digital impact alliance

Spotlight

The era of data infrastructure is here.

History can help us capitalize on its potential.

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Throughout time, infrastructure has proven a critical component of building healthy, prosperous, and interconnected societies. While physical infrastructure, such as bridges, roads, and railways, dominated the 19th and 20th centuries, in today's rapidly digitizing world, good digital and data infrastructure are becoming increasingly important.

Well-designed, implemented, and governed data infrastructure is crucial. It creates the environment for data to be securely collected, accessed, and shared in ways that can be widely beneficial to people and communities across the world. And, while data infrastructure can provide entrance into the information economy, it also delivers essential and foundational digital services.

With recent technological advancements, especially generative artificial intelligence (AI), data infrastructure must be scaled to meet the needs of these innovations. There is both an opportunity and an urgency to ensure it is leveraged to foster development, promote greater equality, and meet people's needs.

As we prepare for the future, there are lessons to be learned from the past. To foster effective data infrastructure, we must harness historical insights from previous infrastructure eras, including how, and by whom, projects were constructed, managed, and financed. By doing so, we can better understand how the era of data infrastructure is both similar and different from its predecessors, and how we can best advance data infrastructure that promotes trust, choice, agency, and participation for people globally.

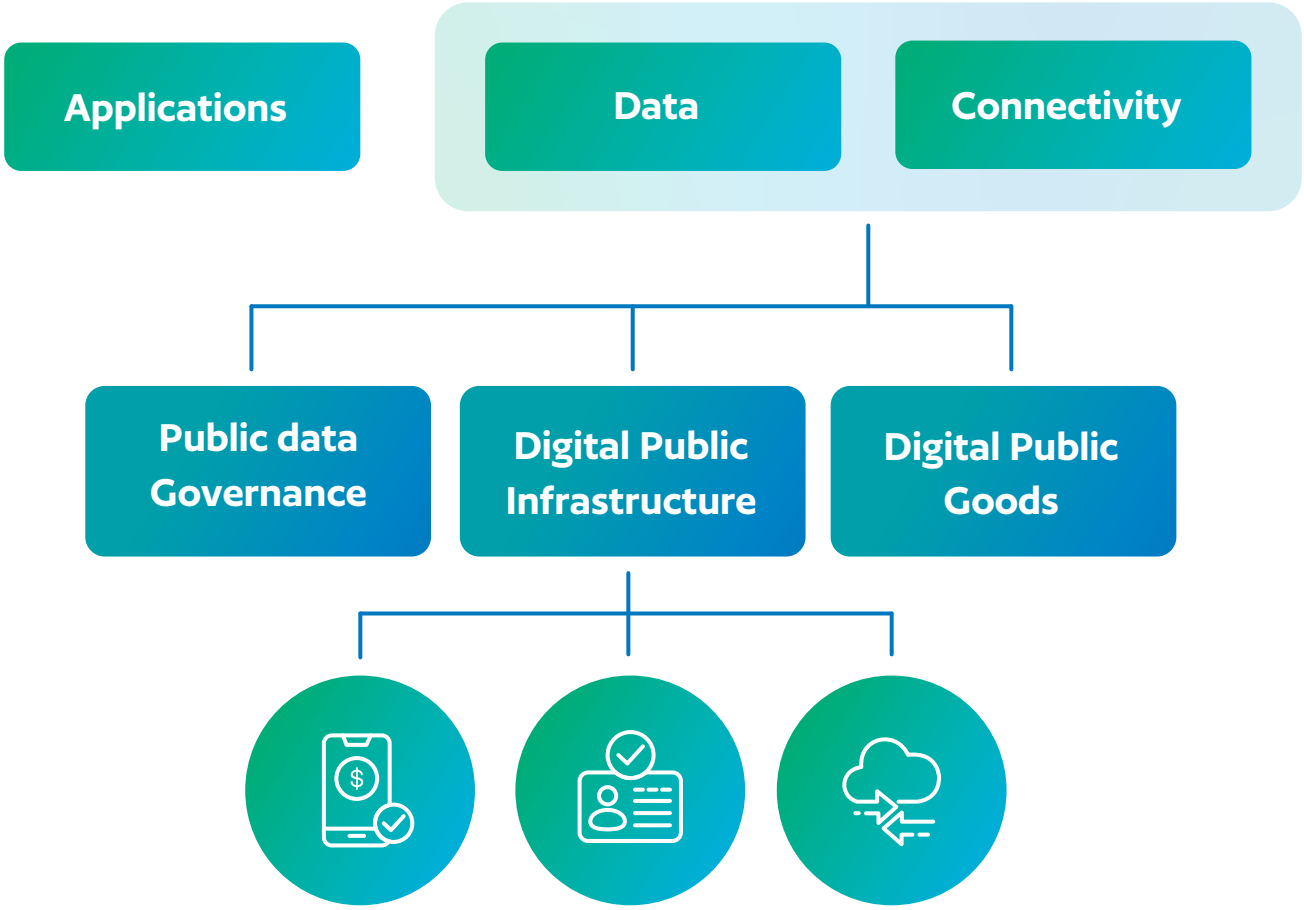
Lesson 1: Infrastructure is a vague term in general. Data infrastructure needs a clearer definition to frame the discussion.

