion Expiration: None

Common Stock Authorized: 50.4 Billion Shares Issue and Outstanding: 15.552 Billion Shares Record Holders: 23,763

Governance

Board of Directors

- Arthur D. Levinson, Ph.D. (Chair, P)
- Susan L. Wagner (A, N)
- Wanda Austin, Ph.D. (A)
- Tim Cook
- Andrea Jung (N, P)
- Monica Lozano (A)
- Ronald D. Sugar, Ph.D. (A)
- Alex Gorsky (N, P)
- Committees: Audit and Finance (A), Nominating and Corporate Governance (N), People and Compensation (P)

Management Team

- CEO: Tim Cook
- SVP, General Counsel: Katherine Adams
- SVP, Services: Eddy Cue
- SVP, Software Engineering: Craig Federighi
- SVP, Machine Learning & AI Strategy: John Giannandrea
- SVP, Worldwide Marketing: Greg "Joz" Joswiak
- SVP, Operations: Sabih Khan
- SVP, CFO: Luca Maestri
- SVP, Retail: Deirdre O'Brien
- SVP, Hardware Technologies: Johny Srouji
- SVP, Hardware Engineering: John Ternus
- COO: Jeff Williams

Corporate Matters

Retail and People
- Talent Acquisition
- Talent Development
- Apple University
- Compensation
- Benefits
- Recruiting
- Culture
- Inclusion and Diversity
- Business Partnership
- Employee Relations and Experience

Finance and Accounting
- Accounting
- Business Support
- Financial Planning and Analysis
- Financial Reporting
- Treasury
- Real Estate
- Investor Relations
- Internal Audit
- Tax

Services
- iTunes Store
- Apple Music
- Apple Pay
- Apple Maps
- Search Ads
- iCloud Services
- Productivity and Creativity Apps
- Worldwide Video Programming

Legal
- Cyber Security
- Corporate Governance
- Antitrust
- Intellectual Property
- Litigation and Securities Compliance
- Global Security
- Privacy

Marketing
- Global Marketing
- Products Marketing
- Product Management

Services

Technologies
- Silicon Engineering
- Batteries
- Application Processors
- Storage Controllers
- Sensors Silicon
- Display Silicon
- Chip Sets

Engineering
- Hardware Engineering Team
- Key Product Engineering (e.g., iPhone, iPad, Mac, and AirPods)

Operations
- Global Supply Chain
- Product Quality
- Planning
- Procurement
- Manufacturing
- Logistics
- Product Fulfillment
- Supplier Responsibility Programs

Software Engineering
- iOS, macOS and Siri Software Development
- User Interface
- Applications
- Frameworks
- Apple CarPlay

Machine Learning
- AI Strategy
- Machine Learning Strategy
- Core Machine Learning Technology Development
- Siri Technology Development

Operations

Business Segments

Americas (FY23 Revenue: $162.6 Billion)

Regions: North America; South America

Offices: Corporate HQ Cupertino, CA; Austin, Texas; Seattle, Washington; San Diego, California; Toronto, Canada; Boulder, Colorado; Mexico City, Mexico

Retail Stores: US - 273; Mexico - 2; Canada - 28; Brazil - 2

Europe (FY23 Revenue: $94.3 Billion)

Regions: Europe; Middle East; Africa; India

Offices: Europe HQ Cork, Ireland; Bengaluru, India; Munich, Germany; Dubai, United Arab Emirates; Paris, France; London, England; Istanbul, Turkey

Retail Stores: United Kingdom - 40; Germany – 16; UAE - 4; India – 2; Sweden – 3; France – 20; Spain – 11; Netherlands - 3; Austria – 1; Italy – 17; Switzerland – 4; Turkey - 3; Belgium – 1

Greater China (FY23 Revenue: $72.6 Billion)

Regions: Taiwan; Hong Kong; China Mainland

Offices: Hong Kong; Shanghai, China; Taipei City, Taiwan

Retail Stores: China Mainland - 46; Hong Kong - 6; Taiwan - 2

Japan (FY23 Sales: $24.3 Billion)

Regions: Japan

Offices: Tokyo, Japan

Retail Stores: Japan - 10

Rest of Asia Pacific (FY23 Revenue: $29.6 Billion)

Regions: Australia; Thailand; South Korea; New Zealand; Indonesia; Vietnam

Offices: Sydney, Australia; Kuala Lumpur, Malaysia; Singapore; Jakarta, Indonesia; Auckland, New Zealand; Seoul, South Korea; Cotai, Macao; Bangkok, Thailand

