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Information technology — Cloud computing and distributed platforms — Taxonomy for digital platforms

Technologies de l'information — Informatique en nuage et plates-formes distribuées — Taxonomie pour les plates-formes numériques

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Foreword

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This document was prepared by Joint Technical Committee ISO/IEC JTC 1, *Information technology*, Subcommittee SC 38, *Cloud computing and distributed platforms*.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html and www.iec.ch/national-committees.

Introduction

Technologies such as cloud computing are supporting the evolution of digital business and accelerating the shift to living and working (in part) online, in ways that would have been impossible a few years ago.

Increased debate about socio-technical developments always runs the risk of multi-disciplinary terminological confusion, due to the potential for the same word to be used for two or more distinct concepts. Moreover, polysemy (the capacity for a word or phrase to have multiple related meanings) is an attribute of many words. Any attempt to provide a single definition for a polysemic word needs to be sufficiently broad to account for all potential meanings.

Terms with alternative meanings in economic, societal, political, regulatory and technical contexts are being labelled with the same or similar names.

Adding clarity on concepts and definitions can assist in the formulation of well-informed policies in important areas such as security, privacy and governance. One of the terms that has been at the forefront of these changes is "platform".

Note that the economic, societal, political, regulatory and technical uses of the word "platform" predate cloud computing by many years.

Taxonomic structures serve many purposes and their topological structure, incorporation (or not) of orthogonal dimensions, levels of refinement, and the decision about the order and approach in which to apply the structuring factors lead to very different outcomes. The terminology and concepts presented in this document can be combined in different ways, depending on the problem being considered, and the factors that potentially influence the decisions driving such structuring are presented with the related concepts.

In a situation where two or more distinct interpretations of the word "platform" are relevant, but only one is taken into account, or where collaborators used two distinct interpretations at cross-purposes, confusion can arise.

Therefore, it is important to understand the difference between the technical, economic and general uses of the word platform in the context of digital services.

The audience for this document is technologists, economists, policy makers, social scientists and others who wish to precisely and unambiguously use these terms (e.g. in multi-disciplinary conversations).

Information technology — Cloud computing and distributed platforms — Taxonomy for digital platforms

1 Scope

This document specifies a taxonomy related to digital platforms, by providing definitions and supporting information that disambiguates different uses of the term platform as it applies to digital services (such as cloud computing and other distributed computing systems).

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO/IEC 22123-1, *Information technology — Cloud computing — Part 1: Vocabulary*

ISO/IEC TS 23167, *Information technology — Cloud computing — Common technologies and techniques*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO/IEC 22123-1, ISO/IEC TS 23167 and the following apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org

3.1 Basic terms

3.1.1
digital service
service offered by one party to another party by means of digital hardware or software technology, or both, including communication over a network

Note 1 to entry: In the context of this document, a service comprises one or more digital capabilities such as a cloud computing, edge computing, or some other distributed computing capability. Such a service will be subject to contract and typically have defined qualities of service, terms, and conditions for use.

Note 2 to entry: Cloud service, edge service, network service, broadcast service, and mobile service are all types of digital service. Not all types are discussed in this document.

3.1.2
digital platform
distributed platform
set of correlated and cohesive *digital services* (3.1.1)

Note 1 to entry: A digital platform as described in this document enables and assists other participant digital services in conducting business with their customers, either by creating and facilitating a multi-sided market for those services, or by enabling the technological creation and operation of those services, or both.

Note 2 to entry: "Distributed platform" is often used as a synonym to emphasise those elements of a digital service, such as edge computing and mobile computing that go beyond the classical datacentres of cloud computing.

3.2 Terms relating to platform participation

3.2.1
platform participant
<digital platform> party that makes use of or otherwise engages with a *digital platform* (3.1.2)

Note 1 to entry: A party can be an individual end user or organisation.

Note 2 to entry: A platform participant can be a member of one or more *participant groups* (3.2.2).

3.2.2
participant group
group of *platform participants* (3.2.1) that share a common set of business requirements that differ significantly from the requirements of one or more other groups of *platform participants* (3.2.1)

Note 1 to entry: Participant groups are not specific to digital services, though they are essential for defining a multi-sided market such as a *digital economic platform* (3.4.2).

Note 2 to entry: Examples of such participant groups include purchasers, vendors, and developers. Purchasers are platform participants seeking to acquire something, vendors are platform participants seeking to offer something, while developers are platform participants seeking to create and sell (or operate) software (or services). Thus, the members of each group have a common objective which is not shared with members of the other participant groups.

3.3 Terms related to digital technology platforms

3.3.1
digital technology platform
<technology> *digital platform* (3.1.2) that provides engineering components required to support creation and deployment of applications and services

Note 1 to entry: Elements provided can include cloud computing resources (see ISO/IEC 22123 series), which can include execution environments, storage, networking, location and mapping services, graphics rendering and specialist processing (such as machine learning or quantum computing).

Note 2 to entry: Popular examples of such digital technology platforms include varieties of the cloud service categories "infrastructure capabilities type" and "platform capabilities type" (see ISO/IEC 22123-1).

Note 3 to entry: This definition is distinct from those in ISO/IEC TS 25025:2021 and ISO/IEC TS 25011:2017.