The term 'infrastructure' was first used in English in the 19th century. Almost two hundred years later, the meaning of the term remains vague. However, as German social historian Dirk van Haak wrote: "infrastructure carries the glow of necessity." This 'glow' renders the term self-defining, covering almost anything that is important to support other societal activities. But this quickly becomes circular: anything important to society is infrastructure; and it becomes important because it is called infrastructure. To have a meaningful conversation about infrastructure, we need to choose and frame our language.

In the mid 20th century, the distinction was first made between hard, or physical, infrastructure like roads; and soft, or social, infrastructure like schools and clinics. Governments in the modern era started to pay attention to the widespread provision of the latter. These distinctions have enabled some measurement: the Global Infrastructure Hub reports annual investment by G20 central governments in different classes of infrastructure. In 2022,

G20 governments budgeted around $1 trillion, of which a fifth was for 'social' infrastructure, and of the rest, physical transportation infrastructure made up around half. By comparison, governments presently allocate around 1% of their total infrastructure spend on what may be considered digital infrastructure.

This differential reflects many factors. One is that private investment has dominated digital infrastructure so far. Another is that digital infrastructure is relatively cheaper to build than bricks and mortar. However, an important reason is simply that there is not (yet) a consistent definition of digital infrastructure against which to measure. So, let us start by proposing one.



The figure above reflects the author's interpretation of converging international discussions on the issue over the past two years.

Firstly, it shows two main layers of digital infrastructure (on the top right) – connectivity and data. These are distinct from the applications layer, which comprises the myriad of digital services that have become pervasive in the era of mass mobile internet. Applications, therefore, are built on top of the digital infrastructure.

Within the digital infrastructure layer, connectivity infrastructure manifests in physical form through deploying fiber optic cables, erecting base stations, building data centers, and making devices. Data infrastructure refers to the soft, cyberinfrastructure built on top of connectivity and storage, which can be reused as the foundation of multiple different applications. Data infrastructure is an umbrella term by which we include three related components (the middle layer):

- **Digital public goods (DPGs)** are the software, data, algorithms, and protocols which power the flow of data. When capitalized, the term Digital Public Goods has a particular reserved definition, of which the Digital Public Goods Alliance is the guardian. This definition specifies the nature of licensing as open and requires that usage must also serve the public good.[4]
- **Digital public infrastructure (DPI)** is a new category, which emerged with greater precision from India's G20 presidency in 2023. DPI is the technology layer that accelerates and directs the flow of data through actual digital systems, which can function at national or international scale. The three components of DPI (on the right) – digital payment systems, digital identity systems, and data exchange systems – are widely accepted as indicative, but not exhaustive.
- **Public data governance** refers not only to rules and protocols by which data moves and is used, but also to the oversight of the DPI institutions that are custodians and switches for data on a large scale.

Other than all being digital, the unifying feature of these subcategories is that they are also 'public.' The 'P' in DPGs or in DPI is widely understood to refer to their public purpose as opposed to public sector ownership of digital systems. More firmly, as proposed in a recent paper by David Eaves and his colleagues at UCL,[5] these digital tools and systems are expected or even required to create public value. Public, in this sense, does not accurately describe most digital infrastructure today. However, it does represent one of the desired characteristics for data infrastructure to move towards.

Lesson 2: Infrastructure is not neutral. It needs a yardstick.

Infrastructure's appeal rests on its "glow of necessity": its claim to serve any and all in a society. Yet despite this allure, history shows that it is always contested, often vulnerable to attack, and never neutral in its effects on society. These contradictions have been witnessed throughout the history of infrastructure building:

- *There are winners and losers*, as seen in the battles over routing railways and highways during the 19th and 20th century. Land speculators drove up land prices, affecting farms and local communities, which would be connected or bypassed. This led to confrontation, even conflict.

