# Responsible Artificial Intelligence

Lisa Giacobazzi

June 2025

# Contents

# 1 What is Technology? – A Comprehensive Reflection

**Technology** is not just a set of tools or machines. It can be understood as:

- A *collection of tools and techniques* used to modify the environment and solve problems;
- A *system of knowledge and practices* that evolves over time;
- An *agent of change*, interacting with society in complex and dynamic ways.

**Importantly, technology is not neutral**: it embodies the *values, intentions, and assumptions* of the people and institutions that create and implement it. This is captured by **Kranzberg's First Law**:

> "Technology is neither good nor bad, nor is it neutral."

## 1.1 Technology vs. Science

Although technology is often described as *applied science*, this view is overly simplistic. The ancient Greek distinction between *technê* (practical knowledge) and *epistêmê* (theoretical knowledge) remains relevant. Technological advancement involves not only scientific discovery but also creativity, historical context, and social needs.

## 1.2 Key Definitions

- **Technology** (term used since 1829): the practical application of knowledge, or the capability/methods used to accomplish technical tasks.
- **Technique** (from 1817): the specific way in which technical details are executed.

## 1.3 Historical Milestones in Technological Development

1. **Agricultural Revolution**: transition from nomadic societies to settled farming communities.
2. **Industrial Revolution**: mechanization of production, leading to urbanization, capitalism, and large-scale societal change.
3. **Digital Revolution**: transformation of communication, labor, and the economy through computing and the internet.

## 1.4 The Digital Era – The "Gold Rush" of Technology

Three main waves mark the evolution of digital technologies:

1. The rise of **personal computing** and early software companies (e.g., Microsoft, Apple);
2. The shift from software to **internet-based services and platforms** (e.g., Amazon, Facebook);
3. Their **convergence** created today's digital powerhouses (e.g., Google, Meta).

This revolution radically reshaped work, communication, and capitalism.

## 1.5 Technology as a Strategic Asset

Technology is more than a commercial product—it is a key *geopolitical asset*. Only a few nations can produce critical technologies (e.g., satellites, microprocessors, advanced weaponry), which gives them a strategic advantage in global politics, economy, and defense. Nations that rely on foreign suppliers for essential technologies face limitations in sovereignty, autonomy, and long-term planning.

A historical example of the intersection between technological and economic control is the **De Gaulle gold exchange controversy** in the 1960s. Under the Bretton Woods system, countries could exchange U.S. dollars for gold. French President Charles de Gaulle saw this monetary structure as a form of American dominance, enabling the U.S. to fund military and technological expansion by printing dollars. In response, France began converting its dollar reserves into gold and repatriating them, directly challenging U.S. economic supremacy.

This episode illustrates that **technological power reinforces economic power**. The United States' dominance was not limited to finance—it extended to the control of early computing systems, communication infrastructures, and military technologies. De Gaulle's challenge implicitly called for technological independence as well as monetary sovereignty. It demonstrated how the ability to develop, produce, and maintain critical technologies is deeply tied to national autonomy.

Therefore, technology should be seen as a strategic domain: countries that fail to achieve technological self-sufficiency remain dependent on external powers for both their economic stability and their digital infrastructure.

## 1.6 The Reciprocal Relationship Between Technology and Society

Technology and society **co-evolve**:

- **Society shapes technology**: through cultural norms, political decisions, and economic interests.

- **Technology shapes society**: by changing how people work, communicate, govern, and understand the world.

### 1.7 Two Theoretical Approaches

1. **Technological Determinism**: technology is seen as the linear, inevitable driver of social change (e.g., industrialization → urbanization).
2. **Social Constructivism**: society determines how technologies are developed and adopted based on context and preferences.

In reality, both views are partially correct: *society and technology influence each other continuously.*

## 2 Relationship between science and technology

### 2.1 The Relationship Between Science and Technology

The relationship between science and technology is complex and reciprocal. While they are often intertwined, they serve different purposes and operate through distinct methods.

- **Science** (*epistêmê*) aims to understand the natural world. It is based on observation, experimentation, and the formulation of theories to explain phenomena.
- **Technology** (*technê*) focuses on the application of knowledge to develop tools, processes, and systems that solve practical problems or enhance human capabilities.

Science and technology influence each other, but not always in predictable or linear ways:

- Sometimes, **science leads to technological innovation**. For example, quantum physics enabled the invention of semiconductors, which are foundational to modern electronics.
- Other times, **technology enables scientific progress**. Instruments like the telescope, the microscope, or the computer have opened entirely new fields of research.

In many historical cases, technology even preceded the scientific understanding of the phenomena it manipulated. Early radio systems, for instance, were built before Maxwell's equations were widely applied in engineering practice.

Moreover, according to Brian Winston's model, technology can advance science due to what he terms a **supervening social necessity**—a pressing societal

or institutional need that drives the development and adoption of certain technologies, even before the underlying scientific theory is fully established.
For example, during World War II, the military need for faster ballistic calculations and cryptographic systems led to the development of the first programmable computers. These technologies were later foundational for scientific research in physics, meteorology, and genetics. Similarly, the telegraph was first implemented in the context of railway systems, based on practical engineering, long before a full scientific understanding of electromagnetism had been formalized. The urgent need to coordinate trains and ensure safety represented a clear example of supervening social necessity.

Thus, the relationship between science and technology is **non-linear**, **mutually reinforcing**, and shaped by historical, institutional, and cultural forces. In some cases, science creates the conditions for new technologies; in others, technology opens new avenues for scientific exploration.

# 3 Kranzberg's First Law

Every technological decision carries consequences, often with ethical and societal implications. The belief that technology is neither bad nor good often shifts responsibility to the users, disregarding the crucial steps that led to its creation and deployment.

**Kranzberg's First Law** states:

> "Technology is neither good nor bad; nor is it neutral."

Coined by historian Melvin Kranzberg, this principle reminds us that technology must be analyzed in its social, political, and historical context. While technologies do not possess intrinsic moral value, they are never neutral because they are designed, developed, and deployed by people—and those people act with specific values, intentions, and assumptions. Some technologies, like cars can be broadly categorized as tools that are shaped by their use. However there are exceptions to this, like in cases such as the atomic bomb and biological weapons, where the potential to harm is built into the very design.

Technologies shape our societies and behaviors in profound ways. Their consequences—both intended and unintended—depend on design choices, implementation strategies, and the power structures that govern them.

## 3.1 Examples and Implications

- **The automobile** was invented as a mechanical replacement for the horse-drawn carriage. But its mass adoption led to urban sprawl, traffic deaths, oil dependency, and environmental degradation—none of which were originally envisioned.

- **The internet**, initially created as a decentralized communication network for academics, has evolved into a heavily centralized infrastructure dominated by a few tech giants. Its uses today include surveillance, misinformation, algorithmic manipulation, and geopolitical control.
- **ChatGPT and generative AI** offer a contemporary case. The initial release of ChatGPT lacked sufficient safeguards and was capable of producing harmful, biased, or unsafe content. While subsequent versions improved on this, the deployment occurred with known risks. This shows how potential harm can be embedded *directly into the technology* from the start, rather than being merely a matter of misuse.

### 3.2 The Long Arc of Technological Introduction

No technology appears overnight. The introduction of any major system involves a long, complex process: it must pass through ideation, prototyping, investment, regulatory approval, societal negotiation, and eventual large-scale deployment. By the time a technology becomes widely available, many decisions have already been made—often without democratic debate or ethical oversight.

### 3.3 The Responsibility of Creators

Kranzberg's Law also underscores the moral and political responsibility of those who create technology. Designers, engineers, and corporations are not neutral agents. They make critical decisions that shape societal outcomes—what a technology does, who it empowers, who it excludes, and what risks it generates. As J. Robert Oppenheimer famously warned after building the atomic bomb, inventors are not only responsible for their creations—but also for the consequences those creations unleash.

In sum, Kranzberg's First Law invites us to reject technological determinism and naive neutrality. Instead, it encourages a critical and contextual understanding of technology as a human, political, and ethical phenomenon.

## 4 In What Sense is Technology a Political Issue?

Technology is shaped by identifiable individuals and institutions. It is not an anonymous force but the **product of choices made by people with specific interests**.

Technology is not shaped in a vacuum; it is molded by existing power structures that determine its accessibility and impact.

*Example:* The case of insulin exemplifies how technology is shaped by human choices and power structures. When it was discovered in 1921, Frederick Banting and his colleagues sold the patent for one dollar, stating that insulin should be accessible to all. However, over time, pharmaceutical companies gained control over its production and pricing. In countries like the United States, insulin—despite being an old and life-saving medicine—became unaffordable for many. This illustrates how the intentions behind a technology can be subverted by institutional, economic and political forces, reinforcing the idea that technology is never autonomous or neutral, but the product of specific choices and interests.

Technology is a deeply political issue because it both reflects and shapes power relations in society. It is political in at least four interconnected senses:

## 4.1 1. Technology is shaped by political decisions

Technological development is not autonomous or neutral. It results from choices made by governments, corporations, and institutions—actors with specific interests, ideologies, and goals. These choices affect:

- What kinds of technologies are developed or funded;
- Who controls technological infrastructures;
- Who benefits from or is excluded by them.