Retail Stores: Australia - 22; *Singapore - 3*; Thailand -2; South Korea - 5; Macau - 2

Product and Service Offerings

Products (FY2023 Revenue: $298.1 Billion)

iPhone (FY23 Revenue: $200.6 Billion)

Smart Phones Based on iOS Operating System

Devices: iPhone 15 Pro; iPhone 15; iPhone 14; iPhone 13; iPhone SE; iPhone Accessories (cases, chargers, adapters)

Smart Phone Competition: Pixel; SAMSUNG; HUAWEI; mi; XIAOMI

Mac (FY23 Revenue: $29.4 Billion)

Personal Computers Based on macOS Operating System

Devices: Laptops: MacBook Air (13" and 15" with M2 chip); MacBook Pro (14" and 16" with M3 chip); Desktops: iMac (24"); Mac Pro; Mac.mini; Mac Studio; Mac Accessories (displays, keyboards, trackpads, mice, adapters)

Laptop/Desktop Competition: DELL Technologies; hp; SONY; Lenovo 联想

iPad (FY23 Revenue: $28.3 Billion)

Multi-Purpose Tablets Based on iPadOS Operating System

Devices: iPad Pro; iPad Air; iPad; iPad mini; iPad Accessories (smart cover, pencil, keyboard, adapters)

Tablet Competition: Google; SAMSUNG; amazon; Microsoft

Wearables, Home and Accessories (FY23 Revenue: $39.8 Billion)

Wearables, Home, and Accessories (includes Apple-Branded and Third-Party Accessories)

Devices: AirPods, AirPods Pro, AirPods Max; Apple TV 4K and Apple TV HD; Apple Watch Ultra 2, Apple Watch Series 9, and Apple Watch SE; Beats Headphone Products; Home Pod and Home Pod mini (high fidelity wireless smart speakers); Accessories (air tags, phone cases, apple watch bands); Apple Vision Pro (virtual headset with spatial computer)

Accessories Competition: HUAWEI; fitbit; BOSE; SAMSUNG; SONY; mi; XIAOMI

Services (FY2023 Revenue: $85.2 Billion)

Advertising Services

Includes Third-Party Licensing Arrangements and Apple's Advertising Platforms

Services: Search Ads

Competition: Meta; amazon; yahoo!; Google Ads

Cloud Services

Keeps Customer's Content Up-To-Date and Available Across Multiple Apple Devices and Windows Personal Computers

Services: iCloud — Cloud-Based Data Storage (Photos, videos, documents, music, contacts, and more)

Ad/Cloud Services Competition: Google; amazon; Microsoft

Apple Care

Fee Based Service and Support Products Under Apple Care Brand

Services: AppleCare (AppleCare is the standard limited warranty that comes with any Apple device purchase, providing 90 days of complimentary support, and AppleCare+ is an extended warranty that can be purchased for purchase separately); AppleCare; AppleCare+; Technical Support; Apple Authorized Repair and Replacement Services; Extended Warranty Coverage (accidental damage and/or theft or loss)

Warranty Competition: ZAGG; AKKO; PROGRESSIVE; asurion; Allstate PROTECTION PLANS

Digital Content

Platforms That Allow Customers to Discover and Download Applications and Digital Content, Some on a Subscription Basis

Services

Platform: App Store (Platform allowing users to browse, purchase and download mobile applications and digital content)

Subscription-Based Services: Arcade; Video Game Subscription Service; Fitness+; Personalized Fitness Service; Music; Curated Listening Experience With On-Demand Radio Stations; News+; Apple News+ (subscription news and magazine service with 300+ magazines and newspapers); tv+; Apple TV+ (offers exclusive original content and sports)

Digital Content Competition: NETFLIX; prime video; max; Disney+; Spotify; YouTube Music; peacock; hulu; Paramount+; pandora; amazon music

Payment Services

Payment Services, including a Co-Branded Credit Card and a Cashless Payment Service

Services

- Apple Card (co-branded credit card with Goldman Sachs)
- Apple Pay (a cashless payment service)
- Apple Buy Now, Pay Later (consumer loans for purchases of Apple products that (1) lets U.S. customers split a purchase into four equal payments over six weeks, with no interest or fees to pay, (2) is available for purchases in apps and online when customers check out with Apple Pay, and (3) is built into Apple Wallet so customers can easily track what they owe and when) — Pay Later. On June 17, 2024, Apple said it is discontinuing the Pay Now, Pay Later service. Users can apply for new loans through Affirm.

