# What is Technology?

Waseda University, SILS,
Science, Technology and Society (LE202)

# The concept of *technology*

The concept of technology, in its modern sense, developed slowly in the late 19th and early 20th centuries, probably due to the development of new socio-technological systems, such as the rail lines and the telegraph.

Prior to this what we call technology was called "machinery" or "mechanical arts," and the neologism *technology* was used to refer to the study of these.

- K. Marx: "Technology discloses man's mode of dealing with Nature, the process of production by which he sustains his life, and thereby also lays bare the mode of formation of his social relations, and of the mental conceptions that flow from them."

The use of the word *technology* (*Technik*, 科学技術) began in the beginning of the 20th century. Technology then became *reified* and the word was also expanded to refer to non-mechanical means of production as well.

# Technology as object

- The commonsense view identifies technology with certain types of objects, such as tools, machines, electronic devices and consumer products.
- We can characterize technology as made up of these machines, and classify and study them. For example:
  - There are active "machines" that produce certain types of motion: printing press, steam engine, etc.
  - And inactive "machines" such as posts, walls, architectural structures.
- Tools can be seen as extensions of the human body.
  - Clothes are extensions of our skin and hair, simple tools extend our hands, electronic media extends our nervous system, etc. (Kapp, *Elements of a Philosophy of Technology*, 1877.)
  - Artificial intelligence (AI) could be regarded as an extension of the human mind.
- In this view, technology is considered as the sum total of certain types of human-made objects, and its volition is ours.

# Technology as process

- Another important aspect to technology are the processes by which these things are *made* and *used*.
  - Engineers tend to focus on *making* things, social scientists on *using* them.
- We can think of technical operations as human activities carried out in a standardized way and *technology itself* as arising as an *epiphenomena* of these.
- The fundamental process of *modern technology* is often identified as the *rational pursuit of efficiency*.
  - For example, the production of food goes from an activity governed by various social or religious sanctions to one governed by standardized, automated procedures.
- Some argue that if all human action is governed by the *ideal of efficiency*, we are in danger of loosing human freedoms. Others counter that rationality, materialism and practical creativity can also be paths to human freedom and fulfillment.

# Technology as knowledge

- We may also take technology broadly as a collection of *ways of knowing* through intervening and controlling.
  - For example we have *sensorimotor skills* (writing on a computer, playing sports), craft-knowledge or *rules of thumb* (cooking), *pragmatic laws* (if we do $A$, we will get $B$), and *theories* (computing, aerodymanics $\rightarrow$ theory of flight), etc.
- In this view, technology becomes an essential constituent of human nature – *homo sapiens*, "man the knower."
- This way of conceiving of technology gives rise to technological philosophies: cybernetics, systems theory, etc.
  - Norbert Wiener (1948): *Cybernetics: Control and communication in the animal and in the machine*.
  - Konrad Zuse (1967): *Rechnender Raum* (calculating space).
- This view reduces objects to processes and instead of focusing on the flow of force, or energy, we are interested in the flow of *information*. A machine becomes an information linkage.

# Technology as volition

- The control of processes depends not only on knowledge of the system, but also on *aims*, *intentions*, *desires*, *choices*.
- It is often assumed that technology is neutral, value-free, and that it simply responds to some act of human will. This is the view of technology as an *extention of human will*.
- It is also possible, however, to think of technology as a kind of volition.
  - We say "I will" in about three senses: "I desire," "I move my body," and "I consent." Technological desires create technological processes, which give rise to new objects, processes and knowledge, which in turn is supported by consent to the technological presence.
  - For Martin Heidegger, technology is not simply objects, processes or theories, but the whole modern volitional stance towards the world. It is an *impersonal volition*.

# Technology as applied science

- A common view, going back the early modern period (Bacon, Descartes, etc.), is the claim that technology is the application of scientific knowledge.
  - Vannevar Bush (MIT Prof., head of the US Office of Scientific Research and Development): "Basic research ... creates the funds from which the practical applications of knowledge must be drawn. New products and new processes do not appear full-grown. They are founded on new principles and new conceptions, which in turn are painstakingly developed by research in the purest realms of science ..."
- This view was championed in the early part of the $20^{\text{th}}$ century and formed the basis for the establishment of government and industrial research labs.