*Example:* During the Cold War, the United States restricted access to advanced computing systems for geopolitical reasons, illustrating how technology serves strategic political ends.

## 4.2 2. Technology produces political effects

Technologies reshape how people work, communicate, and interact. They influence access to knowledge, freedom of expression, surveillance, labor conditions, and public discourse.
The internet, for instance, began as a decentralized network but evolved into a centralized and monetized system, controlled by a few dominant platforms that now mediate communication and information flow worldwide.

## 4.3 3. The governance of technology is a political responsibility

When democratic institutions fail to regulate technological systems, private actors—often large corporations—shape their development in ways that prioritize profit over public interest.

Kranzberg's First Law reminds us that technology is never neutral. It embodies design choices that reflect societal values and produce real-world consequences.

*Example:* The release of generative AI systems like ChatGPT occurred without sufficient preemptive oversight. These tools have significant effects on education, misinformation, and labor, yet their deployment was driven by corporate strategy, not democratic consensus.

### 4.4 4. Modernity introduced the freedom to innovate without preemptive regulation

Starting in the 18$^{th}$ century, modernity brought about a major shift: companies gained unprecedented freedom to introduce new technologies with minimal constraints. Unlike in the past, where monarchs or public authorities could delay or prohibit disruptive innovations (e.g., banning machines that would displace peasants), today's private sector often moves fast and unregulated.

This "freedom to innovate" is a political arrangement: it privileges speed, market logic, and corporate interests over precaution and deliberation.

*Historical example:* The invention of the movable-type printing press in the 15$^{th}$ century led to a rapid increase in book production and literacy. It broke the monopoly of knowledge held by religious and political elites, allowing the public to access and spread new ideas. This technological shift had profound political consequences: in response, institutions introduced mechanisms of control, such as censorship (e.g., the Index of Forbidden Books) and printing licenses. The political system reacted to the disruptive effects of technology by attempting to reassert control over public discourse.

*Example:* The introduction of Facebook's News Feed algorithm and engagement-driven content curation occurred without any ex-ante public oversight. These technologies, deployed by a private actor, were framed as neutral features to enhance user experience. Yet, they contributed to the amplification of misinformation, polarization, and social harm—including ethnic violence and psychological distress—long before regulatory bodies could intervene.

This demonstrates how the "freedom to innovate" often operates as a freedom from accountability, reinforcing the idea that modern tech governance lacks ex-ante safeguards.

### 4.5 5. Regulation is often ex-post, not ex-ante

Modern technology is rarely subject to anticipatory (ex-ante) democratic regulation. Instead, societies respond only after harm becomes visible (ex-post). This delay is often due to:

- Lobbying and corporate pressure;
- Regulatory capture;
- Lack of technical expertise in legislative bodies;

- The deliberate production of doubt (as seen in the tobacco and sugar industries).

This regulatory lag leaves citizens vulnerable, obstructs accountability, and sidelines the public interest.

### 4.6 Conclusion

Claiming that technology is apolitical is itself a political act. It serves to protect the interests of those who benefit from the current distribution of power and risk. Recognizing the political nature of technology means acknowledging that its development and governance must be shaped by democratic principles, public debate, and ethical reflection.

## 5 Technology and Democracy

Technology and democracy are intimately connected, yet often in tension. While certain technologies can expand democratic participation, modern innovation frequently occurs without democratic oversight or accountability.

### 5.1 Technology can support democratic ideals

Historically, some technologies have empowered democratic values. The printing press enabled mass literacy and political mobilization. In its early phase, the internet facilitated decentralized communication, peer-to-peer knowledge sharing, and civic engagement.

These tools expanded access to information and gave individuals a stronger voice in the public sphere.

### 5.2 Modern technologies often bypass democratic control

Today, most new technologies—especially in the digital domain—are developed and deployed by private companies. These actors often introduce innovations without public debate or ex-ante regulation. Technologies like artificial intelligence, facial recognition, and social media algorithms have reshaped public life before their societal consequences were fully understood or democratically evaluated.

This lack of anticipatory governance has allowed profit-driven interests to shape critical infrastructures and decision-making tools.

### 5.3 The absence of democratic governance is a political choice

Modernity has created a system where the “freedom to innovate” is often interpreted as freedom from democratic accountability. Governments have frequently abdicated their role in evaluating and regulating technological systems, allowing markets to dominate the digital sphere.

The result is a concentration of power in a few tech giants, a weakening of citizens' rights (e.g., data privacy), and a deterioration of public discourse.

## 5.4 Why did governments abdicate their role?

The retreat of democratic institutions from the governance of technology is not merely accidental—it reflects ideological, economic, and structural factors. Since the 1980s, many governments have embraced neoliberal policies that prioritize market efficiency over state intervention. Innovation has been framed as a domain best left to private enterprise, with regulation seen as a threat to growth.

Governments also feared that strong regulation would drive innovation and investment elsewhere, weakening national competitiveness in the global tech race. Moreover, technological development often outpaced the expertise and capacity of legislative bodies, leading many policymakers to defer to corporate knowledge and lobbying.

In some cases, governments have deliberately allowed private actors to govern technology, thereby outsourcing political responsibility for controversial outcomes. While this may offer short-term economic gains, it entails a long-term loss of democratic control.

In this context, the "freedom to innovate" has functioned as a form of "freedom from accountability," enabling private actors to shape digital infrastructures, labor conditions, and public discourse with limited oversight.

## 5.5 4. A democratic response requires proactive governance

To ensure that technology serves democratic ends, several conditions must be met:

- Ex-ante regulation to anticipate risks and ensure fairness;
- Transparent and explainable systems, especially those that affect public life;
- Public institutions capable of deliberating on the values embedded in technology;
- Collective action to balance innovation with ethical and social responsibility.

In conclusion, a technology becomes democratic not simply because it is widely adopted, but because it is designed, governed, and monitored in a way that reflects the will and interests of the broader public.

# 6 The Relationship Between Technology and Power

Technology and power are fundamentally intertwined. Technology is both shaped by power and serves as an instrument to exercise it. The relationship is bidirectional: powerful actors influence which technologies are developed and how they are used, while technology, in turn, redistributes or reinforces existing structures of authority and control.

## 6.1 1. Technology concentrates or redistributes power

Technological infrastructures define who controls key societal functions—such as communication, information access, logistics, and surveillance. Platforms like Google, Amazon, and Meta hold immense influence over global discourse and behavior. In this sense, technology is not just a tool, but a domain where power is produced and contested.

## 6.2 2. Power shapes technological development

Technology is never neutral; it embodies the values, goals, and worldviews of those who design and deploy it. Whether funded by states or corporations, technologies often reflect specific interests, while excluding others. For instance, recommender algorithms are typically optimized for engagement and profit, not for public health or social cohesion.

## 6.3 3. Control over technology is a geopolitical asset

Technological capabilities are key indicators of national power. States that dominate critical sectors—such as semiconductors, artificial intelligence, and aerospace—hold strategic leverage over others. In the Cold War, the U.S. restricted access to computing systems; today, microchip supply chains and AI development are central to geopolitical competition.

## 6.4 4. Digital platforms as new power centers

In the digital era, a few private corporations have acquired quasi-sovereign power. They set the rules for online discourse, shape public opinion through algorithmic curation, and influence elections, mental health, and consumption patterns. This raises pressing questions:

- Who governs technological platforms? - The twitter scandal
- How can democratic institutions ensure accountability?
- What role should citizens play in shaping technological systems that affect their lives?

In conclusion, understanding technology requires understanding power. To shape a just technological future, we must consider not only what technologies do, but also who controls them, who benefits, and who bears the risks.

# 7 Who Decides If, When, and How a Technology is Introduced?

In an ideal democratic society, the introduction of a new technology would be a matter of public deliberation. Citizens, institutions, and experts would collectively evaluate its potential benefits, risks, and ethical implications. Decisions about *if*, *when*, and *how* a technology should be introduced would reflect social needs and democratic values.

## 7.1 The social trajectory of technology: Brian Winston's model

According to Brian Winston, the introduction of a technology is not merely a technical achievement, but a social process. Technologies typically follow a trajectory:

1. A scientific or theoretical **base** emerges;
2. An individual or group envisions a possible **ideation** and develops a prototype;
3. A **supervening social necessity**—such as a military, economic, or cultural demand—triggers investment and adoption;
4. The technology is finally recognized as an "invention" and scaled up.

This model helps explain why technologies often emerge in response to pressing societal needs—such as the telegraph, which was scaled up due to the logistical needs of 19$^{\text{th}}$-century railways. However, Winston's model also shows that the "need" is often defined by powerful institutions. In contemporary contexts, this social trajectory is increasingly shaped by corporate actors and market logic, rather than democratic debate or ethical reflection.

## 7.2 In practice: private actors often decide

In reality, the development and deployment of technology is largely driven by private corporations, particularly in the digital and biomedical sectors. Market incentives and competitive pressures prioritize speed and innovation over reflection and regulation.