Payments Competition: G Pay; amazon; PayPal; SAMSUNG Pay

Outside Relationships

Customers | Suppliers | Capital | Regulators

Securities Regulation, Stock Exchange Listing Rules, and Corporate Governance Requirements

Equity Capital

Dividends and Common Stock Repurchases

Professional Services

Communications Regulation

Significant Artificial Intelligence Relationships

License of Right to Make Google the Default Search Engine on Apple's Safari Web Browser

Purchases of Apple Products (and Third-Party Products) and Services Using Apple Card, Apple Pay Later, and Apple Pay Cashless, Contactless Payment Services (consumers receive 3% cash back on purchases)

Apple Pay Cashless, Contactless Payment Services

Issuance of Apple Credit Cards (3% cash back on purchases)

Financial Services Arrangements

Significant Shareholders
- Vanguard Group (8.60%)
- BlackRock Inc. (6.79%)
- Berkshire Hathaway (5.15%)
- State Street Corporation (3.84%)
- Geode Capital Management (2.01%)
- Fidelity Management and Research (1.92%)
- Institutional Ownership 61.66%

Selected Professional Services Firms
- Ernst & Young (audit services)
- TBWA\Media Arts Lab (media services)
- Capitol Tax Partners (lobbying services)
- Key Legal Services Providers: SIDLEY; FISH & RICHARDSON; orrick; WILMERHALE; DLA PIPER; MORRISON FOERSTER

Securities and Corporate Governance Regulators
- U.S. Securities and Exchange Commission (regulation of offers and sales of securities, material event disclosure and financial reporting requirements, and anti-bribery law record-keeping requirements)
- NASDAQ Global Select Market (listing, maintenance and corporate accountability rules)
- California Secretary of State (administration and enforcement of Delaware corporation law governing business entity formation and dissolution, shareholder, board and officer governance / meetings, management duties, financial reporting, charter document amendments, mergers and acquisitions, and compliance / penalties for non-compliance)
- Federal Communications Commission (FCC) (regulation of TV, satellite, radio, wire, and cable communications, broadband access, fair competition, radio secrecy, homeland security, and public safety; regulation of multi-channel video programing distributors)

Selected AI-Related Relationships
- NVIDIA (accelerated computing graphic processing units for generative AI training)
- Alphabet-Owned Google (in exchange for Google's payment of an ~$18 billion fee per year, Apple licenses the right to make Google the default search engine on Apple's Safari web browser)
- OpenAI (in June 2024, OpenAI and Apple announced a partnership to integrate OpenAI's ChatGPT generative AI service into applications and experiences in Apple products)

Payment Services Consumers
- Apple Credit Card Holders
- Apple Device Owners

Apple-Branded Credit Card Program
- Goldman Sachs Bank USA (issuing bank under Apple credit card program)
- Mastercard (credit card network and payment processing services for Apple Card and Pay Later transactions)

Key Company Data (as of 09/30/2023)

Business Overview: Apple designs, manufactures, and markets many of the world's most popular smart phones, personal computers, tablets, wearables, accessories. Apple's flagship products are the iPhone, iMac, MacBook Pro, iPad, and iOS operating system. Apple's wearables, home products and accessories include Air Pods, Apple TV, Apple Watch, Beats headphone products, the HomePod smart speaker, and Apple-branded accessories. Apple also offers various services, including its own Search Ads advertising platform, the Apple Care fee-based repair and replacement service, cloud services to keep customers' content up-to-date and available across multiple devices, platforms such as the App Store, Apple Books, Apple Music, Apple News+, and Apple TV+ that allow customers to download media and games for a fee or digital content on a subscription basis. Apple also offers a co-branded credit card, and cashless and installment payment services.

Share Data
- NASDAQ Stock Exchange Ticker Symbol: AAPL
- Share Price: $214.29 (06/18/2023)
- Earnings Per Share (Trailing 12 Months): $6.44
- Forward Annual Dividend: $1.00/share
- Market Capitalization: $3.29T (06/18/2023)

Financial Highlights

Results of Operations
- Net Sales: $383.2B
- Products: $298.1B
- Services: $85.2B
- Cost of Sales: $213.0B
- Products: $189.3B
- Services: $24.9B
- Gross Margin: $169.1B (43.31%)
- Net Income: $97.0B

Balance Sheet
- Total Assets: $352.6B
- Total Liabilities: $290.4B
- Long-Term Debt: $95.3B
- Equity: $62.1B

Cash Flow
- From Operations: $110.5B
- From Investing: $3.7B
- Used in Financing: ($108.5B)

Financial Returns
- Return on Equity: 171.9%

Resources
- Employees: 161,000
- Headquarters: Cupertino, California
- Patents: 2,000+
- Suppliers: Each year it releases a progress report outlining its supplier relationship efforts as well as a list of its top 200 suppliers, which account for 98% of its procurement.

