June 2022

Overview of the Information Technology Industry: From Data Generation, Storage and Processing to Data Transportation and Consumption

Data Activities

Upstream: Data Production

The Promise of Data. Many experts believe data (and particularly big data) hold the key

Midstream: Data Storage & Processing

growth of the data volume, the installed base of storage capacity is forecast to increas

costs, when to repair equipment, what goods to produce (and the price to sell them), or

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Edge to Core to Cloud. The applications can be located (a) on-device (i.e., on the same computing device where the data are stored), (b) on-premises (i.e., in a data center maintained by an enterprise at a central or core location), (c) at the edge (i.e., at the location near where the data are generated), (d) in the cloud (i.e., a data center operated by a cloud service provider, where over 30% of all stored data is uploaded), or (e) 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.

Downstream:

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 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.

The Internet. Data (called messages) will be transported by its sender to a recipient along the internet, a worldwide computer network (owned and operated by internet service providers) that transmits a variety of data and media across interconnected

in order to be usable.

Data are produced (i.e., mined or generated and captured in

a tangible or digital medium) by their owner in order to be

Data as a If the subjects of data generation, storage and processing, computing devices, information technology infrastructure for data centers and the cloud, and | . There are upstream activities (exploration, mining, and production), midstream telecommunications networks are confusing to you, it helps to think of data in similar terms to the oil and gas industry because data are as much a natural resource as crude oil or natural gas found in Deepwater Offshore Gulf of Mexico or coal mined beneath the earth's surface in Wyoming or West Virginia.

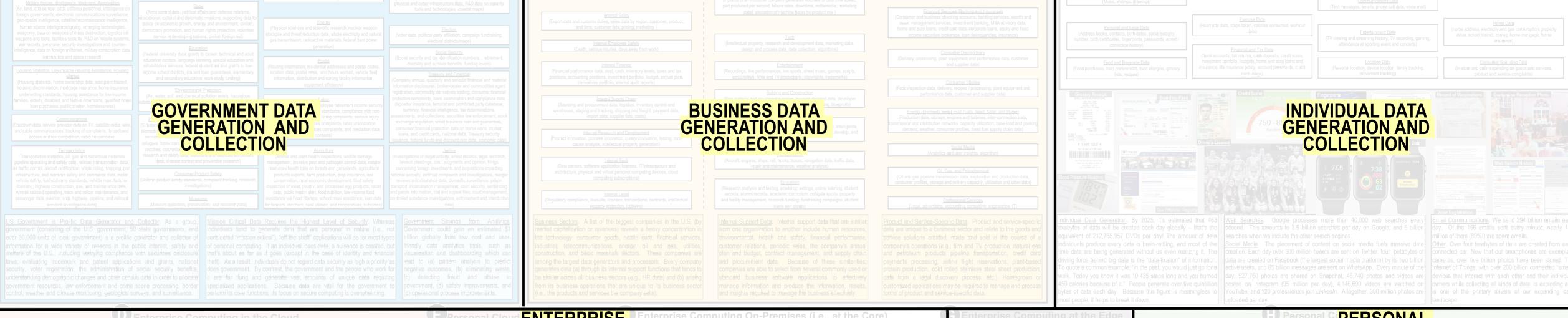
activities (storage, refining and processing), and downstream activities ("last mile pipeline distribution," retail sales, and consumption of finished goods).

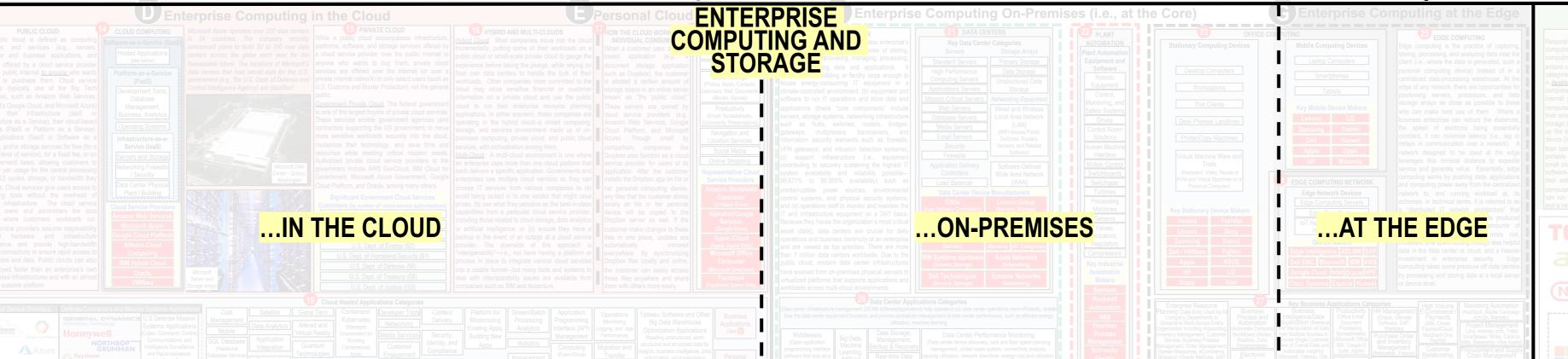
UPSTREAM: PRODUCTION MIDSTREAM: STORAGE AND PROCESSING