3.3.2
software development platform
digital technology platform (3.3.1) that enables or assists the development of software code

3.4 Terms related to digital economic platforms

3.4.1
economic platform
<economics> set of services that provide market intermediation to reduce search or transaction costs

Note 1 to entry: Platforms are environments, computing or otherwise, that connect different groups and derive benefits from others participating in the platform.

Note 2 to entry: A shopping mall provides a non-computing economic platform, connecting merchants (participant group) with visiting customers (participant group) and providing distinct services to each participant group such as a pleasant environment, electricity, storage, parking, network connectivity, and security.

3.4.2
digital economic platform
<economics> one or more *digital platforms* (3.1.2) creating a multi-sided market, which provide goods, services or licensed rights to two or more distinct *participant groups* (3.2.2) who need each other in some way

Note 1 to entry: A digital economic platform is a subtype of both *economic platform* (3.4.1) and *digital platform* (3.1.2).

Note 2 to entry: Examples of licensed rights can include the right to view a movie, to use commercial business data, or to use specific software, each delivered as a licence.

Note 3 to entry: While a digital economic platform is constructed with digital technology, often on top of a digital technology platform (3.3.1), this does not mean that the digital economic platform is a subtype of digital technology platform (any more than a car is a subtype of a road); these two terms are independent.

Note 4 to entry: A digital economic platform can optionally comprise more than one digital platform. For instance, an exchange platform can be combined with a payment platform and appear to the end-user as a single digital economic platform.

3.4.3
ad-funded platform
<economics> *digital economic platform* (3.4.2) where a platform generates revenue by charging advertisers to show advertisements to customers of the service

Note 1 to entry: Advertisers are one participant group, those who view the advertisements are a second, and those who display the advertisements alongside their own content are a third.

3.4.4
exchange platform
<economics> *digital economic platform* (3.4.2) which brings together vendors and potential purchasers and enables them to sell and buy goods and services, potentially generating value for the platform provider by intermediating the transaction

3.4.5
payment platform
<economics> *digital economic platform* (3.4.2) which facilitates the secure completion of payments between *platform participants* (3.2.1)

3.4.6
application marketplace
<economics> *digital economic platform* (3.4.2) where the platform provides means for software developers and publishers to provide applications to customers via the platform

Note 1 to entry: This document describes this concept in the economic platform domain. See also ISO/IEC 19944-1:2020, 3.2.2 for the definition in the device platform domain.

4   Abbreviated terms

AIaaS   artificial intelligence as a service

CaaS [a]   communications as a service/containers as a service

CSC   cloud service customer

CSP   cloud service provider

DSaaS   data storage as a service

FaaS   function as a service

GPU	graphics processing unit
IaaS	infrastructure as a service
ICT	information and communications technology
MLaaS	machine learning as a service
PaaS	platform as a service
QCaaS	quantum computing as a service
SaaS	software as a service
SME	small- or medium-sized enterprise

a The acronym CaaS is unfortunately used by industry for multiple purposes, two of which are listed here, so it is best to use the expanded term to ensure the correct context.

5   Digital platform overview

5.1   General

The term "platform" is used in the English language with a very wide range of meanings, and some of these uses are ambiguous in the context of online or digital services.

This document defines a taxonomy of terms for digital platforms of various kinds and shows how these terms can be structured into hierarchies (see Annex A).

5.1.1   Meanings of "platform"

These uses include but are not limited to the following. These groupings are potentially overlapping, they are not mutually exclusive.

— The traditional non-ICT uses of the term, such as a wooden platform to stand on, a political platform of policies, or a railway platform from which trains will depart, highlight the highly context-dependent use of the word "platform".

— There are online, broadcast and printed media and public discourse settings, that serve as platforms for free expression, expression of political and social viewpoints, artistic and musical expression, discussion and debate. This includes social media.

— There are what can be defined as "economic platforms", which is a way to describe certain business approaches that create multi-sided markets, where two or more distinct groups of participants can do some kind of business together via an intermediary platform. This means that the platform brings together two or more different participant groups and provides a meeting place to facilitate interactions between the participant groups through the platform. Platforms serving two participant groups are called two-sided platforms, and more generally platforms serving two or more such groups are called multi-sided platforms.

— There are many examples of two-sided markets supported by intermediary platforms, including but not limited to: publishers, academic journals and conferences; airports and ports; stock markets, auction houses and real estate brokers; dating and employment agencies; and credit card payment cloud computing systems. An economic platform does not need to involve any technology.

EXAMPLE   A bricks-and-mortar department store or shopping mall creates a multi-sided market between a group of merchants and a group of customers. This type of economic platform existed long before modern digital technology.

— There have also been "technology platforms" for many years, long predating the arrival of online services. Early computer operating systems such as on mainframes were often described as providing a platform for customer programme development. Specialised systems such as telephone networks provided platforms for the deployment of (then) advanced services such as free-phone and premium-rate telephone lines. PBX systems provided platforms for customer development of early call-centre services. All of these existed long before the arrival of the World Wide Web.

— For these technology products and services, the term "platform" is widely used, both as a simple indicator of layering – with many distinct products and services built on a single underlying base – and to articulate a specific purpose for a product (e.g. providing a platform for self-expression or social interaction).