Key Developments

NVIDIA Graphics Processors. Apple plans to spend $4.75 billion on AI servers equipped with Nvidia's HGX H100 8-GPU next year for generative AI training and high- performance computing.

OpenAI Partnership. In June 2024, Apple previewe AI-powered features for iPhone, iPad and Mac in the fall. Most are fueled by Apple's own Apple Intelligence proprietary technology, but the company will offer OpenAI's viral ChatGPT tool in a limited capacity—e.g., when Siri is activated and needs more assistance answering an inquiry.

Manufacturing and Assembly Services

Qualcomm (electronic components such as power trackers and management modules, GPS/DCMA receivers, transceivers, and mobile phone processors)

Taiwan Semiconductor Manufacturing Company (production of Apple's M series advanced chipsets)

Broadcom (5G radio frequency components—e.g., FBAR filters and wireless connectivity components from Broadcom's U.S. manufacturing facilities)

Micron (memory chips)

Samsung (OLED screens and electronic components—e.g., flash memory, mobile DRAM & application processors)

LG Innotek (displays)

Toshiba & Sharp (LCD panels, for Apple iPhone)

Corning (specialty glass for smartphones)

Goertek (speaker, acoustic and wireless components)

Wistron (printed circuit boards)

Hon Hai Technology (dba Foxconn) (precision assembly services)

Luxshare (Apple Vision Pro headset and Air Pods production)

Jabil (electronic manufacturing and assembly services & casings for iPhone and iPad)

Pegatron (assembly services)

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

June 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);
- 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 (1) 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).

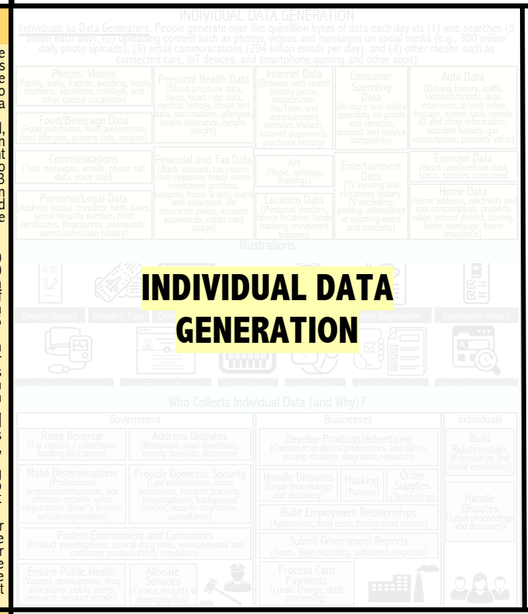
C DOWNSTREAM: DATA CONSUMPTION

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

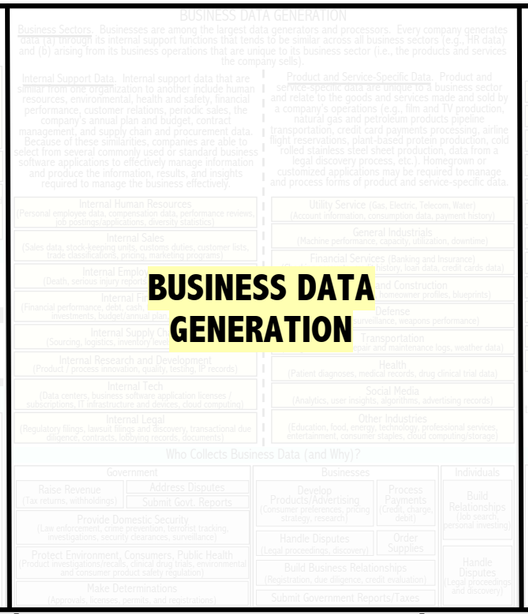
- let the data sit on their device unopened,
- delete the data from their device (e.g., junk mail, remove duplicate images and media)
- consume it, and then:
  - Delete the data, or
  - Store the data on the device, or
- work on the data, which restarts the data cycle of generation, processing, transmission,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