- Oil and gas are brought to the surface via drilling operations Oil and gas are stored and then refined at refineries and production plants by the producer into more valuable intermediate products (e.g., dry (i.e., produced) by the owner of the natural resources rights natural gas, ethane, propane, diesel, jet fuel, gasoline, kerosene, heating oil, dry natural gas, bitumen, and lubricating oil). <u>Data</u> are stored and then processed (using applications on computing devices or in data centers and the cloud) into more valuable products for their
 - producers (or third parties who obtain the data from these producers), such as (a) a photo collection, music playlist, healthy diet plan, or recommended exercise regime for individuals or (b) insights on how to increase business productivity, when to maintain equipment, or how to

DOWNSTREAM: TRANSPORTATION AND CONSUMPTION

- Oil and gas: Finished goods from crude oil, natural gas and petrochemical refining processes will be transported via pipelines, trucks, and tankers and sold into downstream markets where they will be be consumed by end users such as motorists, electric and gas utilities, homeowners, commercial airlines, industrial companies, and commercial establishments.
- <u>Data</u>: Unrefined and refined data will be transported via telecommunications/internet network from the point of storage or refinement to data consumers—i.e. individuals, business enterprises, and government agencies.









Data Transport & Consumption Round-Trip Process. Raw, unprocessed data will be transported from an individual's "round-trip" process, where data is effectively mined, shipped, refined, and shipped again.

devices. In the year 2000, only 52% of US adults used the internet. That number jumped to 90% in 2020. Approximately 7.5 billion people are projected to use the internet by 2030 when 500 billion devices will be connected to the internet.

Receipt and Consumption. Once refined data are received, government agencies enterprises and individuals can delete the data, consume it (and then delete or store the data), or work on the data (which restarts the data cycle).

DATA TRANSMISSION

DATA CONSUMPTION

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Data Activities

Upstream: Data Production

June 2022

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.

<u>Data Creators</u>. Every individual, business enterprise, and government agency anywhere generates data. **Individuals** constantly generate data, primarily of a personal nature. 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 that indicate 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.

<u>Data Collection</u>. 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.

Midstream: Data Storage & Processing

Storage. Once generated, data will be stored until needed (a) on disks embedded in stationary and mobile computing devices (e.g., desktop and laptop computers, tablets, smartphones, digital assistants, wearables/watches, and fitness trackers), (b) in data centers operated by government agencies and business enterprises, and (c) 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%.

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 (a) for individuals, a photo collection or recommended music playlist, healthy diet plan, or exercise regime for individuals or (b) for 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

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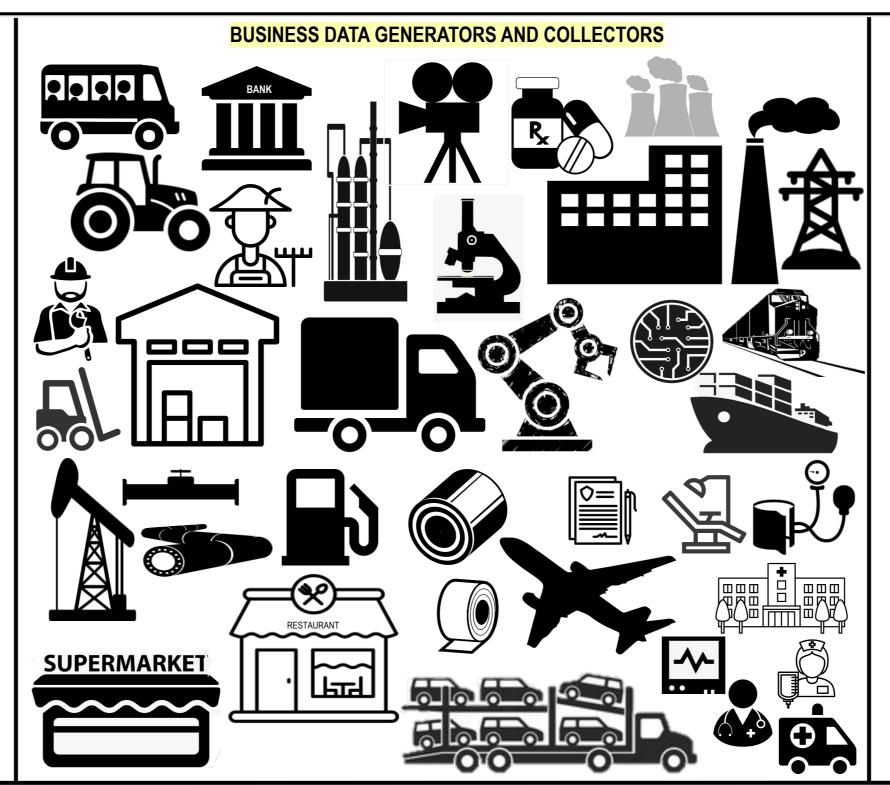
Downstream: Data Transport & Consumption

