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Peer inside the secret world. Learn the language of espionage. Hear about tradecraft—the tools and techniques—and some famous spies. You've heard the saying "knowledge is power"? Well, intelligence is in the knowledge business. Sometimes it might be useless. Sometimes enough to blackmail someone. And sometimes, just sometimes, it influences battles, sways governments, and changes the fate of the world. We're pulling back the curtain on the shadowy world of espionage, here are the Museum's Frequently Asked Questions (FAQs): In the intelligence world, a spy is strictly defined as someone used to steal secrets for an intelligence organization. Also called an agent or asset, a spy is not a professional intelligence officer, and doesn't usually receive formal training (though may be taught basic tradecraft). Instead, a spy either volunteers or is recruited to help steal information, motivated by ideology, patriotism, money, or by a host of other reasons, from blackmail to love. From an intelligence perspective, their most important quality is having access to valuable information. For this reason, a government minister might make a great spy—but so might the janitor or a cafeteria worker in a government ministry. Discover some fascinating spies in our Spies & Spymasters exhibit, such as celebrated dancer Mata Hari, who spied for the French during WWI and Mosab Hassan Yousef, a spy for Israeli intelligence. Of course, the term "spy" also is used much more broadly, often to refer to anyone or anything connected to "spy agencies" (from intelligence analysts to hidden cameras), or any activity done secretly (spy missions, use of malicious computer software). What is an Agent? An agent is another word for a spy: someone who volunteers or is recruited to pass secrets to an intelligence agency, sometimes taking risks to spy on their own country. They may be recruited through money, ideology, coercion, greed, or for another reason, such as love (human beings are complicated). They trust their handler (a professional intelligence officer) to protect them. (You'll find agents in other parts of government as well, but that's a different use of the term: FBI agents and special agents, for example, work in law enforcement. What is a Double Agent? A double agent is essentially someone who works for two sides. In the intelligence world, a true double agent is loyal to one side before being "turned" and transferring loyalties to the other side. George Blake, for example, joined Britain's MI6 in 1944. But when communist North Korea captured him in 1950, he decided he was fighting on the wrong side. After his release, he continued to work for MI6 as he passed secrets to the KGB (including British and American plans for the Berlin Tunnel). True double agents are rare… because their survival is rare. Outside the intelligence world, the term "double agent" is often used much more broadly to refer to someone who pretends to work for one side while secretly working for another, but whose loyalties remain unchanged. What is the difference between a detective and a spy? A detective or investigator works in the field of law enforcement, looking for clues and evidence (usually quite openly) as part of solving a crime. Think Sherlock Homes, or famed FBI agent Melvin Purvis who hunted down gangsters in the 1930s. A spy (or intelligence officer), however, gathers information (usually in secret) about the activities or intentions of a rival government or group in support of national security. Think George Smiley. or the Soviet Union's Oleg Penkovsky who passed secrets to the CIA in the 1950s and 1960s. What is intelligence? The dictionary definition of intelligence is the ability to acquire and apply knowledge and skills. In the spying world, intelligence means information collected by a government or other entity that can help guide decisions and actions regarding national security. But intelligence can also mean the process by which that information is acquired (see Intelligence Cycle). What is counterintelligence? Spy agencies need to play defense. Counterintelligence activities, such as espionage or covert action, aim to prevent other spies from obtaining secrets, and to protect secrets and security against the efforts of other spies. What is the intelligence cycle? The intelligence cycle refers to the process through which spy agencies acquire information. It consists of at least five stages: Planning: Decisionmakers task an intelligence agency to acquire information on certain topics or specific issues of concern ("requirements"). Collection: This is where the spies, agents, case officers, tech ops, scientists, hackers, and others come in, acquiring information from different sources in a myriad of creative ways. Processing: Collected information needs to be narrowed down, prioritized, and put into some kind of digestible format. This might also involve having to decode information. Analysis: This is the stage where collected information becomes something useful that decisionmakers can use: intelligence! Dissemination: Intelligence agencies get the final product to the decisionmaker or "customer." Of course, it's quite possible that this might prompt more questions… and the intelligence cycle begins all over again. What is espionage? Espionage is defined as the act of spying or using spies, agents, assets, and intelligence officers, as well as technology, to collect secret information, usually through illegal means. What is the Espionage Act? The 1917 Espionage Act, passed shortly after the US entered WWI, imposed heavy penalties for spying or any activities that weakened or imperiled the country's defense. In 1953, Julius and Ethel Rosenberg were charged and convicted for giving nuclear secrets to the Soviet Union and became the first and only American civilians executed under the Act. Major parts of the 1917 Espionage Act remain part of US law today. In 2013, NSA contractor Edward Snowden was charged with crimes under the Act for intentionally revealing secret national security information. What is economic espionage? Economic espionage is the clandestine gathering of information from an economic competitor. Governments throughout history have stolen ideas, formulas, and technology to undercut rivals or "borrow" innovations. For millennia, China was a major target, with its silk, tea, and porcelain manufacturing secrets. Today, it's the US—the world's largest investor in research and development (R&D) It is often easier to steal someone else's technology, for example, than to develop your own. How do spies collect intelligence? Intelligence agencies collect information in many different ways. The oldest method is through human sources (HUMINT or human intelligence), relying on spies and intelligence officers using their wits and talents (with support from Tech Ops). But when information is beyond human reach (or in places too dangerous or remote), technology is used to intercept messages (SIGINT or signals intelligence), conduct overhead surveillance (IMINT or imagery intelligence), or even sniff out chemical, biological, and acoustic signatures (MASINT or measurement and signature intelligence). Today, open source intelligence (OSINT) from non-secret, publicly available sources such as webpages and newspapers, makes up a vast amount of collected intelligence. Find out more in the Stealing Secrets gallery. How are spies recruited? Spies are recruited via an approach or pitch by a case officer. This often seeks to persuade the individual through appealing to ideology, patriotism, religion, ego, greed, or love, or sometimes by using blackmail or some other form of coercion. How do you get someone to risk their life and become a spy? Persuading someone to put their life on the line is one of the hardest tasks for any intelligence officer. It takes training, patience, and empathy. Officers use a variety of approaches, based on the subject. A quote from Israeli intelligence officer Gonen Ben Yitzhak helps illustrate the point: "Recruiting is a very difficult art… understanding who the person is… his point of view, his background… then you know how to play with him." How do handlers cultivate trust with a recruited spy? This depends on the specific individual to some extent. But some general ways to cultivate trust include using empathy, building a rapport (perhaps through shared friends, interests or dreams, or even shared frustrations), and showing vulnerability. Honesty (being open about who you are and what you want) may also be used—or, perhaps, false honesty. You can find out more about the relationship between handlers and agents in the Spies & Spymasters exhibit. How do spies go undercover? Intelligence officers often operate abroad under some form of official cover, perhaps as diplomats in an embassy. Others operate without the protection of their government and must create a convincing cover that explains their presence and activities in a country—a businessperson, perhaps, or a student. The Russians call these officers "illegals," the Americans call them "NOCs" (for Non-Official Cover). If caught, they're on their own, and face arrest, even execution. One of the undercover spies you can discover in the Spy Museum is Russian illegal Dmitri Aleksandrovich Bystrolyotov. Find out what happened to him in the Spies & Spymasters exhibit. How do spies communicate? Face-to-face meetings can be impractical, even deadly—especially if spies are caught red-handed passing or receiving classified information or carrying spy equipment. That's why sharing information relies on covert communication or COVCOM. Methods include secret writing (such as invisible ink or tiny microdots) or sending and receiving secure messages using special technology (often concealed or even disguised to look like everyday objects). See examples of COVCOM methods and devices in the Tools of the Trade exhibit. Who was the first spy? It has been suggested that the Twelve Spies that Moses sent to scout the land of Canaan, mentioned in the Book of Numbers in The Bible, might be candidates for the world's first spies. But we know that spying was taking place much earlier than that. One of the earliest sources we have is the "Amarna Letters" from Ancient Egypt, which date to the 14th century BCE. They are diplomatic correspondence, recorded on clay tablets, that discuss among other things intelligence and espionage. Was George Washington a spy? No, George Washington was not a spy. But he was America's first spymaster. During the American Revolutionary War, General Washington fully understood the power of espionage to outsmart and outmaneuver vastly superior forces. He employed spies, relied heavily on intelligence, and made us of codes and ciphers. He even hired Dr. James Jay (brother of "Founding Father" John Jay), to create a secure invisible ink. What are some famous examples of espionage? The Culper Ring A network of spies active during the Revolutionary War, largely in and around Long Island, NY, that provided intelligence directly to General George Washington about Britain's base in New York City. It all started in 1777, when Washington wrote a letter to Nathanial Sackett, a New York merchant active in counterintelligence activities. He offered Sackett $50 a month (more than $1,000 today) to spy for the Continental Army, plus another $500 to set up a spy network. That network would become the Culper Ring—and it helped steer the colonial army to victory. The Cambridge Five In the 1930s, five Cambridge University students—Kim Philby, Guy Burgess, Anthony Blunt, Donald Maclean, and John Cairncross—were recruited to spy for the Soviet Union. They went on to have careers across the British Establishment (including in Britain's Secret Intelligence Service), where they had access to secrets they could pass on to their Soviet handlers. They undercut a number of intelligence operations and the effect of hunt for them—also known as a molehunt—led to growing paranoia in the UK and US intelligence communities. The Russian Ten In 2000, the FBI learned of ten Russian agents operating undercover inside the US. Some of them had been there for years. These sleeper agents (or "illegals") were trained officers sent to the US to blend in, become American, and live what appeared to be normal lives…while secretly gathering information, cultivating relationship, and looking for recruits. For more than a decade, the FBI ran Operation Ghost Stories, keeping an eye (and an ear) on the agents and waiting for the right moment to close in. Are spies real? Yes! Spies are real. Or the International Spy Museum wouldn't exist. Are spy movies realistic? Depends on the movie. There are elements of truth in spying that we see on TV and film, read in spy novels, and find in computer games. But in the real world, spying isn't usually glamorous (it can be downright boring), it isn't always secret, operations fail, gadgets don't work, and there is no "license to kill." That doesn't mean spy fiction isn't important: it plays a significant role in informing the public about the secret world of spying (accurately or not), shaping opinions and expectations. And sometimes, fiction doesn't just influence popular ideas about spying—it actually inspires real spy agencies. What gadgets do spies use? So, so many. You can see many of them throughout our exhibit space. They range from the super high tech to the very low tech, but every one of them tells its own story. What is cyber espionage? Cyber espionage involves using computer systems to steal classified information, often government secrets. Those secrets might be sensitive data related to foreign policy, military technology, or even personal information about individuals. Espionage has been carried out for millennia, but technology has made it possible for hackers (sometimes sponsored by governments) to steal secrets quickly, silently, and with relatively low risk of being caught. Intelligence agencies, however, are increasingly aware of the cyber threat and are developing new counter measures. Is cyber espionage legal? During times of war, espionage against a nation is a crime under the legal code of many nations as well as under international law, and cyber espionage is no different. During peacetime, however, it can be a lot trickier to figure out when espionage crosses the line into illegality—all the more so for cyber spying. If cyber espionage does not cause any real-world physical damage, does it violate a nation's territorial sovereignty? Where, in fact, does territorial sovereignty begin and end in cyberspace? These are just some of the questions being debated in international law regarding cyber espionage. How much does a secret agent make? Professional intelligence officers receive salaries based on their level of experience, like all government employees. Few own vintage Aston Martin DB5s and order beluga caviar on a regular basis. Spies can earn a lot more money, though. In the 1980s, CIA officer Aldrich Ames received over $4 million from the Soviets for betraying US secrets, enough to buy himself a half-million-dollar home in cash and a flashy red Jaguar. But living beyond his salary aroused the suspicions of US intelligence, which ultimately led to his arrest. How can I get a job as a spy? If you are interested in working in intelligence, submit an application. Many intelligence agencies now have websites where you can learn about types of positions available and apply online. Take part in the Museum's Undercover Mission to find out about the skill sets involved in spying and test your own spy skills. What are some words and phrases that spies use? Test your knowledge of spy lingo with our Language of Espionage glossary. How can I learn more about the world of espionage? To learn more about spies and espionage, you can check out the museum's podcast Spycast, our YouTube channel, view our online collection, or attend a virtual event. Governments all over the world use spies to gather information. D-Keine / Getty Images Real-world espionage rarely resembles the on-screen exploits of Hollywood secret agents. Still, spying is a useful and often dangerous way for governments to gather secret information from their enemies. The successes and failures of spies have shaped foreign policy, altered the course of wars and left a deep (though usually hidden) impression on world history. World leaders are faced with making important decisions every day, and information is the key to making the right decision. How many troops does your enemy have? How far are they in developing their secret weapons? Are they planning to negotiate a trade deal with another country? Are some of their generals planning a military coup? While some of this information (known as intelligence) may be readily available, most countries keep information that could be used against them secret. Of course, this secret information is often the most valuable. To gain access to secret information, governments use espionage, a blend of subterfuge, deception, technology and data analysis. Espionage can also be used to counteract the spying efforts of the enemy, mainly be supplying them with false information. Creating Spies Spies are recruited in a number of ways. Some join the intelligence agencies of their home countries, receive training and move on to jobs within the agency. If their background and training fits a certain profile, they may be sent abroad to take on a cover identity (more on this in the next section). The best field agents are those with access to high-ranking officials or secret information in other countries. Spy agencies employ recruiters, people who target citizens of other countries who are likely to turn against their homeland and become spies. These defectors are invaluable spies, since they already have a cover and can provide information almost immediately. There are several factors that can cause someone to defect and become a spy: Ideological disagreement with their home country. During the Cold War, the KGB (the Russian abbreviation for Committee for State Security, the Soviet Union's intelligence and secret police agency) had success recruiting agents in the United States and Britain who were known to support communism or belong to communist organizations.Money. Many spies have turned over crucial, deadly information for nothing more than cash.Desire to be "important". Recruiters look for people in menial positions who have access to important information. Certain psychological factors can drive some people to become spies because it makes them feel powerful.Blackmail. Recruiters who hold evidence of behavior that their target would not want made public, such as an extramarital affair, can threaten to release the evidence if the target doesn't agree to become a spy. Threats of physical harm to the target or her family members also work well. On rare occasions, no recruiting work is needed at all. Someone who wants to provide information walks in to an embassy or consulate and offers to become a spy. These walk-ins may be viewed with distrust as potential sources of misinformation from the enemy, but they can also become valuable spies. Once a recruiter has recruited someone willing to gather information, the new spy will be put in contact with a controller. The controller will offer some training in spying methods and issue instructions for obtaining and transmitting information. The spy will usually have contact with no one else, never learning the names of any other spies or officials. This is known as compartmentalization. Each spy works within his own compartment, so if he is captured and interrogated, he can't reveal vital information or the identities of other spies. Clandestine acquisition of confidential information For other uses, see Espionage (disambiguation). "Spy" and "Secret agent" redirect here. For other uses, see Spy (disambiguation) and Secret agent (disambiguation). This article possibly contains original research. Please improve it by verifying the claims made and adding inline citations. Statements consisting only of original research should be removed. (September 2025) (Learn how and when to remove this message) Part of a series on theIntelligence field and Intelligence Phases of Intelligence Intelligence cycle Intelligence cycle management Espionage Intelligence assessment Intelligence analysis Intelligence collection plan Framework Agent handling Blowback (intelligence) Clandestine HUMINT operational techniques Code name History of espionage Intelligence failure Intelligence requirement Intelligence law Intelligence studies Intelligence sharing Recruitment of spies Security sector governance and reform Total Espionage doctrine Treason Areas of Intelligence Raw intelligence All-source intelligence Counterintelligence I.S.R. Military intelligence Clandestine human intelligence Human intelligence (intelligence gathering) Technical intelligence Cyber threat intelligence Medical intelligence Signals intelligence Open-source intelligence Imagery intelligence Acoustical intelligence Geospatial intelligence Intelligence outsourcing Basic intelligence Strategic intelligence Criminal intelligence Measurement and signature intelligence Communications intelligence Electronic intelligence Foreign instrumentation signals intelligence Telemetry intelligence Air intelligence Naval intelligence Cyber espionage Nuclear espionage Sexpionage Tradecraft Corporate sector Industrial espionage Marketing intelligence Market intelligence Business intelligence Commercial intelligence People Intelligence officer Asset (intelligence) Intelligence community Intelligence agency Private intelligence agency Spy ring Cover (intelligence gathering) Foreign Intelligence Service Military attaché Mole (espionage) Cutout (espionage) Sleeper agent Atomic spies Resident spy Espionage organizations Culture Intelligence literature Spy fiction Spy film International Spy Museum CIA library Kryptos OSS Society CIA Museum N.M.I.S.O. Stasimuseum Bletchley Park The Cold War Museum The Intelligence Summit Spyscape Spy Museum Berlin Spy Museum (Tampere) KGB Espionage Museum Tools Sentient (intelligence analysis system) Concealment device Stone Ghost Pinwale Microdot Threat Intelligence Platform The Thing Enigma machine Synthetic Environment for Analysis and Simulations Lists List of intelligence agencies List of intelligence gathering disciplines List of awards List of defunct intelligence agencies Related topics Counterintelligence state National security Surveillance Global surveillance Disguise Reconnaissance Target acquisition Assassination Criminal investigation Codebreaking Propaganda Graphology Paramilitary Cybersecurity vteCriminal law Elements Actus reus Mens rea Causation Concurrence Scope of criminal liability Accessory Accomplice Complicity Corporate Mandated reporter Principal Use of force continuum Vicarious Severity of offense Felony (or Indictable offense) Misdemeanor (or Summary offense) Infraction (also called violation) Inchoate offenses Attempt Conspiracy Incitement Solicitation Offense against the person Assassination Assault Battery Child abuse Concealment of a corpse Criminal negligence Domestic violence False imprisonment Frameup Harassment Street Home invasion Hate crime Homicide Human trafficking Intimidation Kidnapping Manslaughter (corporate) Mayhem Murder felony Homicide Negligent homicide Reckless homicide Robbery Stalking Stabbing Torture Sexual offenses Adultery Bigamy Child sexual abuse Cybersex trafficking Fornication Homosexuality Groping Incest Indecent exposure Masturbation Obscenity Prostitution Rape Pederasty Sex trafficking Sexual assault Sexual harassment Sexual slavery Voyeurism Crimes against property Arson Arms trafficking Blackmail Bribery Burglary Cybercrime Embezzlement Extortion False pretenses Forgery Fraud Gambling Intellectual property violation Larceny Looting Payola Pickpocketing Possessing stolen property Robbery Smuggling Parallel import Tax evasion Theft Trespass to land Vandalism Mischief Crimes against justice Against public justice Justice delayed Compounding Contempt Malfeasance in office Miscarriage of justice Judicial misconduct Misprision Perjury Perverting the course of justice Crimes against the public Apostasy Corruption Censorship violation Dueling Genocide Ethnic cleansing Hostage-taking People smuggling Insider trading Smuggling Illegal consumption (such as drugs, alcohol, and smoking) Miscegenation Piracy Political corruption Regicide Unreported employment Usurpation War crimes Crimes against animals Cruelty to animals Poaching Wildlife smuggling Bestiality Crimes against the state Lèse-majesté Treason Espionage Secession Sedition Subversion Defenses to liability Actual innocence Automatism Consent Defense of property Diminished responsibility Duress Entrapment Ignorantia juris non excusat Infancy Insanity Intoxication Justification Might makes right Mistake (of law) Necessity Possession is nine-tenths of the law Provocation Sanctuary Self-defense Statute of limitations Other common-law areas Contracts Defenses Evidence Property Torts Wills, trusts and estates Portals Law vte Espionage, spying, or intelligence gathering, as a subfield of the intelligence field, is the act of obtaining secret, confidential, or in some way valuable information. Such information is also referred to as intelligence. A professional trained in conducting intelligence operations by their government may be employed as an intelligence officer.