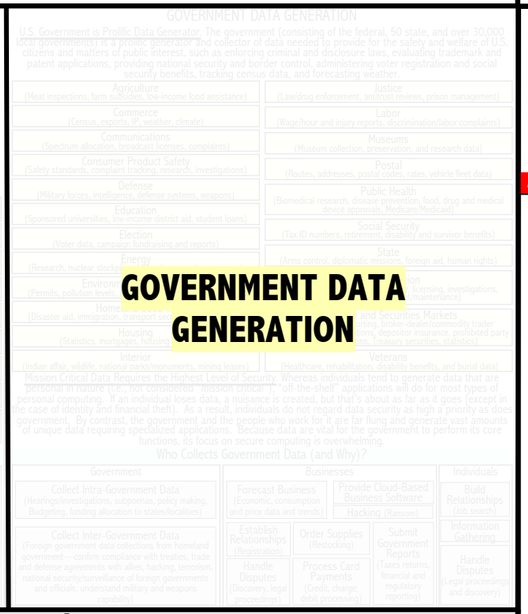
Data Generation, Computing and Consumption



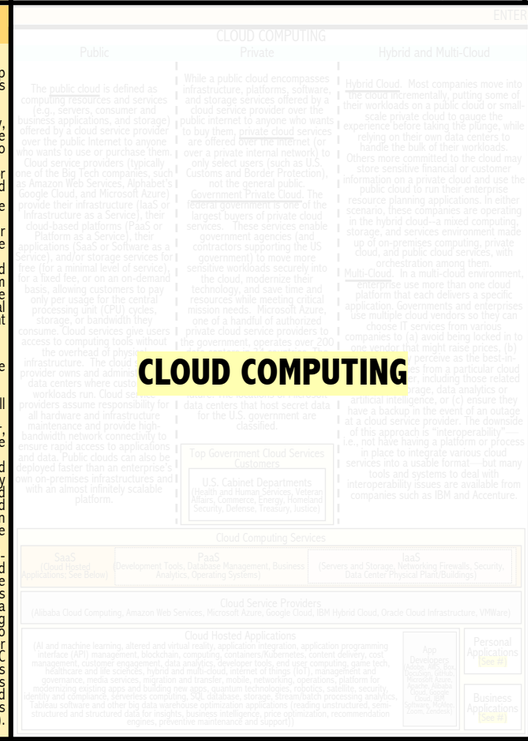
INDIVIDUAL DATA GENERATION



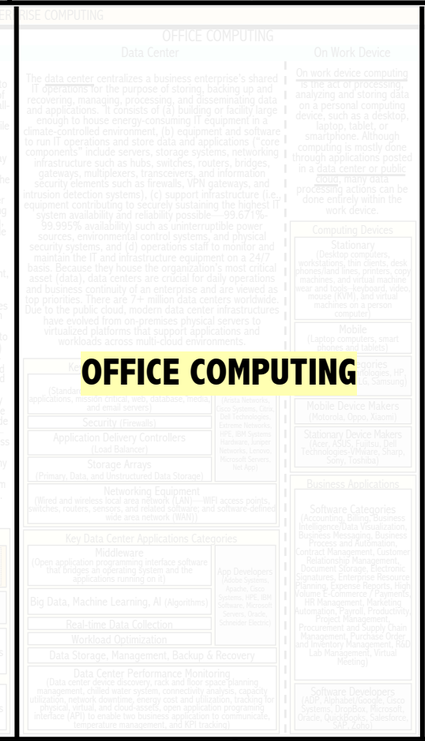
BUSINESS DATA GENERATION



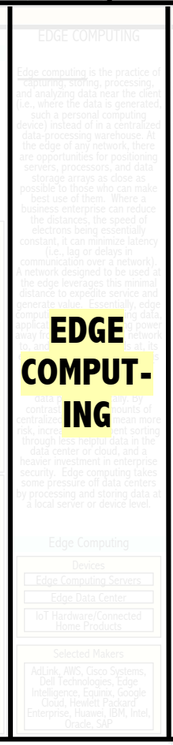
GOVERNMENT DATA GENERATION



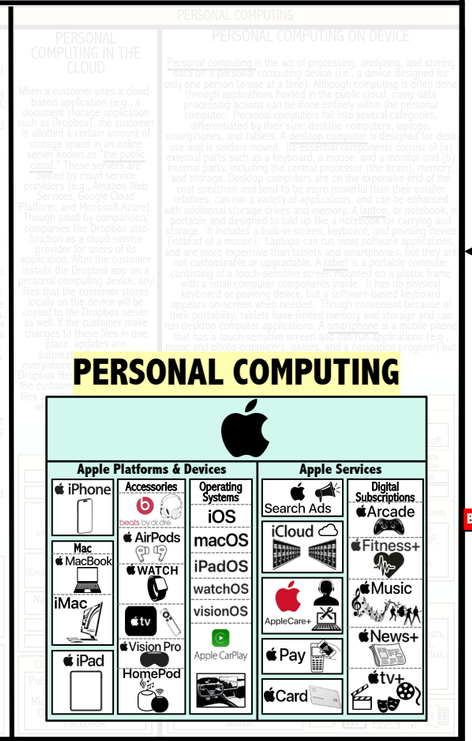
CLOUD COMPUTING



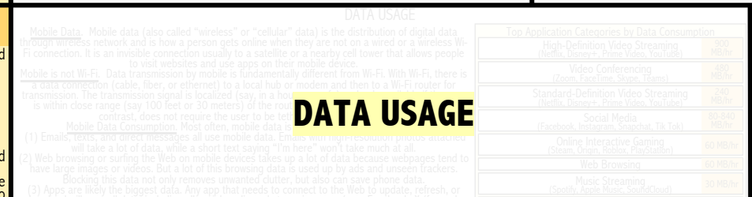
OFFICE COMPUTING



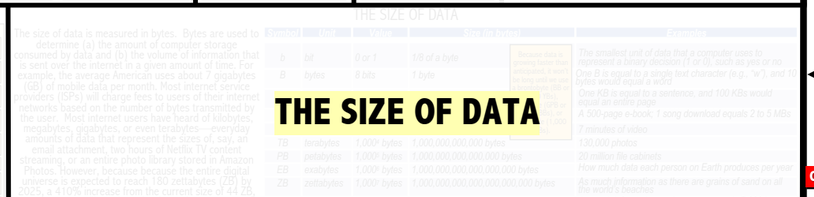
EDGE COMPUT-ING