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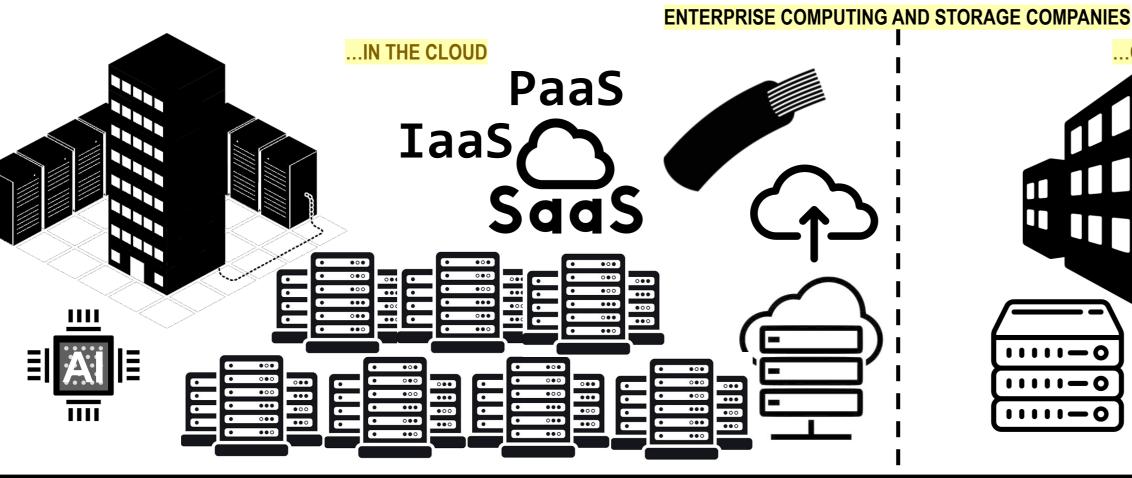
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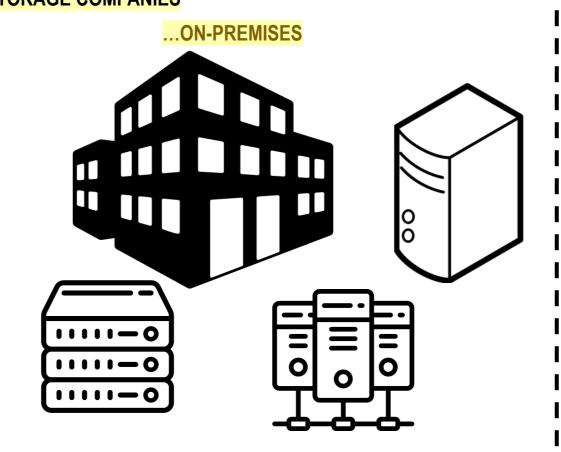
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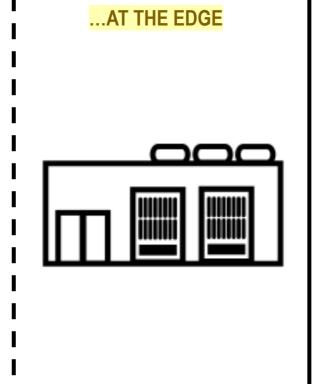


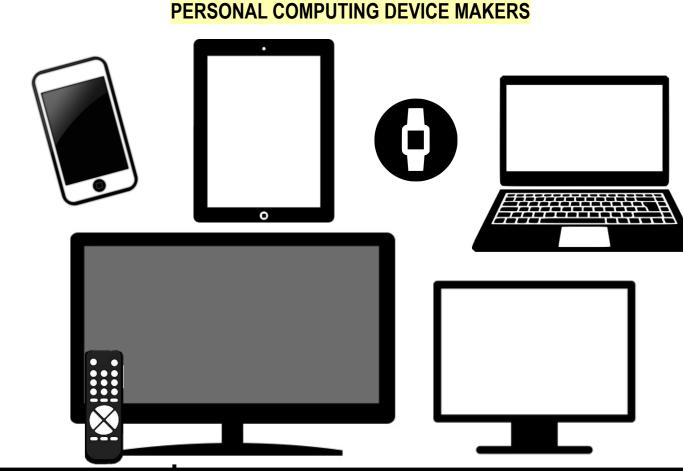






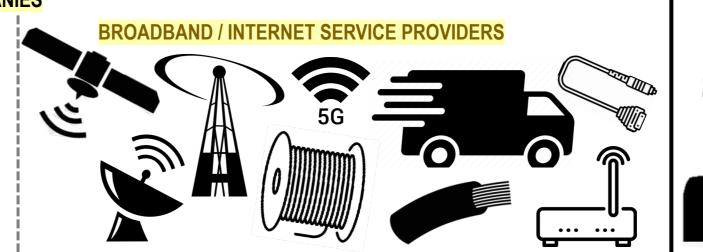






DATA TRANSMISSION COMPANIES







DATA CONSUMPTION

Upstream: **Data Production**

June 2022

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Data Storage & Processing

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Data Activities

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Midstream:

ORACLE

CLOUD

Semiconductors

Ínfineon

Qualcomm

NORTHROP

RENESAS

№ BROADCOM[®]

AMD

TEXAS life.augmented

INSTRUMENTS

GRUMMAN

Google Cloud

Technologies

tsmc

LOCKHEED MARTIN

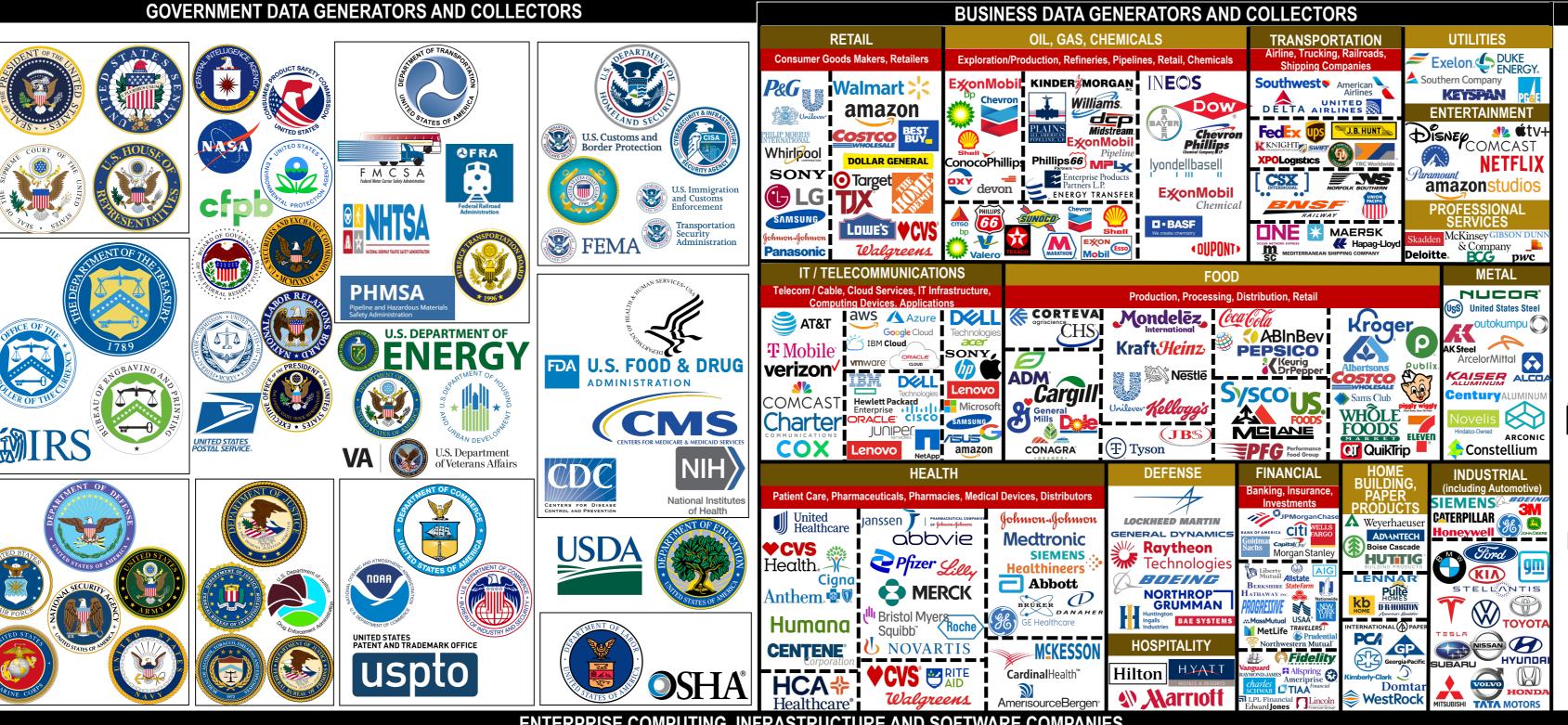
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Downstream:

Data Transport & Consumption

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..AT THE EDGE





TOSHIBA





















/ISUS

















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Overview of the Information Technology Industry: Data Flows