5.1.2 Meanings of "digital platform"

With the arrival of the World Wide Web, many of the platform concepts described above were adapted to the world of online services, such as online shopping services, online dating, online social networks, and many others. Some of these competed with the pre-online service equivalents, while others were wholly new.

In particular, a market demand rapidly emerged for technology companies to provide means for their customers to rapidly enter the online business world without having to develop everything from scratch themselves. In the same way that companies adopted common operating systems on which to build their applications without having to write specific code for every printer and other device, so the online services need platforms that provided the components common to all or most online services, allowing them to concentrate on those components that were unique to their own service offering.

Thus, the parallel development of digital platforms include both digital economic platforms (business models for multi-sided markets) and digital technology platforms (services and components providing customers with the tools to build their own services).

This document is focused on digital platform as it is used in the context of online or digital services of these two types.

5.2 The ambiguity of "platform" for digital services

Within the realm of digital technologies there are specific situations in which the use of "platform" of even "digital platform" becomes ambiguous.

Both terms are sometimes used for both digital economic platforms and digital technology platforms.

— Digital economic platform is described as one or more digital platforms which provide goods, services or licensed rights to two or more distinct participant groups who need each other in some way. The term "platform" in association to economics, is meant to identify multi-sided business relationships.

— Digital technology platform is described as any kind of system that supports the creation, modification, or addition of significant software functionality by the platform customer rather than by the platform service provider.

These two terms are independent, and either, both, or neither may apply to a digital service (see Table 1).

Table 1 — Examples of digital economic platforms and digital technology platforms

	Digital Technology platform (supports the customer building their own application[a])	Other (does not support the customer building their own application)
Digital Economic platform (creates a multi-sided market)	PaaS or Container as a Service (CaaS) implementation that includes a third-party component store	Ad-funded service Exchange service App store Payment service
Other (does not create a multi-sided market)	Basic PaaS, Container as a Service (CaaS), or IaaS service implementation with no "store"	Basic websites Web-based email Many more…
[a] For cloud computing, this includes either infrastructure or platform capabilities type(s), or both (see ISO/IEC 22123-1).		

Digital economic platforms and digital technology platforms are thus independent concepts. Neither is a subset of the other. A given digital service can be one or the other, or both, or neither.

While many digital economic platforms are built to run on top of a digital technology platform, this does not mean they are a subtype of it, just as a car is not a subtype of the road it runs on.

Parties offering digital economic platforms can select different strategies, based on their perceived business interests. Platform strategies, including pricing, are strongly affected by the economic characteristics of digital platform markets.

A digital technology platform which also brings together two or more groups of customers can also be a digital economic platform.

— A digital service provided to only one group of customers, such as data storage or app development tools, is not a digital economic platform.

— Nonetheless, there are some digital technology services that can be described as both digital technology platforms and digital economic platforms.

An individual platform can sometimes pursue more than one of the business models described in this document.

EXAMPLE 1   In a discussion of hydroelectricity, the term "current" could apply to either water current or electrical current, so it would be foolish to use the term in isolation without making clear the context and specific usage of the word. In the language of cloud computing, the same situation pertains to the ambiguous use of "digital platform" or just "platform", so care is needed to avoid incorrect interpretation of the isolated term by readers.

EXAMPLE 2   Referring to European Commission policy statements shown as "Online platform" under the "Shaping Europe's digital future", documents such as "COM/2016/0288 final" frequently mentions "platforms", but seems to be entirely focussed on digital economic platforms. It reads as if this is the only meaning of the term platform and makes no obvious mention of digital technology platforms such as Platform as a Service. This raises the concern that digital technology platforms could be unintentionally brought within scope when this was not really the writers' intent. See Reference [12].

5.3   Characteristics of digital platforms

Digital platforms exhibit various characteristics that can boost their value to customers and potentially affect the competition landscape within an industry.

5.3.1   Network effects

Network externalities, which often arise in platforms, describe the value for a platform participant arising from the size of the network using the product or service, which may arise from participants of

the same participant group ("same-side" network effects) or participants from a different participant group ("cross-side" network effects). Cross-side network effects only arise in multi-sided markets because there are different participant groups involved.

Network effects can be beneficial or detrimental to platform participants, sometimes both arising at the same time. This document does not make any value judgements on these effects.

Network effects between different participant groups can potentially create a barrier to entry. Each side values the other, and it is difficult for a platform provider to attract one side without the other (the "chicken and egg" problem or causality dilemma). Entrants can employ different strategies to try to overcome the barrier to entry, such as focusing on a niche group of users, taking advantage of a technological shift to offer a tailored product, or shifting a group of users from another platform. The concept is further explored in Clause 8.

See Annex B for a consideration of possible monetisation approaches and network effects for various types of digital platform services.

5.3.2 "Private" vs "Open" platforms

Platforms can exist in both private and open forms. Neither of these is exclusive to either digital economic platforms or digital technology platforms.

A "private" platform implies closed membership of some kind, such that only specific customers and users will be able to obtain service. The most obvious would be in a private cloud or community cloud which is only available to employees, departments, or affiliates of the company or government which is acting as cloud service provider. In general, the operating CSP determines the policies that are applicable for using their platform, subject to overriding local legal requirements.