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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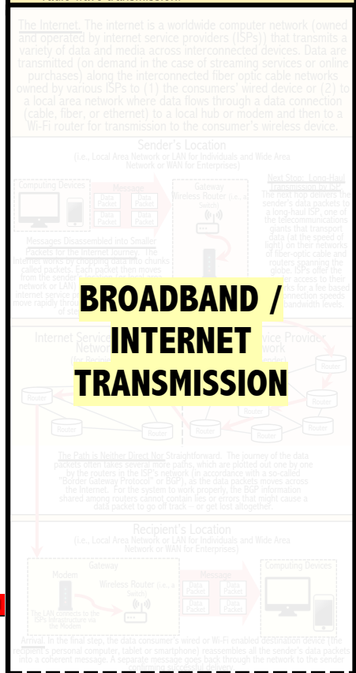
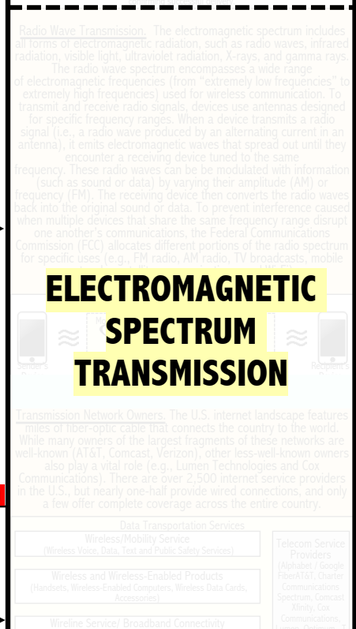


Data Transmission to Midstream Sector B1

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



Overview of the Information Technology Industry: Simplified

June 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.

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- 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.