**Definition (The linear model)**

Basic research ➛ Applied research ➛ Development ⟶ Production

# Questioning the model

- Again, historians and sociologists began to point out that the linear model rarely functioned in practice.
- For example, it is difficult to demonstrate the links empirically. In the 1960s, the US Department of Defence carried out a program to investigate how valuable research was in the production of 20 weapons systems: 91% technological, 8.7% applied science, 0.3% basic science.
- Moreover, scholars began to notice that it is difficult to differentiate between scientific and technological research. Technoscientists use whatever means they must to advance their projects.
    - Scientific knowledge is a resource that engineers use, while at the same time, technical knowledge is a resource that scientists use, etc.
- Rosenberg (1991): "The linear model ... is dead."

# Technological knowledge traditions

- In the linear model, the traditions of engineering know-how are downplayed.
- The history of technology reveals traditions of technical knowledge that are often distinct from scientific knowledge, but which also require extensive study to master.
  - L.J. Henderson (1917): "Science owes more to the steam engine than the steam engine owes to science."
  - The history of aircraft engineering shows that engineers utilize scientific theory when they are able or must, but also develop their own theories.
- Engineers often develop theories in a purely engineering context, without reference to contemporary scientific theories.
- Engineers have their own knowledge traditions, which depend on social networks and material circumstances and which shape the work they do and their conception of this work.