- *The benefits of infrastructure building are not equally felt;* and they become self-reinforcing over time. As a current example, reliable and clean electrical infrastructure in a region attracts the placement of data centers, which in turn generates demand for other infrastructure to connect them and operate them.

- Long before hacking was associated with cyberspace, *there were always 'hackers' who found uses for infrastructure for which it was not intended,*[6] and sometimes these new uses reshaped the infrastructure. Some of the hackers will be malicious; digital infrastructure can expand incentives for cybercriminals, just as it may also claim to offer safety behind its virtual walls.

- By virtue of its importance, *infrastructure's greatest claim – that it is widely open – is also its greatest vulnerability* since enemies in wartime target it for destruction or takeover for their own ends. This is as true in undeclared cyberwarfare today as it has been in conflicts in the past.

Therefore, just as we need language to talk about digital infrastructure, we also need yardsticks to measure its effect on society. Numerous principled frameworks exist. Some, like the Principles for Digital Development, guide how donors and policymakers go about deploying funds in digital projects in general. Others are specific to sub-sectors, like the UN Principles for Responsible Digital Payments or the Principles on Identification for Sustainable Development.

The Digital Impact Alliance has proposed a vision where data and digital technology advance social and economic wellbeing, equity, and inclusion at the same time. Participation, agency, choice and trust are essential components of this vision, and offer a benchmark to understand desired outcomes for users of data infrastructure.

Participation	People can participate. All people are included, can represent their needs and preferences, and be creators and collaborators online to the extent they choose.
Agency	People have agency. All people feel their digital rights are clear, they can access appropriate redress mechanisms, and have confidence in the institutions that oversee and exercise those rights.
Choice	People have choices. All people have a range of reasonably priced digital services driven by healthy competitive markets, and can select what they need based on quality, trustworthiness, and other key factors. Choice includes the option not to use digital services.
Trust	People can trust. All people understand and have trust in digital products or services; how their data is being stored, shared, analyzed, and used to create value; and people trust these products and services do not cause harm to society and the planet.

What digital frameworks are needed, which digital norms must be developed, which innovations tried, and which behaviors and skills encouraged to make the fulfillment of this vision more likely? Further lessons from the history of infrastructure may also apply to the digital space.

Lesson 3: Infrastructure is shaped by how it is financed.

Like physical infrastructure, although over a much longer period, digital infrastructure has been powered by waves of technological change and steered by choices about modes of financing and oversight. In general, infrastructure requires three roles:

- *Financiers,* who must be able to cater to the very lumpy and long-term nature of most infrastructure.
- *Builders,* who must be able to manage multiple stakeholders, often over a complex and contested construction process.
- *Operators,* who take over from the builders to ensure that the infrastructure remains available on a specified basis and may also collect revenue from users.

In the first wave of modern transportation infrastructure building, which lasted into the early 20th century, all three roles were often assumed by private investors and corporations. However, Great Depression-era public works and the need to rebuild following the World War II led to public agencies assuming more direct responsibility in the next - second - wave of physical infrastructure. They financed the capital expenditure, and often operated the resulting infrastructure, even though building itself was still left to large engineering and construction companies.

However, in the late 20th century, as many governments approached their fiscal limits, the public-private partnership approach emerged as a third wave – mobilizing more private sector financing and even operating capacity. By 2014, as much as 15-20% of infrastructure expenditure in developing countries was financed this way. The public-private partnership trend brought into focus the need for a fourth key role in infrastructure provision, which was sometimes subsumed or neglected when the state provided infrastructure directly:

- *Overseer, who, especially where there were substantial societal risks from the failure of infrastructure, act as a supervisor or overseer, usually in the form of a public agency.*

In part because of the difficulties of contracting and overseeing public-private partnerships, some of the early enthusiasm has faded, despite evidence of positive outcomes.[9]

Today, significant shifts are shaping data infrastructure.

Like the first wave of physical infrastructure development, data infrastructure has mainly been privately financed, built, and operated (to date). Using the principles of Participation, Agency, Choice, and Trust as a high-level scorecard, the private data infrastructure era has been highly effective at extending the principle of Participation on some basis to many people across the world, and in a very short space of time. With respect to the principle of Choice, the record of private data infrastructure has been more mixed – there has been plenty of choice, but within digital walled gardens. So, too, with the principle of Trust, where some but not all private operators have consciously and consistently built trust with their users – on at least one side of their platform, if not always both. However, with respect to the principle of Agency, the record has been much poorer. Public interest groups, such as the Center for Human Technology, have broadcast the growing body of evidence of harms caused by the consciously addictive nature of digital media use, lowering the agency of its users as a result.