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C — DOWNSTREAM: DATA CONSUMPTION

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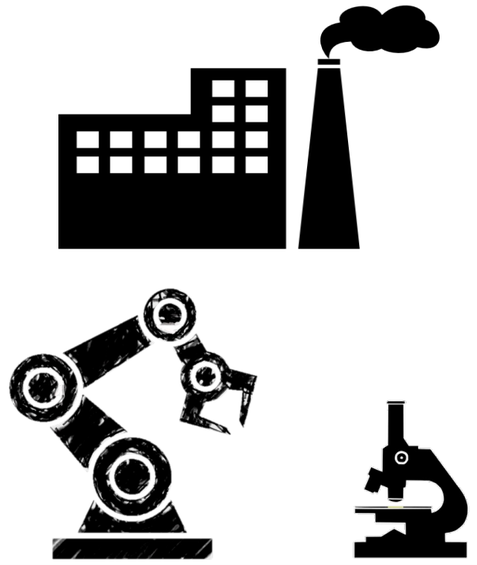
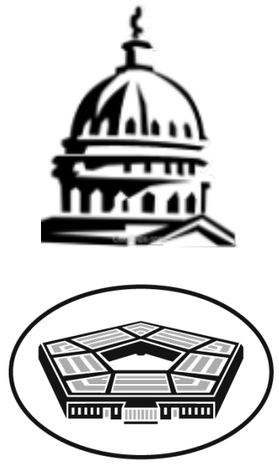
Data Generation, Computing and Consumption

INDIVIDUAL DATA GENERATION

BUSINESS DATA GENERATION



GOVERNMENT DATA GENERATION



ENTERPRISE COMPUTING

CLOUD COMPUTING

Cloud Data Center

OFFICE COMPUTING

On-Premises Data Center

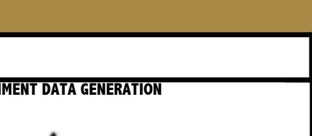
EDGE COMPUTING

PERSONAL COMPUTING

PERSONAL COMPUTING IN THE CLOUD

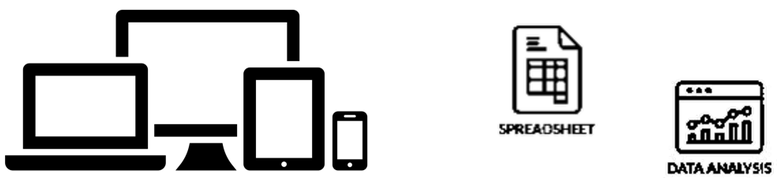
PERSONAL COMPUTING ON DEVICE

Devices



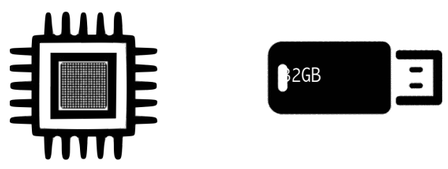
Personal Applications

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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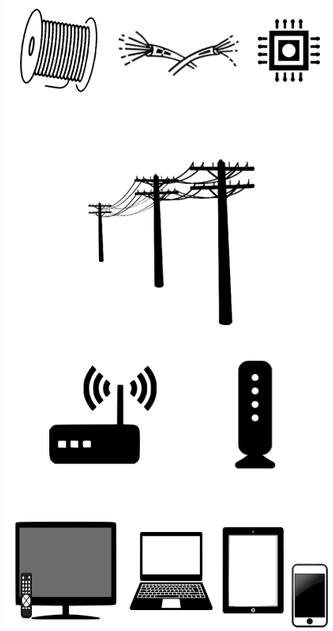
BROADBAND/INTERNET TRANSMISSION



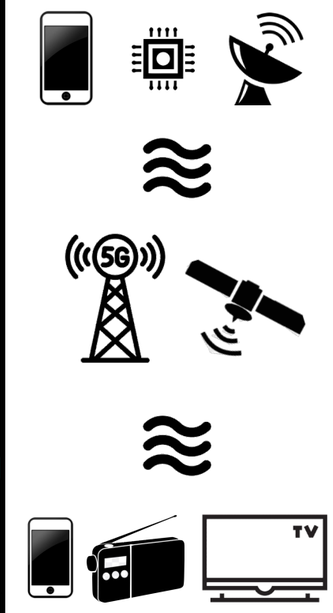
Data Transmission to Midstream Sector — B1

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

ELECTROMAGNETIC SPECTRUM TRANSMISSION



Overview of the Information Technology Industry: Key Players

June 2024

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Data Generation, Computing and Consumption

INDIVIDUAL DATA GENERATION

BUSINESS DATA GENERATION

GOVERNMENT DATA GENERATION

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, Palo Alto Networks, Arista, Fortinet, Lightstream, Huawei, Extreme Networks

EDGE COMPUTING

Edge Intelligence, an ADLINK company; ADLINK Leading Edge Computing; Oracle; Cisco; Dell Technologies; Hewlett Packard Enterprise; IBM