An "open" platform implies that membership is open to anyone who chooses to subscribe to it. This is true for most but not all public cloud services.

An open platform can carry specific national or regional obligations of law, such as consumer protection rules on sale of goods.

In all such cases, these are matters of law for the local jurisdiction and out of scope for this document.

EXAMPLE 1   There are platforms where membership is limited to members of the public who meet certain criteria, such as ethnicity, age, industry affiliation, political or religious affiliation, etc.

EXAMPLE 2   There are platforms which are only open to users of a specific brand of product, such as a brand of television or smartphone. Whether such a platform is treated in law as "open" or "private" will depend on the law of the applicable jurisdiction.

5.3.3   Cross-cutting considerations

When considering the term "platform" in settings which combine both economic and technical considerations, many related factors need to be considered simultaneously irrespective of the specific type of platform under consideration.

These cross-cutting considerations include economic concepts, such as

— matchmaking (see 7.2.1)

— cost of market entry

— various forms of payment

alongside technological considerations such as

— data portability (ISO/IEC 19941)

— application portability (ISO/IEC 19941)

— ease of switching

Some jurisdictions can also define additional concepts such as "gatekeepers" and impose specific additional legal definitions and obligations upon those entities, which are out of scope for this document.

Contractual and technical limitations also apply, such as:

i)   interoperability and portability, especially where there is an obligation imposed by the applicable jurisdiction (e.g. the European Commission Data Act)[6]

ii) the restrictions introduced by data sharing agreements (ISO/IEC 23751) and

iii) the need for clarity for users

which can be improved by means of data use statements (ISO/IEC 19944-1 and ISO/IEC 19944-2) and online privacy notices (ISO/IEC 29184).

Additional legal and regulatory cross-cutting considerations include:

iv) online safety and child protection compliance

v)   cybersecurity compliance

vi) data protection compliance

vii) prevention of online crime, extremism, and misinformation

viii) the need to support mandatory (human) languages and character sets depending on the jurisdiction

ix) the need to enable accessibility to the platform by people with disabilities according to applicable law.

6   Digital technology platforms

6.1   General

As described in this document, a digital technology platform provides engineering components required to support CSC applications and services. Thus, it acts as both a toolbox and an execution environment in which a customer can build (or install) and run their own software rather than relying entirely on software provided by their service provider.

Using such a digital technology platform, a CSC can build their own services or applications without having to buy or operate their own datacentre, server computers, or other necessary components. In some cases, they might still need to provide their own operating systems or database packages. In other cases, this might enable even an SME to draw on powerful functionality that would be impractical for any but the largest organisation to construct or own for themselves, such as huge data stores, massive machine learning and artificial intelligence tools, or in the future even quantum computing capability.

While the industry is currently dominated by the use of cloud computing concepts for this purpose, IT environments other than cloud computing may also be used to create digital technology platforms.

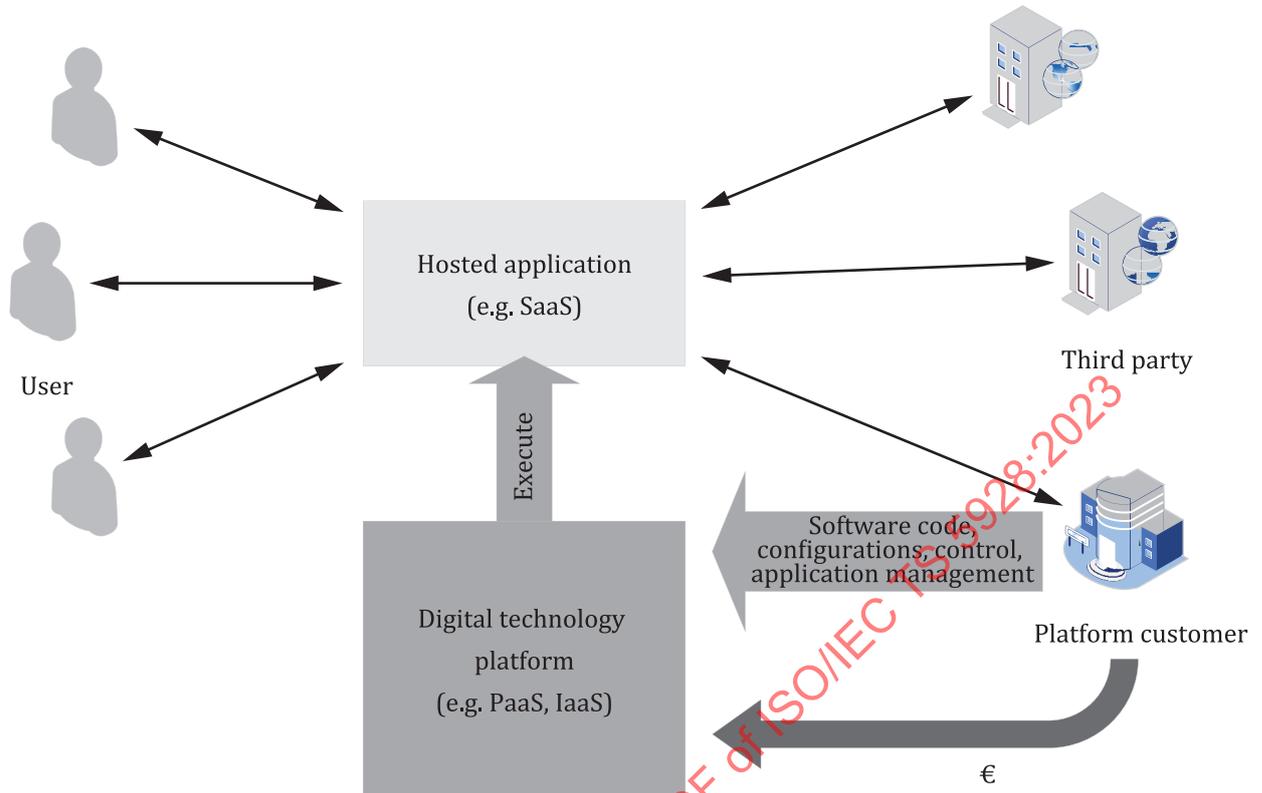Figure 1 illustrates such a digital technology platform.