Technologies such as social media algorithms, facial recognition systems, and generative AI (e.g., ChatGPT) have been introduced without meaningful public consultation or oversight. Decisions about their release, design, and societal integration are typically made by corporate executives and engineers, not by democratically accountable institutions.

### 7.3 Why does this happen?

Several structural and political factors contribute to this dynamic:

- Governments often lack the technical expertise or institutional capacity to anticipate and regulate emerging technologies;
- Powerful lobbying by tech industries pushes against precautionary regulation;
- The ideology of "freedom to innovate" treats technological progress as a private right rather than a public responsibility;
- There are few, if any, ex-ante democratic mechanisms to assess the broader impact of a new technology before its deployment.

### 7.4 What are the consequences?

This arrangement produces several problems:

- Citizens become test subjects for technologies they did not approve;
- Social, psychological, and environmental externalities accumulate without accountability;
- When harms occur, responsibility is diffused—governments blame companies, companies blame users.

In conclusion, decisions about technology are currently made by a small group of actors, often behind closed doors, despite their vast societal consequences. Reclaiming democratic control over technological introduction requires the creation of transparent, anticipatory mechanisms—such as ethics councils, public deliberation forums, and independent regulatory authorities—capable of aligning innovation with the public good.

## 8 Definitions: Lobbying, Regulatory Capture, and Production of Doubts

**Lobbying** Lobbying is the practice by which individuals, organizations, or industry representatives attempt to influence lawmakers and public officials in order to shape regulation or legislation in their favor. Lobbyists often present arguments supported by commissioned research, data, or economic forecasts.

In many democratic systems, lobbying is legal and institutionalized. However, as highlighted in the course, lobbying frequently lacks representation of the general public interest, since no one funds lobbyists to advocate for citizens without economic power.

*Example:* The extension of music copyright duration in Europe was approved against expert legal advice, due to intense lobbying by the music industry (e.g., the Beatles, Queen).

**Regulatory Capture** Regulatory capture occurs when a regulatory agency meant to act in the public interest is influenced or co-opted by the very industries it is supposed to regulate. This happens when industries fund scientific studies, provide career opportunities to regulators and engage in lobbying. This often happens also through mechanisms such as the "revolving door," where individuals move between roles in government and industry, or through the promise of career advancement and funding.

*Example:* Economist Tommaso Valletti led a European Commission case against Google with a small team of 30 experts, while Google assigned an equal-sized team with vastly more resources to counter him. This imbalance, coupled with lucrative job offers, illustrates how powerful industries can exert undue influence on regulatory processes.

**Production of Doubts** The production of doubts refers to a strategic effort by industries or interest groups to delay or derail regulation by casting doubt on scientific evidence or public consensus. Rather than denying facts, this strategy emphasizes uncertainty and the need for further research, thereby postponing legislative or public responses.

*Example:* The tobacco industry funded studies blaming air pollution for cancer instead of smoking. Similarly, the sugar industry suppressed evidence of sugar's health risks and promoted fat as the main dietary threat.

# 9 Did the Personal Computer and the Internet Have Libertarian Power?

Yes. Both the personal computer (PC) and the internet were initially designed with strong libertarian potential. This refers to their ability to decentralize control, empower individuals, and operate without centralized governance or censorship.

## 9.1 1. The Personal Computer (PC)

The PC, particularly in the 1970s and 1980s, was a tool of individual empowerment. It was sold as a modifiable kit, allowing users to:

- Choose their own operating systems;
- Install and run any application;

- Use the machine offline and independently of any central authority.

The PC enabled users to process data, write code, and store information privately and autonomously—without institutional or corporate intermediaries.

## 9.2 2. The Internet

The early internet was also structured around libertarian principles:

- It lacked mandatory ex-ante authentication;
- It used a decentralized, packet-switching architecture;
- It supported open, peer-to-peer protocols (e.g., email, FTP).

These design choices allowed any node to access and transmit information freely, creating an open space for collaboration, innovation, and publishing.

## 9.3 3. Examples of Libertarian Power

- **Wikipedia** embodies the ideal of open, collaborative knowledge creation.
- **Open-source software** projects like Linux and Firefox emerged from this decentralized ethos.
- **Blogs and early websites** allowed individuals to publish content without needing corporate platforms.

## 9.4 4. Decline of Libertarian Characteristics

Over time, this libertarian potential has been weakened by:

- The rise of centralized platforms (e.g., Google, Facebook);
- Locked-down devices and ecosystems (e.g., smartphones);
- Widespread surveillance and algorithmic control;
- Increased reliance on proprietary and closed systems.

Nonetheless, remnants of the original libertarian spirit survive in open-source communities, decentralized protocols, and internet freedom movements.

# 10 Economic and Political Consequences of the Digital Revolution

The digital revolution unfolded in two main waves. Each wave produced distinct economic and political effects.

1. **First Wave (1970s–1990s)**: The rise of personal computing and software. Pioneers like Bill Gates (Microsoft) and Steve Jobs (Apple) introduced technologies that brought computing power to individuals and businesses.

   **Economic:**

   - Growth of the software and hardware industries;
   - Democratization of computing tools for individuals and small businesses.

   **Political:**

   - Empowerment of users and decentralization of computing;
   - Minimal political disruption—technologies were local and private.

2. **Second Wave (1990s–2000s)**: The rise of internet-based platforms and services. Figures like Jeff Bezos (Amazon) and Mark Zuckerberg (Facebook) developed global platforms centered on data extraction, user interaction, and behavioral prediction.

   **Economic:**

   - Shift from product-based value to data monetization;
   - Emergence of monopolistic platforms (Google, Amazon, Facebook);
   - Rise of surveillance capitalism and digital advertising.

   **Political:**

   - Disruption of public discourse via algorithmic content;
   - Delayed regulatory responses to misinformation and centralization;
   - Growing global asymmetries in digital infrastructure.

The convergence of these two waves produced the digital giants—Google, Amazon, Meta, Microsoft—that dominate today's global tech landscape (**third wave**).

## 10.1 Economic Consequences

- **Transformation of capitalism**: Economic value shifted from physical production to digital infrastructure, data, and software.

- **Emergence of surveillance capitalism**: Free services in exchange for personal data enabled new forms of monetization based on attention and behavioral prediction.
- **Winner-takes-all dynamics**: Network effects facilitated monopolistic control over digital markets and infrastructure.
- **Impact on labor**: The digital revolution redefined work, enabling gig economies, remote labor, and algorithmic control, while displacing traditional jobs.

### 10.2 Political Consequences

- **Shift in global power**: Countries that mastered digital technologies gained strategic geopolitical leverage—especially in AI, cybersecurity, and data governance.
- **Weakening of state authority**: Private tech firms now control critical infrastructures once managed by states, such as communication networks, financial systems, and public discourse.
- **Erosion of democracy**: Social media and algorithmic systems contributed to misinformation, polarization, and electoral interference, challenging the resilience of democratic institutions.

In sum, the digital revolution not only restructured the global economy but also transformed the political landscape, concentrating power in the hands of a few corporations and reshaping the relationship between citizens, technology, and the state.

## 11 Why Did Europe Lag Behind in the Computer Industry?

Europe's delay in the computer and digital technology sector is the result of multiple structural, strategic, and cultural factors:

### 11.1 Failure to recognize the strategic value of computing

Unlike the United States and later China, European institutions did not initially view computing and digital technologies as strategically transformative. Instead, the focus remained on traditional sectors such as the automotive, aerospace, and fashion industries.

## 11.2 Fragmentation and lack of a unified strategy

Europe consists of multiple national markets with different regulations and industrial priorities. This fragmentation made it difficult to develop coordinated tech strategies or scale companies to compete globally. The absence of a "European digital champion" contrasts with the rise of U.S. firms like Microsoft, Apple, and Google.

## 11.3 Missed early leadership opportunities

Although Europe contributed significantly to the early history of computing—through pioneers like Alan Turing, Konrad Zuse, and Italy's Olivetti—these efforts were not scaled industrially or supported politically. Early innovation did not translate into global technological leadership.

## 11.4 Underinvestment in infrastructure and venture capital

Compared to the U.S., Europe has historically underinvested in:

- Public–private R&D partnerships;
- Venture capital for tech startups;
- University–industry technology transfer systems.

## 11.5 Dependence on foreign infrastructure

Europe remains dependent on:

- Operating systems developed abroad (e.g., Android, iOS);
- Non-European cloud and data platforms;
- Imported microprocessors and telecommunications infrastructure.

This reliance limits Europe's ability to act autonomously in the digital space.

## 11.6 Weak regulatory foresight and digital sovereignty

Although regulations like the GDPR now set global standards, for many years Europe adopted weak data protection frameworks (e.g., Safe Harbor). At the same time, it failed to build competitive alternatives to foreign digital ecosystems.

### 11.7 Case Studies: Olivetti and ARM

**Olivetti (Italy)** Olivetti, an Italian company, was a pioneer in computer design during the 1950s and 1960s. It developed some of the first commercial computers in Europe and was among the earliest to experiment with the integration of electronics and design. Most notably, the **Programma 101** (1965) is often considered the first personal computer.