[1] Espionage may be conducted in a foreign country, domestically or remotely. The practice is clandestine, as it is by definition unwelcome. In some circumstances, it may be a legal tool of law enforcement and in others, it may be illegal and punishable by law. Espionage is often part of an institutional effort by a government or commercial concern. The term is frequently associated with state spying on potential or actual enemies for military purposes. However, there are many types of espionage. Industrial espionage, for example, involves spying on civilians and their respective business or corporate interests. One way spies gather data and information about a targeted military organization is by infiltrating its ranks. They can then return information such as the size and strength of the enemy forces. They can also find collaborators and dissidents within the organization and influence them to provide further information or defect.[2] Spies can steal technology and sabotage the enemy in various ways. Counterespionage, also known as counterintelligence or offensive counterintelligence, is the practice of thwarting enemy espionage and intelligence gathering. Almost all sovereign states have laws concerning espionage and the penalties for being caught spying are often severe.Madame Minna Craucher (right), a Finnish socialite and spy, with her chauffeur Boris Wolkowski (left) in 1930s Main article: History of espionage Espionage has been recognized as of importance in military affairs since ancient times. The oldest known classified document was a report made by a spy disguised as a diplomatic envoy in the court of King Hammurabi, who died in around 1750 BC. The ancient Egyptians had a developed secret service, and espionage is mentioned in the Iliad, the Bible, and the Amarna letters.[3] Espionage was also prevalent in the Greco-Roman world, when spies employed illiterate subjects in civil services.[4][5][6] The thesis that espionage and intelligence has a central role in war as well as peace was first advanced in The Art of War and in the Arthashastra. "The Art of War," identifies five types of spies that are essential for gathering intelligence and achieving victory: local spies (citizen informants within the enemy's territory), inward spies (recruited double agents within the enemy ranks), converted spies (recruited defectors converted to serve your side), doomed spies (expendable fabricators used to spread disinformation; acts as decoy for counter-intelligence), and surviving spies (spies that provide accurate intelligence after gathering information from the enemy). In the Middle Ages European states excelled at what has later been termed counter-subversion when Catholic inquisitions were staged to annihilate heresy. Inquisitions were marked by centrally organised mass interrogations and detailed record keeping. Western espionage changed fundamentally during the Renaissance when Italian city-states installed resident ambassadors in capital cities to collect intelligence. In Asia, the Mongol Empire relied on a state-sponsored network of spies, often disguised as merchants, who gathered intelligence on enemy strengths, weaknesses and potential allies in a series of conquests. Feudal Japan utilized specialized covert agents called shinobi (ninja), who were mercenaries hired by feudal lords for espionage, sabotage and infiltration, often operating outside the code of the samurai. Renaissance Venice became so obsessed with espionage that the Council of Ten, which was nominally responsible for security, did not even allow the doge to consult government archives freely. In 1481 the Council of Ten barred all Venetian government officials from making contact with ambassadors or foreigners. Those revealing official secrets could face the death penalty. Venice became obsessed with espionage because successful international trade demanded that the city-state could protect its trade secrets. Under Queen Elizabeth I of England (r. 1558–1603), Francis Walsingham (c. 1532–1590) was appointed foreign secretary and intelligence chief.[7] The novelist and journalist Daniel Defoe (died 1731) not only spied for the British government, but also developed a theory of espionage foreshadowing modern police-state methods.[8] During the American Revolution, Nathan Hale and Benedict Arnold achieved their fame as spies, and there was considerable use of spies on both sides during the American Civil War.[9] Though not a spy himself, George Washington was America's first spymaster, utilizing espionage tactics against the British.[3] In the 20th century, at the height of World War I, all great powers except the United States had elaborate civilian espionage systems, and all national military establishments had intelligence units. In order to protect the country against foreign agents, the U.S. Congress passed the Espionage Act of 1917. Mata Hari, who obtained information for Germany by seducing French officials, was the most noted espionage agent of World War I. Prior to World War II, Germany and Imperial Japan established elaborate espionage nets. In 1942 the Office of Strategic Services was founded by Gen. William J. Donovan. However, the British Special Operations Executive was the keystone of Allied intelligence. Numerous resistance groups such as the Austrian Maier-Messner Group, the French Resistance, the Witte Brigade, Milorg and the Polish Home Army worked against Nazi Germany and provided the Allied secret services with information that was very important for the war effort. Since the end of World War II, the activity of espionage has enlarged, much of it growing out of the Cold War between the United States and the former USSR. The Russian Empire and its successor, the Soviet Union, have had a long tradition of espionage ranging from the Okhrana to the KGB (Committee for State Security), which also acted as a secret police force. In the United States, the 1947 National Security Act created the Central Intelligence Agency (CIA) to coordinate intelligence and the National Security Agency for research into codes and electronic communication. In addition to these, the United States has 13 other intelligence gathering agencies; most of the U.S. expenditures for intelligence gathering are budgeted to various Defense Dept. agencies and their programs. Under the intelligence reorganization of 2004, the director of national intelligence is responsible for overseeing and coordinating the activities and budgets of the U.S. intelligence agencies. In the Cold War, espionage cases included Alger Hiss, Whittaker Chambers and the Rosenberg Case. In 1952 the Communist Chinese captured two CIA agents and in 1960 Francis Gary Powers, flying a U-2 reconnaissance mission over the Soviet Union for the CIA, was shot down and captured. During the Cold War, many Soviet intelligence officials defected to the West, including Gen. Walter Krivitsky, Victor Kravchenko, Vladimir Petrov, Peter Deriabin, Pawel Monat and Oleg Penkovsky of the GRU. Among Western officials who defected to the Soviet Union are Guy Burgess and Donald D. Maclean of Great Britain in 1951, Otto John of West Germany in 1954, William H. Martin and Bernon F. Mitchell, U.S. cryptographers, in 1960, and Harold (Kim) Philby of Great Britain in 1962. U.S. acknowledgment of its U-2 flights and the exchange of Francis Gary Powers for Rudolf Abel in 1962 implied the legitimacy of some espionage as an arm of foreign policy. China has a very cost-effective intelligence program that is especially effective in monitoring neighboring countries such as Mongolia, Russia and India. Smaller countries can also mount effective and focused espionage efforts. For instance, the Vietnamese communists had consistently superior intelligence during the Vietnam War. Some Islamic countries, including Libya, Iran and Syria, have highly developed operations as well. SAVAK, the secret police of the Pahlavi dynasty, was particularly feared by Iranian dissidents before the 1979 Iranian Revolution. Today, spy agencies target the illegal drug trade and terrorists as well as state actors.[10] Intelligence services value certain intelligence collection techniques over others. The former Soviet Union, for example, preferred human sources over research in open sources, while the United States has tended to emphasize technological methods such as SIGINT and IMINT. In the Soviet Union, both political (KGB) and military intelligence (GRU)[11] officers were judged by the number of agents they recruited. Espionage agents are usually trained experts in a targeted field so they can differentiate mundane information from targets of value to their own organizational development. Correct identification of the target at its execution is the sole purpose of the espionage operation.[citation needed] Broad areas of espionage targeting expertise include:[citation needed] Natural resources: strategic production identification and assessment (food, energy, materials). Agents are usually found among bureaucrats who administer these resources in their own countries Popular sentiment towards domestic and foreign policies (popular, middle class, elites). Agents often recruited from field journalistic crews, exchange postgraduate students and sociology researchers Strategic economic strengths (production, research, manufacture, infrastructure). Agents recruited from science and technology academia, commercial enterprises, and more rarely from among military technologists Military capability intelligence (offensive, defensive, manoeuvre, naval, air, space). Agents are trained by military espionage education facilities and posted to an area of operation with covert identities to minimize prosecution Counterintelligence operations targeting opponent's intelligence services themselves, such as breaching the confidentiality of communications and recruiting defectors or moles Although the news media may speak of "spy satellites" and the like, espionage is not a synonym for all intelligence-gathering disciplines. It is a specific form of human source intelligence (HUMINT). Codebreaking (cryptanalysis or COMINT), aircraft or satellite photography (IMINT), and analysis of publicly available data sources (OSINT) are all intelligence gathering disciplines, but none of them is considered espionage. Many HUMINT activities, such as prisoner interrogation, reports from military reconnaissance patrols and from diplomats, etc., are not considered espionage. Espionage is the disclosure of sensitive information (classified) to people who are not cleared for that information or access to that sensitive information. Unlike other forms of intelligence collection disciplines, espionage usually involves accessing the place where the desired information is stored or accessing the people who know the information and will divulge it through some kind of subterfuge. There are exceptions to physical meetings, such as the Oslo Report, or the insistence of Robert Hanssen in never meeting the people who bought his information. The US defines espionage towards itself as "the act of obtaining, delivering, transmitting, communicating, or receiving information about the national defence with an intent, or reason to believe, that the information may be used to the injury of the United States or to the advantage of any foreign nation". Black's Law Dictionary (1990) defines espionage as: "... gathering, transmitting, or losing ... information related to the national defense". Espionage is a violation of United States law, 18 U.S.C. §§ 792–798 and Article 106a of the Uniform Code of Military Justice.[12] The United States, like most nations, conducts espionage against other nations, under the control of the National Clandestine Service.This article needs to be updated. The reason given is: What about the Defense Department, and the Director of National Intelligence?. Please help update this article to reflect recent events or newly available information. (December 2021) Britain's espionage activities are controlled by the Secret Intelligence Service. See also: Tradecraft and List of intelligence gathering disciplines Agent handling Biographic leverage Concealment device Covert agent Covert listening device Cut-out Cyber spying Dead drop False flag operations Front organisation Gate-crashing Human intelligence (HUMINT) Honeypot Impersonation Impostor Interrogation Non-official cover Numbers messaging Official cover Open-source intelligence (OSINT) One-way voice link Sabotage Safe house Side channel attack Signals intelligence (SIGINT) Spy ship Steganography Surveillance Surveillance aircraft Surveillance balloon Source:[13] A spy is a person employed to seek out secret information from a source.[14] Within the United States Intelligence Community, "asset" is more common usage. A case officer or Special Agent, who may have diplomatic status (i.e., official cover or non-official cover), supports and directs the human collector. Cut-outs are couriers who do not know the agent or case officer but transfer messages. A safe house is a refuge for spies. Spies often seek to obtain secret information from another source. In larger networks, the organization can be complex with many methods to avoid detection, including clandestine cell systems. Often the players have never met. Case officers are stationed in foreign countries to recruit and supervise intelligence agents,[14] who in turn spy on targets in the countries where they are assigned. A spy need not be a citizen of the target country and hence does not automatically commit treason when operating within it. While the more common practice is to recruit a person already trusted with access to sensitive information, sometimes a person with a well-prepared synthetic identity (cover background), called a legend[14] in tradecraft, may attempt to infiltrate a target organization. These agents can be moles (who are recruited before they get access to secrets), defectors (who are recruited after they get access to secrets and leave their country) or defectors in place (who get access but do not leave). A legend is also employed for an individual who is not an illegal agent, but is an ordinary citizen who is "relocated", for example, a "protected witness". Nevertheless, such a non-agent very likely will also have a case officer who will act as a controller. As in most, if not all synthetic identity schemes, for whatever purpose (illegal or legal), the assistance of a controller is required. Spies may also be used to spread disinformation in the organization in which they are planted, such as giving false reports about their country's military movements, or about a competing company's ability to bring a product to market. Spies may be given other roles that also require infiltration, such as sabotage. Many governments spy on their allies as well as their enemies, although they typically maintain a policy of not commenting on this. Governments also employ private companies to collect information on their behalf such as SCG International Risk, International Intelligence Limited and others. Many organizations, both national and non-national, conduct espionage operations. It should not be assumed that espionage is always directed at the most secret operations of a target country. National and terrorist organizations and other groups are also targeted.[15] This is because governments want to retrieve information that they can use to be proactive in protecting their nation from potential terrorist attacks. Communications both are necessary to espionage and clandestine operations, and also a great vulnerability when the adversary has sophisticated SIGINT detection and interception capability. Spies rely on COVCOM or covert communication through technically advanced spy devices.[3] Agents must also transfer money securely. Main article: Industrial espionage Industrial espionage, also known as economic espionage, corporate spying, or corporate espionage, is a form of espionage conducted for commercial purposes instead of purely national security.[16] While political espionage is conducted or orchestrated by governments and is international in scope, industrial or corporate espionage is more often national and occurs between companies or corporations. It may include the acquisition of intellectual property, such as information on industrial manufacture, ideas, techniques and processes, recipes and formulas. Or it could include sequestration of proprietary or operational information, such as that on customer datasets, pricing, sales, marketing, research and development, policies, prospective bids, planning or marketing strategies or the changing compositions and locations of production. It may describe activities such as theft of trade secrets, bribery, blackmail and technological surveillance. As well as orchestrating espionage on commercial organizations, governments can also be targets – for example, to determine the terms of a tender for a government contract. Reportedly Canada is losing $12 billion[17] and German companies are estimated to be losing about €50 billion ($87 billion) and 30,000 jobs[18] to industrial espionage every year. In espionage jargon, an "agent" is the person who does the spying. They may be a citizen of a country recruited by that country to spy on another; a citizen of a country recruited by that country to carry out false flag assignments disrupting his own country; a citizen of one country who is recruited by a second country to spy on or work against his own country or a third country, and more. In popular usage, this term is sometimes confused with an intelligence officer, intelligence operative, or case officer who recruits and handles agents. Among the most common forms of agent are: Agent provocateur: instigates trouble or provides information to gather as many people as possible into one location for an arrest. Intelligence agent: provides access to sensitive information through the use of special privileges. If used in corporate intelligence gathering, this may include gathering information of a corporate business venture or stock portfolio. In economic intelligence, "Economic Analysts may use their specialized skills to analyze and interpret economic trends and developments, assess and track foreign financial activities, and develop new econometric and modelling methodologies."[19] This may also include information of trade or tariff. Agent-of-influence: provides political influence in an area of interest, possibly including publications needed to further an intelligence service agenda.[14] The use of the media to print a story to mislead a foreign service into action, exposing their operations while under surveillance. Double agent: engages in clandestine activity for two intelligence or security services (or more in joint operations), who provides information about one or about each to the other, and who wittingly withholds significant information from one on the instructions of the other or is unwittingly manipulated by one so that significant facts are withheld from the adversary. Peddlers, fabricators, and others who work for themselves rather than a service are not double agents because they are not agents. The fact that double agents have an agent relationship with both sides distinguishes them from penetrations, who normally are placed with the target service in a staff or officer capacity."[20] Redoubled agent: forced to mislead the foreign intelligence service after being caught as a double agent. Unwitting double agent: offers or is forced to recruit as a double or redoubled agent and in the process is recruited by either a third-party intelligence service or his own government without the knowledge of the intended target intelligence service or the agent. This can be useful in capturing important information from an agent that is attempting to seek allegiance with another country. The double agent usually has knowledge of both intelligence services and can identify operational techniques of both, thus making third-party recruitment difficult or impossible. The knowledge of operational techniques can also affect the relationship between the operations officer (or case officer) and the agent if the case is transferred by an operational targeting officer] to a new operations officer, leaving the new officer vulnerable to attack. This type of transfer may occur when an officer has completed his term of service or when his cover is blown. Triple agent: works for three intelligence services.[how?] Fabricator: used to spread disinformation. Sleeper agent: recruited to wake up and perform a specific set of tasks or functions while living undercover in an area of interest. This type of agent is not the same as a deep cover operative, who continually contacts a case officer to file intelligence reports. A sleeper agent is not in contact with anyone until activated. Less common or lesser known forms of agent include: Access agent: provides access to other potential agents by providing offender profiling information that can help lead to recruitment into an intelligence service. Confusion agent: an individual who is dispatched for the primary purpose of confounding the intelligence or counterintelligence apparatus of another country, rather than for the purpose of collecting and transmitting information. Such an individual may provide misleading information, among other confusion tactics.[21] Facilities agent: provides access to buildings, such as garages or offices used for staging operations, resupply, etc. Illegal agent: lives in another country under false credentials and does not report to a local station. A nonofficial cover operative can be dubbed an "illegal"[22] when working in another country without diplomatic protection. Principal agent: functions as a handler for an established network of agents, usually considered "blue chip". See also: Private intelligence agency and Private military company Private espionage is a large scale industry involving a vast array of different companies and individuals who provide a variety of services. These companies may be employed to act independently without any connection to a state agency or they may be hired to work in an integrated manner with a state agency, or agencies, in order to provide the specific services which are required. In terms of scale, the writer Frederic Lemieux states that 'In 2010. it was estimated that 1,931 private intelligence firms were working within the intelligence community in the United States, employing approximately 265, 000 contractors with top-secret clearances.'[23] He goes on to state, however, that only about 110 of them represent 90% of the market. These include: AEGIS, BAE Systems, Booz Allen Hamilton (BAH), CACI International Inc., CSRA Inc., General Dynamics, Leidos, Northrop Grumman, and Science Applications International Corporation.[24] Main article: Intelligence law The examples and perspective in this article may not represent a worldwide view of the subject. You may improve this article, discuss the issue on the talk page, or create a new article, as appropriate. (August 2024) (Learn how and when to remove this message) Espionage against a nation is a crime under the legal code of many world states. In the United States, it is covered by the Espionage Act of 1917. The risks of espionage vary. A spy violating the host country's laws may be deported, imprisoned, or even executed. A spy violating its own country's laws can be imprisoned for espionage or/and treason (which in the United States and some other jurisdictions can only occur if they take up arms or aids the enemy against their own country during wartime), or even executed, as the Rosenbergs were. For example, when Aldrich Ames handed a stack of dossiers of U.S. Central Intelligence Agency (CIA) agents in the Eastern Bloc to his KGB-officer "handler", the KGB "rolled up" several networks, and at least ten people were secretly shot. When Ames was arrested by the U.S. Federal Bureau of Investigation (FBI), he faced life in prison; his contact, who had diplomatic immunity, was declared persona non grata and taken to the airport. Ames' wife was threatened with life imprisonment if her husband did not cooperate; he did, and she was given a five-year sentence. Hugh Francis Redmond, a CIA officer in China, spent nineteen years in a Chinese prison for espionage—and died there—as he was operating without diplomatic cover and immunity.