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, Xiaomi, HP, Apple, Lenovo, Acer, Huawei, Google

Applications Developers

Openxcell, Tencent, eleks, Willowtree (a TELUS International Company), amazon, Intuz, EA, YML, intellectsoft, Google, Apple, Microsoft Activision Blizzard, Spotify, Netflix

DATA USAGE

Data Transmission

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BROADBAND/INTERNET TRANSMISSION

AT&T, verizon, Comcast xfinity, Charter Spectrum, Google Fiber, Cox, Lumen

ELECTROMAGNETIC SPECTRUM TRANSMISSION

AT&T, verizon, T-Mobile, uscellular

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 at A)

Overview of the Information Technology Industry: Detailed

June 2024

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- 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);
- 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.

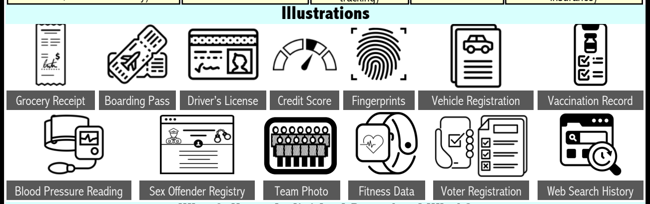
Data Generation, Computing and Consumption

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)

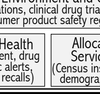
- Photos, Videos (Family, baby, friends, wedding, family reunions, vacations, holidays, and other special occasions)
- Food/Beverage Data (Food purchases, food preferences, food allergies, grocery lists, recipes)
- Communications (Text messages, emails, phone call data, voice mail)
- Personal/Legal Data (Address books, contacts, birth dates, social security number, birth certificates, fingerprints, passwords, arrest/conviction history)
- Personal Health Data (Blood pressure data, sleep, heart rate data, medical history, blood test data, vaccinations, allergies, health insurance, height, weight)
- 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)
- Internet Data (Browser web search history (porn, amazon.com, YouTube, and entertainment websites visited), account passwords, purchase history)
- Art (Music, writings, drawings)
- Location Data (Personal location, device location, family tracking, movement tracking)
- Consumer Spending Data (In-store and online spending on goods and services, product and service complaints)
- Entertainment Data (TV viewing and streaming history, TV recording, gaming, attendance at sporting event and concerts)
- 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)
- 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)

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

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)

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)

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.

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)

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

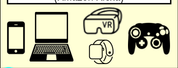
Cloud Service Providers
Publicly Available: Amazon Drive, Google Drive, Microsoft OneDrive Users Only: Apple iCloud and Facebook

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, VR headsets)
- 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

A — Data Transmission from Upstream Sector

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)

D Connecting Streams: Data Transport

23 Upstream to Midstream to Downstream

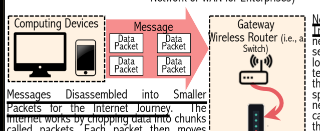
Round-Trip Process. Raw, unprocessed data will be transported from an individual's device (whether acting alone or for a business or government entity) to a data center, private cloud or public cloud and back again as refined data. This cycle is essentially a "round-trip" process, where data is effectively 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.

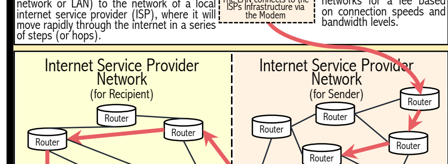
The Internet. The internet is a worldwide computer network (owned and operated by internet service providers (ISPs)) that transmits a variety of data and media across interconnected devices. Data are transmitted (on demand in the case of streaming services or online purchases) along the interconnected 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)



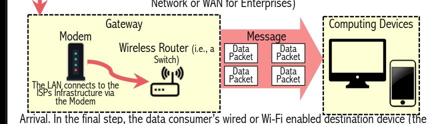
Messages Disassembled into Smaller Packets for the Internet Journey. The internet works by chopping data into chunks called packets. Each packet then moves from the sender's location (or local area network or LAN) to the network of a local internet service provider (ISP), where it will move rapidly through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

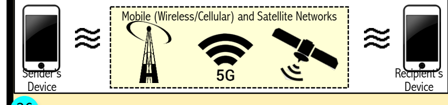


Arrival. In the final step, the data consumer's wired or Wi-Fi enabled destination device (the recipient's personal computer, tablet or smartphone) reassembles all the sender's data packets into a coherent message. A separate message goes back through the network to the sender confirming successful delivery.

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)