With this mixed record, the era in which these private digital infrastructure operators were celebrated and almost universally welcomed has ended. Awe and appreciation for their free services has been replaced by rising concerns about the implications of their sheer size and extent of control over access and usage. Geopolitical rivalry has stoked the fire: most digital infrastructure is controlled by operators in just two countries.[10] The degree of contestation has grown proportionately with the scale and importance of the infrastructure.

Several forces are now driving change in how data infrastructure is developed and deployed.

The first is the shift in preferences and attitudes towards asserting greater national control over essential infrastructure.

There are many factors contributing to this shift. One is the general encouragement of a more active, even entrepreneurial, role for the state, proposed by Mariana Mazzucato.[11] The desire for more public control is also often linked to growing awareness of data as a

valuable national asset, from the exploitation of which the benefits should be more evenly distributed. It also stems from a desire to reset the playing fields to allow for more 'home firm' advantage, a form of digital nationalism. A further factor is rising concern over vulnerabilities: national governments are now more likely to see risks, like the risk of sanctions resulting in the sudden termination of access to essential digital services, rather than benefits alone from being closely dependent on private providers.

As well as being privately owned, the dominant data infrastructures so far have generally been centralized, meaning operated by a single entity. There are significant exceptions: the internet protocol on which the mass online era has been built is both public and decentralized, while the GPS system on which much modern navigation depends is publicly owned although centralized, and hence vulnerable to failure.[12] Substantial economies of scale have driven infrastructure centralization, resulting in close to zero marginal cost for usage. Large network externalities cause value to increase exponentially with the number of connections to a data infrastructure. The result has been to centralize control in a handful of major private corporations, which operate essential services from online search to cloud storage to digital payments. These have been the dominant builders and operators of major digital infrastructure in most places.

The rising profile of digital public infrastructure (DPI) as a means to unlock the power of data encourages, and enables, nations' desires to control more of their own infrastructure. However, the nature of much DPI is still centralized in that there is a single operator – albeit that the operator is now a public agency, rather than a private one. In that sense, the risk profile of centralized infrastructure in an age of increasing cyberattacks is not significantly changed, unless the public agency is able to simultaneously protect users and win their trust when possible. To ensure that a DPI-centric era fulfills its promise of yielding better outcomes, specifically participation, agency, choice, and trust for people, it requires more than creating a domestic public competitor - it requires actively building local national ecosystems of trust in which public usage can thrive. The early evidence from instant payment systems in countries such as India, Brazil, and Thailand suggest that this is possible, though not necessarily easy.[13]

The second shift underway is a response to the vulnerability of centralized infrastructure, whether operated by state or private.

This is the shift towards more widespread use of decentralized protocols. In the financial sector, bitcoin has demonstrated the resilience of decentralized infrastructure without a single operator and beyond the control of any nation state, though it has points of influence. Data sharing protocols, like X-Road,[14] go part way down this route by federating a data ecosystem so there is decentralized exchange, though there are central control nodes.

European data spaces reflect the desire to create federated ecosystems in which data can be exchanged safely, with the aid of open-source software tools like SIMPL[15] that is under construction. The private Foundation for Interoperability in Digital Economy (FIDE) has supported the development of the Beckn protocol,[16] which provides the software architecture for decentralized e-commerce. However, protocols like this are new, and as such, will require considerable refinement and support to reach mass adoption in competition with private centralized alternatives, which will continue to evolve.

Success will depend on different factors – including capacity and trust.

These shifts may generate forces which will challenge the dominance of private data infrastructure in time. However, whether the emerging approaches will scale and thrive will depend on several factors.

Firstly, a major factor is the capacity of governments to perform the complex roles of orchestrating, even if not owning and operating, DPI. Approaches like DPI-as-a-service can reduce the national capacity required, but do not eliminate the need for high-level coordination.

Secondly, another factor is the level of public trust in digital services and their operators, which can be febrile in an era of cyberthreats and attacks. Trust in DPI is clearly linked to the growth of government capacity to effectively manage it, to earn and sustain that trust. If capacity does not grow, then decentralized approaches are likely to increase in usage. What marks out these decentralized approaches is that they are often beyond the control of any one national government, and hence require new forms of governance. These so-called “trustless” approaches are only trustless until a major incident – a breach or a fork – happens and users realize their need for recourse to restore and sustain trust.