- That is, there are paradigms for engineering work.

# Technology as history

- A number of thinkers have put forward the idea that technology is the *driving force* in history (F. Bacon, K. Marx, etc.).
  - Marx: "The hand-mill gives you a society with the feudal lord, the steam-mill, society with the industrial capitalist."
  - Engles: "The automatic machinery of a big factory is much more despotic than the small capitalist, who employs workers, has ever been."
- Because economic and political actors (people and institutions) make (somewhat) rational choices, class structure is based on available technology.
- This gives us a *materialist* picture of historical change.

**Definition (Technological determinism)**

This is the view that material forces, especially the properties of available technologies, determine social and political events.

# Technological primacy

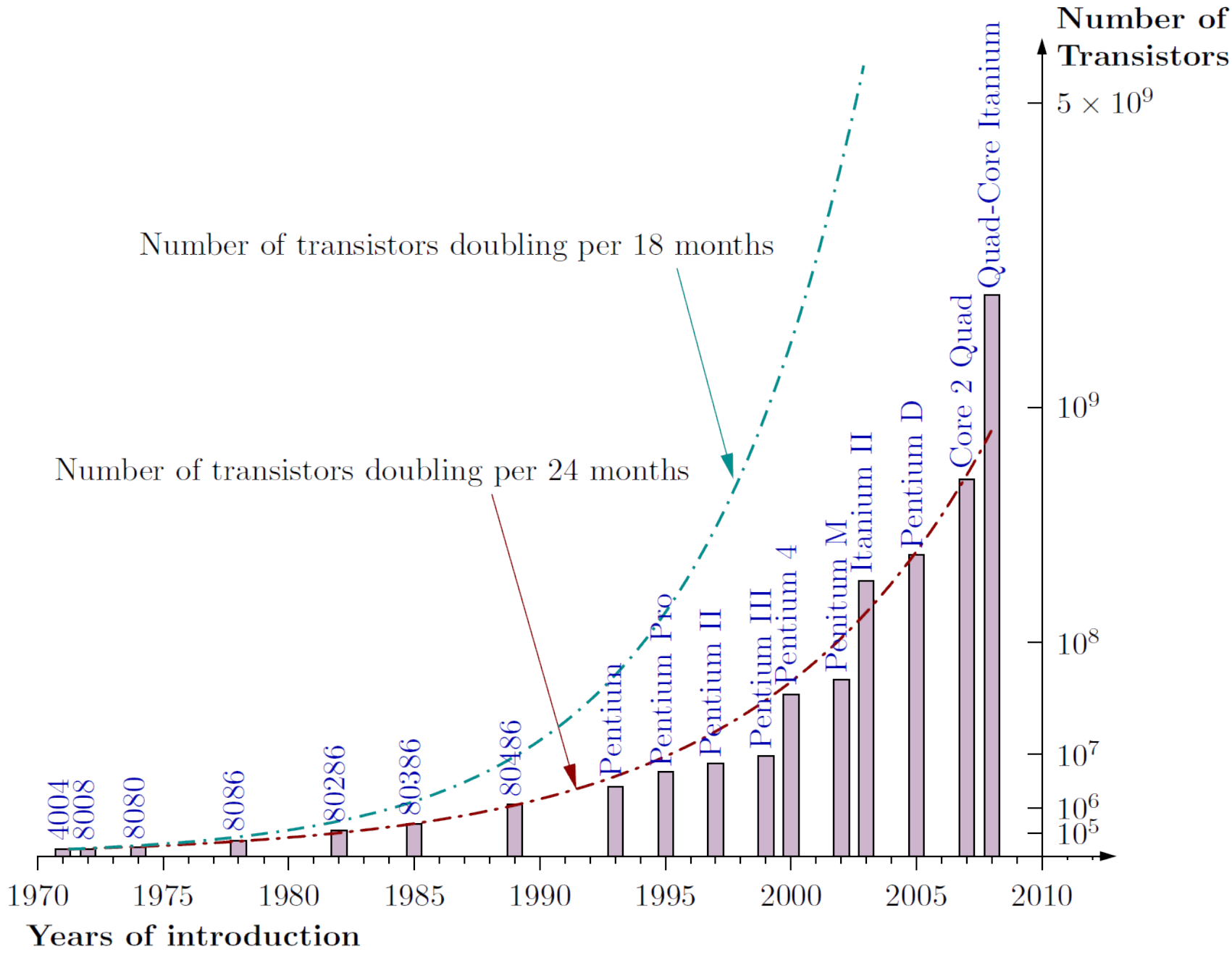
- A view that describes technology as the primary determinate of our social and cultural life is known as technological primacy.
  - L. White (1949): "We may view a cultural system as a series of three horizontal strata: the technological layer on the bottom, the philosophical on the top, the sociological stratum in between... The technological system is basic and primary. Social systems are functions of technologies; and philosophies express technological forces and reflect social systems. The technological factor is therefore the determinant of a cultural system as a whole. It determines the form of social systems, and technology and society together determine the content and orientation of philosophy."
- The biologist P. Medawar argued that we owe our biological success as a species more to our technological progress than to our biological evolution.