Data Activities

Upstream: Data Production

June 2022

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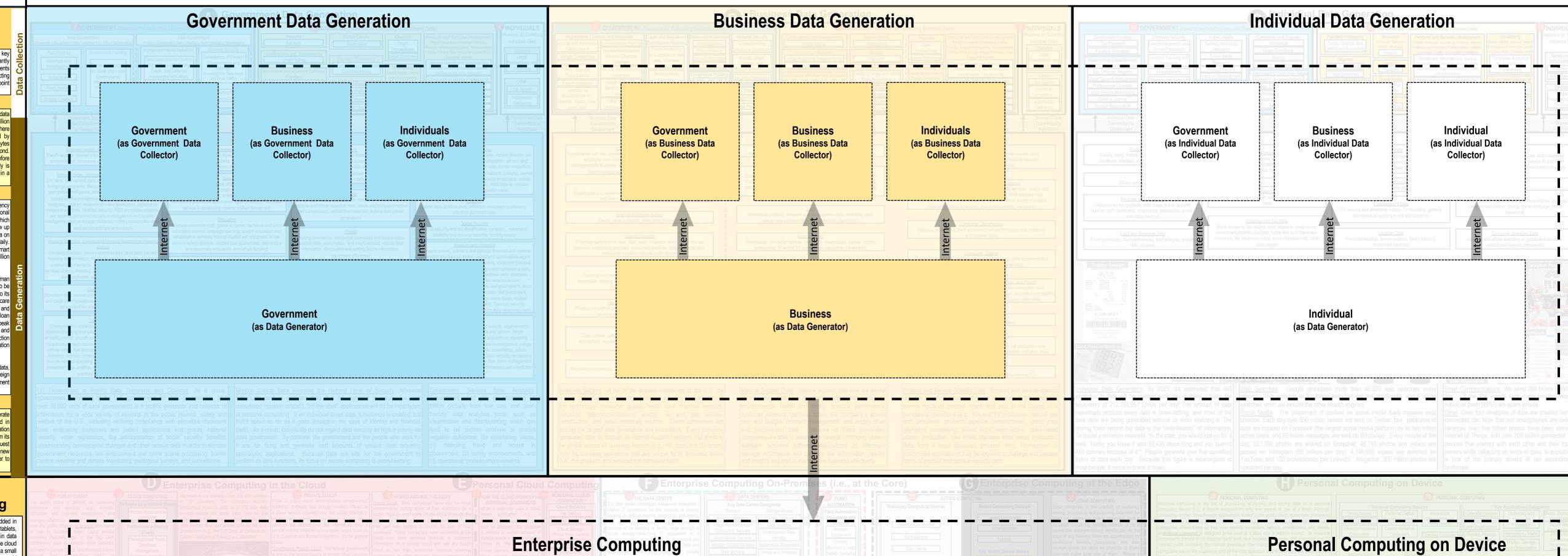
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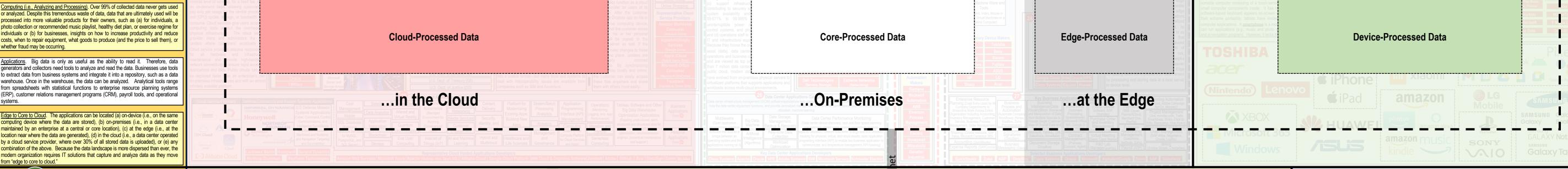
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Data Transmission

Internet Service Provider's Telecommunications Network

Data Consumption



Individuals (as Data Consumer)

Overview of the Information Technology Industry: Detailed

Data Activities

June 2022

Upstream: Data Production

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o use or purchase them. Cloud service

iders (typically one of the Big Tech

abet's Google Cloud, and Microsoft Azu

tforms (PaaS or Platform as a Service

applications (SaaS or Software as

vice), and/or storage services for free (for

n on-demand basis, allowing customers t by only per usage for the central processing of the central processing (CPU) cycles, storage, or bandwidth the

ume. Cloud services give users access

hysical infrastructure. The cloud serv

provider owns and administers the data

enters where customers' workloads ru

ud service providers assume respon-

astructure as a Service), their cloud-

Database Management,

Operating System

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Computing (i.e., Analyzing and Processing). Over 99% of collected data never gets used