However, despite its innovation, Olivetti's computing division suffered from a lack of sustained state support and strategic industrial policy. The company gradually lost its leadership position and exited the computing industry, marking a missed opportunity for Italy and Europe to lead in personal computing.

**ARM (United Kingdom)** ARM (originally Acorn RISC Machine) was founded in the UK in the 1990s and became a global leader in the design of low-power microprocessors, which are now used in the vast majority of smartphones and mobile devices worldwide.

While ARM succeeded technically and commercially, it illustrates a broader European vulnerability: the **inability to maintain sovereignty over strategic digital infrastructure**. ARM was eventually acquired by Japanese conglomerate SoftBank in 2016 and is now headquartered in the UK but operates globally with foreign investment. In 2020, it was proposed for acquisition by NVIDIA, a U.S. company, although the deal was later blocked.

This case underscores Europe's difficulty in scaling and protecting strategic technological assets in a highly competitive global market.
In conclusion, Europe's delay is not due to lack of talent or innovation, but to missed strategic choices, institutional fragmentation, and underestimation of digital technologies as a core dimension of geopolitical and economic power.

# 12 What Does "Luddite" Usually Mean, and What Does It Actually Mean?

**Common usage (misconception):** Today, the term **"Luddite"** is commonly used to describe someone who irrationally fears or rejects new technology. It is often used pejoratively to label people as anti-progress, nostalgic, or out of touch with modern innovation.

*Example:* "She refuses to use smartphones — she's such a Luddite."

**Historical meaning (actual):** Historically, the Luddites were **skilled textile workers in early 19$^{\text{th}}$-century England** (1811–1816) who resisted the introduction of industrial machinery that threatened their livelihoods.

They did not oppose technology in general, but rather the **social and economic consequences** of its deployment:

- Machines were used to undercut wages;

- Skilled labor was replaced with untrained, cheaper labor;
- Changes were implemented without negotiation or worker protections.

In this sense, the Luddites were not anti-technology — they were against the way technology was being used to exploit labor and destroy communities.

**Key point:** Luddism was a political and strategic form of resistance, not technophobia. The real issue was not innovation itself, but the **conditions under which innovation was introduced** and the absence of protections for those affected.

*In short: the Luddites were not against machines. They were against starvation.*

**The origin of the negative connotation: a political smear campaign** The negative connotations associated with the term "Luddite" did not arise organically. They were largely the result of a deliberate political and rhetorical campaign to delegitimize the movement. During the Luddite uprisings, the British government—concerned with maintaining industrial order and suppressing dissent—mobilized military forces, passed harsh laws (including capital punishment for machine-breaking), and worked with industrial elites to portray the Luddites as irrational, violent, and anti-progress.

This framing was amplified by conservative newspapers and factory owners. The goal was to strip the movement of its political legitimacy and reduce it to caricature. As a result, the term "Luddite" has continued to carry pejorative connotations into the present day, despite the fact that the original Luddites were acting with strategic intent to protect their economic survival and labor rights.

In truth, their struggle was not against machines—but against the social injustice enabled by unregulated technological change.

*Reclaiming the true meaning of Luddism means repoliticizing technological criticism and recognizing that not all resistance to innovation is irrational.*

## 13 The Office for Technology Assessment (OTA)

The Office for Technology Assessment (OTA) was a nonpartisan advisory body established by the United States Congress in 1972. Its mission was to provide anticipatory, research-based evaluations of emerging technologies and their potential social, economic, environmental, and ethical consequences.

### Cultural and Political Context

The OTA was created during a period of growing public concern about the unintended effects of unregulated technological advancement. The early 1970s saw the rise of:

- Environmental awareness (e.g., nuclear risks, pollution);
- Public skepticism toward military and industrial authority;
- The influence of the civil rights and consumer protection movements.

This cultural climate emphasized the need for democratic oversight of technological development. The OTA reflected a belief that lawmakers required expert guidance to make informed decisions about complex and rapidly evolving scientific fields.

#### Role and Purpose

The OTA's function was not to regulate, but to advise Congress through comprehensive reports on technologies ranging from energy systems to biotechnology. It institutionalized the principle that technology should be evaluated before widespread implementation—*ex-ante*—to ensure alignment with public interest and social justice.

#### Defunding and Closure

In 1995, the OTA was defunded by a Republican-led Congress that favored market-driven innovation and saw the agency as a potential obstacle to deregulation. Its closure marked a shift toward less anticipatory and more reactive governance of technological change.
The OTA remains a historical example of how democratic systems can be equipped to govern technology—if they choose to invest in institutional foresight.

## 14 Brian Winston's Model of Technological Innovation

Brian Winston, in his book *Media, Technology and Society*, proposed a social model to describe how technologies emerge and spread. He challenges the linear view of technological progress and argues that innovation is shaped by a combination of scientific knowledge, social needs, institutional structures, and power dynamics.

#### Stages of the Model

1. **Scientific Base:** A theoretical or scientific foundation becomes available, often with no immediate application.
   *Example:* Maxwell's equations in electromagnetism.
2. **Ideation:** A person or group imagines a technological application based on that base, aiming to fulfill a need or solve a problem.

3. **Prototyping:** Various actors build early, imperfect versions of the envisioned technology. Innovation is often distributed and fragmented at this stage.

4. **Supervening Social Necessity:** A societal demand—military, economic, cultural—creates the conditions for widespread adoption and investment.

   **Note:** According to Winston, the supervening social necessity is not just one phase among others—it is the essential trigger. Without it, even a fully functional prototype based on a strong scientific base may never become an "invention." The social necessity justifies the investment, scaling, and institutionalization of the technology. In this sense, invention is not merely technical; it is also a social and economic event.
   In 1855, an Italian lawyer created the Cembalo Scribano, a typewriter-like device. But society didn't feel the need for mass writing tools yet. By contrast, the telegraph was already being prototyped, but it only became an "invention" when the need to coordinate trains made it indispensable.

5. **Invention (as social recognition):** The technology is institutionalized, named, and scaled up. At this point, it becomes socially and commercially viable.

6. **Law of Suppression of Radical Potential:** Dominant institutions may delay or restrict technologies that threaten existing structures.
   *Example:* FM radio suppressed by AM broadcasters; early electric cars sidelined by oil industry.

   It is not necessarily a negative thing.
   While the Law of the Suppression of Radical Potential highlights how dominant institutions may limit disruptive technologies to preserve existing power structures, this suppression can serve different functions—some harmful, others necessary.

   In some cases, suppression is justified to:

   - Protect public health and safety (e.g., restricting premature biotech applications);
   - Allow time for democratic oversight and ethical deliberation;
   - Prevent monopolistic dominance and market instability.

   However, suppression becomes problematic when it:

   - Serves private profit over public interest (e.g., delaying electric vehicles);
   - Silences democratic expression (e.g., censoring communication platforms);
   - Obstructs socially beneficial innovation.

Therefore, suppression is not inherently good or bad—it depends on **who is suppressing what, why, and in whose interest**.

### Implications

Winston's model emphasizes that technological development is not inevitable or autonomous. It is driven by complex social forces and shaped by institutional choices, political contexts, and economic pressures.

Technologies are often delayed, suppressed, or reconfigured depending on how they align with the interests of dominant power structures.

# 15 From Ancient Computation to Modern Computing: Expanding Needs and Changing Labor

## 15.1 Pre-modern Computation: Astronomy and Census

Even before modern computing, certain human activities required extensive calculation. Two primary domains stood out:

- **Astronomy:** Used for calendar construction, agricultural planning, navigation, and political legitimacy. Civilizations like the Babylonians, Chinese, Mayans, and Islamic scholars developed astronomical tables, instruments, and predictive models.
- **Fiscal and Population Censuses:** Ancient empires maintained large-scale registries for taxation, labor distribution, and military organization. Examples include Roman censuses, Egyptian land surveys, and Chinese household registries.

## 15.2 Modernity: New Activities and Increased Computational Demand

With the Industrial Revolution and the emergence of modern states, computational needs expanded dramatically. Key domains included:

- **Navigation:** Required trigonometry, timekeeping, and celestial charts for global exploration.
- **Industrial Engineering:** Demanded precision in machinery design, material stress calculations, and thermodynamics.
- **Infrastructure Projects:** Construction of railways, tunnels, bridges, and canals involved geometry, load-bearing calculations, and hydrodynamics.
- **Large Organizations:** States and corporations needed systems for census, taxation, budgeting, logistics, and actuarial science.
- **Scientific Research:** Introduced error analysis, modeling, data processing, and standardized measurement.

This expansion of complexity created a “crisis of calculation”—a situation in which human capacities for computation became insufficient.

## 15.3 Mechanical Computing and Institutional Responses

To address these challenges, modern societies developed mechanical computing devices:

- **Charles Babbage's** Difference and Analytical Engines;
- **Logarithmic tables** and slide rules for engineers and navigators;
- **Hollerith's punched-card tabulator** for the 1890 U.S. census;
- Early tabulating machines in government, insurance, and finance.

These inventions marked the transition toward machine-assisted computation.