# Technological reductionism

- *Technological determinism* attempts to present a linear, cause-to-effect mechanism for *historical change*.
- In this sense, it is a type of reductionism, which aims to reduce a complex whole to the effects of one part upon the other parts.
- Reductionism can be contrasted with holism, which is concerned to study complex phenomena as an interlinked network, rather than isolating individual parts.
- The reductionist tendency usually goes together with the identification of technology with tools or machines.
- In this reduction, we become reduced to a tool-making and tool-using creature: *homo faber*, "man the maker."

# Technological autonomy

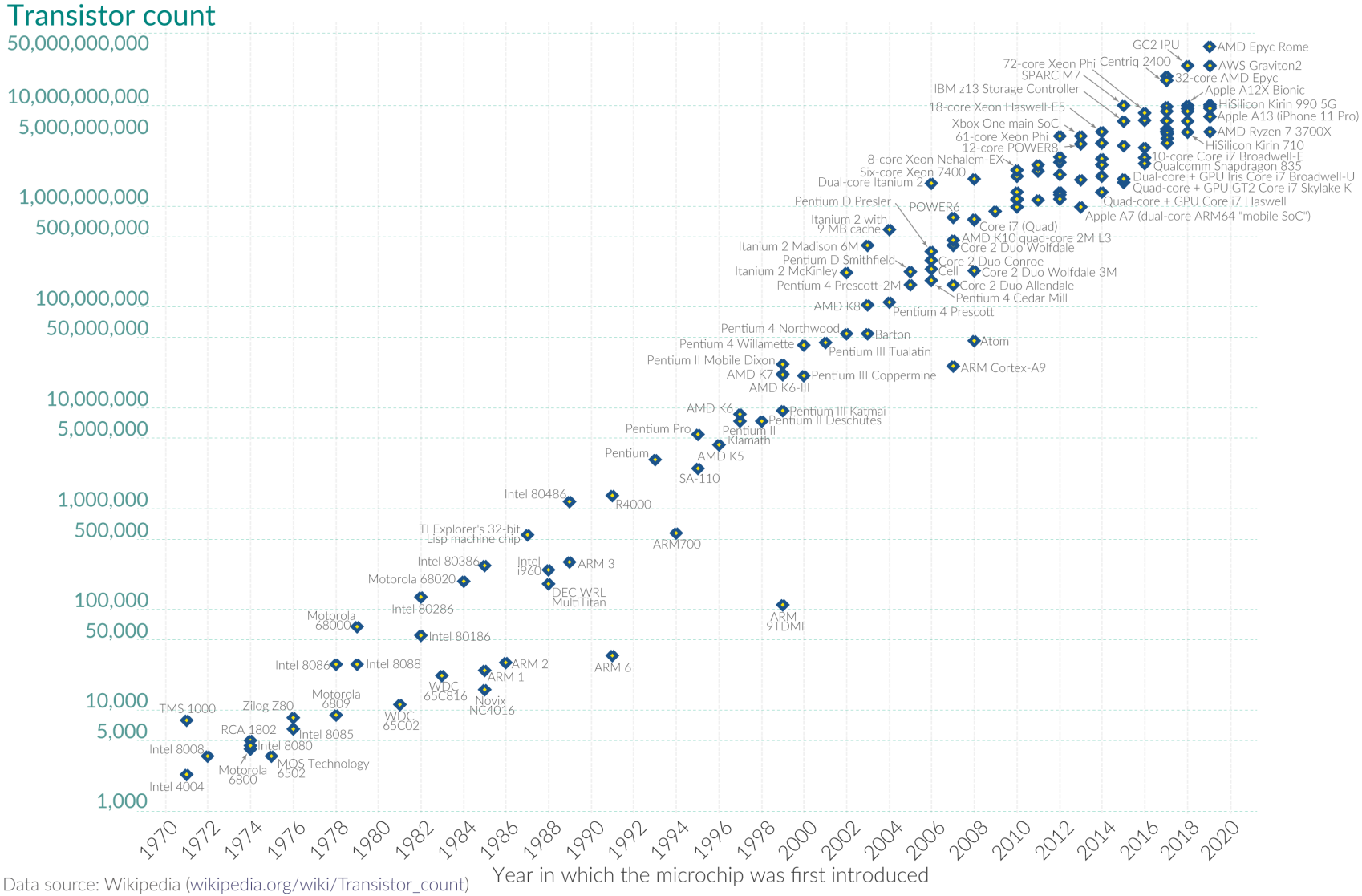
- Technology is often perceived as something outside of society, as a sort of self-controlling, self-determining, self-generating, self-propelling, self-perpetuating and self-expanding force.
  - Asimov (1981): "The whole trend in technology has been to devise machines that are less and less under direct control and more and more seem to have the beginning of a will of their own."
- This conception of technology is known as technical autonomy.
- It is often presented as a danger to the human condition.
  - Ellul (1964): "There can be no human autonomy in the face of technical autonomy."
- There is a tendency for the process or the method to become the *driving force*.
  - Postman (1979): "a method for doing something becomes the reason for doing it."


Number of Transistors
$5 \times 10^9$
$10^9$
$10^8$
$10^7$
$10^6$
$10^5$
Number of transistors doubling per 18 months
Number of transistors doubling per 24 months
4004
8008
8080
8086
80286
80386
80486
Pentium
Pentium Pro
Pentium II
Pentium III
Pentium 4
Penitum M
Itanium II
Pentium D
Core 2 Quad
Quad-Core Itanium
1970
1975
1980
1985
1990
1995
2000
2005
2010
Years of introduction

# Moore's Law: The number of transistors on microchips doubles every two years

Moore's law describes the empirical regularity that the number of transistors on integrated circuits doubles approximately every two years. This advancement is important for other aspects of technological progress in computing – such as processing speed or the price of computers.

Our World in Data




Data source: Wikipedia (wikipedia.org/wiki/Transistor_count)