Figure 1 — Digital technology platform

Such a technology service provides hardware, the premises to hold it, and much of the software on which an application can be constructed. The hosted application can be anything at all, including but not limited to any of the digital economic platform models described in this document. The digital technology platform provider will often be unaware of what the application does, provided that it doesn't violate any platform rules.

6.2 Cloud service capabilities types indicative of digital technology platforms

ISO/IEC 22123-1 defines three capabilities types as follows:

— infrastructure capabilities type

— platform capabilities type

— application capabilities type

Cloud services offering infrastructure or platform capabilities types are often instances of digital technology platforms, in that they provide the CSC with a platform on which they can construct or customise their own application.

Cloud services that offer only the application capabilities type would not normally be regarded as digital technology platforms since the CSC is very rarely writing their own code to build a new application on top of them, though some of them may act as digital economic platforms as described in Clause 7.

Some cloud services offer an application capabilities type while also providing some platform capabilities type features, such as CSC code to customise the application. This is why it is very difficult to draw a rigid line between "PaaS" and "SaaS" type applications, since there are many cloud services that straddle that division to some extent.

Most of the cloud service categories that offer the capabilities types described above are one-sided digital technologies platforms (see 3.3.1 and 6.7.1) in that the CSC has a relationship only with the

CSP, not with any other CSCs. The cloud service that they build and deploy using the digital technology platform may itself be a multi-sided digital economic platform (see 3.4.2 and Clause 7 below), though this will depend on the nature of the application and its usage by the customer.

Note that a software development platform (see 3.3.2 above and 6.5 below) can sometimes create a multi-sided market, such as by offering the sale of third-party software components.

For multi-sided digital technology platforms, see 6.7.2 below.

6.3   Cloud services offering infrastructure capabilities type

Infrastructure capabilities type refers to the offering of real or virtualised hardware (usually computer, storage, or network hardware) to the customer, on which they can install their own operating system or other software.

The most common cloud service category of this kind is Infrastructure as a Service (IaaS), which provides a platform on which a customer can install and run their own virtual machine images (VMs) more or less as if they own and run their own computer server in their own datacentre.

Services such as Container as a Service are also sometimes described as exhibiting infrastructure capabilities type, however in recent years these are increasingly being treated as platform capabilities type since container hosting does not really match the original concept of real or virtualised hardware.

Some infrastructure services offer more than "conventional" computing server environments, such as offering direct access to Graphics Processing Units (GPUs) which can provide greater parallel processing capacity, suitable for rendering graphical imagery, certain complex algorithms (such as chemistry and biology applications), and machine learning applications. Refer to ISO/IEC TS 23167:2020, 5.2.2.

NOTE   The original form of "VM-only" IaaS is becoming less common as customers seek to derive benefits from more advanced functionality.

6.4   Cloud services offering platform capabilities type

Platform capabilities type means the ability of the customer to develop or otherwise obtain software that they can run within a cloud service, but where they do not need to provide a complete virtual machine image. As such they do not need to worry about crafting a "guest" operating system image and dealing with all the maintenance and security issues of such a virtual machine. Rather, they are able to concentrate their efforts on providing the code that directly addresses their business need.

A great many cloud service categories today offer some form of platform capabilities.

The best known such cloud service category is Platform as a Service (PaaS), however it would be a mistake to assume that this is the only one. While PaaS offers a "pure" platform service, in that the customer provides or obtains all the code necessary for their application, there are other services where customers can offer their own code (sometimes substantial amounts of it) to enhance or customise the service offering to their needs.

6.4.1   Platform as a Service (PaaS)

In a PaaS service offering, the technology platform provides generic functionality to support a CSC's application. This will often include tools to aid in the development, testing, staging and distribution of the customer's code across a range of actual servers or virtual machines, without the customer having to deal with the complex details of managing individual computing machines.

A common PaaS approach, not envisaged when the original cloud computing terms were decided, is to use a "container management system" (such as Kubernetes) such that customers can upload and

manage Containers that they have created or otherwise obtained and run them within the managed cloud service. See ISO/IEC TS 23167:2020, Clause 7.