## 4. The Gendered Labor of "Human Computers"

Before digital computers, the term "computer" referred to a person. By the late $19^{\text{th}}$ and early $20^{\text{th}}$ centuries, many human computers were women:

- Employed for their precision and low wages;
- Active in fields such as astronomy (e.g., the Harvard Computers), ballistics (e.g., ENIAC programmers), and space science (e.g., NASA's Black women computers);
- Frequently excluded from authorship, recognition, and leadership roles despite their foundational contributions.

## Conclusion

From antiquity to modernity, the demand for computation has been continuous. Modernity intensified this need, introduced new domains of complexity, and restructured the labor and tools of computation. This historical trajectory laid the foundation for the emergence of digital computing—and for the questions of equity and visibility that still shape its development today.

# 16 Which thinkers first introduced the hypothesis that the mind worked like a machine?

The hypothesis that humans could be understood as machines—mechanical rather than exclusively biological or spiritual entities—emerged with early modern philosophy and the rise of mechanistic science. Several key thinkers contributed to this idea:

- **Raimondo Lullo** (c. 1232–1316): In the Middle Ages, Lullo developed combinatorial diagrams to model logical and theological reasoning. While his approach was mystical and theological in intent, it introduced the idea that reasoning could be systematized through symbols and rules, inspiring later efforts to mechanize thought. He thought that if we could list all the fundamental concepts (like virtue, wisdom...) we could be able to combine them in any way.

- **René Descartes** (1596–1650): Descartes proposed that the human *body* functions like a machine, composed of gears, levers, and hydraulics. Although he maintained a dualistic separation between body (*res extensa*) and mind (*res cogitans*), his view of the body as an automaton laid the foundation for later mechanistic models of the mind. He famously claimed that animals were mere machines, devoid of reason or soul.
- **Thomas Hobbes** (1588–1679): In *Leviathan*, Hobbes extended the mechanical metaphor to the whole human being. He described life as "but a motion of limbs," likening the body—and by extension, thought and emotion—to a clock or engine, where God is the watchmaker. Hobbes treated imagination, memory, and reasoning as sequences of mechanical operations, introducing a fully materialist psychology.
- **Gottfried Wilhelm Leibniz** (1646–1716): Leibniz imagined a future where reasoning could be mechanized through symbolic logic. He develops binary logic and designs a base 2 calculator. He intraduces the notion of the *calculus ratiocinator* aimed to formalize thought processes, anticipating computational models of the mind. *Calculemus!* - he wanted to the politicize conflicts by obtaining a completely rational way of "thinking"

These thinkers transformed the understanding of human nature, shifting from spiritual or vitalist models toward one in which cognition and behavior could be explained in mechanical, systematic terms. Their legacy underpins contemporary computational theories of mind and artificial intelligence.

# 17 What are the first calculating machines?

The first mechanical calculating machines were developed in the $17^{\text{th}}$ and early $18^{\text{th}}$ centuries to perform basic arithmetic operations. These devices represent the early stages of mechanizing mathematical computation.

- **The Pascaline** (1642) — *Blaise Pascal*: Invented by the French mathematician and philosopher Blaise Pascal, the Pascaline was one of the first mechanical calculators. It was capable of performing:
  - **Addition**
  - **Subtraction** (through complementary techniques)

  The machine used a system of interlocking gears and was designed to assist Pascal's father, a tax collector, in carrying out routine calculations.

- **Leibniz's Stepped Reckoner** (1673–1700) — Leibniz improved on Pascal's design by creating a machine capable of performing all four basic arithmetic operations:

  - **Addition**
  - **Subtraction**
  - **Multiplication**
  - **Division**

  His device used a stepped drum mechanism (known as the "Leibniz wheel"), which remained influential in later calculator designs.

Both machines were manually operated and mechanically complex, but they mark the beginning of the automation of calculation. They also reflect the broader intellectual context of early modern Europe, which increasingly sought to systematize and mechanize knowledge.

## 18 What was "Leibniz's Dream"?

Gottfried Wilhelm Leibniz envisioned a future in which human reasoning could be mechanized and rendered as precise as arithmetic. His dream combined two key components:

1. **A universal catalogue of all human concepts:** Inspired by Ramon Llull's combinatorial diagrams, Leibniz imagined a symbolic system in which every idea could be broken down into its logical components and systematically represented. This would allow the classification and manipulation of knowledge using a universal language.

2. **The algebric formalization of logic:** Leibniz sought to transform Aristotelian syllogistic logic into a symbolic, rule-based system—essentially, to *algebraize* deductive reasoning. This would make logical inference a matter of calculation.

These two elements would enable what he famously described as a future of rational dispute resolution:

> "*When there are disputes, there will be no need for argument between two philosophers. We shall simply say: let us calculate.*"

This vision laid the foundation for modern symbolic logic, algorithmic reasoning, and, ultimately, the idea of computing machines capable of simulating thought.

# 19 Who Actually Managed to Algebraize Aristotle's Logic?

Leibniz's dream of transforming Aristotelian logic into a symbolic, algebric system was first realized by the English mathematician and logician:

**George Boole** (1815–1864), who wanted to prove that the logical reasoning can be mathematically formalized. In the 1840s, Boole developed what is now known as **Boolean algebra**, a formal system that uses binary variables and logical operators (such as AND, OR, NOT) to represent and manipulate logical statements.

Boole's work successfully:

- Abstracted classical syllogistic logic into an algebraic form;
- Provided a mathematical structure for logic;
- Laid the foundation for modern symbolic logic and digital circuit design.

Boole's achievement turned logical reasoning into a calculable process, thus fulfilling one of the core aspirations of Leibniz's philosophical project.

# 20 Hilbert's project to prove the foundations of mathematics and the beginning of computer science

At the turn of the $20^{\text{th}}$ century, the German mathematician **David Hilbert** launched a program to formalize all of mathematics using a finite set of axioms and rules of inference. The goal was to demonstrate that mathematics was:

- **Complete**: every true mathematical statement could be proven;
- **Consistent**: no contradictions could arise within the system;
- **Decidable**: there existed an algorithmic procedure to decide the truth or falsity of any mathematical statement.

However, two foundational breakthroughs in the $20^{\text{th}}$ century disrupted this project and simultaneously laid the groundwork for modern computer science:

- **Kurt Gödel's Incompleteness Theorems** (1931): Gödel proved that in any sufficiently powerful formal system (like arithmetic):
  - There are true statements that cannot be proven within the system (incompleteness);
  - The system cannot demonstrate its own consistency.

This shattered the hope that mathematics could be both complete and self-contained.

- **Alan Turing's 1936 Paper**: Turing approached the problem of *decidability* using an abstract machine model (now called the **Turing Machine**). He proved that:
  - Some mathematical problems are undecidable—not because they are false, but because no algorithm can determine their truth in a finite number of steps.
  - The notion of **computability** could be formally defined using machines that manipulate symbols step-by-step according to finite rules.

Turing's work not only confirmed Gödel's negative result from a computational perspective but also gave rise to the theoretical foundations of **computer science**. His abstract machines became the model for what it means to compute—and continue to underpin the theory of algorithms and programming today.

# 21 What is a Turing Machine?

A **Turing Machine**, introduced by Alan Turing in 1936, is a hypothetical computational device designed to formalize the concept of algorithmic computation. It serves as an abstract model of a general-purpose computer.

**Key Features:**

- It consists of an infinite tape divided into discrete cells, each capable of holding a symbol (usually binary: 0 or 1).
- A read/write head moves along the tape one cell at a time.
- The machine is governed by a finite set of instructions (a "program") that dictate:
  - What to write or erase on the tape;
  - Whether to move left or right;
  - How to update the internal state of the machine.
- At each step, the machine's behavior depends **only on the current state and the symbol it reads**—not on any history or external context.

**Computational Power:** Despite its simplicity, a Turing Machine can implement **any algorithm** that can be described using finite rules. It captures the essence of what it means to compute.
Turing's insight was that even this minimal device could model any computation performable by a human using pencil and paper—provided enough time and tape. This idea became the foundation for the modern theory of computation and the design of digital computers.

**Conclusion:** A Turing Machine is not a physical machine but a conceptual model that illustrates how **simple mechanical rules**, applied step-by-step, can execute **any algorithmically definable process**.

# 22 Between the Second Half of the 19th Century and the 1930s, What Kind of Office Equipment Became Popular?

During this period, rapid industrialization, urbanization, and the expansion of public administration created an increasing need for the mechanization of clerical tasks. This gave rise to a new set of office technologies that automated writing, calculating, and data management—especially in large bureaucracies, insurance companies, banks, and census offices.

## 22.1 Mechanical Calculators

Mechanical calculators (such as the Arithmometer and later devices) became widespread in offices for performing arithmetic operations. These machines:

- Allowed users to perform addition, subtraction, multiplication, and division;
- Replaced manual computation and reduced human error;
- Were used in banking, taxation, and administrative accounting.

*Significance:* They accelerated and standardized numerical work, anticipating the logic of later computational machines.