[25] In United States law, treason,[26] espionage,[27] and spying[28] are separate crimes. Treason and espionage have graduated punishment levels. The United States in World War I passed the Espionage Act of 1917. Over the years, many spies, such as the Soble spy ring, Robert Lee Johnson, the Rosenberg ring, Aldrich Hazen Ames,[29] Robert Philip Hanssen,[30] Jonathan Pollard, John Anthony Walker, James Hall III, and others have been prosecuted under this law. In modern times, many people convicted of espionage have been given penal sentences rather than execution. For example, Aldrich Hazen Ames is an American CIA analyst, turned KGB mole, who was convicted of espionage in 1994; he is serving a life sentence without the possibility of parole in the high-security Allenwood U.S. Penitentiary.[31] Ames was formerly a 31-year CIA counterintelligence officer and analyst who committed espionage against his country by spying for the Soviet Union and Russia.[32] So far as it is known, Ames compromised the second-largest number of CIA agents, second only to Robert Hanssen, who also served a prison sentence until his death in 2023.[33] Espionage laws are also used to prosecute non-spies. In the United States, the Espionage Act of 1917 was used against socialist politician Eugene V. Debs (at that time the Act had much stricter guidelines and amongst other things banned speech against military recruiting). The law was later used to suppress publication of periodicals, for example of Father Coughlin in World War II. In the early 21st century, the act was used to prosecute whistleblowers such as Thomas Andrews Drake, John Kiriakou, and Edward Snowden, as well as officials who communicated with journalists for innocuous reasons, such as Stephen Jin-Woo Kim.[34][35] As of 2012[update], India and Pakistan were holding several hundred prisoners of each other's country for minor violations like trespass or visa overstay, often with accusations of espionage attached. Some of these include cases where Pakistan and India both deny citizenship to these people, leaving them stateless.[citation needed] The BBC reported in 2012 on one such case, that of Mohammed Idrees, who was held under Indian police control for approximately 13 years for overstaying his 15-day visa by 2–3 days after seeing his ill parents in 1999. Much of the 13 years were spent in prison waiting for a hearing, and more time was spent homeless or living with generous families. The Indian People's Union for Civil Liberties and Human Rights Law Network both decried his treatment. The BBC attributed some of the problems to tensions caused by the Kashmir conflict.[36] From ancient times, the penalty for espionage in many countries was execution. This was true right up until the era of World War II; for example, Josef Jakobs was a Nazi spy who parachuted into Great Britain in 1941 and was executed for espionage. Espionage is illegal in the UK under the National Security Act 2023, which repealed prior Official Secrets Acts and creates three separate offences for espionage. A person is liable to be imprisoned for life for committing an offence under Section 1 of the Act, or 14 years for an offence under Sections 2 and 3 Government intelligence is very much distinct from espionage, and is not illegal in the UK, providing that the organisations of individuals are registered, often with the ICO, and are acting within the restrictions of the Regulation of Investigatory Powers Act (RIPA). 'Intelligence' is considered legally as "information of all sorts gathered by a government or organisation to guide its decisions. It includes information that may be both public and private, obtained from much different public or secret sources. It could consist entirely of information from either publicly available or secret sources, or be a combination of the two."[37] However, espionage and intelligence can be linked. According to the MI5 website, "foreign intelligence officers acting in the UK under diplomatic cover may enjoy immunity from prosecution. Such persons can only be tried for spying (or, indeed, any criminal offence) if diplomatic immunity is waived beforehand. Those officers operating without diplomatic cover have no such immunity from prosecution". There are also laws surrounding government and organisational intelligence and surveillance. Generally, the body involved should be issued with some form of warrant or permission from the government and should be enacting their procedures in the interest of protecting national security or the safety of public citizens. Those carrying out intelligence missions should act within not only RIPA but also the Data Protection Act and Human Rights Act. However, there are spy equipment laws and legal requirements around intelligence methods that vary for each form of intelligence enacted. Painting of French spy captured during the Franco-Prussian War by Alphonse de Neuville, 1880 In war, espionage is considered permissible as many nations recognize the inevitability of opposing sides seeking intelligence each about the dispositions of the other. To make the mission easier and successful, combatants wear disguises to conceal their true identity from the enemy while penetrating enemy lines for intelligence gathering. However, if they are caught behind enemy lines in disguises, they are not entitled to prisoner-of-war status and subject to prosecution and punishment—including execution. The Hague Convention of 1907 addresses the status of wartime spies, specifically within "Laws and Customs of War on Land" (Hague IV); October 18, 1907: Chapter II Spies".[38] Article 29 states that a person is considered a spy who, acts clandestinely or on false pretences, infiltrates enemy lines with the intention of acquiring intelligence about the enemy and communicate it to the belligerent during times of war. Soldiers who penetrate enemy lines in proper uniforms for the purpose of acquiring intelligence are not considered spies but are lawful combatants entitled to be treated as prisoners of war upon capture by the enemy. Article 30 states that a spy captured behind enemy lines may only be punished following a trial. However, Article 31 provides that if a spy successfully rejoined his own military and is then captured by the enemy as a lawful combatant, he cannot be punished for his previous acts of espionage and must be treated as a prisoner of war. This provision does not apply to citizens who committed treason against their own country or co-belligerents of that country and may be captured and prosecuted at any place or any time regardless whether he rejoined the military to which he belongs or not or during or after the war.[39][40] The ones that are excluded from being treated as spies while behind enemy lines are escaping prisoners of war and downed airmen as international law distinguishes between a disguised spy and a disguised escaper.[13] It is permissible for these groups to wear enemy uniforms or civilian clothes in order to facilitate their escape back to friendly lines so long as they do not attack enemy forces, collect military intelligence, or engage in similar military operations while so disguised.[41][42] Soldiers who are wearing enemy uniforms or civilian clothes simply for the sake of warmth along with other purposes rather than engaging in espionage or similar military operations while so attired are also excluded from being treated as unlawful combatants.[13] Saboteurs are treated as spies as they too wear disguises behind enemy lines for the purpose of waging destruction on an enemy's vital targets in addition to intelligence gathering.[43][44] For example, during World War II, eight German agents entered the U.S. in June 1942 as part of Operation Pastorius, a sabotage mission against U.S. economic targets. Two weeks later, all were arrested in civilian clothes by the FBI thanks to two German agents betraying the mission to the U.S. Under the Hague Convention of 1907, these Germans were classified as spies and tried by a military tribunal in Washington D.C.[45] On August 3, 1942, all eight were found guilty and sentenced to death. Five days later, six were executed by electric chair at the District of Columbia jail. Two who had given evidence against the others had their sentences reduced by President Franklin D. Roosevelt to prison terms. In 1948, they were released by President Harry S. Truman and deported to the American Zone of occupied Germany. Eighteen German soldiers were shot by the United States Army after being caught in American uniform as part of Operation Greif during the Battle of the Bulge in 1944.[46][47] In June 1945, after Germany had been occupied by the allies, the US Army executed six individuals, including two German youths aged 16 and 17, for espionage committed against American forces during the final stages of World War II.[48][49] For further discussion, see Capital punishment by the United States military. The U.S. codification of enemy spies is Article 106 of the Uniform Code of Military Justice. This provides a mandatory death sentence if a person captured in the act is proven to be "lurking as a spy or acting as a spy in or about any place, vessel, or aircraft, within the control or

jurisdiction of any of the armed forces, or in or about any shipyard, any manufacturing or industrial plant, or any other place or institution engaged in work in aid of the prosecution of the war by the United States, or elsewhere".[50] Main article: Spy fiction Spies have long been favorite topics for novelists and filmmakers.[51] An early example of espionage literature is Kim by the English novelist Rudyard Kipling, with a description of the training of an intelligence agent in the Great Game between the UK and Russia in 19th century Central Asia. An even earlier work was James Fenimore Cooper's classic novel, The Spy, written in 1821, about an American spy in New York during the Revolutionary War. During the many 20th-century spy scandals, much information became publicly known about national spy agencies and dozens of real-life secret agents. These sensational stories piqued public interest in a profession largely off-limits to human interest news reporting, a natural consequence of the secrecy inherent in their work. To fill in the blanks, the popular conception of the secret agent has been formed largely by 20th and 21st-century fiction and film. Attractive and sociable real-life agents such as Valerie Plame find little employment in serious fiction, however. The fictional secret agent is more often a loner, sometimes amoral—an existential hero operating outside the everyday constraints of society. Loner spy personalities may have been a stereotype of convenience for authors who already knew how to write loner private investigator characters that sold well from the 1920s to the present.[52] Johnny Fedora achieved popularity as a fictional agent of early Cold War espionage, but James Bond is the most commercially successful of the many spy characters created by intelligence insiders during that struggle. Other fictional agents include Le Carré's George Smiley, and Harry Palmer as played by Michael Caine. Jumping on the spy bandwagon, other writers also started writing about spy fiction featuring female spies as protagonists, such as The Baroness, which has more graphic action and sex, as compared to other novels featuring male protagonists. Spy fiction has permeated the video game world as well, in games such as Perfect Dark, GoldenEye 007, No One Lives Forever, Tom Clancy's Splinter Cell and the Metal Gear series. Espionage has also made its way into comedy depictions. The 1960s TV series Get Smart, the 1983 Finnish film Agent 000 and the Deadly Curves, and Johnny English film trilogy portrays an inept spy, while the 1985 movie Spies Like Us depicts a pair of none-too-bright men sent to the Soviet Union to investigate a missile. The historical novel The Emperor and the Spy highlights the adventurous life of U.S. Colonel Sidney Forrester Mashbir, who during the 1920s and 1930s attempted to prevent war with Japan, and when war did erupt, he became General MacArthur's top advisor in the Pacific Theater of World War Two.[53][54] Black Widow is also a fictional agent who was introduced as a Russian spy, an antagonist of the superhero Iron Man. She later became an agent of the fictional spy agency S.H.I.E.L.D. and a member of the superhero team the Avengers. Unlike much of the spy fiction, real life espionage is described as routine and boring work.[55][56] American espionage in China Central Intelligence Agency Chinese espionage in the United States Clandestine operation Cover (intelligence gathering) Covert operation Detective Federal Bureau of Investigation Foreign agent History of Soviet espionage Human intelligence (intelligence gathering) Intelligence assessment James Gannon (author) List of intelligence agencies List of intelligence gathering disciplines MI5 Military intelligence Secret identity Secret service Sleeper agent Special agent Spying on United Nations leaders by United States diplomats Undercover operation

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Krugman, Paul, "The American Way of Economic war: Is Washington Overusing Its Most Powerful Weapons?" (review of Henry Farrell and Abraham Newman, Underground Empire: How America Weaponized the World Economy, Henry Holt, 2023, 288 pp.), Foreign Affairs, vol. 103, no. 1 (January/February 2024), pp. 150–156. "The [U.S.] dollar is one of the few currencies that almost all major banks will accept, and... the most widely used... As a result, the dollar is the currency that many companies must use... to do international business." (p. 150.) "[L]ocal banks facilitating that trade... normally... buy U.S. dollars and then use dollars to buy [another local currency]. To do so, however, the banks must have access to the U.S. financial system and... follow rules laid out by Washington." (pp. 151–152.) "But there is another, lesser-known reason why the [U.S.] commands overwhelming economic power. Most of the world's fiber-optic cables, which carry data and messages around the planet, travel through the United States." (p. 152.) "[T]he U.S. government has installed 'splitters': prisms that divide the beams of light carrying information into two streams. One... goes on to the intended recipients, ... the other goes to the National Security Agency, which then uses high-powered computation to analyze the data. As a result, the [U.S.] can monitor almost all international communication." (p. 154) This has allowed the U.S. "to effectively cut Iran out of the world financial system... Iran's economy stagnated... Eventually, Tehran agreed to cut back its nuclear programs in exchange for relief." (pp. 153–154.) "[A] few years ago, American officials... were in a panic about [the Chinese company] Huawei... which... seemed poised to supply 5G equipment to much of the planet [thereby possibly] giv[ing] China the power to eavesdrop on the rest of the world – just as the [U.S.] has done.... The [U.S.] learned that Huawei had been dealing surreptitiously with Iran – and therefore violating U.S. sanctions. Then, it... used its special access to information on international bank data to [show] that [Huawei]'s chief financial officer, Meng Wanzhou (... the founder's daughter), had committed bank fraud by falsely telling the British financial services company HSBC that her company was not doing business with Iran. Canadian authorities, acting on a U.S. request, arrested her... in December 2018. After... almost three years under house arrest... Meng... was allowed to return to China... But by [then] the prospects for Chinese dominance of 5G had vanished..." (pp. 154–155.) Farrell and Newman, writes Krugman, "are worried about the possibility of [U.S. Underground Empire] overreach. [I]f the [U.S.] weaponizes the dollar against too many countries, they might... band together and adopt alternative methods of international payment. If countries become deeply worried about U.S. spying, they could lay fiber-optic cables that bypass the [U.S.]. And if Washington puts too many restrictions on American exports, foreign firms might turn away from U.S. technology." (p. 155.) Lerner, Brenda Wilmoth & K. Lee Lerner, eds. Terrorism: essential primary sources Thomas Gale 2006 ISBN 978-1-4144-0621-3 Lerner, K. Lee and Brenda Wilmoth Lerner, eds. Encyclopedia of Espionage, Intelligence and Security (2003), worldwide recent coverage 1100 pages. May, Ernest R. (ed.). Knowing One's Enemies: Intelligence Assessment Before the Two World Wars (1984). O'Toole, George. Honorable Treachery: A History of U.S. Intelligence, Espionage, Covert Action from the American Revolution to the CIA 1991 Murray, Williamson, and Allan Reed Millett, eds. Calculations: net assessment and the coming of World War II (1992). Owen, David. Hidden Secrets: A Complete History of Espionage and the Technology Used to Support It Richelson, Jeffery T. A Century of Spies: Intelligence in the Twentieth Century (1977) Richelson, Jeffery T. The U.S. Intelligence Community (1999, fourth edition) Shaw, Tamsin, "Ethical Espionage" (review of Calder Walton, Spies: The Epic Intelligence War Between East and West, Simon and Schuster, 2023, 672 pp.; and Cécile Fabre, Spying Through a Glass Darkly: The Ethics of Espionage and Counter-Intelligence, Oxford University Press, 251 pp., 2024), The New York Review of Books, vol. LXXI, no. 2 (8 February 2024), pp. 32, 34–35. "[I]n Walton's view, there was scarcely a US covert action that was a long-term strategic success, with the possible exception of intervention in the Soviet–Afghan War (a disastrous military fiasco for the Soviets) and perhaps support for the anti-Soviet Solidarity movement in Poland." (p. 34.) Smith, W. Thomas Jr. Encyclopedia of the Central Intelligence Agency (2003) Tuchman, Barbara W., The Zimmermann Telegram, New York, Macmillan, 1962. Warner, Michael. The Rise and Fall of Intelligence: An International Security History (2014) Zegart, Amy B. Spies, Lies, and Algorithms: The History and Future of American Intelligence (2022), university textbook. online reviews Wikimedia Commons has media related to Espionage. Wikiquote has quotations related to Espionage. Look up espionage in Wiktionary, the free dictionary. History of an espionage in Russia Retrieved from " 2Broadband cellular network standard For other uses, see 5G (disambiguation). This article's lead section may need to be rewritten. Please review the lead guide and help improve the lead of this article if you can. (November 2025) (Learn how and when to remove this message) 3GPP logo for 5G 5G is the fifth generation of cellular network technology and the successor to 4G. It was first rolled out in 2019.[1] The 3rd Generation Partnership Project (3GPP) develops its technical standards in cooperation with the ITU's IMT-2020 program.[2] 5G networks divide coverage areas into smaller zones called cells. Devices connect to local base stations by radio. Each station links to the telephone network and the Internet through fast optical fiber or wireless backhaul.[3] Compared with 4G, 5G can transfer data much faster—up to 10 Gbit/s in tests—and respond quicker, with delays of only a few milliseconds. These improvements let networks handle more users and support uses such as extended reality, autonomous vehicles, remote surgery trials, and fixed wireless access for home internet.[4] 5G also connects large numbers of sensors and machines, known as the IoT, and uses edge computing to process data closer to where it is generated. A 5G cell site using Ericsson equipment in the United States. Building 5G networks requires new infrastructure and access to suitable radio spectrum. Network operators report high costs and continue to improve energy efficiency and security.[5] 5G adoption is carried out incrementally. It differs among countries depending on income, geography, and national policy. Analysts expect 5G to support telehealth, smart transport, and digital media, while operating alongside 4G networks into the 2030s.[5] Cellular network standards and generation timeline In 2008, NASA and the Machine-to-Machine Intelligence Corporation (M2Mi) conducted nanosatellite communication studies that influenced early next-generation network concepts.[6] In 2012, New York University established NYU Wireless, a research center focused on millimeter-wave communication.[7] The same year, the University of Surrey founded the 5G Innovation Centre, funded by £35 million from public and industry partners including Huawei and Samsung.[8] Also in 2012, the European Union launched the Mobile and Wireless Communications Enablers for the Twenty-Twenty Information Society (METIS) project to align emerging network research with international standardization.[9] In 2013, the ITU-R Working Party 5D began studies on IMT-2020, later formalized as the 5G standard.[10] During the same period, major firms such as Samsung Electronics, NTT Docomo, and Huawei conducted early trials. Samsung tested a prototype achieving more than 1 Gbit/s across 2 km using 8 × 8 MIMO antennas.[11] NTT Docomo received a government award at CEATEC for high-speed network development,[12] while Huawei announced a US$600 million program to advance mobile network technology.[13] On April 3, 2019, South Korea launched its national network, the first full commercial deployment.[14] Hours later, Verizon began limited service in select U.S. cities.[15] In June 2019, Globe Telecom introduced the Philippines' first next-generation network,[16] and in December 2019, AT&T launched a consumer service in the United States that expanded nationwide during 2020.[17] Commercial 5G deployment expanded rapidly through 2020. Beyond public mobile networks, it was also adopted in private industrial and enterprise systems, including operation in unlicensed spectrum (NR-U) and licensed non-public networks (NPNs).[18] Private 5G networks became important for Industry 4.0 automation and smart manufacturing.[19] Early rollouts used non-standalone (NSA) mode—with 4G cores—before networks transitioned to standalone (SA) mode with dedicated 5G cores.[20] South Korea's 2019 rollout used equipment from Samsung, Ericsson, and Nokia; LG U Plus also deployed Huawei hardware.[21] Samsung supplied most of the roughly 86,000 sites, while SK Telecom, KT Corporation, and LG U Plus concentrated coverage in major cities using the 3.5 GHz band under NSA operation. Reported download speeds averaged 200–400 Mbit/s, and subscriptions grew from about 260,000 to 4.7 million during 2019.[22] Following these early deployments, T-Mobile US launched the first nationwide standalone network in 2020.[23] Ericsson projected that by the mid-2020s, 5G networks would reach about 65 percent of the global population.[24] Major suppliers of 5G radio and core systems included Altiostar, Cisco Systems, Datang Telecom/Fiberhome, Ericsson, Huawei, Nokia, Qualcomm, Samsung, and ZTE. Huawei was estimated to hold about 70 percent of global 5G base stations by 2023.[25] By 2022, network speeds in many regions had stabilized, and operators began testing 5.5G upgrades to improve capacity and latency.[26] By the early 2020s, large-scale commercial 5G networks were active across most developed markets, and rollout in developing regions was still accelerating.[27][28] Main article: Small cell Small cells are low-power radio nodes that extend network capacity in dense or indoor areas. They operate over short distances, typically a few dozen to a few hundred metres, and are used to maintain coverage for mmWave signals.[29] Typical FR2 cell characteristics Cell type Environment Users (approx.) Power (W) Range (m) Femtocell Homes, offices 4–32 0.01–1 up to 50 Picocell Public venues 64–128 0.1–5 up to 100 Microcell Urban areas 128–256 5–10 200–500 Macrocell Wide-area coverage over 250 10–20 300–1000 See also: Multi-user MIMO Massive multiple-input multiple-output (MIMO) systems use large antenna arrays to increase capacity and spectral efficiency. They extend conventional MIMO by serving multiple users simultaneously and steering signals toward them to reduce interference.[30] Main article: Beamforming Beamforming directs radio energy toward specific users. In analogue beamforming, antenna outputs are combined to focus signal power in one direction. Digital beamforming transmits data streams across multiple layers to improve signal strength and reliability.[31] Non-orthogonal multiple access assigns different power levels to users sharing the same frequency resources to improve spectral efficiency.[32] 5G NR uses polar codes for control channels and low-density parity-check codes (LDPC) for data channels, replacing the turbo codes used in 4G.[33] Research has explored the use of 5G mmWave networks for wireless power transfer. Studies using wavelengths between 1 mm and 10 mm remain experimental.