NOTE   It is not uncommon to refer to such a system as "CaaS" for "Container(s) as a Service", which contrasts with the original CaaS (Communication as a Service).

This allows for customers to build application architectures based on microservices, Functions as a Service (FaaS) and serverless computing. See ISO/IEC TS 23167 for descriptions of these concepts.

6.4.2   Data Storage as a Service (DSaaS)

While basic access to raw data storage capacity, often as virtualised hard drives or solid state drives, is covered by infrastructure capabilities type, there are many more sophisticated data storage services that allow for customers to install their own code to work with the stored data. The most common of these is probably the support for SQL Stored Procedures within cloud-based SQL databases. However, this is not unique; there are other advanced storage technologies such as Hadoop processing for Big Data. For more details see ISO/IEC TS 23167:2020, Clause 12.

6.4.3   Communications as a Service (CaaS)

NOTE   This use of the abbreviation CaaS is not to be confused with the same abbreviation also being used for Container as a Service.

Communications as a Service (CaaS) has become a vitally important cloud service category during the Covid-19 pandemic, providing businesses and citizens with the online tools they need to remain in contact through video calls, meetings, family gatherings and social events online through cameras, microphones, computers and mobile devices.

This form of Communications as a Service is usually regarded as a subset of SaaS with a common experience for all users, though in some cases there may also be some platform capabilities for certain customers. This can include significant programmability for business customers, such as the ability to create apps that customers can add to their Communications as a Service experience, and customer-specific code to handle things such as routing of customer service calls to the appropriate operator or subsidiary.

A Communications as a Service can be categorised a digital economic service when it goes beyond peer-to-peer communication between end users, if it starts to offer things like "yellow pages" listings for specific businesses. This can also apply if the service provides a different calling service to "providers" than it does to regular end users. As usual, this concept is independent of whether it acts as a digital technology platform or not.

6.4.4   Emerging cloud services with platform capabilities

There are additional areas of cloud computing where standards are still evolving, however it can be anticipated that these will be relevant to future technology platform services.

6.4.4.1   AI as a Service (AIaaS) / Machine Learning as a Service (MLaaS)

Refer to ISO/IEC 22989. AiaaS and MlaaS are generally synonymous terms. In each case it refers to a cloud-based service that offers large parts of the functionality needed to process data using AI techniques. This will include the basic AI algorithms, the APIs for other customer code to be able to communicate with the AI elements, the ability to train and refine the AI solution, and other AI related functions.

AI services of this kind can be very generic, or they can be specialised for specific purposes such as image processing/machine vision, audio processing (speech, music and sounds), language (for voice control, language translation, writing assistance, etc.), industry specialities (e.g. chemistry), automotive, or other purposes. Some service will provide training sets of data; others will require the customer to bring their own.

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6.4.4.2 Quantum Computing as a Service (QCaaS)

While there are few quantum computing services available at this time, it is reasonable to anticipate that they will eventually be made available as functions that can be employed via cloud services such as PaaS. In fact, even today there are some conventional cloud computing services such as Quantum Inspired Optimisation (QIO) that have developed from ideas originally conceived for use in quantum computing, but which have proved practical for use on conventional computing systems.

6.5 Software development platforms

One distinct type of digital technology platform enables or assists the development of software code, including the ability to create, edit, manage, and compile software source code and other required resources that will go together to make up a software application or component.

Many PaaS services include a software development platform as one of their capabilities.

While such a software development platform will typically offer an application capability type for the development environment itself, most will also provide a platform capabilities type where the written and compiled code can be run and tested.

Software development platforms can also be included with or attached to one or more application marketplaces (see 3.4.6 above) to enable sale of the developed software products.

Some software development platforms include catalogues of available components that can be incorporated in software projects. Such catalogues can include open source or commercial software components and tools. When this capability is present, the software development platform can also exhibit the characteristics of a digital exchange platform (see 3.4.4 above).