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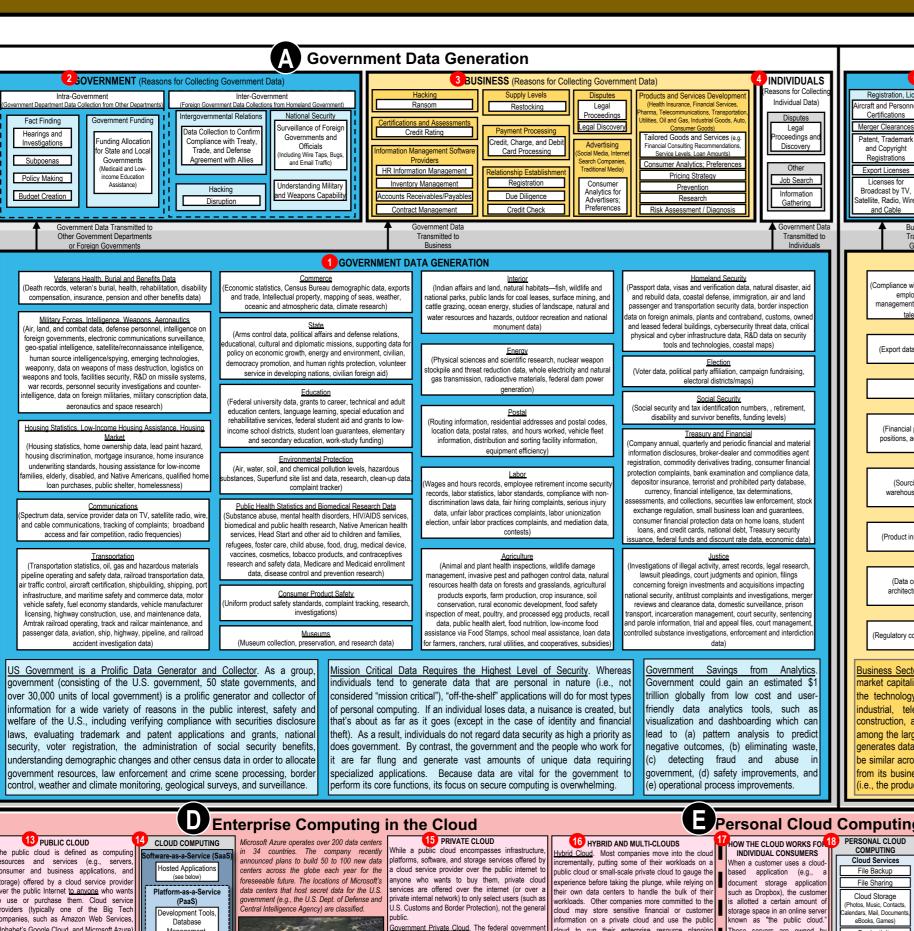
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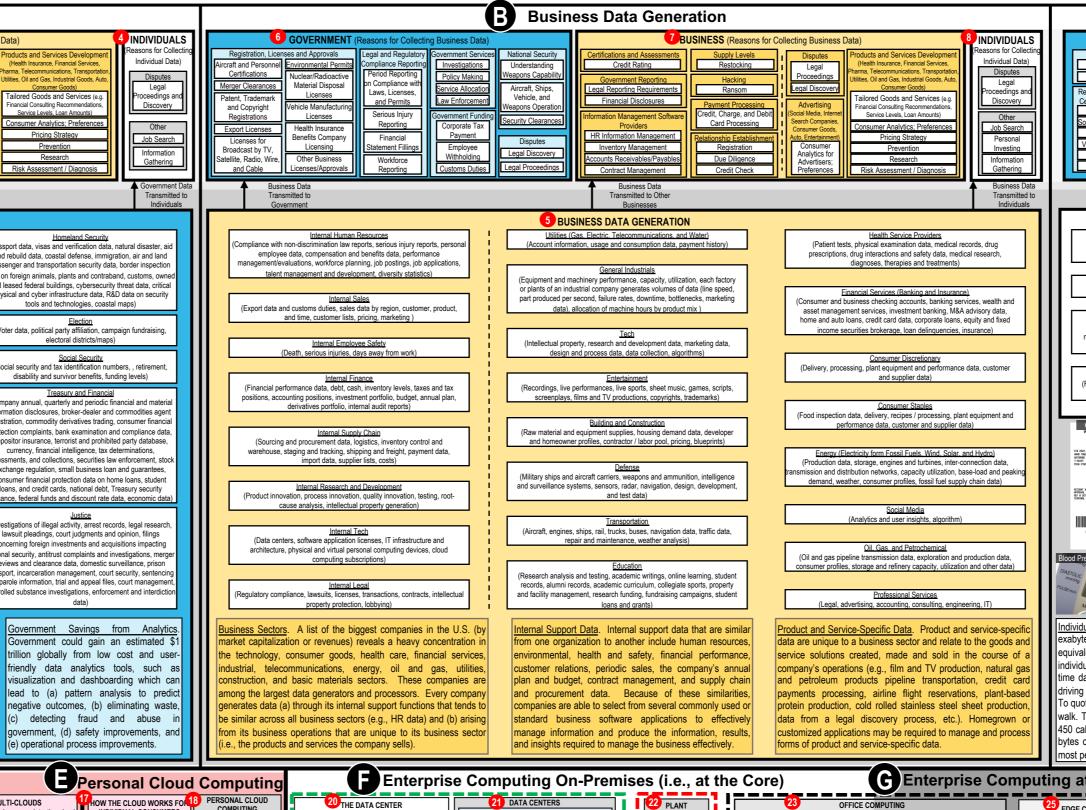
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AUTOMATION