## 22.2 Electromechanical Calculators

By the early 20$^{\text{th}}$ century, mechanical calculators were gradually electrified, leading to faster and more reliable electromechanical models. These devices:

- Could perform chained operations more efficiently;
- Began to integrate features like automated printing of results;
- Were especially useful in large financial or governmental offices.

## 22.3 Typewriters

The typewriter was one of the most transformative office technologies of this period. It:

- Standardized and professionalized office writing;
- Enabled faster document production compared to handwriting;
- Was associated with the feminization of office labor (typists and secretaries).

*Cultural impact:* The typewriter helped define the modern office as a space of mechanical routine and information standardization.

## 22.4 Sorting and Tabulating Machines

**Herman Hollerith** developed punched-card tabulating machines for the 1890 U.S. Census. These machines:

- Used punched cards to encode information (e.g., age, race, occupation);
- Mechanically sorted and counted data categories;
- Greatly accelerated statistical processing in large organizations.

*Evolution:* Hollerith's company eventually became **IBM**, which continued to produce data processing systems used in government, insurance, and railways.

## 22.5 Conclusion

From mechanical calculators to punched-card sorters, this period witnessed the birth of the modern office as a site of routine computation and mechanized record-keeping. These tools were not just about efficiency—they redefined the nature of clerical work and laid the infrastructural foundations for digital computing.

# 23 What Did the Word "Computer" Mean Until the 1960s?

Until the mid-20$^{th}$ century, the term **"computer"** referred not to a machine but to a person. Human computers were individuals—often women—employed to carry out complex mathematical calculations by hand or using mechanical calculators.

### 23.1 Human Computers

- Worked in astronomy, ballistics, engineering, and statistics;
- Used mechanical calculators (e.g., arithmometers, electromechanical machines);
- Played essential roles in scientific and military institutions, including NASA, observatories, and weapons labs.

*Cultural Note:* The feminization of this labor (especially from the early 20$^{\text{th}}$ century onward) meant that many essential contributors to scientific computing remained historically invisible or under-credited.

## 24 How Were Large Calculations Handled from the 1790s to the 1960s?

Before the widespread adoption of electronic computers, large-scale computations were executed using a **factory model** of labor. This method, in use from the late 18$^{\text{th}}$ century through the mid-20$^{\text{th}}$, broke down complex calculations into smaller, discrete tasks and distributed them among many human computers.

### 24.1 The Factory Approach to Calculation

- Calculations were divided into small operations that could be performed by individuals working in parallel;
- Teams were coordinated hierarchically, often with supervisors who organized work and verified results;
- Redundancy techniques were used: the same calculation was assigned to two or more separate groups to minimize errors;
- Tabulated results were compiled into printed tables (e.g., logarithms, astronomical charts, artillery firing tables).

*Historical Examples:*

- French revolutionary *Tables du Cadastre* project (1790s);
- British Nautical Almanac;
- U.S. and German wartime ballistics calculations.

## 24.2 Significance

This period saw the emergence of computation as organized labor—anticipating the logic of later digital systems. Though manually executed, the system already reflected key principles of modern computing: modularity, parallelism, redundancy, and supervision.

# 25 The Evolution of Calculators from Z3 and ENIAC to Today

The development of calculators and computers followed a historical trajectory marked by increasing speed, automation, miniaturization, and accessibility. From electromechanical machines to intelligent devices, each generation of computing technology transformed what could be calculated and who could calculate.

## 25.1 Z3 (1941)

Developed by Konrad Zuse in Nazi Germany, the **Z3** was the first fully functional programmable electromechanical computer. It used binary arithmetic and executed instructions via punched tape.

*Significance:* Introduced the principle of general-purpose programmable computation. Its impact was limited by the wartime context and lack of postwar continuity.

## 25.2 Harvard Mark I (1944)

An electromechanical relay-based computer developed by Howard Aiken at Harvard University with IBM support. It performed sequential operations and was used by the U.S. Navy for **ballistic and mathematical calculations**.

*Significance:* Demonstrated the feasibility of large-scale automatic computation in military and scientific contexts.

## 25.3 ENIAC (1945)

The **ENIAC** (Electronic Numerical Integrator and Computer), developed by Mauchly and Eckert, was the first general-purpose fully electronic computer. It used vacuum tubes and was exponentially faster than its electromechanical predecessors.

*Significance:* Introduced high-speed electronic computation. Programs were wired manually, limiting flexibility but proving electronic machines viable.

## 25.4 EDVAC and the von Neumann Architecture (1949)

EDVAC implemented the revolutionary concept of the **stored-program architecture**, whereby both data and instructions were stored in memory. Proposed by John von Neumann, this design became the foundation of modern digital computers.

*Significance:* Enabled flexible, programmable computation and became the standard model for subsequent computing systems.

### 25.5 UNIVAC (1951)

The **UNIVAC I** (Universal Automatic Computer) was the first commercial computer in the United States, designed by the creators of ENIAC. It was used by the Census Bureau and private industry.

*Significance:* Marked the transition from military/scientific machines to commercial and administrative computing. Its televised prediction of the 1952 U.S. presidential election showed the power of electronic computation to the public.

## 26 The Development of Electronic Computing During World War II

According to Brian Winston's model, a technology spreads and matures when a **supervening social necessity** justifies its development and deployment. The Second World War created several such necessities that led to the invention or acceleration of computing technologies across multiple countries.

### 26.1 The Supervening Social Necessity in the United States: Ballistics

In the United States, the development of the first electronic computer—the **ENIAC** (Electronic Numerical Integrator and Computer)—was directly linked to a military need: the rapid and accurate computation of **ballistic firing tables** for artillery.

- These tables were essential to correctly aim long-range weapons;
- Human computers and electromechanical calculators were too slow and error-prone;
- ENIAC, developed at the University of Pennsylvania, could perform in seconds what previously took days.

*Outcome:* The military investment in ENIAC marks a clear case of technological acceleration driven by wartime necessity. It became the first general-purpose, fully electronic, programmable computer.

## 26.2 Other WWII Computing Developments: The UK and Germany

Besides the U.S., significant developments in computing occurred in:

- The United Kingdom (cryptanalysis and special-purpose machines);
- Germany (programmable electromechanical computers).

### 26.2.1 The United Kingdom: Cryptographic Computation at Bletchley Park

At Bletchley Park, British mathematicians and engineers developed machines to assist in decrypting enemy communications, particularly the German Enigma. These machines were **special-purpose**—designed for very specific tasks, not general computation.

*Significance:* Though not general-purpose, the work at Bletchley Park pushed forward the design of high-speed, programmable logic systems. It also introduced the idea of machine-based intelligence in codebreaking.

### 26.2.2 Germany: Zuse's Z3 and the First Programmable Machine

German engineer **Konrad Zuse** developed the **Z3** in 1941, which is considered the first fully functional, **general-purpose programmable electromechanical computer**.

- Used binary floating-point arithmetic and was Turing-complete in principle;
- Lacked large-scale institutional support and was largely unknown outside Germany;
- The Z3 was destroyed in Allied bombings, and Zuse's work remained marginal until rediscovered post-war.

*Significance:* Zuse's Z3 was a technological milestone, but without a strong institutional or military integration, it had less immediate impact than ENIAC or Colossus.

## 26.3 Conclusion

World War II provided the **supervening social necessities**—military accuracy, cryptanalysis, and scientific warfare—that led to major breakthroughs in computation. Each country took a different path:

- **The U.S.** developed a general-purpose **electronic** computer (ENIAC);
- **The U.K.** built **electronic special-purpose** machines for cryptanalysis;

- **Germany** created the first **general-purpose electromechanical** computer (Z3), though with less immediate impact.

These parallel developments shaped the foundational landscape of modern computing.

# 27 The Computing Scenario from 1946 to 1956

The decade following World War II was a foundational phase for the development of electronic computing. Between 1946 and 1956, computers were:

- Large in size and power consumption;
- Extremely expensive to build and maintain;
- Difficult to program and operate;
- Very few in number, and concentrated in government, military, and scientific institutions.

Despite these limitations, this period saw the emergence of both national computing programs and the early formation of a computer industry.

## 27.1 United States

After the government-funded prototypes such as **ENIAC**, **EDVAC**, and **IAS**, the United States became the birthplace of the commercial computer industry.

- In **1951**, the first commercial computer—the **UNIVAC I**—was delivered.
- Between 1951 and 1954, around **20 UNIVAC systems** were sold, primarily to:
  - U.S. government agencies (e.g., Census Bureau, military);
  - Large industrial corporations (e.g., U.S. Steel, insurance firms).
- UNIVAC was also used in nuclear weapons development, including the design of the hydrogen bomb.

*Significance:* The U.S. laid the groundwork for the computer as a dual-use (civilian and military) infrastructure.

## 27.2 United Kingdom

The U.K. continued its computing efforts through institutions linked to Alan Turing's wartime work.

- Major post-war research centers included the **University of Manchester** and the **National Physical Laboratory**.

- Unlike the U.S., the U.K. built a **smaller-scale computer**, focusing on compactness and experimental architectures.
- The Manchester Baby (1948) was the first working computer to use a stored program.