6.6 Example of digital technology platforms in context

The following example illustrates a typical situation, from an end-user perspective, in which multiple institutions, as CSCs of cloud services, each employ a digital technology platform to enable the creation of their own business application(s) to serve the end-users. End-users see multiple distinct institutions, each with their own product offering, and may choose to use one or more of them Each institution composes their offering by combining services offered by cloud vendors, sometimes using similar services from multiple vendors. The effect created is of several markets interacting, with complex shared and overlapping supply chains, forming an integrated ecosystem and web of relationships.
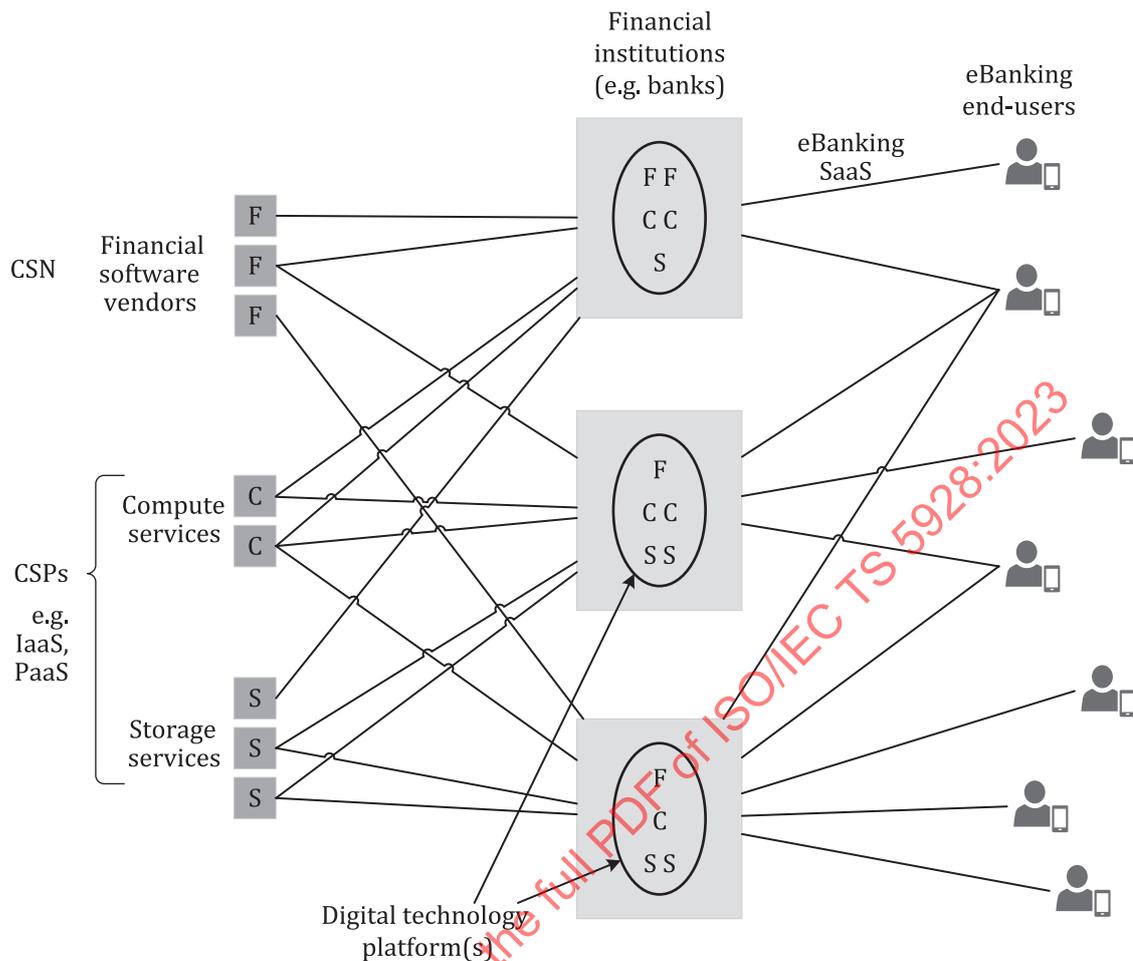
Figure 2 — Example cloud service supply chain

Figure 2 shows an example of a typical supply chain in cloud computing.

Financial institutions, rather than operating their own data centres and servers, rent capacity from cloud service providers (CSPs), for example, compute capacity (C), storage and backup services (S), and licence the use of specialist financial software packages (F).

They purchase financial software from vendors, customise the software packages to their own needs, install them on the platforms provided by the CSPs, and offer them to their eBanking customers.

In this scenario, the financial institutions are cloud service customers to the platform CSPs (e.g. IaaS or PaaS) and are themselves cloud service providers (SaaS) to their own end user customers.

The eBanking end-users have no visibility of the hosting platforms or software vendors, nor any contractual arrangement with them.

This example illustrates the graph structure of real-world supply chains, where each link may appear to be a single set of agreements between two parties, but the effect is an overlapping mesh of multi-party agreements and multi-sided markets.

6.7 One-sided and multi-sided technology platforms

The creation of a multi-sided digital platform (3.1.2) is a defining characteristic for a digital economic platform (3.4.2) but might not be the only distinguishing characteristic (see also Clause 7).

However, while technology platforms are generally assumed to create a single-sided market, there are also situations where a technology platform also gives rise to a multi-sided market.

6.7.1 One-sided technology platform

A digital technology platform that serves only a single participant group can be described as a one-sided technology platform. Specifically, this concept describes a service that does not directly create a multi-sided platform in economic terms.

EXAMPLE 1   A service which provides infrastructure such as storage and compute resources to customers (infrastructure capabilities type, see ISO/IEC 22123-1).

EXAMPLE 2   A service which provides code development and execution environments to customers (platform capabilities type, see ISO/IEC 22123-1).

6.7.2 Two-sided or Multi-sided digital technology platform

This term describes a digital technology platform that also creates a market between two (or more) distinct participant groups. Such a digital technology platform can therefore also be categorised as a digital economic platform, though the terms are orthogonal (see 5.2 above).

A digital technology platform which permits a platform participant to choose and use a third-party resource (rather than the platform directly supplying the resource) is likely to be characterised as a two-sided or multi-sided digital technology platform. This is not uncommon where third-party software companies make their technologies available within a digital technology platform offered by another company.