Desktop Computers

Workstations

Thin Clients

Desk Phones/ Landlines

Printer/Copy Machines

Virtual Machine Ware and

Keyboard, Video, Mouse o

TRANSPORTATION

Public Safety Services)
Wireless and WirelessEnabled Products

(Handsets, Wireless-Enal

Computers, Wireless Data Cards, Accessories)

Wireline Service/ Broadband Connectiv

EDGE COMPUTING NETWORK

Edge Network Devices

Home Products

Device Makers

Key Data Center Categories

Email Servers

Recipient's Location

((_{[1}))

i.e., Local Area Network or LAN for Individuals and Wide Area Network or WAN for Enterprises)

Message
Data Packet
Data Packet
Data Packet
Data Packet

Data Storage
Unstructured Data

(WAN)

ed IT operations for the purpose of storing,

nd disseminating data and applications. I

onsists of (a) building or facility large enough to ouse energy-consuming IT equipment in a

eways, multiplexers, transceivers, and

/PN gateways, and intrusion detection systems),

support infrastructure (i.e., equipment ntributing to securely sustaining the highest IT

nterruptible power sources, environmental

T and infrastructure equipment on a 24/7 basis.

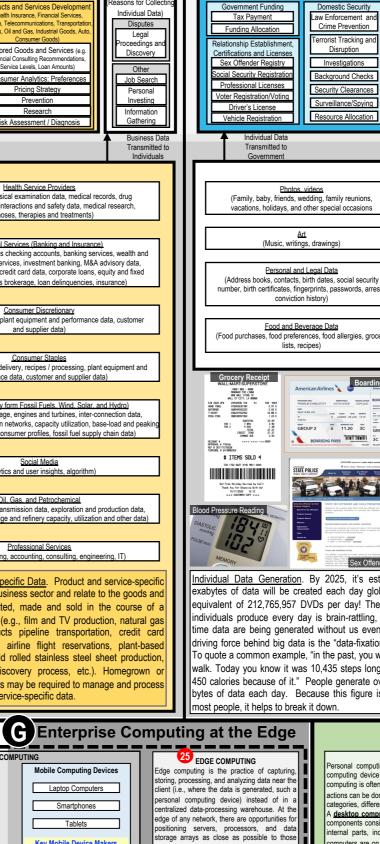
asset (data), data centers are crucial for daily

han 7 million data centers worldwide. Due to the

have evolved from on-premises physical servers to

nate-controlled environment, (b) equipment and Applications Servers

polications (these "core components" include Web Servers



who can make best use of them. Where

nstant, it can minimize latency (i.e., lag

etwork designed to be used at the ed-

vice and generate value. Essentially, edg

puting works by pushing data, applications computing power away from the central

twork to, and running workloads at,

extremes. In technical terms, it is referred to a a "distributed IT network architecture" th

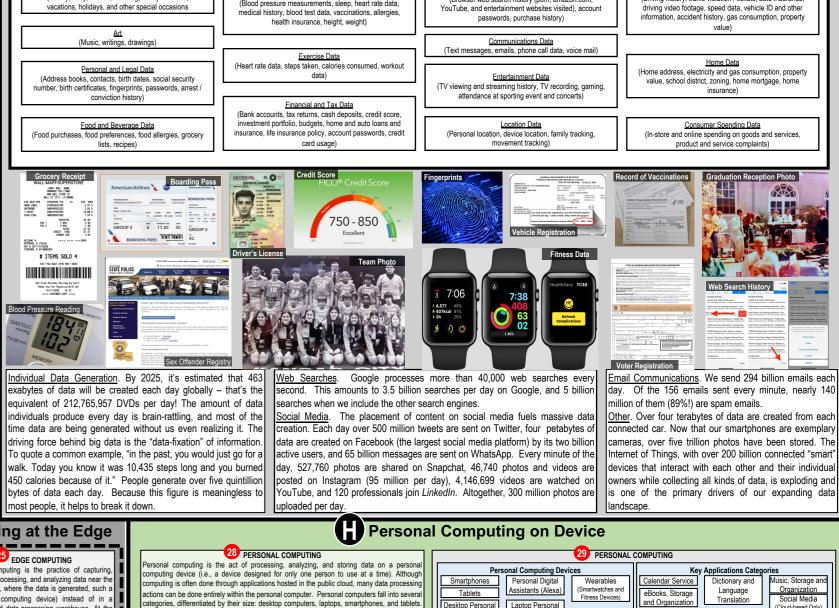
ables mobile computing for data product

ntralized data often mean more ri

cessing and storing data at a local ser

data in the data center or cloud, and a heav

the speed of electrons being esse



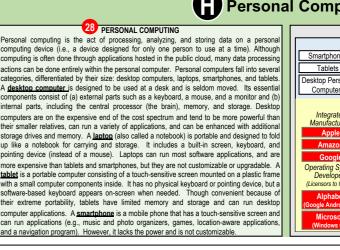
Individual Data Generation

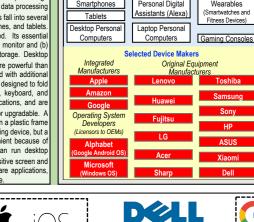
9 INDIVIDUAL DATA GENERATION

passwords, purchase history)