[34] The 5G core (5GC) is a service-oriented, software-defined system that separates control and user planes and supports flexible deployment. It replaces the 4G Evolved Packet Core with modular, software-based network functions. Main articles: Software-defined networking, SD-WAN, Network function virtualization, and 5G network slicing Software-defined networking (SDN) and network function virtualization (NFV) enable software-based configuration, scaling, and management of networks. Together with network slicing, these technologies support applications such as the Internet of Things, connected vehicles, and industrial automation.[35] Service-based architecture (SBA) integrates SDN and NFV principles and replaces the 4G EPC framework with modular network functions that communicate through RESTful APIs. Each function registers with a network repository function (NRF), which enables independent scaling and interoperability.[36] Each network function performs a defined role within the 5G core, replacing or extending elements from the 4G EPC.[37] Core network functions in 5G Function Acronym 4G equivalent Authentication server function AUSF MME; HSS Access and mobility management function AMF MME Session management function SMF MME; PGW-C User plane function UPF SGW-U; PGW-U Policy control function PCF PCRF Unified data management UDM HSS Unified data repository UDR HSS database Network exposure function NEF None Network slice selection function NSSF None Network data analytics function NWDAF None Charging function CHF CSCF Additional components manage roaming and inter-network connectivity: Security Edge Protection Proxy (SEPP) Non-3GPP Interworking Function (N3IWF) Trusted Non-3GPP Gateway Function (TNGF) Wireline Access Gateway Function (W-AGF) Trusted WLAN Interworking Function (TWIF) Further information: 5G NR frequency bands 5G networks use multiple parts of the radio spectrum. They operate across three main frequency ranges—low, mid, and high bands—which balance speed, coverage, and signal quality differently.[38] Between 2016 and 2019, regulators in many regions, including the United States and the European Union, reallocated large sections of spectrum for 5G through auctions and new licensing rules.[39] By 2019, more than 50 countries had assigned or planned to assign 5G frequencies.[40] In 3GPP Release 16, the standard added 5G NR-U, allowing operation in unlicensed as well as licensed spectrum.[41] The 5G New Radio (NR) interface defines two main operating ranges: Frequency Range 1 (FR1) – below 7.125 GHz, also called sub-6 GHz. It covers low- and mid-band frequencies and supports channel bandwidths up to 100 MHz. Typical download speeds range from 5 to 900 Mbit/s depending on conditions. Frequency Range 2 (FR2) – 24–71 GHz, known as millimeter wave or high band. It supports wider channel bandwidths—up to 400 MHz per carrier—and can reach multi-gigabit data rates. These signals travel only short distances and are easily blocked by walls, windows, and vegetation, so FR2 is mainly used in dense urban areas such as stadiums and city centers.[42] Low- and mid-band 5G provide broad coverage and reliable indoor reception. High-band signals weaken rapidly and may lose over 100 dB when passing through common building materials.[43] Operators use beamforming antennas, small cells, and signal repeaters to extend range and improve indoor coverage. Technologies such as License Assisted Access (LAA) and LTE-WLAN Aggregation (LWA) let mobile networks share unlicensed spectrum with Wi-Fi. Cloud-based RAN systems and dense small-cell layouts help narrow the performance gap between cellular and Wi-Fi links.[44] The ITU-R defines three main application areas for 5G: enhanced mobile broadband (eMBB), ultra-reliable low-latency communications (URLLC), and massive machine-type communications (mMTC).[45] These categories describe the main uses of 5G: faster mobile connections (eMBB), highly reliable and responsive communication (URLLC), and large-scale links between machines (mMTC). By 2020, eMBB was widely deployed, while URLLC and mMTC were still in development.[46] Enhanced mobile broadband (eMBB) provides much faster internet and higher capacity than 4G. It supports intensive data use in busy areas such as city centres, stadiums, and transport hubs.[47] Ultra-reliable low-latency communications (URLLC) are designed for time-critical applications such as factory automation, remote medical procedures, and traffic systems. Shorter transmission delays improve precision and reliability. Massive machine-type communications (mMTC) connect large numbers of low-power devices such as sensors and meters. These networks underpin the Internet of Things (IoT) by allowing machines to exchange data autonomously in industry, transport, and urban systems.[48] 5G is used in transport, manufacturing, and energy systems that require constant, low-latency communication. The 5G Automotive Association develops vehicle-to-everything (C-V2X) standards that allow cars to exchange safety information with nearby vehicles and infrastructure.[49] Drones and autonomous vehicles use 5G for navigation, remote control, and real-time data transmission.[50] Low-latency connections also enable digital twin models—virtual copies of machines or buildings that show real-time performance data used for monitoring and maintenance. 5G extends to public safety, broadband access, and media delivery. Emergency services use it for live video, data, and reliable push-to-talk communication.[51] Fixed wireless access (FWA) provides home and business broadband using 5G radio links instead of wired connections, especially in rural areas where laying cables is costly.[52] 5G Broadcast trials in Europe show that local 5G networks can deliver live television and radio to many devices simultaneously without using mobile data plans.[53] Voice over NR (VoNR) allows phone calls to be made over 5G's internet-based network, similar to Voice over LTE (VoLTE) on 4G.[54] This section needs to be updated. Please help update this article to reflect recent events or newly available information. (October 2025) 5G can deliver much higher data rates than 4G, up to ten times faster.[55][56] Theoretical peak download speeds reach up to 20 Gbit/s.[57] In practice, average 5G download speeds in the United States have been measured at about 186 Mbit/s by T-Mobile,[58] while South Korea in 2022 led globally with averages near 430 Mbit/s.[59][60] 5G networks are also designed to provide much greater total capacity and efficiency than 4G, with up to a hundredfold projected increase.[61] The most widely deployed version, sub-6 GHz (mid-band) 5G, provides speeds of roughly 10–1000 Mbit/s with wider reach than mmWave bands. C-Band (n77/n78) was introduced in the U.S. in 2022, though activation by Verizon and AT&T was briefly delayed due to FAA safety concerns. The highest 5G speed measured in a deployed network is 5.9 Gbit/s (2023).[62] Low-band frequencies such as n5 cover larger areas per cell but deliver lower data rates of around 5–250 Mbit/s.[63] Typical air latency for 5G is around 8–12 ms, excluding retransmissions and handovers. Verizon reported about 30 ms latency in early deployments.[64] Edge servers located near base stations can reduce round-trip time to roughly 14 ms and minimize jitter to about 1.8 ms.[65] Latency increases substantially during handovers, ranging from 50 to 500 ms depending on network conditions.[citation needed] Ongoing research focuses on reducing these interruptions by adjusting handover margins and time-to-trigger parameters. 5G uses adaptive modulation and coding schemes (MCS) to maintain a low block error rate (BLER). When the error rate exceeds a threshold, the system automatically switches to a lower MCS to prioritize reliability over speed. The range of 5G varies with transmit power, frequency, and interference. High-frequency mmWave bands (e.g., n258) have a shorter range than mid-band (n78), which in turn has a shorter range than low-band (n5). Operators use network simulation and drive testing to measure the actual range and coverage of these bands, as real-world performance can differ from marketing claims. The term 5G was first associated with the International Telecommunication Union's IMT-2020 standard. It defines peak download and upload rates of 20 and 10 Gbit/s.[66] The 3rd Generation Partnership Project (3GPP) later proposed its 5G New Radio (NR) technology for IMT-2020.[67][68] 5G NR operates in two bands: FR1 (below 6 GHz): lower frequencies with wide coverage and moderate speeds FR2 (above 24 GHz): millimetre-wave frequencies with higher speeds but shorter range Early FR1 deployments reusing 4G infrastructure (non-standalone mode) have been reported to provide 15–50 percent higher throughput than advanced 4G networks.[69] 3GPP and ETSI publish key technical specifications, including: TS 23.501 – system architecture for the 5G system (5GS) TS 24.501 – Non-Access-Stratum (NAS) protocol for 5GS TS 23.003 – numbering, addressing and identification[70] Other organizations also contribute to 5G standards. The DECT-2020 specification defines DECT NR+, a non-cellular, mesh-based radio system recognized by ITU as part of 5G.[71][72] The IEEE defines standards for wired links between the remote radio unit (RRU) and the baseband unit (BBU). IEEE 1914.1 describes the architecture of the fronthaul network connecting these components IEEE 1914.3 defines an Ethernet format for transmitting I/Q data based on 3GPP functional splits[73] 5Gi was developed in India by IIT Madras, IIT Hyderabad, the Telecommunications Standards Development Society India (TSDSI) and the Centre of Excellence in Wireless Technology (CEWiT). It extends 5G coverage in rural and remote areas through low-mobility large-cell (LMLC) configurations.[74] 5Gi was merged in April 2022 into the global 5G NR standard in 3GPP Release 17.[75] In the internet of things (IoT), 3GPP defines the evolution of NB-IoT and eMTC to support low-power wide-area applications such as connected sensors and meters.[76] 3GPP also defines non-terrestrial networks (NTN) that use satellites and airborne platforms to provide coverage where ground networks are impractical.[77][78] 5G-Advanced, also known as 5.5G, is defined in 3GPP Release 18 as a transition between 5G and 6G. It adds features for more efficient spectrum use, lower energy demand and higher reliability. The release introduces AI and ML-based network management, extended-reality services and communication for autonomous systems.[79][80][81] Release 18 specifies improved time-synchronization methods independent of the GNSS and built-in geolocation functions. It extends non-terrestrial support to satellite and airborne communication. Samsung Galaxy S10 showing 5G signal The Global Mobile Suppliers Association (GSA) compiled the first database of 5G-compatible products, listing 23 manufacturers and 33 models across categories such as smartphones, hotspots, and customer-premises equipment.[82] Later surveys recorded more than one hundred announced products from over fifty vendors.[83] Early 5G modem chipsets were released by Intel, MediaTek, Qualcomm, and Samsung, followed by additional platforms in subsequent product generations.[84] The Samsung Galaxy S10 5G was among the first smartphones to support 5G networks.[85] Other early 5G models included the Nokia 8.3 5G, designed for operation across low- to mid-band frequencies;[86] the Google Pixel 5 and Pixel 4a (5G);[87] and Apple's iPhone 12 series, the company's first generation with 5G capability.[88][89] By the early 2020s, most high-end smartphones featured 5G capability, while some consumer devices still lack full support. As a result, the practical benefits for mid range phone users have been modest, and 5G adoption has lagged behind expectations.[90] In 2019, the European Commission and the European Union Agency for Cybersecurity (ENISA) warned that 5G networks could expand potential attack surfaces for state actors, recommending diversification of suppliers. Nokia and Ericsson are the only European manufacturers.[91] Researchers from ETH Zurich and partner universities found weaknesses in the 5G authentication process that could expose users to new security risks.[92] They concluded that the system was still immature and that its higher data capacity could increase exposure to attacks.[93] A 2022 study identified a design flaw in the Evolved Packet System (EPS) that could affect device behavior during network switching.[94] Growth of the IoT increases the number of devices connected through 5G. IoT Analytics estimated growth from about 7 billion devices in 2018 to over 21 billion by 2025, raising exposure to DDoS attacks, cryptojacking, and other cyberattacks.[95] Concerns about espionage and data access have influenced national policies. The United States, Australia, and the United Kingdom have restricted or banned Chinese-made equipment.[96] A 2012 report by the United States House Permanent Select Committee on Intelligence concluded that equipment from Huawei and ZTE could pose national-security risks.[97] Later assessments by U.S. intelligence agencies warned that Huawei products could allow covert data access.[98] In 2022, the FBI reported that Huawei equipment near U.S. military bases could interfere with nuclear communications.[99] Huawei and the Chinese government deny the allegations. Analysts note that China's National Security Law could require companies to provide data to authorities if requested.[100] In 2020, the U.S. State Department launched the Clean Network initiative to promote data privacy and security among allied nations. By year-end, more than 60 countries and 200 telecommunications companies had joined, including most NATO, EU, and OECD members.[101] Some 5G bands, such as n258 at 26 GHz, are close to frequencies used for passive remote sensing by weather and Earth observation satellites, including water vapor measurements at 23.8 GHz.[102] Interference with satellite observations could reduce the accuracy of numerical weather prediction models and affect sectors such as commercial aviation.[103] NASA, NOAA, and the U.S. Navy warned that out-of-band emissions from 5G transmissions near 24 GHz could degrade forecasts by up to 30 %.[104] The 2019 World Radiocommunication Conference set an interim limit of −33 dBW until 2027, followed by −39 dBW. The World Meteorological Organization (WMO) and European Centre for Medium-Range Weather Forecasts (ECMWF) warned that these limits could reduce forecast reliability.[105] In 2021–2022, the Federal Aviation Administration (FAA) warned that some 5G signals could interfere with aircraft radar altimeters, which operate at 4.2–4.4 GHz, while new 5G services use 3.7–4.0 GHz.[106] Europe uses lower frequencies (3.4–3.8 GHz), reducing the risk.[107] Further information: C band (IEEE) Some 5G allocations overlap with frequencies used by C band satellite communication systems. Interference can occur when networks operate in 3.3–3.6 GHz, near satellite reception at 3.4–4.2 GHz[108] Mitigation uses low-noise block downconverters and waveguide filters. 5G and Wi-Fi 6E share the 6 GHz band, which enables efficient spectrum use but requires coordination to prevent interference. Both operate under unlicensed conditions in the US and EU, supporting NR-U and Wi-Fi 6E technologies.[109] Analysts note that marketing of 5G has often overstated its capabilities.[110] Common concerns include limited user benefits, short range of mmWave signals, and rebranding of non-5G improvements as 5G.[111] A 2020 survey by McKinsey & Company found that operators identified few immediately profitable use cases.[112] Consumer surveys show mixed attitudes, with skepticism about marketing claims and uneven coverage in early deployments.[113] Industry groups and network operators state that 5G enables faster speeds and lower latency, though results depend on infrastructure rollout and available spectrum. In contrast to the initial excitement about the prospects, many firms striving for deployment have encountered reality, users are not eager to upgrade the technology.[114] Five years after its launch, a majority of users have yet to transition to the new standard.[115] Main article: 5G misinformation Further information: Wireless device radiation and health Public concern about the effects of wireless signals predates 5G technology. Similar concerns were raised about earlier mobile standards in the 1990s and 2000s. According to the Centers for Disease Control and Prevention (CDC), "exposure to intense, direct amounts of non-ionizing radiation may result in tissue damage due to heat. This is uncommon and mainly a workplace concern for those working with large sources of non-ionizing radiation."[116] Some critics argue that existing exposure limits are too lenient or influenced by industry lobbying. Claims that the use of 5G mobile networks can cause cancer are unsupported by scientific evidence.[117] Several books making unverified claims about wireless health effects have been published. One, by Joseph Mercola, alleged links to ADHD, heart disease, and brain cancer. Mercola was criticized for promoting misinformation during the COVID-19 pandemic and warned by the Food and Drug Administration (FDA) for selling unapproved COVID-19 cures.[118][119] According to The New York Times, controversy regarding 5G health effects partly originated from an unpublished 2000 report by physicist Bill P. Curry for the Broward County School Board, which incorrectly concluded that higher-frequency microwaves are absorbed more deeply by the brain.[120] Later analyses showed that this was a misunderstanding of in vitro research results. Experts noted that millimeter-wave frequencies used by 5G cannot penetrate the skin or reach internal organs. In a 2019 article, the same newspaper reported that RT America promoted claims linking 5G to diseases such as brain cancer, infertility, and Alzheimer's disease. The network aired several such programs in 2019, later cited by numerous blogs and websites.[121] In 2019, cities such as Brussels and Geneva temporarily halted 5G rollouts pending radiation assessments.[122][123] The Swiss Telecommunications Association stated that studies had not demonstrated adverse health effects from 5G exposure.[124] Similar debates occurred in the Netherlands, the United States, and the United Kingdom, where some municipalities briefly delayed deployments or issued precautionary statements.[125][126] The Food and Drug Administration maintains that existing exposure limits for cellphone radiofrequency energy are sufficient to protect public health.[127] Low-level electromagnetic fields (EMF) can have measurable biological effects in plants and animals, but research remains inconclusive about health risks to humans.[128] A 2019 meta-analysis found that while many in vitro and in vivo studies detected biological responses to radiofrequency exposure, the evidence did not establish health risks.[129] A World Health Organization infographic debunking false claims that 5G spreads COVID-19. The rollout of 5G technology began during the COVID-19 pandemic, prompting conspiracy theories that linked 5G to the pandemic.[130] These claims led to arson attacks on telecom masts in parts of Europe, including the Netherlands, the United Kingdom, and Italy.[131][132][133] In the United Kingdom, at least 61 mobile masts were reportedly set on fire.[134] During the early months of the pandemic, Australian anti-lockdown protesters carried anti-5G signs, later connected to broader conspiracy groups. Two main versions of the conspiracy theory exist:[135] The first claims that radiation from 5G weakens the immune system, making people more vulnerable to SARS-CoV-2, the virus that causes COVID-19. The second claims that 5G causes COVID-19. Some versions claim the pandemic hid illnesses blamed on 5G, while others suggest COVID-19 began in Wuhan, one of the first cities with early 5G rollout. Main articles: 5G Evolution, LTE Advanced Pro, and LTE Advanced This section needs expansion. You can help by adding to it. (October 2023) The marketing of non-5G services refers to the promotion of enhanced 4G networks that are presented as precursors or equivalents to 5G. Some mobile network operators marketed upgraded 4G technologies using terms that suggested 5G capability. These offerings, sometimes described by carriers as "pre-5G" or "5G-ready", used LTE Advanced Pro features, including 4×4 MIMO, to deliver higher data rates. However, they did not meet the criteria defined for 5G by the 3GPP. A notable example was 5G Evolution, introduced by AT&T in 2017 to market faster speeds based on existing LTE Advanced Pro infrastructure.[136] According to an AT&T statement at the time, it served as "a foundation for our evolution to 5G while the 5G standards are being finalized". A technology publication stated that such branding was likely to cause confusion among consumers, as the network did not represent true 5G technology.[137] As of 2024, 5G deployment had expanded, but 4G networks remained widely used. Many developed countries reported that more than 90% of the population was covered by LTE networks.[138] In the United States, mobile operators continued to sell 4G plans at lower prices than 5G plans.[139][140] Typical 5G plans cost about US$85 per month for premium data tiers.

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Part of a series on theWireless network technologies Analog 0G1G (1.5G) Digital 2G (2.5G, 2.75G, 2.9G)3G (3.5G, 3.75G, 3.9G/3.95G)4G (4G/4.5G, 4.5G, 4.9G)5G (5.5G)6G Mobile telecommunicationsvte 4G refers to the fourth generation of cellular network technology, first introduced in the late 2000s and early 2010s. Compared to preceding third-generation (3G) technologies, 4G has been designed to support all-IP communications and broadband services, and eliminates circuit switching in voice telephony.[1] It also has considerably higher data bandwidth compared to 3G, enabling a variety of data-intensive applications[2] such as high-definition media streaming and the expansion of Internet of Things (IoT) applications.[1] The earliest deployed technologies marketed as "4G" were Long Term Evolution (LTE), developed by the 3GPP group, and Mobile Worldwide Interoperability for Microwave Access (Mobile WiMAX), based on IEEE specifications.[3][4] These provided significant enhancements over previous 3G and 2G. In November 2008, the International Telecommunication Union-Radio communications sector (ITU-R) specified a set of requirements for 4G standards, named the International Mobile Telecommunications Advanced (IMT-Advanced) specification, setting peak speed requirements for 4G service at 100 megabits per second (Mbit/s)(=12.5 megabytes per second) for high mobility communication (such as from trains and cars) and 1 gigabit per second (Gbit/s) for low mobility communication (such as pedestrians and stationary users).[5] Since the first-release versions of Mobile WiMAX and LTE support much less than 1 Gbit/s peak bit rate, they are not fully IMT-Advanced compliant, but are often branded 4G by service providers. According to operators, a generation of the network refers to the deployment of a new non-backward-compatible technology. On December 6, 2010, ITU-R recognized that these two technologies, as well as other beyond-3G technologies that do not fulfill the IMT-Advanced requirements, could nevertheless be considered "4G", provided they represent forerunners to IMT-Advanced compliant versions and "a substantial level of improvement in performance and capabilities with respect to the initial third generation systems now deployed". Both the original LTE and WiMAX standards had previously sometimes been referred to as 3.9G/3.95G.[6][7] The ITU's new definition for 4G also included Evolved High Speed Packet Access (HSPA+).[8] Mobile WiMAX Release 2 (also known as WirelessMAN-Advanced or IEEE 802.16m) and LTE Advanced (LTE-A) are IMT-Advanced compliant backwards compatible versions of the above two systems, standardized during the spring 2011,[citation needed] and promising speeds in the order of 1 Gbit/s. In January 2012, the ITU backtracked on its previous definition for 4G, claiming that Mobile WiMAX 2 and LTE Advanced are "true 4G" while their predecessors are "transitional" 3G-4G.[1] As opposed to earlier generations, a 4G system does not support traditional circuit-switched telephony service, but instead relies on all-Internet Protocol (IP) based communication such as IP telephony. As seen below, the spread spectrum radio technology used in 3G systems is abandoned in all 4G candidate systems and replaced by OFDMA multi-carrier transmission and other frequency-domain equalization (FDE) schemes, making it possible to transfer very high bit rates despite extensive multi-path radio propagation (echoes). The peak bit rate is further improved by smart antenna arrays for multiple-input multiple-output (MIMO) communications. In the field of mobile communications, a "generation" generally refers to a change in