Data infrastructure is different from physical infrastructure. In key ways, it is more amenable to change.

While there are parallels between the current nature of data infrastructure and the earlier waves of physical infrastructure development, there are also profound differences.

The first difference is data infrastructure is relatively cheaper to deploy, which makes it more amenable to philanthropic investment: certainly, once the connectivity infrastructures of broadband and cloud computing are in place. Private philanthropy played a very little role in the early roll out of physical infrastructure in the 20th century, in part because of the large sums involved. This started to change with the deployment of digital connectivity infrastructure in the first decades of the 21st century. Philanthropies have provided support to connect underserved groups and have financed research and advocacy efforts that shine a light on the nature and scale of the connectivity challenge. However, the sheer size of the remaining connectivity challenge means that closing the gaps rests largely in the hands of national governments, large corporations, and multilateral agencies. Together, they have created large scale public-private alliances, such as the Edison Alliance, which is dedicated to overcoming the remaining broadband usage gap by 2030. As a result of this, new initiatives to build data infrastructure can benefit from this expanding connectivity layer and focus investment on the software, protocols, and the institutions to deploy them.

The second difference is how extensible data infrastructure is: with pervasive digital connectivity, software and algorithms can function globally at low marginal cost.

The third difference is its apparent reversibility: unlike a road or bridge, data infrastructure can, at least in theory, be switched off if it doesn't work – encouraging agile experimentation. However, there can still be pervasive consequences in terms of attitudes and behaviors, which long outlast the use of a particular widespread data infrastructure – underlining the need to monitor and hold up appropriate measures of its effects on its users over time.

To promote good data infrastructure, we all have a role to play.

Good data infrastructure, with its ability to provide essential public services, offers incredible promise. Yet, in order to effectively build, manage, and govern these systems, we must learn from history, gleaning insights from both the successes and failures of previous waves of infrastructure. Ultimately, to foster a healthy and trusted data ecosystem, we must prioritize data infrastructure that advances social and economic wellbeing – while facilitating trust, encouraging participation, and promoting agency for people and communities globally.

Endnotes - References

[1]As reflected in the Google ngram viewer.
[2] His book, Lifelines of our times, was first published in English in 2023.
[3] GI Hub Infratracker insights
[4] The UN-affiliated DPGA has created a precise definition and maintains a register of qualifying DPGs.
[5] Eaves, Mazzucato, and Vasconcellos, DPI and public value: what is public about DPI?, Institute for Innovation and Public Purpose Working Paper 2024/2025.
[6] Van Haak describes amusingly how a German TV game show in the late 1960s experimented with audience participation. They invited viewers to flush their toilets at particular times to vote for their preferred winner, judging the outcome by the extent water levels changed. Because this became too wasteful of water, they then measured surges of electricity usage caused by flicking lights on and off as a voting mechanism. These novel uses of water and electrical infrastructure were surely not contemplated by their designers.
[7] Van Haak uses the example of bicyclists who traverse both roads and sidewalks to get around more quickly, without obeying the rules of either, leading to the introduction of specific cycle lanes in urban road systems.
[8] The Digital Impact Alliance's vision for people-centered digital transformation.
[9] WBG Support to Public Private Partnerships, World Bank Independent Evaluation Group 2014.
[10] The IEG report concluded in its assessment of the World Bank Group's support to public-private partnerships over 2002-2012, "Public-private partnerships, if implemented well, can help overcome inadequate infrastructure that constrains economic growth, particularly in developing countries."
[11] This was a core focus of UNCTAD's Digital Economy Report 2021.
[12] The Entrepreneurial State
[13] One Satellite Signal Rules Modern Life. What if Someone Knocks it out. An article by the NY Times raised this concern.
[14] A March 2024 BIS Quarterly Review article by Jon Frost et al highlights adoption trends across 10 countries, including these three.
[15] X-Road, the open-source federated protocol launched in Estonia in 2001, and jointly developed by the three Nordic countries that are members of NIIS, is now deployed in 20 countries around the world.
[16] The EU has developed SIMPL as an open source middleware protocol to support secure and interoperable sharing within and across European Data Spaces, for which a contract was awarded in December 2023 to a consortium to develop, with MVP expected by end 2024.
[17] The Foundation for Interoperability in a Digital Economy (FIDE) launched the Beckn protocol to enable the creation of open playgrounds in the digital economy. The Edison Alliance is a collaborative initiative that aims to foster global digital inclusion, by connecting 1 billion people by 2025 to essential services via digital platforms.