*Significance:* The U.K. remained technologically innovative, though lacked the industrial scale of the U.S.

### 27.3 Germany

Konrad Zuse, who had already built the Z3 during the war, founded the **world's first commercial computer company** in 1949.

- In the same year, Zuse's **Z4** became the first commercial computer installed in Europe, delivered to **ETH Zurich**.
- Zuse's company produced general-purpose electromechanical computers, although they were limited in production and reach.

*Significance:* Germany made an early move toward computer commercialization, although its impact was initially modest compared to U.S. developments.

### 27.4 Conclusion

Between 1946 and 1956, computing transitioned from wartime innovation to postwar infrastructure. Though machines were still rare, costly, and cumbersome, this period laid the technical, institutional, and commercial foundations for the global computer revolution that would follow.

## 28 The Olivetti Experience in Computing (1949–1963)

Between 1949 and 1963, Olivetti—originally a typewriter and mechanical calculator company—undertook one of the most advanced and visionary experiments in computing in postwar Europe. Its trajectory combined technological innovation, aesthetic design, and a unique corporate philosophy grounded in humanism and social responsibility.

### 28.1 Origins and Early Research (1949–1955)

- In **1949**, Olivetti launched its first internal studies on electronic computing, initially inspired by the American ENIAC and EDVAC models.
- A dedicated electronic research lab was established in **Pisa** in 1955, signaling a transition from mechanical to electronic computation.

*Significance:* Olivetti became the first Italian company—and among the first in Europe—to invest seriously in digital electronics.

## 28.2 The First Italian Computer: ELEA

- In **1957**, the **ELEA 9001** prototype (ELaboratore Elettronico Aritmetico) was developed in Pisa.
- In **1959**, Olivetti began industrial production with the **ELEA 9003**, a fully transistorized commercial computer.
- The machine was praised for its reliability, modular architecture, and exceptional industrial design (by Ettore Sottsass).

*Use Cases:* Banks, insurance companies, and public institutions adopted ELEA systems for large-scale data processing.

## 28.3 A Humanist Vision of Technology

Under the leadership of **Adriano Olivetti**, the company embraced a philosophy that combined:

- Technological innovation;
- Worker well-being and community development;
- Aesthetic design and architectural excellence.

*Vision:* Computing was not only an industrial opportunity but also a cultural and ethical project that should reflect human values.

## 28.4 Crisis and End of the Computing Division (1962–1963)

- In **1960**, Adriano Olivetti died suddenly, leaving a leadership vacuum.
- By **1962–63**, the computing division (Divisone Elettronica) was sold to General Electric.
- The sale marked the end of Olivetti's role as a major independent player in computing.

*Consequences:* Italy lost its most promising position in the international computer industry. The sale is still viewed as a turning point of missed national technological sovereignty.

## 28.5 Conclusion

The Olivetti experience was one of the most advanced, elegant, and ethically oriented attempts to create a European alternative to American computer dominance. Despite its premature end, it remains a key chapter in the history of computing—and a rare example of integrating industrial technology with social and cultural ambition.

# 29 Olivetti's Computing Activities (1963–1993)

After the sale of its electronic computing division to General Electric in 1964, Olivetti did not abandon computing. Instead, the company shifted focus toward integrating electronics into office machines and later entered the personal computing market. Between 1963 and 1993, Olivetti remained a key player in the transition from electromechanical to digital office technologies.

## 29.1 Programma 101 (P101)

- Released in **1965**, the **Programma 101** was a revolutionary product—often considered the **first personal computer** or programmable desktop calculator.
- It was developed by a small team of Olivetti engineers led by **Pier Giorgio Perotto**[1], who worked on the machine **in their spare time**[2].
- Despite the dismantling of the main computing infrastructure, this team designed a compact, elegant, and programmable device capable of:
  - Performing basic arithmetic operations;
  - Storing values and instructions in memory;
  - Executing simple programs via magnetic cards.
- The P101 was widely adopted in institutional contexts, including by **NASA**, and was publicly showcased at the **1965 New York World's Fair**[3].

*Significance:* The Programma 101 was not only a technical success, but also a symbolic act of innovation without institutional mandate. It anticipated key aspects of the personal computer—accessibility, programmability, portability—years before the PC revolution.

## 29.2 Computerized Typewriters and Word Processors

Throughout the 1970s and early 1980s, Olivetti remained a world leader in typewriter production by gradually transforming them into digital machines.

- Developed **electronic typewriters** with built-in logic and memory;
- Created **word processing systems** with limited editing and formatting capabilities;

[1] Perotto was an engineer who had worked on earlier computing efforts within Olivetti. After the sale of the electronic division to GE, he continued research independently.

[2] The development occurred after the 1964 sale of Olivetti's electronic division to General Electric. Lacking official institutional support, the team worked informally and with limited resources.

[3] The Programma 101 received international acclaim at the 1965 World's Fair in New York, where it was celebrated as a futuristic office machine.

- These devices bridged the gap between analog machines and full personal computers.

*Impact:* Preserved Olivetti's dominant role in office equipment while preparing its user base for digital transition.

### 29.3 Olivetti Personal Computers (1980s–1990s)

In the 1980s, Olivetti launched a series of personal computers, competing in both European and international markets.

- **M20** (1982): Based on the Zilog Z8000 processor; ran Olivetti's proprietary operating system (PCOS).
- **M24** (1983): Fully IBM PC compatible; became one of Olivetti's best-selling models internationally.
- Additional models included laptops, servers, and workstations throughout the late 1980s and early 1990s.

*Strategy:* Combined hardware design with software integration and international partnerships (e.g., AT&T).

### 29.4 Conclusion

Between 1963 and 1993, Olivetti continued to play a major role in the evolution of computing—transitioning from programmable calculators to personal computers. While no longer an independent computing innovator at the scale of the ELEA era, it remained a crucial European actor in office automation and early PC history.

## 30 In Which Other Industries, Besides Computing, Was Italy at the Forefront in the Early 1960s?

During the Italian economic boom, the country was not only active in the development of computers, but also among the international leaders in two other strategic sectors: oil and gas, and nuclear energy.

### 30.1 ENI and Enrico Mattei

Enrico Mattei, former partisan, became the head of a small state-owned oil company initially intended for liquidation;
Instead, he transformed it into a major industrial force: **ENI** (Ente Nazionale Idrocarburi);
In the 1950s, Mattei established ENI as an independent national oil company;

He challenged the dominance of the major American and Dutch oil corporations by offering significantly more favorable contracts to oil-producing countries;
His actions gained him many enemies, and in 1962 he died in a mysterious plane crash, suspected to be a sabotage.
*Note:* Mattei's legacy remains central to discussions about Italy's energy independence.

### 30.2 Nuclear Energy and Felice Ippolito

After World War II, there was widespread enthusiasm for nuclear energy, especially for civilian uses;
Italy, a country with limited domestic energy resources, saw nuclear power as a great opportunity;
**Felice Ippolito**, a geologist and engineer, was one of the first to promote civilian nuclear power in Italy;
He founded the **CNEN** (Comitato Nazionale per l'Energia Nucleare), aiming to make Italy a leader in the field;
Major industrial actors such as **FIAT** also took interest in nuclear energy, viewing it as a strategic resource;
In 1964, Ippolito was arrested for alleged administrative irregularities in the management of CNEN. This led to his removal and a general downsizing of the entire Italian nuclear program.

*Note:* The decline of nuclear ambition in Italy began with the fall of its most prominent institutional promoter .

## 31 What Did Enrico Fermi Recommend the University of Pisa to Do in 1954?

In 1954, **Enrico Fermi** wrote a letter to the rector of the University of Pisa in which he advised the university to **design and build their own electronic computer**, rather than purchase one from abroad.

- Fermi saw in the construction of a domestic computer an opportunity to strengthen the entire national research system;
- His suggestion gave rise to the **CEP project** (*Calcolatrice Elettronica Pisana*);
- The CEP was developed with the support of **Olivetti**, and became one of the first Italian computing initiatives;
- The first prototype was completed in **1957**, and the final version released in **1961**;

- The machine combined vacuum tubes and transistors and was among the earliest to use the **Fortran** programming language for scientific applications.

*Significance:* The CEP marked a major step in postwar Italian computing, demonstrating that university-industry collaboration could lead to pioneering digital technologies

### 31.1 The Link with Olivetti and Mario Tchou

The CEP project at Pisa created a fertile environment that would soon lead to further advances in Italian computing through collaboration with **Olivetti**. This connection was catalyzed by:

- The recruitment of **Mario Tchou**, a young Italo-Chinese engineer trained at Columbia University;

- Tchou was hired by Olivetti in **1955** and tasked with creating an independent electronics division in Pisa;

- This new division would later produce the **ELEA 9003**, one of the most advanced transistorized commercial computers in Europe;

- The Pisa-based collaboration between academia and industry represented an early and visionary model of innovation in the Italian context.

*Significance:* Fermi's recommendation not only initiated the CEP project, but also indirectly led to Olivetti's deeper involvement in digital computing—through Pisa, Tchou, and the creation of a national electronics industry with global aspirations.