the fundamental nature of the service, non-backwards-compatible transmission technology, higher peak bit rates, new frequency bands, wider channel frequency bandwidth in Hertz, and higher capacity for many simultaneous data transfers (higher system spectral efficiency in bit/second/Hertz/site). New mobile generations have appeared about every ten years since the first move from 1981 analog (1G) to digital (2G) transmission in 1992. This was followed, in 2001, by 3G multi-media support, spread spectrum transmission and a minimum peak bit rate of 200 kbit/s, in 2011/2012 to be followed by "real" 4G, which refers to all-IP packet-switched networks giving mobile ultra-broadband (gigabit speed) access. While the ITU has adopted recommendations for technologies that would be used for future global communications, they do not actually perform the standardization or development work themselves, instead relying on the work of other standard bodies such as IEEE, WiMAX Forum, and 3GPP. In the mid-1990s, the ITU-R standardization organization released the IMT-2000 requirements as a framework for what standards should be considered 3G systems, requiring 2000 kbit/s peak bit rate.[9] The fastest 3G-based standard in the UMTS family is the HSPA+ standard, which has been commercially available since 2009 and offers 21 Mbit/s downstream (11 Mbit/s upstream) without MIMO, i.e. with only one antenna, and in 2011 accelerated up to 42 Mbit/s peak bit rate downstream using either DC-HSPA+ (simultaneous use of two 5 MHz UMTS carriers)[10] or 2x2 MIMO. In theory speeds up to 672 Mbit/s are possible, but have not been deployed yet. The fastest 3G-based standard in the CDMA2000 family is the EV-DO Rev. B, which is available since 2010 and offers 15.67 Mbit/s downstream. In 2008, ITU-R specified the IMT Advanced (International Mobile Telecommunications Advanced) requirements for 4G systems. Main article: LTE frequency bands This article refers to 4G using IMT-Advanced (International Mobile Telecommunications Advanced), as defined by ITU-R. An IMT-Advanced cellular system must fulfill the following requirements:[11] Be based on an all-IP packet switched network. Have peak data rates of up to approximately 100 Mbit/s for high mobility such as mobile access and up to approximately 1 Gbit/s for low mobility such as nomadic/local wireless access.[5] Be able to dynamically share and use the network resources to support more simultaneous users per cell. Use scalable channel bandwidths of 5–20 MHz, optionally up to 40 MHz.[5][12] Have peak link spectral efficiency of 15 bit/s·Hz in the downlink, and 6.75 bit/s·Hz in the up link (meaning that 1 Gbit/s in the downlink should be possible over less than 67 MHz bandwidth). System spectral efficiency is, in indoor cases, 3 bit/s·Hz·cell for downlink and 2.25 bit/s·Hz·cell for up link.[5] Smooth handovers across heterogeneous networks. In September 2009, the technology proposals were submitted to the International Telecommunication Union (ITU) as 4G candidates.[13] Basically all proposals are based on two technologies: LTE Advanced standardized by the 3GPP 802.16m standardized by the IEEE Implementations of Mobile WiMAX and first-release LTE were largely considered a stopgap solution that would offer a considerable boost until WiMAX 2 (based on the 802.16m specification) and LTE Advanced was deployed. The latter's standard versions were ratified in spring 2011. The first set of 3GPP requirements on LTE Advanced was approved in June 2008.[14] LTE Advanced was standardized in 2010 as part of Release 10 of the 3GPP specification. Some sources consider first-release LTE and Mobile WiMAX implementations as pre-4G or near-4G, as they do not fully comply with the planned requirements of 1 Gbit/s for stationary reception and 100 Mbit/s for mobile. Confusion has been caused by some mobile carriers who have launched products advertised as 4G but which according to some sources are pre-4G versions, commonly referred to as 3.9G, which do not follow the ITU-R defined principles for 4G standards, but today can be called 4G according to ITU-R. Vodafone Netherlands for example, advertised LTE as 4G, while advertising LTE Advanced as their '4G+' service. A common argument for branding 3.9G systems as new-generation is that they use different frequency bands from 3G technologies; that they are based on a new radio-interface paradigm; and that the standards are not backwards compatible with 3G, whilst some of the standards are forwards compatible with IMT-2000 compliant versions of the same standards. As of October 2010, ITU-R Working Party 5D approved two industry-developed technologies (LTE Advanced and WirelessMAN-Advanced)[15] for inclusion in the ITU's International Mobile Telecommunications Advanced program (IMT-Advanced program), which is focused on global communication systems that will be available several years from now. Main article: LTE Advanced LTE Advanced (Long Term Evolution Advanced) is a candidate for IMT-Advanced standard, formally submitted by the 3GPP organization to ITU-T in the fall 2009, and as of 2013 has been released to the public.[16][needs update]The target of 3GPP LTE Advanced is to reach and surpass the ITU requirements.[17] LTE Advanced is essentially an enhancement to LTE. It is not a new technology, but rather an improvement on the existing LTE network. This upgrade path makes it more cost effective for vendors to offer LTE and then upgrade to LTE Advanced which is similar to the upgrade from WCDMA to HSPA. LTE and LTE Advanced will also make use of additional spectrums and multiplexing to allow it to achieve higher data speeds. Coordinated Multi-point Transmission will also allow more system capacity to help handle the enhanced data speeds. Data speeds of LTE-Advanced LTE Advanced Peak download 1000 Mbit/s Peak upload 0500 Mbit/s This section needs to be updated. Please help update this article to reflect recent events or newly available information. (August 2021) The IEEE 802.16m or WirelessMAN-Advanced (WiMAX 2) evolution of 802.16e is under development, with the objective to fulfill the IMT-Advanced criteria of 1 Gbit/s for stationary reception and 100 Mbit/s for mobile reception.[18] Main article: LTE (telecommunication) Telia-branded Samsung LTE modem Huawei 4G+ Dual Band Modem The pre-4G 3GPP Long Term Evolution (LTE) technology is often branded "4G – LTE", but the first LTE release does not fully comply with the IMT-Advanced requirements. LTE has a theoretical net bit rate capacity of up to 100 Mbit/s in the downlink and 50 Mbit/s in the uplink if a 20 MHz channel is used — and more if multiple-input multiple-output (MIMO), i.e. antenna arrays, are used. The physical radio interface was at an early stage named High Speed OFDM Packet Access (HSOPA), now named Evolved UMTS Terrestrial Radio Access (E-UTRA). The first LTE USB dongles do not support any other radio interface. The world's first publicly available LTE service was opened in the two Scandinavian capitals, Stockholm (Ericsson and Nokia Siemens Networks systems) and Oslo (a Huawei system) on December 14, 2009, and branded 4G. The user terminals were manufactured by Samsung.[19] As of November 2012, the five publicly available LTE services in the United States are provided by MetroPCS,[20] Verizon Wireless,[21] AT&T Mobility, U.S. Cellular,[22] Sprint,[23] and T-Mobile US.[24] T-Mobile Hungary launched a public beta test (called friendly user test) on 7 October 2011, and has offered commercial 4G LTE services since 1 January 2012.[citation needed] In South Korea, SK Telecom and LG U+ have enabled access to LTE service since 1 July 2011 for data devices, slated to go nationwide by 2012.[25] KT Telecom closed its 2G service by March 2012 and completed nationwide LTE service in the same frequency around 1.8 GHz by June 2012. In the United Kingdom, LTE services were launched by EE in October 2012,[26] by O2 and Vodafone in August 2013,[27] and by Three in December 2013.[28] Data speeds of LTE[29] LTE Peak download 0150 Mbit/s Peak upload 0050 Mbit/s The Mobile WiMAX (IEEE 802.16e-2005) mobile wireless broadband access (MWBA) standard (also known as WiBro in South Korea) is sometimes branded 4G, and offers peak data rates of 128 Mbit/s downlink and 56 Mbit/s uplink over 20 MHz wide channels. [citation needed] In June 2006, the world's first commercial mobile WiMAX service was opened by KT in Seoul, South Korea.[30] Sprint has begun using Mobile WiMAX, as of 29 September 2008, branding it as a "4G" network even though the current version does not fulfill the IMT Advanced requirements on 4G systems.[31] In Russia, Belarus and Nicaragua WiMax broadband internet access were offered by a Russian company Scartel, and was also branded 4G, Yota.[32] Data speeds of WiMAX WiMAX Peak download 0128 Mbit/s Peak upload 0056 Mbit/s In the latest version of the standard, WiMax 2.1, the standard has been updated to be not compatible with earlier WiMax standard, and is instead interchangeable with LTE-TDD system, effectively merging WiMax standard with LTE. This section possibly contains original synthesis. Source material should verifiably mention and relate to the main topic. Relevant discussion may be found on the talk page. (April 2017) (Learn how and when to remove this message) Just as Long-Term Evolution (LTE) and WiMAX are being vigorously promoted in the global telecommunications industry, the former (LTE) is also the most powerful 4G mobile communications leading technology and has quickly occupied the Chinese market. TD-LTE, one of the two variants of the LTE air interface technologies, is not yet mature, but many domestic and international wireless carriers are, one after the other turning to TD-LTE. IBM's data shows that 67% of the operators are considering LTE because this is the main source of their future market. The above news also confirms IBM's statement that while only 8% of the operators are considering the use of WiMAX, WiMAX can provide the fastest network transmission to its customers on the market and could challenge LTE. TD-LTE is not the first 4G wireless mobile broadband network data standard, but it is China's 4G standard that was amended and published by China's largest telecom operator – China Mobile. After a series of field trials, is expected to be released into the commercial phase in the next two years. Ulf Ewaldsson, Ericsson's vice president said: "the Chinese Ministry of Industry and China Mobile in the fourth quarter of this year will hold a large-scale field test, by then, Ericsson will help the hand." But viewing from the current development trend, whether this standard advocated by China Mobile will be widely recognized by the international market is still debatable. Main article: Ultra Mobile Broadband UMB (Ultra Mobile Broadband) was the brand name for a discontinued 4G project within the 3GPP2 standardization group to improve the CDMA2000 mobile phone standard for next generation applications and requirements. In November 2008, Qualcomm, UMB's lead sponsor, announced it was ending development of the technology, favoring LTE instead.[33] The objective was to achieve data speeds over 275 Mbit/s downstream and over 75 Mbit/s upstream. At an early stage the Flash-OFDM system was expected to be further developed into a 4G standard. The iBurst system (or HC-SDMA, High Capacity Spatial Division Multiple Access) was at an early stage considered to be a 4G predecessor. It was later further developed into the Mobile Broadband Wireless Access (MBWA) system, also known as IEEE 802.20. This section needs additional citations for verification. Please help improve this article by adding citations to reliable sources in this section. Unsourced material may be challenged and removed. (August 2015) (Learn how and when to remove this message) The following key features can be observed in all suggested 4G technologies: Physical layer transmission techniques are as follows:[34] MIMO: To attain ultra high spectral efficiency by means of spatial processing including multi-antenna and multi-user MIMO Frequency-domain-equalization, for example multi-carrier modulation (OFDM) in the downlink or single-carrier frequency-domain-equalization (SC-FDE) in the uplink: To exploit the frequency selective channel property without complex equalization Frequency-domain statistical multiplexing, for example (OFDMA) or (single-carrier FDMA) (SC-FDMA, a.k.a. linearly precoded OFDMA, LP-OFDMA) in the uplink: Variable bit rate by assigning different sub-channels to different users based on the channel conditions.[35] Turbo principle error-correcting codes: To minimize the required SNR at the reception side Channel-dependent scheduling: To use the time-varying channel Link adaptation: Adaptive modulation and error-correcting codes Mobile IP utilized for mobility IP-based femtocells (home nodes connected to fixed Internet broadband infrastructure) As opposed to earlier generations, 4G systems do not support circuit switched telephony. IEEE 802.20, UMB and OFDM standards[36] lack soft-handover support, also known as cooperative relaying. This section may contain information not important or relevant to the article's subject. Please help improve this section. (May 2010) (Learn how and when to remove this message) Recently, new access schemes like Orthogonal FDMA (OFDMA), Single Carrier FDMA (SC-FDMA), Interleaved FDMA, and Multi-carrier CDMA (MC-CDMA) are gaining more importance for the next generation systems. These are based on efficient FFT algorithms and frequency domain equalization, resulting in a lower number of multiplications per second. They also make it possible to control the bandwidth and form the spectrum in a flexible way. However, they require advanced dynamic channel allocation and adaptive traffic scheduling. WiMax is using OFDMA in the downlink and in the uplink. For the LTE (telecommunication), OFDMA is used for the downlink; by contrast, Single-carrier FDMA is used for the uplink since OFDMA contributes more to the PAPR related issues and results in nonlinear operation of amplifiers. IFDMA provides less power fluctuation and thus requires energy-inefficient linear amplifiers. Similarly, MC-CDMA is in the proposal for the IEEE 802.20 standard. These access schemes offer the same efficiencies as older technologies like CDMA. Apart from this, scalability and higher data rates can be achieved. The other important advantage of the above-mentioned access techniques is that they require less complexity for equalization at the receiver. This is an added advantage especially in the MIMO environments since the spatial multiplexing transmission of MIMO systems inherently require high complexity equalization at the receiver. In addition to improvements in these multiplexing systems, improved modulation techniques are being used. Whereas earlier standards largely used Phase-shift keying, more efficient systems such as 64QAM are being proposed for use with the 3GPP Long Term Evolution standards. Unlike 3G, which is based on two parallel infrastructures consisting of circuit switched and packet switched network nodes, 4G is based on packet switching only. This requires low-latency data transmission. As IPv4 addresses are (nearly) exhausted, [Note 1] IPv6 is essential to support the large number of wireless-enabled devices that communicate using IP. By increasing the number of IP addresses available, IPv6 removes the need for network address translation (NAT), a method of sharing a limited number of addresses among a larger group of devices, which has a number of problems and limitations. When using IPv6, some kind of NAT is still required for communication with legacy IPv4 devices that are not also IPv6-connected. As of June 2009[update], Verizon has posted specifications that require any 4G devices on its network to support IPv6.[37][38] Main articles: MIMO and Multi-user MIMO The performance of radio communications depends on an antenna system, termed smart or intelligent antenna. Recently, multiple antenna technologies are emerging to achieve the goal of 4G systems such as high rate, high reliability, and long range communications. In the early 1990s, to cater for the growing data rate needs of data communication, many transmission schemes were proposed. One technology, spatial multiplexing, gained importance for its bandwidth conservation and power efficiency. Spatial multiplexing involves deploying multiple antennas at the transmitter and at the receiver. Independent streams can then be transmitted simultaneously from all the antennas. This technology, called MIMO (as a branch of intelligent antenna), multiplies the base data rate by (the smaller of) the number of transmit antennas or the number of receive antennas. Apart from this, the reliability in transmitting high speed data in the fading channel can be improved by using more antennas at the transmitter or at the receiver. This is called transmit or receive diversity. Both transmit/receive diversity and transmit spatial multiplexing are categorized into the space-time coding techniques, which does not necessarily require the channel knowledge at the transmitter. The other category is closed-loop multiple antenna technologies, which require channel knowledge at the transmitter. One of the key technologies for 4G and beyond is called Open Wireless Architecture (OWA), supporting multiple wireless air interfaces in an open architecture platform. SDR is one form of open wireless architecture (OWA). Since 4G is a collection of wireless standards, the final form of a 4G device will constitute various standards. This can be efficiently realized using SDR technology, which is categorized to the area of the radio convergence. In 1991, WiLAN founders Hatim Zaghloul and Michel Fattouche invented wideband orthogonal frequency-division multiplexing (WOFDM), the basis for wideband wireless communication applications,[39] including 4G mobile communications.[40]Cellular network standards and generation timeline. The 4G system was originally envisioned by the DARPA, the US Defense Advanced Research Projects Agency.[citation needed] DARPA selected the distributed architecture and end-to-end Internet protocol (IP), and believed at an early stage in peer-to-peer networking in which every mobile device would be both a transceiver and a router for other devices in the network, eliminating the spoke-and-hub weakness of 2G and 3G cellular systems.[41][page needed] Since the 2.5G GPRS system, cellular systems have provided dual infrastructures: packet switched nodes for data services, and circuit switched nodes for voice calls. In 4G systems, the circuit-switched infrastructure is abandoned and only a packet-switched network is provided, while 2.5G and 3G systems require both packet-switched and circuit-switched network nodes, i.e. two infrastructures in parallel. This means that in 4G traditional voice calls are replaced by IP telephony. In 2002, the strategic vision for 4G—which ITU designated as IMT Advanced—was laid out. In 2004, LTE was first proposed by NTT DoCoMo of Japan.[42] In 2005, OFDMA transmission technology is chosen as candidate for the HSOPA downlink, later renamed 3GPP Long Term Evolution (LTE) air interface E-UTRA. In November 2005, KT Corporation demonstrated mobile WiMAX service in Busan, South Korea.[43] In April 2006, KT Corporation started the world's first commercial mobile WiMAX service in Seoul, South Korea.[44] In mid-2006, Sprint announced that it would invest about US$5 billion in a WiMAX technology buildout over the next few years[45] ($7.8 billion in real terms[46]). Since that time Sprint has faced many setbacks that have resulted in steep quarterly losses. On 7 May 2008, Sprint, Imagine, Google, Intel, Comcast, Bright House, and Time Warner announced a pooling of an average of 120 MHz of spectrum; Sprint merged its Xohm WiMAX division with Clearwire to form a company which will take the name "Clear". In February 2007, the Japanese company NTT DoCoMo tested a 4G communication system prototype with 4×4 MIMO called VSF-OFCDM at 100 Mbit/s while moving, and 1 Gbit/s while stationary. NTT DoCoMo completed a trial in which they reached a maximum packet transmission rate of approximately 5 Gbit/s in the downlink with 12×12 MIMO using a 100 MHz frequency bandwidth while moving at 10 km/h,[47] and is planning on releasing the first commercial network in 2010. In September 2007, NTT Docomo demonstrated e-UTRA data rates of 200 Mbit/s with power consumption below 100 mW during the test.[48] In January 2008, a U.S. Federal Communications Commission (FCC) spectrum auction for the 700 MHz former analog TV frequencies began. As a result, the biggest share of the spectrum went to Verizon Wireless and the next biggest to AT&T.[49] Both of these companies have stated their intention of supporting LTE. In January 2008, EU commissioner Viviane Reding suggested re-allocation of 500–800 MHz spectrum for wireless communication, including WiMAX.[50] On 15 February 2008, Skyworks Solutions released a front-end module for e-UTRAN.[51][52][53] In November 2008, ITU-R established the detailed performance requirements of IMT-Advanced, by issuing a Circular Letter calling for candidate Radio Access Technologies (RATs) for IMT-Advanced.[54] In April 2008, just after receiving the circular letter, the 3GPP organized a workshop on IMT-Advanced where it was decided that LTE Advanced, an evolution of current LTE standard, will meet or even exceed IMT-Advanced requirements following the ITU-R agenda. In April 2008, LG and Nortel demonstrated e-UTRA data rates of 50 Mbit/s while travelling at 110 km/h.[55] On 12 November 2008, HTC announced the first WiMAX-enabled mobile phone, the Max 4G[56] On 15 December 2008, San Miguel Corporation, the largest food and beverage conglomerate in southeast Asia, has signed a memorandum of understanding with Qatar Telecom QSC (Qtel) to build wireless broadband and mobile communications projects in the Philippines. The joint-venture formed wi-tribe Philippines, which offers 4G in the country.[57] Around the same time Globe Telecom rolled out the first WiMAX service in the Philippines. On 3 March 2009, Lithuania's LRTC announcing the first operational "4G" mobile WiMAX network in Baltic states.[58] In December 2009, Sprint began advertising "4G" service in selected cities in the United States, despite average download speeds of only 3–6 Mbit/s with peak speeds of 10 Mbit/s (not available in all markets).[59] On 14 December 2009, the first commercial LTE deployment was in the Scandinavian capitals Stockholm and Oslo by the Swedish-Finnish network operator TeliaSonera and its Norwegian brandname NetCom (Norway). TeliaSonera branded the network "4G". The modem devices on offer were manufactured by Samsung (dongle GT-B3710), and the network infrastructure created by Huawei (in Oslo) and Ericsson (in Stockholm). TeliaSonera plans to roll out nationwide LTE across Sweden, Norway and Finland.[60][61] TeliaSonera used spectral bandwidth of 10 MHz, and single-in-single-out, which should provide physical layer net bit rates of up to 50 Mbit/s downlink and 25 Mbit/s in the uplink. Introductory tests showed a TCP throughput of 42.8 Mbit/s downlink and 5.3 Mbit/s uplink in Stockholm.[62] On 4 June 2010, Sprint released the first WiMAX smartphone in the US, the HTC Evo 4G.[63] On November 4, 2010, the Samsung Craft offered by MetroPCS is the first commercially available LTE smartphone[64] On 6 December 2010, at the ITU World Radiocommunication Seminar 2010, the ITU stated that LTE, WiMAX and similar "evolved 3G technologies" could be considered "4G".[65] In 2011, Argentina's Claro launched a pre-4G HSPA+ network in the country. In 2011, Thailand's Truemove-H launched a pre-4G HSPA+ network with nationwide availability. On March 17, 2011, the HTC Thunderbolt offered by Verizon in the U.S. was the second LTE smartphone to be sold commercially.[66][67] In February 2012, Ericsson demonstrated mobile-TV over LTE, utilizing the new eMBMS service (enhanced Multimedia Broadcast Multicast Service).[68] Since 2009, the LTE-Standard has strongly evolved over the years, resulting in many deployments by various operators across the globe. For an overview of commercial LTE networks and their respective historic development see: List of LTE networks. Among the vast range of deployments, many operators are considering the deployment and operation of LTE networks. A compilation of planned LTE deployments can be found at: List of planned LTE networks. 4G introduces a potential inconvenience for those who travel internationally or wish to switch carriers. In order to make and receive 4G voice calls (VoLTE), the subscriber handset must not only have a matching frequency band (and in some cases require unlocking), it must also have the matching enablement settings for the local carrier and/or country. While a phone purchased from a given carrier can be expected to work with that carrier, making 4G voice calls on another carrier's network (including international roaming) may be impossible without a software update specific to the local carrier and the phone model in question, which may or may not be available (although fallback to 2G/3G for voice calling may still be possible if a 2G/3G network is available with a matching frequency band).