overnment Services

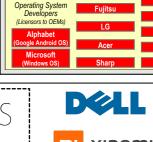
Personal Health Dat





HUAWE

/ISUS











Fitness Devices)





o chromebook

Auto Data

Driving history, traffic violation / tickets, auto insurance

Games, Storage Navigation / Maps

Photos, Storage

and Organization



34 DATA CONSUMPTION IN BYTES 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 or GB of mobile data per month. Most 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, or even terabytes—everyday amounts of data that represent the

only a few offer complete coverage across the entire country.





he U.S. internet landscape features miles of fiber-optic cable that connects the country to the world.

Verizon), other less-well-known owners also play a vital role (e.g., Lumen Technologies). There are

over 2,500 internet service providers in the U.S., but nearly one-half provide wired connections, and

While many owners of the largest fragments of these networks are well-known (AT&T, Comcast,



Nintendo[®]) Lenovo

XBOX

Microsoft 365

Windows

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. states of information (a binary decision), such as yes or no kilobytes 1,000 bytes 1,000 bytes One KB is equal to a sentence, and 100 KBs would equal an entire page A 500-page e-book: 1 song download equals 2 to 5 MBs megabytes 1,0002 bytes 1,000,000 bytes

The smallest unit of data that a computer uses. It can be used to represent two One B is equal to a single text character (e.g., "w"), and 10 bytes would equal a word gigabytes 1,000³ bytes 1,000,000,000 bytes 7 minutes of video terabytes 1,000⁴ bytes 1,000,000,000,000 bytes 130,000 photos petabytes 1.000⁵ bytes 1.000.000.000.000.000 bytes 20 million file cabinets exabytes 1,000⁶ bytes 1,000,000,000,000,000,000 bytes How much data each person on Earth produces per year zettabytes 1,000⁷ bytes 1,000,000,000,000,000,000,000 bytes As much information as there are grains of sand on all the w yottabytes 1,0008 bytes 1,000,000,000,000,000,000,000,000 bytes As much information as there are atoms in 7,000 human bodies

30 Sender's Location (i.e., Local Area Network or LAN for Individuals and Wide Area Network or WAN for Enterprises Router (i.e. ((_{[1})) Data Packet The LAN connects to the ISPs

Satellite Game Tech

Virtual Reality

Messages Disassembled into Smaller Packets for the Internet Journey. Next Stop: Long-Haul Transmission by ISP. The next hop delivers the The Internet works by chopping data into chunks called packets. Each sender's data packets to a long-haul ISP, one of the telecommunications

 $\underline{\text{The Path is Neither Direct Nor Straightforward}}. \ \ \text{The journey of the data packets often takes several more}$ 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 packet then moves from the sender's location (or local area network or giants that transport data (at the speed of light) on their networks of fiberproperly, the BGP information shared among routers cannot contain lies or errors that might cause a data LAN) to the network of a local internet service provider (ISP), where it optic cable and routers spanning the globe. ISPs offer the sender access to packet to go off track - or get lost altogether. will move rapidly through the internet in a series of steps (or hops). their networks for a fee based on connection speeds and bandwidth levels.

31 Internet Service Provider Network

Router

services, will orchestration and service providers to the emment include AWS GovCloud, IBM Cloud for mement include AWS GovCloud, IBM Cloud for each delivers a specific application. Governments and limitable dead unadors es they are

cluding those related to cloud storage, data analytics

backup in the event of an outage at a cloud service provider. The downside of this approach interoperability"—i.e., not have having a platform

process in place to integrate various cloud services

enterprises use multiple cloud vendors so they can choose IT services from various companies to (a) installs the Dropbox app on his or choose IT services from various companies to (a)

avoid being locked in to one vendor that might raise any files that the customer stores

prices, (b) use what they perceive as the best-in-class locally on his or her person capabilities from a particular cloud service provider,

or artificial intelligence, or (c) ensure they have a backup in the event of an outage at a cloud service files in one place, updates are

Dropbox server as well. If the

How the Internet Works

Big Data Warehouse

ernize their technology, and save time and

Internet Service Provider Network

Router

(for Recipient)

separate message goes back through the network confirming successful delivery.)

Router Arrival. In the final step, the destination device (the recipient's computing device) reassembles all the sender's data packets into a coherent message. (A