## 32 Main Technical Developments in Computing Between 1947 and 1974

- **Transistor** (1947)
  Replaces vacuum tubes; allows smaller, more reliable, and energy-efficient components.

- **Integrated Circuit** (1957)
  Combines multiple components on a single chip; enables miniaturization and faster performance.

- **Microprocessor** (1969)
  Central processor on a single chip; represents a major step in computing integration.

- **First commercially available microprocessor: Intel 4004** (1971) Originally developed for a calculator; became general-purpose and widely adopted.
- **First microprocessor-based personal computer: Altair 8800** (1974) Sold as a kit; opened the era of personal computing.

*As a result of these innovations, computers began to proliferate: they became progressively smaller, cheaper, and easier to program and use.*

# 33 What Architectural Choices Were Made When Designing the First Personal Computers (and Above All the IBM PC, 1981)?

The architecture of the first personal computers—and especially that of the **IBM PC**, released in 1981—was based on a set of open and modular principles that allowed flexibility, interoperability, and rapid adoption. The key architectural choices were:

1. **Perfectly Known Hardware**
   - The technical specifications of the IBM PC's hardware were fully published;
   - This openness enabled third parties to produce compatible hardware ("IBM-compatible PCs").
2. **Operating System Independence**
   - The IBM PC was designed to support multiple operating systems;
   - MS-DOS became the most popular, but the hardware allowed others to be developed and used.
3. **Application Flexibility**
   - Any developer could write and distribute software for the platform;
   - There were no restrictions imposed by IBM on third-party applications.

*Significance:* These three choices—**open hardware**, **OS independence**, and **application openness**—made the IBM PC a general-purpose platform. They also allowed the PC ecosystem to grow explosively through contributions from third-party developers and manufacturers.

# 34 ARPANET and Internet Origins, with Its Military Significance

The origins of ARPANET—and later, the Internet—are deeply embedded in the military and strategic concerns of the Cold War era.

## 34.1 Origins of ARPANET

- After the launch of the Soviet satellite Sputnik (1957), the United States intensified investment in high-risk scientific research;
- In 1958, the U.S. Department of Defense created **ARPA** (Advanced Research Projects Agency) to coordinate this effort;
- One of ARPA's major projects was **ARPANET**, the first packet-switching computer network, launched in 1969;
- The network initially connected UCLA, Stanford Research Institute, UC Santa Barbara, and the University of Utah

## 34.2 Military Objectives and Significance

- ARPANET was designed to create a **resilient, distributed communication network** capable of withstanding failures or attacks—key concerns in the context of nuclear war;
- The goal was to interconnect the computing resources of different branches of the military (Army, Navy, Air Force) to ensure operational continuity
- Analog telephone systems were vulnerable to interception—digital networks like ARPANET promised encrypted, secure communication;
- Real-time communication (including early concepts of videoconferencing) was envisioned for battlefield coordination and presidential command

## 34.3 Field Applications and Strategic Use

- During the Vietnam War, ARPA deployed **sensor networks** (acoustic, seismic, chemical) to track enemy movement, with data transmitted to command centers in real time;
  This anticipated the development of digital command rooms and automated targeting systems
- ARPA also funded extensive **social science research** (anthropology, sociology, psychology) to model local power structures and influence populations, especially in Southeast
  The need to rapidly collect, analyze, and share massive datasets drove advances in **database systems, information retrieval, and communication protocols**—all foundational for today's Internet

### 34.4 Conclusion

ARPANET was not a neutral scientific initiative: it was born from strategic imperatives of the Cold War. The goal was **not just to improve communication**, but to support **military command, surveillance, and control**. What we now call the Internet emerged from this infrastructure, shaped by decades of military funding, experimentation, and geopolitical pressure.

## 35 The Birth of the Internet: ARPANET, NSFNet, Privatization and Sociological Concerns

### 35.1 From ARPANET to NSFNet

- The development of **ARPANET** began in 1969 under the U.S. military agency ARPA (later DARPA), aiming to create a resilient, decentralized communication network capable of withstanding failures and attacks;
  It was designed to interconnect incompatible military systems and ensure global communication between command centers in real time;
- The network introduced **packet switching**, a key innovation later reused in Internet protocols;
- By the 1970s, services such as **email**, **file sharing**, and even early voice communication were available on ARPANET;
- In 1980, ARPA declared its goals completed and transferred civilian management to the **National Science Foundation (NSF)**, which created **NSFNet**, a network for universities and research institutions.

### 35.2 The Privatization of the Network

- During the Reagan era, public investment gave way to market-driven policies;
  NSFNet, although publicly funded, was gradually opened to commercial Internet Service Providers (ISPs);
- By **1995**, the infrastructure (cables, routers, backbone) was entirely in private hands;
- No public referendum or political debate preceded the transition—it was an administrative decision made by bureaucrats and technicians
  Attempts to reserve part of the network for civic use (education, NGOs) failed.

*Outcome:* The network originally built with public and military funds became the foundation for the global commercial Internet.

## 35.3 Sociological Concerns and the Origins of Profiling

- During the Vietnam War, ARPA funded large-scale social science research—especially in Southeast Asia—aimed at modeling human behavior and controlling populations;
- Psychologists, anthropologists, and sociologists were employed to study social structures and design predictive models of insurgency and obedience;
- In **Thailand**, researchers funded by ARPA conducted a project to identify the "ideal psychological profile" of the perfect U.S. soldier:
  - Variables such as education, family background, job history, religion, and hobbies were collected;
  - The goal was to identify the conditions under which a soldier would **obey orders without question—even to kill**
  - This represents one of the earliest examples of **predictive social profiling through data aggregation**.
- These methods prefigure modern algorithmic profiling and behavioral prediction based on user data;
- With the expansion of the Web, profiling shifted from soldiers and populations to consumers and citizens—through **IP tracking**, **click patterns**, and **content preferences**;
  In the United States, the practice of compiling **personal dossiers** and evaluating citizens through a **credit scoring system** has been widespread since the $20^{\text{th}}$ century;
  This system aggregates behavioral and financial data to assess individuals' trustworthiness and grant or deny access to loans, housing, and even employment;
  Structurally, it shares many features with the later **Chinese "social credit" system**, which similarly combines behavioral tracking, state databases, and algorithmic reputation scoring to enable or restrict citizens' rights

*Significance:* The logic of profiling—first deployed in military and colonial contexts—was inherited by the digital infrastructure of the Internet, often without public awareness or ethical safeguards.

## 35.4 Conclusion

The Internet did not arise solely from entrepreneurial ingenuity. It grew from a complex interaction of:

- Military needs;
- Public research funding;

- Administrative decisions;
- And, later, private appropriation.

It enabled extraordinary innovation and global connectivity—but also facilitated the rise of surveillance infrastructures and data-driven control mechanisms still debated today.

# 36 Did the Personal Computer Create the Software Industry for Standalone Software?

Yes. The advent of the **personal computer**—especially starting from the late 1970s and early 1980s—led directly to the birth of the software industry focused on **standalone applications**.

Before the PC, most software was developed in-house for mainframes or bundled with hardware by manufacturers;
With the spread of personal computers, a market emerged for independently developed software that users could install, run, and update on their own machines
This new model enabled the rise of companies like **Microsoft**, which began by developing interpreters and operating systems, and later led the market in standalone applications (e.g., word processors, spreadsheets)
Many other companies followed, creating a rich ecosystem of productivity, educational, gaming, and creative software for home and business use.

*Significance:* The personal computer shifted software from being a service or accessory to becoming a standalone, commercial product—thus founding the modern software industry.

# 37 What Was the Socio-Cultural-Political Environment That Shaped the Design of the Personal Computer (and of the Internet)?

The design and diffusion of both the **personal computer** and the **Internet** were influenced not only by technological advances, but by the broader socio-cultural and political environment of the late 1960s and 1970s.

## 37.1 Counterculture and Technological Imagination

- The **counterculture** of the 1960s and 1970s rejected centralized authority and promoted decentralization, self-expression, and technological empowerment;

- This influenced the idea of the computer not as a tool for bureaucracy or military command, but as a **personal and creative device** for individuals;
- Initiatives like the *Whole Earth Catalog* and communities around early hacker culture promoted access to tools as a form of liberation.

## 37.2 Social Awareness Among Scientists and Engineers

- The Vietnam War, Cold War militarization, and environmental crises led many researchers to reflect critically on the societal impact of their work;
- There emerged a strong push for **responsible innovation** and for technologies that would serve civil society rather than state or corporate control;
- The creation of user-centered computing environments reflected a broader desire to democratize access to information and computational power.

## 37.3 Political Institutions and Technology Oversight

- In 1972, the United States Congress established the **Office of Technology Assessment (OTA)** to evaluate the long-term consequences of technological developments;
- This marked a growing awareness in political institutions of the need for anticipatory governance and democratic oversight over emerging technologies.

## 37.4 Conclusion

The personal computer and the Internet were born not just from laboratories, but from a historical moment that valued decentralization, civil empowerment, and critical reflection on technology's societal impact. These cultural values left a lasting imprint on how these systems were initially designed and perceived.