[69] Main article: 5G A major issue in 4G systems is to make the high bit rates available in a larger portion of the cell, especially to users in an exposed position in between several base stations. In current research, this issue is addressed by macro-diversity techniques, also known as group cooperative relay, and also by Beam-Division Multiple Access (BDMA).[70] Pervasive networks are an amorphous and at present entirely hypothetical concept where the user can be simultaneously connected to several wireless access technologies and can seamlessly move between them (See vertical handoff, IEEE 802.21). These access technologies can be Wi-Fi, UMTS, EDGE, or any other future access technology. Included in this concept is also smart-radio (also known as cognitive radio) technology to efficiently manage spectrum use and transmission power as well as the use of mesh routing protocols to create a pervasive network. As of 2023, many countries and regions have started the transition from 4G to 5G, the next generation of cellular technology. 5G promises even faster speeds, lower latency, and the ability to connect a vast number of devices simultaneously. 4G networks are expected to coexist with 5G networks for several years, providing coverage in areas where 5G is not available. This section is about WiMAX & LTE network shutdowns. For shutdowns of HSPA+ (UMTS) networks that are sometimes labeled as 4G, see 3G § Phase-out. Country Network Shutdown date Standard Notes Canada Xplore Mobile 2022-08-31 LTE [71] Jamaica Digicel 2018-10-31 WiMAX [72] Macau Smartone 2024-11-11 LTE Smartone ceased operation in Macau and surrendered its license to government.[73] Malaysia Yes 4G 2019-10-01 WiMAX [74][75] Nepal Nepal Telecom 2021-12-31 WiMAX [76] Trinidad and Tobago Blink bmobile (TSTT) 2015-03-03 WiMAX [77] United States Sprint 2016-03-31 WiMAX [78][79] T-Mobile (Sprint) 2022-06-30 LTE [80][81][82] T-Mobile 2035 LTE [83] 1G 2G 3G 5G 6G 4G-LTE filter Comparison of mobile phone standards Comparison of wireless data standards Wireless device radiation and health ^ The exact exhaustion status is difficult to determine, as it is unknown how many unused addresses exist at ISPs, and how many of the addresses that are permanently unused by their owners can still be freed and transferred to others. ^ a b c Gompa, Neal (January 23, 2012). "ITU designates LTE-Advanced as "True 4G"". ExtremeTech. 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4First generation of cellular technology Not to be confused with GPRS, a 2G mobile data indicator sometimes shown as "G" on mobile devices. 1G (first generation) refers to the analog mobile telecommunications standards introduced in the late 1970s. The term was later applied retroactively to distinguish these early cellular network systems from later digital generations. Timeline showing the evolution of cellular network standards by generation The first commercial cellular network was launched by Nippon Telegraph and Telephone (NTT) in Japan in 1979, initially covering Tokyo. Within five years it expanded nationwide and became the world's first full-scale cellular system. Earlier, Bell Laboratories tested a network around Chicago in 1978.[1] The Nordic countries jointly developed the Nordic Mobile Telephone (NMT) standard, first deployed in Sweden in 1981. NMT introduced international roaming, a feature later adopted by other systems. In 1983, Ameritech launched the first 1G network in the United States using the Advanced Mobile Phone System (AMPS) and the Motorola DynaTAC handset. By the mid-1980s, 1G networks operated across most of Europe, Asia, and the Middle East. Adoption varied: Western Europe and North America expanded rapidly, while Eastern Europe and parts of Africa adopted the technology later due to economic and political limits.[2] 1G introduced the cellular network concept—dividing service areas into cells, each served by a low-power transmitter, which enabled frequency reuse and higher capacity.[3] Although some parts of the network backbone used digital signaling, voice transmission between handset and base station remained analog, typically using frequency modulation similar to land mobile radio systems. Analog cellular standards of the 1G era included:[4] Advanced Mobile Phone System (AMPS) – United States and other regions[5] Nordic Mobile Telephone (NMT) – Nordic countries and parts of Eastern Europe Total Access Communication System (TACS) – United Kingdom and other regions C-450 – West Germany, Portugal, and South Africa Radiocom 2000 – France, operated by France Télécom RTMI – Italy MCS-L1 and MCS-L2 – Japan, developed by NTT JTACS – Japan, variant of TACS operated by DDI By the early 1990s, analog 1G systems were replaced by digital GSM and cdmaOne networks, which offered higher capacity, encryption, and text messaging. Most 1G networks were decommissioned by the early 2000s, though some persisted longer in remote or developing regions. The last known operational 1G service, in Russia, closed in 2017. List of mobile phone generations 2G 3G 4G 5G 6G ^ Shi, Mingtao (2007). Technology base of mobile cellular operators in Germany and China: a comparative study from the perspective of the resource-based view (in German). Berlin: Technische Universität Berlin. p. 60. ISBN 9783798320574. ^ Shi, Mingtao (2007). Technology base of mobile cellular operators in Germany and China: a comparative study from the perspective of the resource-based view (in German). Berlin: Technische Universität Berlin. p. 63. ISBN 9783798320574. ^ Shi, Mingtao (2007). Technology base of mobile cellular operators in Germany and China: a comparative study from the perspective of the resource-based view (in German). Berlin: Technische Universität Berlin. p. 56. ISBN 9783798320574. ^ "To open or not to open a technological system: insights from the history of mobile phones and their application to 5G" (PDF). Charles River Associates. May 2021. Archived from the original (PDF) on 15 July 2023. Retrieved 13 October 2025. ^ "Advanced Mobile Phone System". Australian Mobile Telecommunications Association. Archived from the original on 17 April 2008. Retrieved 13 October 2025. Retrieved from "

5First generation of digital cellular networks For other uses, see 2G (disambiguation). Part of a series on theWireless network technologies Analog 0G1G (1.5G) Digital 2G (2.5G, 2.75G, 2.9G)3G (3.5G, 3.75G, 3.9G/3.95G)4G (4G/4.5G, 4.5G, 4.9G)5G (5.5G)6G Mobile telecommunicationsvte 2G refers to the second generation of cellular network technology, which were rolled out globally starting in the early 1990s. The main differentiator to previous mobile telephone systems, retrospectively dubbed 1G, is that the radio signals of 2G networks are digital rather than analog, for communication between mobile devices and base stations. In addition to voice telephony, 2G also made possible the use of data services. The most common 2G technology has been the GSM standard, which became the first globally adopted framework for mobile communications. Other 2G technologies include cdmaOne and the now-discontinued Digital AMPS (D-AMPS/TDMA),[1] as well as the Personal Digital Cellular (PDC) and Personal Handy-phone System (PHS) in Japan. The transition to digital technology enabled the implementation of encryption for voice calls and data transmission, significantly improving the security of mobile communications while also increasing capacity and efficiency compared to earlier analog systems. 2G networks were primarily designed to support voice calls and Short Message Service (SMS), with later advancements such as General Packet Radio Service (GPRS) enabling always-on packet data services, including email and limited internet access. 2G was succeeded by 3G technology, which provided higher data transfer rates and expanded mobile internet capabilities. In 1990, AT&T Bell Labs engineers Jesse Russell, Farhad Barzegar and Can A. Eryaman filed a patent for a digital mobile phone that supports the transmission of digital data. Their patent was cited several years later by Nokia and Motorola when they were developing 2G digital mobile phones.[2] 2G was first commercially launched in 1991 by Radiolinja (now part of Elisa Oyj) in Finland in the form of GSM, which was defined by the European Telecommunications Standards Institute (ETSI).[3] The Telecommunications Industry Association (TIA) defined the cdmaOne (IS-95) 2G standard, with an eight to ten fold increase in voice call capacity compared to analog AMPS.[4] The first deployment of cdmaOne was in 1995.[5] In North America, Digital AMPS (IS-54 and IS-136) and cdmaOne (IS-95) were dominant, but GSM was also used. Later 2G releases in the GSM space, often referred to as 2.5G and 2.75G, include General Packet Radio Service (GPRS) and Enhanced Data Rates for GSM Evolution (EDGE). GPRS allows 2G networks to achieve a theoretical maximum transfer speed of 40 kbit/s (5 kB/s). EDGE increases this capacity, providing a theoretical maximum transfer speed of 384 kbit/s (48 kB/s). Three primary benefits of 2G networks over their 1G predecessors were: Digitally encrypted phone conversations, at least between the mobile phone and the cellular base station but not necessarily in the rest of the network. Significantly more efficient use of the radio frequency spectrum enabling more users per frequency band. Data services for mobile, starting with SMS text messages then expanding to Multimedia Messaging Service (MMS). Cellular network standards and generation timeline. (Large titles on the colored area refer to the lines to their right. Main article: GPRS 2.5G ("second-and-a-half generation") refers to 2G systems that incorporate a packet-switched domain alongside the existing circuit-switched domain, most commonly implemented through General Packet Radio Service (GPRS).[6] GPRS enables packet-based data transmission by dynamically allocating multiple timeslots to users, improving network efficiency. However, this does not inherently provide faster speeds, as similar techniques, such as timeslot bundling, are also employed in circuit-switched data services like High-Speed Circuit-Switched Data (HSCSD). Within GPRS-enabled 2G systems, the theoretical maximum transfer rate is 40 kbit/s (5 kB/s).[7] Main article: EDGE (telecommunication) 2.75G refers to the evolution of GPRS networks into EDGE (Enhanced Data Rates for GSM Evolution) networks, achieved through the introduction of 8PSK (8 Phase Shift Keying) encoding. While the symbol rate remained constant at 270.833 samples per second, the use of 8PSK allowed each symbol to carry three bits instead of one, significantly increasing data transmission efficiency. Enhanced Data Rates for GSM Evolution (EDGE), also known as Enhanced GPRS (EGPRS) or IMT Single Carrier (IMT-SC), is a backward-compatible digital mobile phone technology built as an extension to standard GSM. First deployed in 2003 by AT&T in the United States, EDGE offers a theoretical maximum transfer speed of 384 kbit/s (48 kB/s).[7] Evolved EDGE (also known as EDGE Evolution or 2.875G) is an enhancement of the EDGE mobile technology that was introduced as a late-stage upgrade to 2G networks. While EDGE was first deployed in the early 2000s as part of GSM networks, Evolved EDGE was launched much later, coinciding with the widespread adoption of 3G technologies such as HSPA and just before the emergence of 4G networks. This timing limited its practical application. Evolved EDGE increased data throughput and reduced latencies (down to 80 ms) by utilizing improved modulation techniques, dual carrier support, dual antennas, and turbo codes. It achieved peak data rates of up to 1 Mbit/s, significantly enhancing network efficiency for operators that had not yet transitioned to 3G or 4G infrastructures. However, despite its technical improvements, Evolved EDGE was never widely deployed. By the time it became available, most network operators were focused on implementing more advanced technologies like UMTS and LTE. As of 2016, no commercial networks were reported to support Evolved EDGE. See also: GSM § Discontinuation 2G, understood as GSM and CdmaOne, has been superseded by newer technologies such as 3G (UMTS / CDMA2000), 4G (LTE / WiMAX) and 5G (5G NR). However, 2G networks were still available as of 2023[update] in most parts of the world, while notably excluding the majority of carriers in North America, East Asia, and Australia.[8][9][10] Many modern LTE-enabled devices have the ability to fall back to 2G for phone calls, necessary especially in rural areas where later generations have not yet been implemented.[11] In some places, its successor 3G is being shut down rather than 2G – Vodafone previously announced that it had switched off 3G across Europe in 2020 but still retains 2G as a fallback service.[12] In the US T-Mobile shut down their 3G services while retaining their 2G GSM network.[13][14] Various carriers have made announcements that 2G technology in the United States, Japan, Australia, and other countries are in the process of being shut down, or have already shut down 2G services so that carriers can re-use the frequencies for newer technologies (e.g. 4G, 5G).[15][16] As a legacy protocol, 2G connectivity is considered insecure.[17] Specifically, there exist well known methods to attack weaknesses in GSM since 2009[18] with practical use in crime.[19] Attack routes on 2G CdmaOne were found later and remain less publicized.[20] Android 12 and later provide a network setting to disable 2G connectivity for the device.[21] iOS 16 and later can disable 2G connectivity by enabling Lockdown Mode.[22] In some parts of the world, including the United Kingdom, 2G remains widely used for older feature phones and for internet of things (IoT) devices such as smart meters, eCall systems and vehicle trackers to avoid the high patent licensing cost of newer technologies.[23] Terminating 2G services could leave vulnerable people who rely on 2G infrastructure unable to communicate even with emergency contacts, causing harm and possibly deaths.[24] Country Status Network Shutdown date Standard Notes Åland Ålcom 2025-02-03 GSM [25] Anguilla Digicel active GSM 900 MHz: 5 MHz GSM + 5 MHz UMTS1900 MHz: 5 MHz UMTS [26][27][28][29] FLOW 2024-04-22 GSM [30][31] Antigua and Barbuda No Service APUA 2018-04-01 GSM [32] Digicel 2024-05-31 GSM [33] FLOW 2024-07-31 GSM [34] Aruba partiallyunconfirmed Digicel 2024-06-30 GSM [35] SETAR active GSM GSM-900 & GSM-1900 Australia No Service Hutchison 3 2006-08-09 cdmaOne [36][37][38][39][40] Optus 2017-08-01 GSM 2G shut down in WA and NT on 3 Apr 2017.[41][42] Telstra 2008-04-28 cdmaOne [43][44][45][46][47] Telstra 2016-12-01 GSM [48] Vodafone 2018-06-14 GSM [49] Bahamas No Service Aliv N/A (no 2G) BTC 2024-06-30 GSM [50][51][52] Bahrain Batelco 2021-11-30 GSM [53] Barbados partiallyunconfirmed Digicel 2025-03-31 GSM 900 MHz: 6 MHz GSM /1800 MHz: 12 MHz GSM [54] FLOW 2024-04-22 GSM Belgium Orange 2030 GSM [55] Telenet 2027 GSM [56] Proximus 2027 GSM [57] Bermuda Digicel active GSM 1900 MHz: 15 MHz GSM + 15 MHz LTE [58] One active GSM 1900 MHz: 5 MHz GSM + 20 MHz LTE [58] Bonaire partiallyunconfirmed Digicel 2025-03-31 GSM FLOW 2024-04-22 GSM British Virgin Islands CCT active GSM 1900 MHz: 10 MHz GSM + 20 MHz LTE [59] Digicel active GSM 1800 MHz: 15 MHz GSM1900 MHz: 5 MHz GSM + 10 MHz UMTS [59] FLOW 2024-04-22 GSM [60] Brunei No Service UNN 2021-06-01 GSM National Wholesale Network used by DSTCom, Progresif and imagine.[61][62] Canada Bell 2019-04-30 cdmaOne Shutdown of CDMA transmitters commenced in remote areas in 2017, followed by an official announcement in June 2018 that 2G devices will lose service soon.[63][64] Rogers Wireless TBD GSM 1900 MHz shutdown in Jun 2021.850 MHz remains active.[65][66][67][68] SaskTel 2017-07-31 cdmaOne [69][70] Telus Mobility 2017-05-31 cdmaOne [71] [72] Cayman Islands partiallyunconfirmed Digicel 2020-07-01 GSM [73][74] FLOW 2024-04-22 GSM China China Mobile active GSM 900 MHz: 15 MHz GSM1800 MHz: 25 MHz GSM [75] China Telecom 2025 cdmaOne Local shutdown commenced on 01 Jun 2020.CDMA2000 1xRTT, EV-DO Rev. A/B (3G) service also terminates.[75][76][77] China Unicom 2025 GSM Local shutdown commenced on 18 Apr 2018.[75][78][79][77][80] Chile Entel 2024 Q3 GSM Local shutdown commenced on 22 Jul 2024 in the Arica and Parinacota Region.[81] Colombia Claro 2023-02-23 GSM [82][83] Tigo 2022-11-01 GSM [84] Curaçao Digicel 2025-03-31 GSM FLOW 2024-02-29 GSM [85][86] Dominica partiallyunconfirmed Digicel 2027-03-31 GSM FLOW 2024-03-?? GSM [87] France Bouygues 2026-12-31 GSM [88] Orange 2026-09 GSM [55] SFR 2026 GSM [89] Germany Deutsche Telekom 2028-06-30 GSM [90] Vodafone 2028-10-01 /2030-12-31 (IoT) GSM [91][92] Telefónica (O2) TBD GSM Grenada unconfirmed Digicel 2024-03-31 GSM FLOW 2024-04-22 GSM Guam unconfirmed GTA Teleguam ? GSM Hong Kong 3 2008-11-20 cdmaOne Shut down due to license expiry. Government originally did not allow the license to be renewed due to unpopularity, however the government later reversed the decision and held an auction for CDMA2000 service, which PCCW-HKT won the auction and provided CDMA2000 service immediately after 3's license expiry. 3 2021-09-30 GSM [93] CMHK active GSM CSL 2005 D-AMPS Service previously provided by Pacific Link, which subsequently merged into CSL. Shut down due to license expiry. Government did not allow the license to be renewed due to unpopularity. CSL 2017-10-31 cdmaOne Service previously provided by PCCW. After acquisition of CSL by HKT, its mobile business PCCW Mobile was merged into CSL. No service for local customers, only served incoming roaming tourists.CSL terminated its CDMA family business upon its licence expiry, and CDMA2000 1xRTT, EV-DO Rev. A (3G) service has also terminated along with cdmaOne.[94] CSL 2024-11-08 GSM [95] SmarTone 2022-10-14 GSM [96] Iceland Nova 2025-01-28 GSM [97] Síminn 2025 Q4 GSM [98] Sýn 2025-06-01 GSM [99] Israel Hot Mobile 2019-12-31 iDEN [100] 2025 GSM Per government statement.[101] Jamaica No Service Digicel 2024-08-31 GSM [102][103] FLOW 2024-04-15 GSM [104][103][105] Japan No Service au KDDI 2012-07-22 cdmaOne [106] NTT Docomo 2012-03-31 PDC [107] Softbank 2010-03-31 PDC [108] Jordan Umniah 2021-03-11 GSM [109] Luxembourg Orange 2030 GSM [55] Macau No Service CTM 2019-08-01 GSM Service for local customers terminated on 4 Jun 2015, but remained for roaming users.[110][111][112] 3 2019-08-01 GSM Service for local customers terminated on 4 Jun 2015, but remained for roaming users.[110][111] SmarTone 2019-08-01 GSM Service for local customers terminated on 4 Jun 2015, but remained for roaming users.[110][111] Mexico AT&T 2019-09-01 GSM [113]Local shutdown commenced in Q1 2019. Movistar 2021-01-01 GSM [114] Montserrat unconfirmed Digicel ? GSM FLOW 2024-04-22 GSM Netherlands KPN 2027-12-01 GSM [115] T-Mobile 2021-06-01 /2023-11-15 (IoT) GSM [116] New Caledonia OPT-NC 2025 GSM Shutdown commenced in 2022.[117] New Zealand 2degrees 2018-03-15 GSM [118] Spark 2012-07-31 cdmaOne [119][120] Norway Telenor 2027 GSM [121] Telia 2025 GSM [121] Panama Digicel 2022-06-30 GSM Complete shutdown of operations and market exit.[122][123][124][125] Peru Bitel N/A (no 2G) Poland Orange 2030 GSM [55] Romania Orange 2030 GSM [55] Saint Kitts and Nevis Digicel 2027-03-31 GSM FLOW 2024-04-22 GSM [126] Saint Lucia partiallyunconfirmed Digicel 2027-03-31 GSM FLOW 2024-04-22 GSM [127] Saint Vincent and the Grenadines Digicel 2027-03-31 GSM FLOW 2023-09-30 GSM [128][129][130][131] Saudi Arabia stc 2025 Q4 GSM [132] Singapore No Service M1 2017-04-18 GSM [133] Singtel 2017-04-18 GSM [133] StarHub 2017-04-18 GSM [133] Sint Maarten Saba Sint Eustatius No Service TelCell 2019-01-01 GSM [134] FLOW (UTS) 2017-09-26 GSM [135] Slovakia Orange 2030 GSM [55] South Africa TBD GSM Per government statement.[136][137] South Korea No Service KT 2012-03-19 cdmaOne CDMA2000 1xRTT, EV-DO Rel. 0 (3G) service has also terminated.[138] LG Uplus 2021-06-30 cdmaOne CDMA2000 1xRTT, EV-DO Rev. A/B (3G) service has also terminated.[139] SK Telecom 2020-07-27 cdmaOne CDMA2000 1xRTT, EV-DO Rel. 0 (3G) service has also terminated.[140] Spain Orange 2030 GSM [55] Sweden Net4Mobility (Telenor/Tele2) 2025-12-31 GSM 2G network will be shut down by the end of 2025.[141][142][143] Telia 2027 GSM Shutdown pushed back from 2025 to 2027.[144][145] Switzerland No Service Salt 2020-12-31 GSM Shutdown commenced on 1 Jul 2020. A few single 2G-only sites remained until Sep 2023 to preserve CSFB functionality.[146][147][148] Sunrise 2023-01-03 GSM With the introduction of S-RAN in 2018 phaseout was previously postponed to 2022.[149][150][151] Swisscom 2021-04-07 GSM Official shutdown on 31 Dec 2020 (guaranteed availability).[152][153][154] Taiwan No Service Chunghwa Telecom 2017-06-30 GSM [155] FarEasTone 2017-06-30 GSM [155] Taiwan Mobile 2017-06-30 GSM [155] Trinidad and Tobago Digicel 2024-12-31 GSM [156][157][158] bmobile (TSTT) TBD GSM 850 MHz: 2.5 MHz GSM + 5 MHz UMTS [159][160] Turks and Caicos Islands Digicel 2025-06-30 GSM 900 MHz: 9.8 MHz GSM [161] FLOW 2024-04-22 GSM [162] United Arab Emirates No Service Du 2023-12-31 GSM [163] Etisalat 2023-12-31 GSM [164] United Kingdom 2033 GSM Per government statement on confirmation by mobile providers.[165][166][167] United States Puerto Rico US Virgin Islands AT&T 2008-02-18 D-AMPS TDMA (D-AMPS) on 1900 MHz shut down on 15 July 2007.[168] 2017-01-01 GSM [169] Cellcom(US only) 2023-12-01 cdmaOne CDMA2000 1xRTT, EV-DO Rev. A (3G) service has also terminated.[170] Claro(PR only) 2028-12-31 GSM Commnet Wireless (Choice)(US only) 2022-12-31 cdmaOne CDMA2000 1xRTT, EV-DO Rev. A (3G) service has also terminated.[171] Copper Valley Wireless 2022-09-30 cdmaOne CDMA2000 1xRTT, EV-DO Rev. A (3G) service has also terminated.[172] Edge Wireless 2007-06-30 D-AMPS [173] Inland Cellular 2025-09-03 cdmaOne CDMA2000 1xRTT, EV-DO Rev. A (3G) service has also terminated.[174] T-Mobile 2025 GSM Shutdown commenced on 9 Feb 2025.[175][176] T-Mobile (Sprint) 2022-05-31 cdmaOne CDMA2000 1xRTT, EV-DO Rev. A (3G) service has also terminated.Shutdown commenced on 31 Mar 2022.[177][178][179][180] UScellular(US only) 2009-02 D-AMPS [181] UScellular(US only) 2024-01-14 cdmaOne CDMA2000 1xRTT, EV-DO Rev. A (3G) service has also terminated.[182][183] Verizon(US only) 2022-12-31 cdmaOne CDMA2000 1xRTT, EV-DO Rev. A (3G) service has also terminated.[184] Venezuela Digitel 2024-03-08 GSM Shutdown commenced in May 2021.[185][186] Movilnet 2025 GSM [185] Movistar 2025 GSM Shutdown commenced on 01 Jul 2022.[185] Vietnam No Service Gmobile 2024-10-16 GSM per government regulation[187] Mobifone 2024-10-16 GSM per government regulation[187] Vietnamobile N/A (no 2G) Viettel 2024-10-16 GSM per government regulation[187] Vinaphone 2024-10-16 GSM per government regulation[187] Cliff effect Dropout List of mobile phone generations Mobile radio telephone, also known as 0G 1G 3G 4G 5G 6G Wireless device radiation and health ^ "2G Sunset Brings Faster Speeds, Newer Technologies". 16 January 2017. Retrieved 27 January 2023. ^ US5257397A, Barzegar, Farhad; Eryaman, Can A. & Russell, Jesse E. et al., "Mobile data telephone", issued 1993-10-26 (filed 1990-08-13) ^ "Radiolinja's History". 20 April 2004. Archived from the original on 23 October 2006. 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6Third generation of wireless mobile telecommunications technology For other uses, see 3G (disambiguation). A USB modem for 3G plugged into a laptop. Part of a series on theWireless network technologies Analog 0G1G (1.5G) Digital 2G (2.5G, 2.75G, 2.9G)3G (3.5G, 3.75G, 3.9G/3.95G)4G (4G/4.5G, 4.5G, 4.9G)5G (5.5G)6G Mobile telecommunicationsvte 3G refers to the third generation of cellular network technology. These networks were rolled out beginning in the early 2000s and represented a significant advancement over the second generation (2G), particularly in terms of data transfer speeds and mobile internet capabilities. The major 3G standards are UMTS (developed by 3GPP, succeeding GSM) and CDMA2000 (developed by Qualcomm, succeeding cdmaOne);[1][2] both of these are based on the IMT-2000 specifications established by the International Telecommunication Union (ITU). While 2G networks such as GPRS and EDGE supported limited data services, 3G introduced significantly higher-speed mobile internet and enhanced multimedia capabilities, in addition to improved voice quality.[3] It provided moderate internet speeds suitable for general web browsing and multimedia content including video calling and mobile TV,[3] supporting services that provide an information transfer rate of at least 144 kbit/s.[4][5] Later 3G releases, often referred to as 3.5G (HSPA) and 3.75G (HSPA+) as well as EV-DO, introduced important improvements, enabling 3G networks to offer mobile broadband access with speeds ranging from several Mbit/s up to 42 Mbit/s.