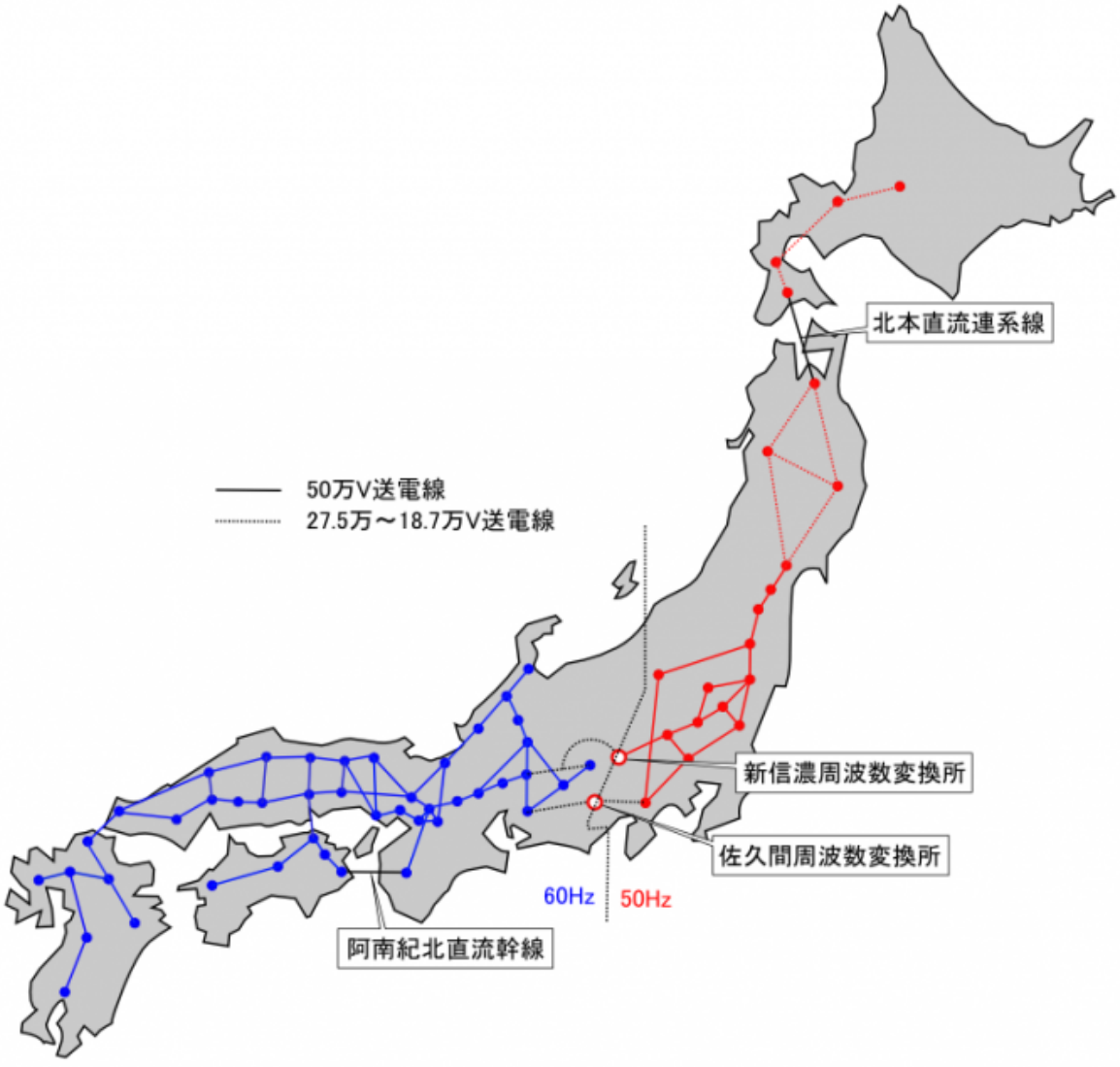
OurWorldinData.org – Research and data to make progress against the world's largest problems.

# Path dependency

- Even for non-deteminists, the cumulative effects of the presence of actual technology and technological decisions are important. In practical terms, the set of technical decisions that one is making at any given time are limited by the decisions that were made in the past. Some of these factors are technical but others are economic, political, social, etc.
- This is called path dependency, of which there are two main types.
  - (1) The amplification of small differences are a disproportionate cause.
    - Ex., The videotape format wars: VHS vs. Beta. VHS was lower quality, cheaper, with longer recording times. Rental stores noticed more VHS rentals and bought more VHS stock. Manufactures switched to VHS because they expected HVS to win. There was a sort of snowballing effect.
  - (2) The decisions made in the past limit current options.
    - Japanese power grid: west 60Hz (US) vs. east 50Hz (German).