[6] These updates improved the reliability and speed of internet browsing, video streaming, and online gaming, enhancing the overall user experience for smartphones and mobile modems in comparison to earlier 3G technologies. 3G was later succeeded by 4G technology, which provided even higher data transfer rates and introduced advancements in network performance. A new generation of cellular standards has emerged roughly every decade since the introduction of 1G systems in 1979. Each generation is defined by the introduction of new frequency bands, higher data rates, and transmission technologies that are not backward-compatible due to the need for significant changes in network architecture and infrastructure. Several telecommunications companies marketed wireless mobile Internet services as 3G, indicating that the advertised service was provided over a 3G wireless network. However, 3G services have largely been supplanted in marketing by 4G and 5G services in most areas of the world. Services advertised as 3G are required to meet IMT-2000 technical standards, including standards for reliability and speed (data transfer rates). To meet the IMT-2000 standards, Third-generation mobile networks, or 3G, must maintain minimum consistent Internet speeds of 144 Kbps.[5] However, many services advertised as 3G provide higher speed than the minimum technical requirements for a 3G service.[7] Subsequent 3G releases, denoted 3.5G and 3.75G, provided mobile broadband access of several Mbit/s for smartphones and mobile modems in laptop computers.[8] 3G branded standards: The UMTS (Universal Mobile Telecommunications System) system, standardized by 3GPP in 2001, was used in Europe, Japan, China (with a different radio interface) and other regions predominated by GSM (Global Systems for Mobile Communications) 2G system infrastructure. The cell phones are typically UMTS and GSM hybrids. Several radio interfaces are offered, sharing the same infrastructure: The original and most widespread radio interface is called W-CDMA (Wideband Code Division Multiple Access). The TD-SCDMA radio interface was commercialized in 2009 and only offered in China. The latest UMTS release, HSPA+, can provide peak data rates up to 56 Mbit/s in the downlink in theory (28 Mbit/s in existing services) and 22 Mbit/s in the uplink. The CDMA2000 system, first offered in 2002, standardized by 3GPP2, used especially in North America and South Korea, sharing infrastructure with the IS-95 2G standard. The cell phones are typically CDMA2000 and IS-95 hybrids. The latest release EVDO Rev. B offers peak rates of 14.7 Mbit/s downstream. The 3G systems and radio interfaces are based on spread spectrum radio transmission technology. While the GSM EDGE standard ("2.9G"), DECT cordless phones and Mobile WiMAX standards formally also fulfill the IMT-2000 requirements and are approved as 3G standards by ITU, these are typically not branded as 3G and are based on completely different technologies. The common standards complying with the IMT2000/3G standard are: EDGE, a revision by the 3GPP organization to the older 2G GSM based transmission methods, which utilizes the same switching nodes, base station sites, and frequencies as GPRS, but includes a new base station and cellphone RF circuits. It is based on the three times as efficient 8PSK modulation scheme as a supplement to the original GMSK modulation scheme. EDGE is still used extensively due to its ease of upgrade from existing 2G GSM infrastructure and cell phones. EDGE combined with the GPRS 2.5G technology is called EGPRS, and allows peak data rates in the order of 200 kbit/s, just like the original UMTS WCDMA versions and thus formally fulfill the IMT2000 requirements on 3G systems. However, in practice, EDGE is seldom marketed as a 3G system, but a 2.9G system. EDGE shows slightly better system spectral efficiency than the original UMTS and CDMA2000 systems, but it is difficult to reach much higher peak data rates due to the limited GSM spectral bandwidth of 200 kHz, and it is thus a dead end. EDGE was also a mode in the IS-136 TDMA system, no longer used. Evolved EDGE, the latest revision, has peaks of 1 Mbit/s downstream and 400 kbit/s upstream but is not commercially used. The Universal Mobile Telecommunications System, created and revised by the 3GPP. The family is a full revision from GSM in terms of encoding methods and hardware, although some GSM sites can be retrofitted to broadcast in the UMTS/W-CDMA format. W-CDMA is the most common deployment, commonly operated on the 2,100 MHz band. A few others use the 850, 900, and 1,900 MHz bands. HSPA is an amalgamation of several upgrades to the original W-CDMA standard and offers speeds of 14.4 Mbit/s down and 5.76 Mbit/s up. HSPA is backward-compatible and uses the same frequencies as W-CDMA. HSPA+, a further revision and upgrade of HSPA, can provide theoretical peak data rates up to 168 Mbit/s in the downlink and 22 Mbit/s in the uplink, using a combination of air interface improvements as well as multi-carrier HSPA and MIMO. Technically though, MIMO and DC-HSPA can be used without the "+" enhancements of HSPA+. The CDMA2000 system, or IS-2000, including CDMA2000 1x and CDMA2000 High Rate Packet Data (or EVDO), standardized by 3GPP2 (differing from the 3GPP), evolving from the original IS-95 CDMA system, is used especially in North America, China, India, Pakistan, Japan, South Korea, Southeast Asia, Europe, and Africa. CDMA2000 1x Rev. E has an increased voice capacity (by three times the original amount) compared to Rev. 0 EVDO Rev. B offers downstream peak rates of 14.7 Mbit/s while Rev. C enhanced existing and new terminal user experience. While DECT cordless phones and Mobile WiMAX standards formally also fulfill the IMT-2000 requirements, they are not usually considered due to their rarity and unsuitability for usage with mobile phones.[9] The 3G (UMTS and CDMA2000) research and development projects started in 1992. In 1999, ITU approved five radio interfaces for IMT-2000 as a part of the ITU-R M.1457 Recommendation; WiMAX was added in 2007.[10] There are evolutionary standards (EDGE and CDMA) that are backward-compatible extensions to pre-existing 2G networks as well as revolutionary standards that require all-new network hardware and frequency allocations. The cell phones use UMTS in combination with 2G GSM standards and bandwidths, but do not support EDGE. The latter group is the UMTS family, which consists of standards developed for IMT-2000, as well as the independently developed standards DECT and WiMAX, which were included because they fit the IMT-2000 definition. While EDGE fulfills the 3G specifications, most GSM/UMTS phones report EDGE ("2.75G") and UMTS ("3G") functionality.[11] Cellular network standards and generation timeline. 3G technology was the result of research and development work carried out by the International Telecommunication Union (ITU) in the early 1980s. 3G specifications and standards were developed in fifteen years. The technical specifications were made available to the public under the name IMT-2000. The communication spectrum between 400 MHz to 3 GHz was allocated for 3G. Both the government and communication companies approved the 3G standard. The first pre-commercial 3G network was launched by NTT DoCoMo in Japan in 1998,[12] branded as FOMA. It was first available in May 2001 as a pre-release (test) of W-CDMA technology. The first commercial launch of 3G was also by NTT DoCoMo in Japan on 1 October 2001, although it was initially somewhat limited in scope;[13][14] broader availability of the system was delayed by apparent concerns over its reliability.[15][16][17][18][19] The first European pre-commercial network was an UMTS network on the Isle of Man by Manx Telecom, the operator then owned by British Telecom, and the first commercial network (also UMTS based W-CDMA) in Europe was opened for business by Telenor in December 2001 with no commercial handsets and thus no paying customers. The first network to go commercially live was by SK Telecom in South Korea on the CDMA-based 1xEV-DO technology in January 2002. By May 2002, the second South Korean 3G network was by KT on EV-DO and thus the South Koreans were the first to see competition among 3G operators. The first commercial United States 3G network was by Monet Mobile Networks, on CDMA2000 1x EV-DO technology, but the network provider later shut down operations. The second 3G network operator in the US was Verizon Wireless in July 2002, also on CDMA2000 1x EV-DO. AT&T Mobility was also a true 3G UMTS network, having completed its upgrade of the 3G network to HSUPA. The first commercial United Kingdom 3G network was started by Hutchison Telecom which was originally behind Orange S.A.[20] In 2003, it announced first commercial third generation or 3G mobile phone network in the UK. The first pre-commercial demonstration network in the southern hemisphere was built in Adelaide, South Australia, by m.Net Corporation in February 2002 using UMTS on 2100 MHz. This was a demonstration network for the 2002 IT World Congress. The first commercial 3G network was launched by Hutchison Telecommunications branded as Three or "3" in June 2003.[21] In India, on 11 December 2008, the first 3G mobile and internet services were launched by a state-owned company, Mahanagar Telecom Nigam Limited (MTNL), within the metropolitan cities of Delhi and Mumbai. After MTNL, another state-owned company, Bharat Sanchar Nigam Limited (BSNL), began deploying the 3G networks country-wide. Emtel launched the first 3G network in Africa.[22] Videotelephony through cellular networks were made possible using 3G technologies Japan was one of the first countries to adopt 3G, the reason being the process of 3G spectrum allocation, which in Japan was awarded without much upfront cost. The frequency spectrum was allocated in the US and Europe based on auctioning, thereby requiring a huge initial investment for any company wishing to provide 3G services. European companies collectively paid over 100 billion dollars in their spectrum auctions.[23] Nepal Telecom adopted 3G Service for the first time in southern Asia. However, its 3G was relatively slow to be adopted in Nepal. In some instances, 3G networks do not use the same radio frequencies as 2G, so mobile operators must build entirely new networks and license entirely new frequencies, especially to achieve high data transmission rates. Other countries' delays were due to the expenses of upgrading transmission hardware, especially for UMTS, whose deployment required the replacement of most broadcast towers. Due to these issues and difficulties with deployment, many carriers could not or delayed the acquisition of these updated capabilities. In December 2007, 190 3G networks were operating in 40 countries and 154 HSDPA networks were operating in 71 countries, according to the Global Mobile Suppliers Association (GSA). In Asia, Europe, Canada, and the US, telecommunication companies use W-CDMA technology with the support of around 100 terminal designs to operate 3G mobile networks. The roll-out of 3G networks was delayed by the enormous costs of additional spectrum licensing fees in some countries. The license fees in some European countries were particularly high, bolstered by government auctions of a limited number of licenses and sealed bid auctions, and initial excitement over 3G's potential. This led to a telecoms crash that ran concurrently with similar crashes in the fibre-optic and dot.com fields. The 3G standard is perhaps well known because of a massive expansion of the mobile communications market post-2G and advances of the consumer mobile phone. An especially notable development during this time is the smartphone (for example, the iPhone, and the Android family), combining the abilities of a PDA with a mobile phone, leading to widespread demand for mobile internet connectivity. 3G has also introduced the term "mobile broadband" because its speed and capability made it a viable alternative for internet browsing, and USB Modems connecting to 3G networks, and now 4G became increasingly common. By June 2007, the 200 millionth 3G subscriber had been connected of which 10 million were in Nepal and 8.2 million in India. This 200 millionth is only 6.7% of the 3 billion mobile phone subscriptions worldwide. (When counting CDMA2000 1x RTT customers—max bitrate 72% of the 200 kbit/s which defines 3G—the total size of the nearly-3G subscriber base was 475 million as of June 2007, which was 15.8% of all subscribers worldwide.) In the countries where 3G was launched first – Japan and South Korea – 3G penetration is over 70%.[24] In Europe the leading country[when?] for 3G penetration is Italy with a third of its subscribers migrated to 3G. Other leading countries[when?] for 3G use include Nepal, UK, Austria, Australia and Singapore at the 32% migration level. According to ITU estimates,[25] as of Q4 2012 there were 2096 million active mobile-broadband[vague] subscribers worldwide out of a total of 6835 million subscribers—this is just over 30%. About half the mobile-broadband subscriptions are for subscribers in developed nations, 934 million out of 1600 million total, well over 50%. Note however that there is a distinction between a phone with mobile-broadband connectivity and a smart phone with a large display and so on—although according[26] to the ITU and informatandm.com the US has 321 million mobile subscriptions, including 256 million that are 3G or 4G, which is both 80% of the subscriber base and 80% of the US population, according[25] to ComScore just a year earlier in Q4 2011 only about 42% of people surveyed in the US reported they owned a smart phone. In Japan, 3G penetration was similar at about 81%, but smart phone ownership was lower at about 17%.[25] In China, there were 486.5 million 3G subscribers in June 2014,[27] in a population of 1,385,566,537 (2013 UN estimate). Since the increasing adoption of 4G networks across the globe, 3G use has been in decline. Several operators around the world have already or are in the process of shutting down their 3G networks (see table below). In several places, 3G is being shut down while its older predecessor 2G is being kept in operation; Vodafone UK is doing this, citing 2G's usefulness as a low-power fallback.[28] EE in the UK, plans to switch off their 3G networks in early 2024.[29] In the US, Verizon shutdown their 3G services on 31 December 2022,[30] T-Mobile shut down Sprint's networks on 31 March 2022 and shutdown their main networks on 1 July 2022,[31] and AT&T has done so on 22 February 2022.[32] According to Telenor IoT, 3G sunsets outpace 2G in Europe, where 19 operators in 14 countries plan to phase out 3G by 2025. Only 8 operators in 8 nations are scheduled to shut down their 2G networks by the same year however. [33] Currently 3G around the world is declining in availability and support. Technology that depends on 3G for usage are becoming inoperable in many places. For example, the European Union plans to ensure that member countries maintain 2G networks as a fallback[citation needed], so 3G devices that are backwards compatible with 2G frequencies can continue to be used. However, in countries that plan to decommission 2G networks or have already done so as well, such as the United States and Singapore, devices supporting only 3G and backwards compatible with 2G are becoming inoperable.[34] As of February 2022, less than 1% of cell phone customers in the United States used 3G; AT&T offered free replacement devices to some customers in the run-up to its shutdown.[35] It has been estimated that there are almost 8,000 patents declared essential (FRAND) related to the 483 technical specifications which form the 3GPP and 3GPP2 standards.[36][37] Twelve companies accounted in 2004 for 90% of the patents (Qualcomm, Ericsson, Nokia, Motorola, Philips, NTT DoCoMo, Siemens, Mitsubishi, Fujitsu, Hitachi, InterDigital, and Matsushita). Even then, some patents essential to 3G might not have been declared by their patent holders. It is believed that Nortel and Lucent have undisclosed patents essential to these standards.[37] Furthermore, the existing 3G Patent Platform Partnership Patent pool has little impact on FRAND protection because it excludes the four largest patent owners for 3G.[38][39] ITU has not provided a clear[40][vague] definition of the data rate that users can expect from 3G equipment or providers. Thus users sold 3G service may not be able to point to a standard and say that the rates it specifies are not being met. While stating in commentary that "it is expected that IMT-2000 will provide higher transmission rates: a minimum data rate of 2 Mbit/s for stationary or walking users, and 348 kbit/s in a moving vehicle,"[41] the ITU does not actually clearly specify minimum required rates, nor required average rates, nor what modes[clarification needed] of the interfaces qualify as 3G, so various[vague] data rates are sold as '3G' in the market. In a market implementation, 3G downlink data speeds defined by telecom service providers vary depending on the underlying technology deployed; up to 384 kbit/s for UMTS (WCDMA), up to 7.2 Mbit/sec for HSPA, and a theoretical maximum of 21.1 Mbit/s for HSPA+ and 42.2 Mbit/s for DC-HSPA+ (technically 3.5G, but usually clubbed under the tradename of 3G).[citation needed] See also: Mobile security § Attacks based on the GSM networks 3G networks offer greater security than their 2G predecessors. By allowing the UE (User Equipment) to authenticate the network it is attaching to, the user can be sure the network is the intended one and not an impersonator.[42] 3G networks use the KASUMI block cipher instead of the older A5/1 stream cipher. However, a number of serious weaknesses in the KASUMI cipher have been identified. In addition to the 3G network infrastructure security, end-to-end security is offered when application frameworks such as IMS are accessed, although this is not strictly a 3G property. The bandwidth and location capabilities introduced by 3G networks enabled a wide range of applications that were previously impractical or unavailable on 2G networks. Among the most significant advancements was the ability to perform data-intensive tasks, such as browsing the internet seamlessly while on the move, as well as engaging in other activities that benefited from faster data speeds and enhanced reliability. Beyond personal communication, 3G networks supported applications in various fields, including medical devices, fire alarms, and ankle monitors. This versatility marked a significant milestone in cellular communications, as 3G became the first network to enable such a broad range of use cases.[43] By expanding its functionality beyond traditional mobile phone usage, 3G set the stage for the integration of cellular networks into a wide array of technologies and services, paving the way for further advancements with subsequent generations of mobile networks. Both 3GPP and 3GPP2 are working on the extensions to 3G standards that are based on an all-IP network infrastructure and using advanced wireless technologies such as MIMO. These specifications already display features characteristic for IMT-Advanced (4G), the successor of 3G. However, falling short of the bandwidth requirements for 4G (which is 1 Gbit/s for stationary and 100 Mbit/s for mobile operation), these standards are classified as 3.9G or Pre-4G. 3GPP plans to meet the 4G goals with LTE Advanced, whereas Qualcomm has halted UMB development in favour of the LTE family.[44] On 14 December 2009, TeliaSonera announced in an official press release that "We are very proud to be the first operator in the world to offer our customers 4G services."[45] With the launch of their LTE network, initially they are offering pre-4G (or beyond 3G) services in Stockholm, Sweden and Oslo, Norway. Country Status Network Shutdown date Standard References Notes Argentina Personal TBD UMTS [46] Local shutdowns commenced in Q1 2023. Australia No Service including grey import 4G and 5G devices[47] Optus 2024-10-28 UMTS [48][49] Telstra 2024-10-28 UMTS [50][51][49] Service on 2100 MHz band ended on 25 Mar 2019. 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Media related to 3G at Wikimedia Commons Preceded by2nd Generation (2G) Mobile Telephony Generations Succeeded by4th Generation (4G) Retrieved from " 7Mobile phone specification system project 3rd Generation Partnership Project 2Abbreviation3GPP2TypeStandards organization The 3rd Generation Partnership Project 2 (3GPP2) was a collaboration between telecommunications associations to make a globally applicable third generation (3G) mobile phone system specification within the scope of the ITU's IMT-2000 project. In practice, 3GPP2 was the standardization group for CDMA2000, the set of 3G standards based on the earlier cdmaOne 2G CDMA technology. The participating associations were ARIB/TTC (Japan), China Communications Standards Association, Telecommunications Industry Association (North America) and Telecommunications Technology Association (South Korea). The agreement was established in December 1998. Ultra Mobile Broadband (UMB) was a 3GPP2 project to develop a fourth-generation successor to CDMA2000. In November 2008, Qualcomm, UMB's lead sponsor, announced it was ending development of the technology, favoring LTE instead.[1] 3GPP2 should not be confused with 3GPP; 3GPP is the standard body behind the Universal Mobile Telecommunications System (UMTS) that is the 3G upgrade to GSM networks, while 3GPP2 was the standard body behind the competing 3G standard CDMA2000 that is the 3G upgrade to cdmaOne networks that was used mostly in the United States (and to some extent also in Japan, China, Canada, South Korea and India). GSM/UMTS were the most widespread 2G/3G wireless standards worldwide. Most countries used only the GSM family. A few countries, including China, the United States, Canada, Ukraine, Trinidad and Tobago, India, South Korea and Japan, used both standards. 3GPP2 had its last activity in 2013,[2] and the group has been dormant ever since. The 3GPP2 website was taken offline in 2023, primarily due to CDMA carriers deploying 3GPP's LTE instead of UMB the decade prior and later shutting down CDMA networks making the 3GPP2 redundant and unneeded. However, as of 2024 the 3GPP2 website has since come back online. ^ Qualcomm halts UMB project, Reuters, 13 November 2008 ^ "3GPP2 Technology Webinar". 3GPP2. 3GPP2 Official Web site About 3GPP2 TIA – U.S. 3GPP2 Standards Developer This article about wireless technology is a stub. You can help Wikipedia by expanding it.vte Retrieved from " 8This article is about the mobile telecommunications standards organizations. For the multimedia formats, see 3GP and 3G2. Mobile telecommunications standards body 3rd Generation Partnership ProjectAbbreviation3GPPFormation1998; 27 years ago (1998)TypeStandards organizationRegion served WorldwideWebsitewww.3gpp.org The 3rd Generation Partnership Project (3GPP) is an umbrella term for a number of standards organizations which develop protocols for mobile telecommunications. Its best known work is the development and maintenance of:[1] GSM and related 2G, 2.5G, and 2.75G standards, including GPRS and EDGE UMTS and related 3G standards, including HSPA and HSPA+ LTE and related 4G standards, including LTE Advanced and LTE Advanced Pro 5G NR and related 5G standards, including 5G-Advanced An evolved IP Multimedia Subsystem (IMS) developed in an access independent manner 3GPP is a consortium with seven national or regional telecommunication standards organizations as primary members ("organizational partners") and a variety of other organizations as associate members ("market representation partners"). The 3GPP organizes its work into three different streams: Radio Access Networks, Services and Systems Aspects, and Core Network and Terminals.[2] The project was established in December 1998 with the goal of developing a specification for a 3G mobile phone system based on the 2G GSM system, within the scope of the International Telecommunication Union's International Mobile Telecommunications-2000, hence the name 3GPP.[3] It should not be confused with 3rd Generation Partnership Project 2 (3GPP2), which developed a competing 3G system, CDMA2000.[4] The 3GPP administrative support team (known as the "Mobile Competence Centre") is located at the European Telecommunications Standards Institute headquarters in the Sophia Antipolis technology park in France.[5] The seven 3GPP organizational partners are from Asia, Europe and North America. Their aim is to determine the general policy and strategy of 3GPP and perform the following tasks: The approval and maintenance of the 3GPP scope; The maintenance of the partnership project description; Take the decision to create or cease a Technical Specification Groups, and approve their scope and terms of reference; The approval of organizational partner funding requirements; The allocation of human and financial resources provided by the organizational partners to the Project Co-ordination Group; Act as a body of appeal on procedural matters referred to them. Together with the market representation partners (MRPs) perform the following tasks: The maintenance of the partnership project agreement; The approval of applications for 3GPP partnership; Take the decision against a possible dissolution of 3GPP. The organizational partners are:[6] Organizational partners Organization Country/region Website Association of Radio Industries and Businesses (ARIB) Japan ARIB Alliance for Telecommunications Industry Solutions (ATIS) USA ATIS China Communications Standards Association (CCSA) China CCSA European Telecommunications Standards Institute (ETSI) Europe ETSI Telecommunications Standards Development Society (TSDSI) India TSDSI Telecommunications Technology Association [ko] (TTA) South Korea TTA Telecommunication Technology Committee (TTC) Japan TTC The 3GPP organizational partners can invite a market representation partner to take part in 3GPP, which: Has the ability to offer market advice to 3GPP and to bring into 3GPP a consensus view of market requirements (e.g., services, features and functionality) falling within the 3GPP scope; Does not have the capability and authority to define, publish and set standards within the 3GPP scope, nationally or regionally; Has committed itself to all or part of the 3GPP scope; Has signed the partnership project agreement. As of January 2025[update], the market representation partners are:[6] Market representation partners Organization Website 5G-ACIA 5G Automotive Association 5G Americas Deterministic Networking Alliance (5GDNA) 6G Smart Network and Services Industry Association (6G-IA) 5G Slicing Association (5GSA) 5G Media Action Group (5G-MAG) Automotive Edge Computing Consortium (AECC) Broadband India Forum Cellular Operators Association of India (COAI) China Society of Automotive Engineers [zh] (CSAE) CTIA Global Satellite Operators Association (GSOA) Global Certification Forum (GCF) Global mobile Suppliers Association (GSA) GSMA IPV6 Forum Next Generation Mobile Networks (NGMN) Public Safety Communication Europe (PSCE) Forum Small Cell Forum TCCA TD Industry Alliance Wireless Broadband Alliance 3GPP standards are structured as Releases. Discussion of 3GPP thus frequently refers to the functionality in one release or another. Version[7] Released[8] Info Phase 1 1992 GSM features Phase 2 1995 GSM features, EFR codec, Release 96 1997 Q1 GSM features, 14.4 kbit/s user data rate, Release 97 1998 Q1 GSM features, GPRS Release 98 1999 Q1 GSM features, AMR codec, EDGE, GPRS for PCS1900 Release 99 2000 Q1 Specified the first UMTS 3G networks, incorporating a CDMA air interface[9] Release 4 2001-06-21 Originally called the Release 2000 – added features including an all-IP core network[10] Release 5 2002-09-12 Introduced IMS and HSDPA[11] Release 6 2005-09-28 Integrated operation with Wireless LAN networks and adds HSUPA, MBMS, enhancements to IMS such as Push to Talk over Cellular (PoC), GAN[12] Release 7 2008-03-13 Focuses on decreasing latency, improvements to QoS and real-time applications such as VoIP.[13] This specification also focus on HSPA+ (High Speed Packet Access Evolution), SIM high-speed protocol and contactless front-end interface (near-field communication enabling operators to deliver contactless services like Mobile Payments), EDGE Evolution. Release 8 2009-03-12 First LTE release. All-IP network (SAE). New OFDMA, FDE and MIMO based radio interface, not backwards compatible with previous CDMA interfaces. Dual-cell HSDPA. UMTS HNB. Release 9 2010-03-25 SAES Enhancements, WiMAX and LTE/UMTS Interoperability. Dual-cell HSDPA with MIMO, Dual-cell HSUPA. LTE HeNB. Evolved multimedia broadcast and multicast service (eMBMS). Release 10 2011-06-08 LTE Advanced fulfilling IMT Advanced 4G requirements. Backwards compatible with release 8 (LTE). Multi-cell HSDPA (4 carriers). Release 11 2013-03-06 Advanced IP interconnection of services. Service layer interconnection between national operators/carriers as well as third-party application providers. Heterogeneous networks (HetNet) improvements, coordinated multi-point operation (CoMP). In-device co-existence (IDC). Release 12 2015-03-13 Enhanced small cells (higher order modulation, dual connectivity, cell discovery, self configuration), Carrier aggregation (2 uplink carriers, 3 downlink carriers, FDD/TDD carrier aggregation), MIMO (3D channel modeling, elevation beamforming, massive MIMO), New and enhanced services (cost and range of MTC, D2D communication, eMBMS enhancements)[14] Release 13 2016-03-11 LTE-Advanced Pro. LTE in unlicensed, LTE enhancements for machine-type communication. Elevation beamforming / full-dimension MIMO, indoor positioning.[15] Release 14 2017-06-09 Energy efficiency, location services (LCS), mission-critical data over LTE, mission-critical video over LTE, flexible mobile service steering (FMSS), multimedia broadcast supplement for public warning system (MBSP), enhancement for TV services over eMBMS, massive Internet of things, cell broadcast service (CBS)[16] Release 15 2019-06-07 First 5G NR ("New Radio") release. Support for 5G vehicle-to-x service, IP Multimedia Core Network Subsystem (IMS), future railway mobile communication system[17] Release 16 2020-07-03 The 5G system – phase 2: 5G enhancements, NR-based access to unlicensed spectrum (NR-U), satellite access[18] Release 17 2022-06-10 TSG RAN: several features that continue to be important for overall efficiency and performance of 5G NR: MIMO, spectrum sharing enhancements, UE power saving and coverage enhancements. RAN1 will also undertake the necessary study and specification work to enhance the physical layer to support frequency bands up to 71 GHz. TSG SA groups focused on further enhancements to the 5G system and enablers for new features and services: Enhanced support of: non-public networks, industrial Internet of things, low complexity NR devices, edge computing in 5GC, access traffic steering, switch and splitting support, network automation for 5G, network slicing, advanced V2X service, multiple USIM support, proximity-based services in 5GS, 5G multicast broadcast services, unmanned aerial systems (UAS), satellite access in 5G, 5GC location services, multimedia priority service...[19] Release 18 2024-06-21 5G-Advanced. Introducing further machine-learning based techniques at different levels of the wireless network. Edge computing, evolution of IMS multimedia telephony service, smart energy and infrastructure, vehicle-mounted relays, low power high accuracy positioning for industrial IoT scenarios, enhanced access to and support of network slicing, satellite backhaul in 5G...[20][21][19] Release 19 [22] Target 2025 Q4 5G-Advanced. Each release incorporates hundreds of individual technical specification and technical report documents, each of which may have been through many revisions. Current 3GPP standards incorporate the latest revision of the GSM standards. The documents are made available without charge on 3GPP's web site. The technical specifications cover not only the radio part ("air interface") and core network, but also billing information and speech coding down to source code level. Cryptographic aspects (such as authentication, confidentiality) are also specified. The 3GPP specification work is done in Technical Specification Groups (TSGs) and Working Groups (WGs).[23] There are three Technical Specifications Groups, each of which consists of multiple WGs: RAN (Radio Access Network): RAN specifies the UTRAN and the E-UTRAN. It is composed of six working groups. WG Shorthand Scope Specifications RAN WG1 RAN1 Radio Layer 1 (Physical layer) List of specs RAN WG2 RAN2 Radio Layer 2 and Radio Layer 3 Radio Resource Control List of specs RAN WG3 RAN3 UTRAN, E-UTRAN, NG-RAN architecture and related network interfaces List of specs RAN WG4 RAN4 Radio performance and protocol aspects List of specs RAN WG5 RAN5 Mobile terminal conformance testing List of specs SA (Service and System Aspects): SA specifies the service requirements and the overall architecture of the 3GPP system. It is also responsible for the coordination of the project. SA is composed of six working groups. WG Shorthand Scope Specifications SA WG1 SA1 Services List of specs SA WG2 SA2 Architecture List of specs SA WG3 SA3 Security List of specs SA WG4 SA4 Codec List of specs SA WG5 SA5 Management, Orchestration and Charging List of specs SA WG6 SA6 Application Enablement and Critical Communication Applications List of specs CT (Core Network and Terminals): CT specifies the core network and terminal parts of 3GPP. It includes the core network – terminal layer 3 protocols. It is composed of five working groups. WG Shorthand Scope Specifications CT WG1 CT1 User Equipment – Core Network protocols List of specs CT WG2 CT2 closed CT WG3 CT3 Interworking with external networks List of specs CT WG4 CT4 Core Network Protocols List of specs CT WG5 (closed) CT5 Open Services Access (OSA) Succeeded by the Open Mobile Alliance CT WG6 CT6 Smart Card Application Aspects List of specs GERAN (GSM/EDGE Radio Access Network): The closure of GERAN was announced in January 2016.[24] The specification work on legacy GSM/EDGE system was transferred to RAN WG, RAN6. RAN6 was closed in July 2020 (. The 3GPP structure also includes a Project Coordination Group, which is the highest decision-making body. Its missions include the management of overall timeframe and work progress. 3GPP standardization work is contribution-driven. Companies ("individual members") participate through their membership to a 3GPP organizational partner. As of December 2020, 3GPP is composed of 719 individual members.[25] Specification work is done at WG and at TSG level:[26] the 3GPP WGs hold several meetings a year. They prepare and discuss change requests against 3GPP specifications. A change request accepted at WG level is called "agreed". the 3GPP TSGs hold plenary meetings quarterly. The TSGs can "approve" the change requests that were agreed at WG level. Some specifications are under the direct responsibility of TSGs and therefore, change requests can also be handled at TSG level. The approved change requests are subsequently incorporated in 3GPP specifications. 3GPP follows a three-stage methodology as defined in ITU-T Recommendation I.130:[27] stage 1 specifications define the service requirements from the user point of view. stage 2 specifications define an architecture to support the service requirements. stage 3 specifications define an implementation of the architecture by specifying protocols in details. Test specifications are sometimes defined as stage 4, as they follow stage 3. Specifications are grouped into releases. A release consists of a set of internally consistent set of features and specifications. Timeframes are defined for each release by specifying freezing dates. Once a release is frozen, only essential corrections are allowed (i.e. addition and modifications of functions are forbidden). Freezing dates are defined for each stage. The 3GPP specifications are transposed into deliverables by the organizational partners. List of mobile phone generations Universal Mobile Telecommunications System (UMTS) 3GPP Long Term Evolution Evolution to 3G IP Multimedia Subsystem 3GP 3GPP2 – The 3GPP's counterpart in the CDMA2000 sphere. GSM services LoRaWAN Telecoms & Internet converged Services & Protocols for Advanced Networks (TISPAN) Open Mobile Alliance Service data adaptation protocol Service layer European Telecommunications Standards Institute ^ 3GPP Scope and Objectives, 31 August 2007 ^ "About 3GPP". 3GPP. Retrieved 10 March 2019. ^ "3GPP Background". 7 June 2000. Archived from the original on 6 July 2000. ^ "3rd Generation Partnership Project 2". Archived from the original on 23 January 2004. Retrieved 25 November 2012. ^ "Mobile Competence Centre". 3GPP. Retrieved 10 March 2019. ^ a b "Partners". 3GPP. Retrieved 1 January 2025. ^ Releases ^ "3GPP Specifications – Releases (and phases and stages)". Retrieved 16 September 2010. ^ Overview of 3GPP Release 99, Summary of all Release 99 Features. ETSI Mobile Competence Centre, Version xx/07/04 ^ Overview of 3GPP Release 4, Summary of all Release 4 Features, v.1.1.0 (draft) ETSI Mobile Competence Centre 2004 ^ Summary of all Release 5 Features, ETSI Mobile Competence Centre, Version 9 September 2003 ^ Overview of 3GPP Release 6, Summary of all Release 6 Features, Version TSG #33, ETSI Mobile Competence Centre 2006 ^ Review of the Work Plan at Plenaries #31, 3GPP, SP-060232 3GPP TSG SA#31 Sanya, 13–16 March 2006 ^ "Highlights of 3GPP Release 12". Retrieved 20 November 2014. ^ "Release 13 priorities". Retrieved 20 November 2014. ^ "3GPP Portal > Specifications". portal.3gpp.org. Retrieved 27 October 2016. ^ "3GPP Portal > Specifications". portal.3gpp.org. Retrieved 27 October 2016. ^ "3GPP Portal > Specifications". portal.3gpp.org. Retrieved 14 July 2020. ^ a b "5G evolution toward 5G advanced: An overview of 3GPP releases 17 and 18". Ericsson. Retrieved 25 August 2022. ^ "Release 18". 3gpp.org. Retrieved 25 November 2021. ^ "5G-Advanced's system architecture begins taking shape at 3GPP". Nokia. Retrieved 25 November 2021. ^ "Release 19". 3GPP. Retrieved 8 September 2024. ^ "Specification Groups". Archived from the original on 9 May 2011. Retrieved 11 April 2011. ^ closure of GERAN ^ 3GPP membership ^ 3GPP TR 21.900 Technical Specification Group working methods ^ ITU-T Recommendation I.130 3GPP website 3GPP Standards List of Acronyms & Terminology 3GPP freely published, detailed technical specifications 3GPP releases descriptions ETSI GSM UMTS 3GPP Numbering Cross Reference TS/TR specification numbering Tool for visualizing multiple inter-related 3gpp standards Tool for visualizing, decoding, encoding network protocol messages defined by 3gpp LTE-3GPP.info: online 3GPP messages decoder fully supporting Rel.15 Retrieved from " 9This article is about the multimedia formats. For the mobile telecommunications standards organizations, see 3GPP. Multimedia file format families 3GPFilename extension .3gp, .3gppInternet media type video/3gpp, audio/3gppUniform Type Identifier (UTI)public.3gppDeveloped by3GPPInitial release4 April 2003; 22 years ago (2003-04-04)[1]Latest release17.0.0[1]7 April 2022; 3 years ago (2022-04-07) Type of formatContainer formatContainer foraudio, video, textExtended fromMPEG-4 Part 12Open format?YesFree format?No 3G2Filename extension .3g2, .3gp2, .3gpp2Internet media type video/3gpp2, audio/3gpp2Uniform Type Identifier (UTI)public.3gpp2Developed by3GPP2Initial releaseJanuary 2004; 21 years ago (2004-01)[2]Latest releaseC.S0050-B v1.0[2]September 2024; 1 year ago (2024-09) Type of formatContainer formatContainer foraudio, video, textExtended fromMPEG-4 Part 12Open format?YesFree format?yes 3GP (3GPP file format) is a digital multimedia container format defined by the Third Generation Partnership Project (3GPP) for 3G UMTS multimedia services, largely based on MPEG-4 Part 12. A 3GP container may consist of H.263 or H.264 video codecs or AMR or AAC-LC audio codecs. 3G2 (3GPP2 file format) is a multimedia container format defined by the 3GPP2 for 3G CDMA2000 multimedia services. It is very similar to the 3GP file format but consumes less space and bandwidth, and has some extensions and limitations in comparison to 3GP. 3GP is defined in the ETSI 3GPP technical specification.[1] 3GP is a required file format for video and associated speech/audio media types and timed text in ETSI 3GPP technical specifications for IP Multimedia Subsystem (IMS), Multimedia Messaging Service (MMS), Multimedia Broadcast/Multicast Service (MBMS) and Transparent end-to-end Packet-switched Streaming Service (PSS).[3][4][5][6] 3G2 is defined in the 3GPP2 technical specification.[2] The factual accuracy of parts of this article (those related to 3GP codec list (see release 12 of 2016 p.65)) may be compromised due to out-of-date information. The reason given is: 3GP has expanded codec lists while 3G2 has stagnated. Please help update this article to reflect recent events or newly available information. (February 2021) Relations between ISO Base Media File Format, MP4 File Format, 3GPP file format and 3GPP2 file format. Based on the 3GPP2 technical specification published on 18 May 2007.[7] The 3GP and 3G2 file formats are both structurally based on the ISO base media file format defined in ISO/IEC 14496-12 – MPEG-4 Part 12,[8][9][10] but older versions of the 3GP file format did not use some of its features.[7] 3GP and 3G2 are container formats similar to MPEG-4 Part 14 (MP4), which is also based on MPEG-4 Part 12. The 3GP and 3G2 file format were designed to decrease storage and bandwidth requirements to accommodate mobile phones. They are good for lower end smartphones for faster streaming & download. 3GP and 3G2 are similar standards, but with some differences: 3GPP file format was designed for GSM-based phones and may have the filename extension .3gp 3GPP2 file format was designed for CDMA-based phones and may have the filename extension .3g2 Some cell phones use the .mp4 extension for 3GP video. The 3GP file format stores video streams as MPEG-4 Part 2, H.263, or MPEG-4 Part 10 (AVC/H.264), and audio streams as AMR-NB, AMR-WB, AMR-WB+, AAC-LC, HE-AAC v1 or Enhanced aacPlus (HE-AAC v2). 3GPP allowed use of AMR and H.263 codecs in the ISO base media file format (MPEG-4 Part 12), because 3GPP specified the usage of the Sample Entry and template fields in the ISO base media file format as well as defining new boxes to which codecs refer. These extensions were registered by the registration authority for code-points in ISO base media file format ("MP4 Family" files).[11][12] For the storage of MPEG-4 media specific information in 3GP files, the 3GP specification refers to MP4 and the AVC file format, which are also based on the ISO base media file format. The MP4 and the AVC file format specifications described usage of MPEG-4 content in the ISO base media file format.[8] A 3GP file is always big-endian, storing and transferring the most significant bytes first. [citation needed] The 3G2 file format can store the same video streams and most of the audio streams used in the 2007 3GP file format. In addition, 3G2 stores audio streams as EVRC, EVRC-B, EVRC-WB, 13K (QCELP), SMV or VMR-WB, which was specified by 3GPP2 for use in ISO base media file format.[12] The 3G2 specification also defined some enhancements to 3GPP Timed Text. 3G2 file format does not store Enhanced aacPlus (HE-AAC v2) and AMR-WB+ audio streams.[7] For the storage of MPEG-4 media (AAC audio, MPEG-4 Part 2 video, MPEG-4 Part 10 – H.264/AVC) in 3G2 files, the 3G2 specification refers to the MP4 file format and the AVC file format specification, which described usage of this content in the ISO base media file format. For the storage of H.263 and AMR content 3G2 specification refers to the 3GP file format specification.[7] Most 3G capable mobile phones support the playback and recording of video in 3GP format (memory, maximum filesize for playback and recording, and resolution limits exist and vary).[citation needed] Some newer/higher-end phones without 3G capabilities may also playback and record in this format (again, with said limitations).[citation needed] Audio imported from CD onto a PlayStation 3 when it is set to encode to the MPEG-4 AAC format copies onto USB devices in the 3GP format. [citation needed] The Nintendo 3DS used 3GP technology to play YouTube videos. 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Retrieved 2009-06-12. ^ a b "3GPP TS 26.244; Transparent end-to-end packet switched streaming service (PSS); 3GPP file format (3GP)" (PDF). ETSI 3GPP. 2008-12-11. p. 9. Retrieved 2009-05-30. ^ "ISO Base Media File Format white paper – Proposal". April 2006. Archived from the original on 2008-07-14. Retrieved 2009-12-26. ^ "ISO Base Media File Format white paper – Proposal". Chiariglione. October 2009. Retrieved 2009-12-26. ^ "ISO/IEC 14496-12:2008, Information technology -- Coding of audio-visual objects -- Part 12: ISO base media file format" (PDF). International Organization for Standardization. 2008. p. 95. Retrieved 2009-05-30. ^ a b "Registered types – Codecs". Registration authority for code-points in "MP4 Family" files – mp4ra.org. 2008. Archived from the original on 2009-04-19. Retrieved 2009-05-31. ^ "File types supported by Windows Media Player". Microsoft. Retrieved 2020-07-25. ^ "What's New in QuickTime 6.3 + 3GPP". Apple, Inc. 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Multimedia file format families 3GPFilename extension .3gp, .3gppInternet media type video/3gpp, audio/3gppUniform Type Identifier (UTI)public.3gppDeveloped by3GPPInitial release4 April 2003; 22 years ago (2003-04-04)[1]Latest release17.0.0[1]7 April 2022; 3 years ago (2022-04-07) Type of formatContainer formatContainer foraudio, video, textExtended fromMPEG-4 Part 12Open format?YesFree format?No 3G2Filename extension .3g2, .3gp2, .3gpp2Internet media type video/3gpp2, audio/3gpp2Uniform Type Identifier (UTI)public.3gpp2Developed by3GPP2Initial releaseJanuary 2004; 21 years ago (2004-01)[2]Latest releaseC.S0050-B v1.0[2]September 2024; 1 year ago (2024-09) Type of formatContainer formatContainer foraudio, video, textExtended fromMPEG-4 Part 12Open format?YesFree format?yes 3GP (3GPP file format) is a digital multimedia container format defined by the Third Generation Partnership Project (3GPP) for 3G UMTS multimedia services, largely based on MPEG-4 Part 12. A 3GP container may consist of H.263 or H.264 video codecs or AMR or AAC-LC audio codecs. 3G2 (3GPP2 file format) is a multimedia container format defined by the 3GPP2 for 3G CDMA2000 multimedia services. It is very similar to the 3GP file format but consumes less space and bandwidth, and has some extensions and limitations in comparison to 3GP. 3GP is defined in the ETSI 3GPP technical specification.[1] 3GP is a required file format for video and associated speech/audio media types and timed text in ETSI 3GPP technical specifications for IP Multimedia Subsystem (IMS), Multimedia Messaging Service (MMS), Multimedia Broadcast/Multicast Service (MBMS) and Transparent end-to-end Packet-switched Streaming Service (PSS).[3][4][5][6] 3G2 is defined in the 3GPP2 technical specification.[2] The factual accuracy of parts of this article (those related to 3GP codec list (see release 12 of 2016 p.65)) may be compromised due to out-of-date information. The reason given is: 3GP has expanded codec lists while 3G2 has stagnated. Please help update this article to reflect recent events or newly available information. (February 2021) Relations between ISO Base Media File Format, MP4 File Format, 3GPP file format and 3GPP2 file format. Based on the 3GPP2 technical specification published on 18 May 2007.[7] The 3GP and 3G2 file formats are both structurally based on the ISO base media file format defined in ISO/IEC 14496-12 – MPEG-4 Part 12,[8][9][10] but older versions of the 3GP file format did not use some of its features.[7] 3GP and 3G2 are container formats similar to MPEG-4 Part 14 (MP4), which is also based on MPEG-4 Part 12. The 3GP and 3G2 file format were designed to decrease storage and bandwidth requirements to accommodate mobile phones. They are good for lower end smartphones for faster streaming & download. 3GP and 3G2 are similar standards, but with some differences: 3GPP file format was designed for GSM-based phones and may have the filename extension .3gp 3GPP2 file format was designed for CDMA-based phones and may have the filename extension .3g2 Some cell phones use the .mp4 extension for 3GP video. The 3GP file format stores video streams as MPEG-4 Part 2, H.263, or MPEG-4 Part 10 (AVC/H.264), and audio streams as AMR-NB, AMR-WB, AMR-WB+, AAC-LC, HE-AAC v1 or Enhanced aacPlus (HE-AAC v2). 3GPP allowed use of AMR and H.263 codecs in the ISO base media file format (MPEG-4 Part 12), because 3GPP specified the usage of the Sample Entry and template fields in the ISO base media file format as well as defining new boxes to which codecs refer. These extensions were registered by the registration authority for code-points in ISO base media file format ("MP4 Family" files).[11][12] For the storage of MPEG-4 media specific information in 3GP files, the 3GP specification refers to MP4 and the AVC file format, which are also based on the ISO base media file format. The MP4 and the AVC file format specifications described usage of MPEG-4 content in the ISO base media file format.[8] A 3GP file is always big-endian, storing and transferring the most significant bytes first. [citation needed] The 3G2 file format can store the same video streams and most of the audio streams used in the 2007 3GP file format. 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