# The Video Format Wars


# Japan's Power Grid



# Do Technological objects have essential features?

- However, in order for technology to act as a *force in history*, it must have some essential characteristics, that is, it must be some definite thing.
- Many scholars, however, have doubted this claim.
- No technological object has only one potential use. Many users modify products for their own personal use, or use them in a way for which they were not originally intended.
  - Bicycles for power generation, truck engines for lifting, etc.
- The "success" of a technology depends on the size and social strength of the group that adopts it.
- Thus, the good design of a product cannot be an *independent* cause of its success.

# The social construction of objects

- In the production of new technologies there is a feedback loop: users ↔ designers ↔ manufacturers ↔ users.
- Lead users tend to make substantial innovations in technologies.
  - Ex., Linux and the open-source software scene.
- Users must also be *modified*, or trained, to meet the specifications of the product.
  - Ex., PalmPilot devices, the birth control pill.
- The product must be presented in a socially acceptable form.
  - Ex., In a period when masturbation was taboo, the electrical vibrator was widely sold to women as a medical device to cure "hysteria."
- All of these things indicate that the *meaning* of a thing, that is its *essence*, is determined by a network of users, makers and institutions.

# Soft determinism

- Instead of claiming that technology drives history, we should admit that social forces play a vital role in shaping technology's effects.
- Nevertheless, the reason we are so interested in technology is because artifacts *appear* to do things. We often have the *feeling* of technological determinism.
- There is a sort of interdependence between the social and the technological.
  - Bijker (1995): "Purely social relations are to be found only in the imaginations of sociologists or among baboons, and purely technological relations are to be found only in the wilder reaches of science fiction."
- We can call this soft determinism.

# Heidegger's theory of technology, 1

- Martin Heidegger (1889–1979) was a German philosopher known for his work in existentialism and phenomenology.
- His ideas, published, 1949, in *Die Frage nach der Technik* (The question concerning technology), have been deeply influential on modern thinking about the nature of technology
- His ideas are expressed in obscure language, and it is difficult to interpret them precisely. Nevertheless, I will attempt a brief summary.
- Heidegger's concern is with *modern technology*, not with all forms of tool-making and tool-using.
- The core idea is that Heidegger rejects the claim that technology is merely a kind of instrument and human activity, but rather claims that it has to do with *truth*. That is, it is a way of revealing, or disclosing, what *is*.

# Heidegger's theory of technology, 2

- Technology *challenges* (herausforden) nature to yield its resources to humans. (Windmill and the hydro-electric dam.)
- Technology *positions* (stellen) and *orders* (bestellen) the yields of nature so that they are available and disposable to humans. (The whole *system* of modern technology.)
- The things that are so positioned and ordered (including humans), become a *resource* (der Bestand), a stock, a standing-reserve. (Commodities, energy, human resources.)
- This general way of understanding and disclosing nature, Heidegger calls the *framework* (der Gestell), and it is the essence of technology.

# Heidegger's theory of technology, 3

- Heidegger claims that the *framework* is prior to modern science, and that the modern sciences have the form that they do *because* they take place within the *framework* that is the essence of technology.
    - "Because physics, indeed already pure theory, sets nature up to exhibit itself as a coherence of forces calculable in advance, it orders its experiments precisely for the purpose of asking whether and how nature reports itself when set up in this way."
- He then claims that the *framework* produces a kind of destiny, which is neither an inevitable fate nor the result of human willing.
- The disclosure of this destiny and human freedom are one and the same.

# Heidegger's theory of technology, 4

- The destiny of technology, however has a twofold danger.
- (1) The first is that humans reduce themselves to a mere resource, and appearing to have total control, encounter only themselves.
- (2) The second is that the *framework* closes off every other way of revealing, including the fact that it is itself a disclosure.
- But, because the *framework* is a disclosure – that is, a human activity – it has within it the possibility of a saving power.
- The discussion of the saving power is very obscure, but it has to do with "the thing," the "here and now and what is inconspicuous." The example that Heidegger uses for "the thing" is the arts, not as a special sector of cultural activity – as they are now – but, rather, as an original act of creation, bringing things into being, into truth.

# Final Remarks

- We have looked a number of different ways of thinking about technology.
- We have *questioned* two often held positions:
  - Technology is applied science.
  - Technology is the engine of history.
- We have looked at the idea that artifacts do not have essences.
- We have looked at Heidegger's philosophy of technology.