The economic aspects of this type of digital technology platform can be described using one or more of the digital economic platform terms. This is orthogonal and additional to describing the service as a digital technology platform.

EXAMPLE   A PaaS service (or a software development platform, see 6.5) includes some form of catalogue of third-party components, connectors, data sources, payment mechanisms, or other elements that a customer can employ in building their application, this can constitute a multi-sided market as described elsewhere in this document even if this is not the primary purposes of the PaaS service. Whether the PaaS service itself constitutes such a multi-sided market will largely depend on how much freedom the customer has to ignore those offered components, or to create or bring in alternatives (such as open-source code) instead, or indeed if they have no need of such components at all. This will often depend on the customer's specific needs.

7 Digital economic platforms

7.1 General

Economists have identified several main categories of digital economic platforms that create multi-sided markets.

The taxonomy and descriptions in this clause are intended to clarify the concepts beyond the wording in the definitions in Clause 3.

7.2 Common characteristics of digital economic platforms

The following should be considered for all categories.

7.2.1 Digital economic platforms as matchmakers

Digital economic platforms, in addition to their other functions, often act as matchmakers between parties who can otherwise be unaware of one another. A matchmaker connects participants and interacts with participants in more than one participant group.

More sophisticated matchmakers may utilise richer contextualisations and user preferences, where available, as well as knowledge about prior matchings, as part of the personalisation of match results.

EXAMPLE 1   Where ads appear in a search engine, the search engine incorporates a matchmaking function, determining which ads to show in response to which searches. If the matching is purely immediately contextual, the matchmaker requires knowledge of the user context and their information needs, as well as an ability to assess ad applicability to that context.

EXAMPLE 2   Ensuring language and locational compatibility is important: there is no point in answering a search for "nearby car parking" with pure-text directions written in a language and script the user cannot understand or links to webpages about facilities in another country, even if they are in a place named "Nearby".

7.2.2   Payment for use of a digital economic platform

Monetisation in a digital economic platform can be direct (payment for a service is made by the user with money) or indirect (payment for provision of the service is made by a third party) or deferred (up-front costs are covered by investors expecting a subsequent return on their investment due to later monetisation, which may not be directly linkable to this user). Payment can be immediate (pay per use), paid in advance (e.g. through purchase of a licence), paid continuously (through rental), or paid in kind (e.g. through publicity). In practice there can be many forms of payment inherent in the use of a platform, which combine to make the platform provider economically viable.

Forms of payment can include but are not limited to:

— money;

— passive attention (e.g. watching brand-building videos);

— secondary task completion (e.g. answering anonymous surveys, completing minor user studies);

— material (e.g. contributing reviews, or adding data to a broker's repository intended for subsequent sale);

— direct participation (e.g. an online multi-player game or dating app is not viable without enough users);

— commission or fees (e.g. as revenue share for subsequent in-app purchases).

Payment comes in many forms and in practice is often a hybrid multi-dimensional economic exchange dispersed over time, and the concept of consumption is non-trivial in digital settings. For example, when watching a movie on streaming video, the user is not "consuming" the film in the sense of using it up. Though they are using bandwidth which can have otherwise gone unused (bandwidth is a perishable good), or which could have been put to another purpose. So, they may in practice be imposing an externality on their neighbour, whose Internet service is slightly degraded while the movie is streaming. Since the payment to the streaming service is distinct from the payment to the ISP, the customer is in effect paying:

i)   a time-limited content licence fee, albeit bundled into a flat-rate monthly subscription,

ii)   for bandwidth to be provided for a given month or year, that they've chosen to utilise at this time,

iii)   for devices on which to receive and watch the film, via past hardware purchases, and

iv)   with their attention, through the opportunity cost of sitting and watching the film rather than doing something else.

EXAMPLE   A user purchases a games console (providing money as a cost of entry), receives some games for free as part of the console package, purchases other games for cash, pays a recurrent licence fee for yet more games, and downloads "free to play" games from an online store, possibly making subsequent "in app" purchases, such as "loot packs", accelerators or in-game currency for purchasing enhancements or accelerators. While playing games in solo game-playing modes, the user is either focused on the game or occasionally distracted by ads (e.g. for other games). Feedback is potentially (explicitly or implicitly) provided about the game dynamics, structure, or tooling through their actions. If the game is played as a multi-player collaboration or competition, with remote participants initially unknown to the user, then the user is also providing value through participation – since the larger pool of players can make the ecosystem more attractive to other new users.

7.3   Examples of digital economic platforms

This document describes many of the most common categories, though it is certainly not fully inclusive of all.

The categories can sometimes be combined. A single digital economic platform can sometimes match multiple categories.

7.3.1   Exchange platform

In this case, the platform facilitates discovery and business transactions between purchasers and vendors.

As illustrated in Figure 3, an exchange platform brings together two distinct groups of users: purchasers and vendors (or "sellers"). The platform provides a common meeting place and facilitates discovery, interactions and transactions between purchasers and vendors. Exchanges can provide information for purchasers to compare different vendors (e.g. providing price comparison) and can provide information on purchasers to vendors (e.g. reviews). Typically, purchasers value access to more vendors and vendors value access to more purchasers, showing the presence of cross-side network effects.
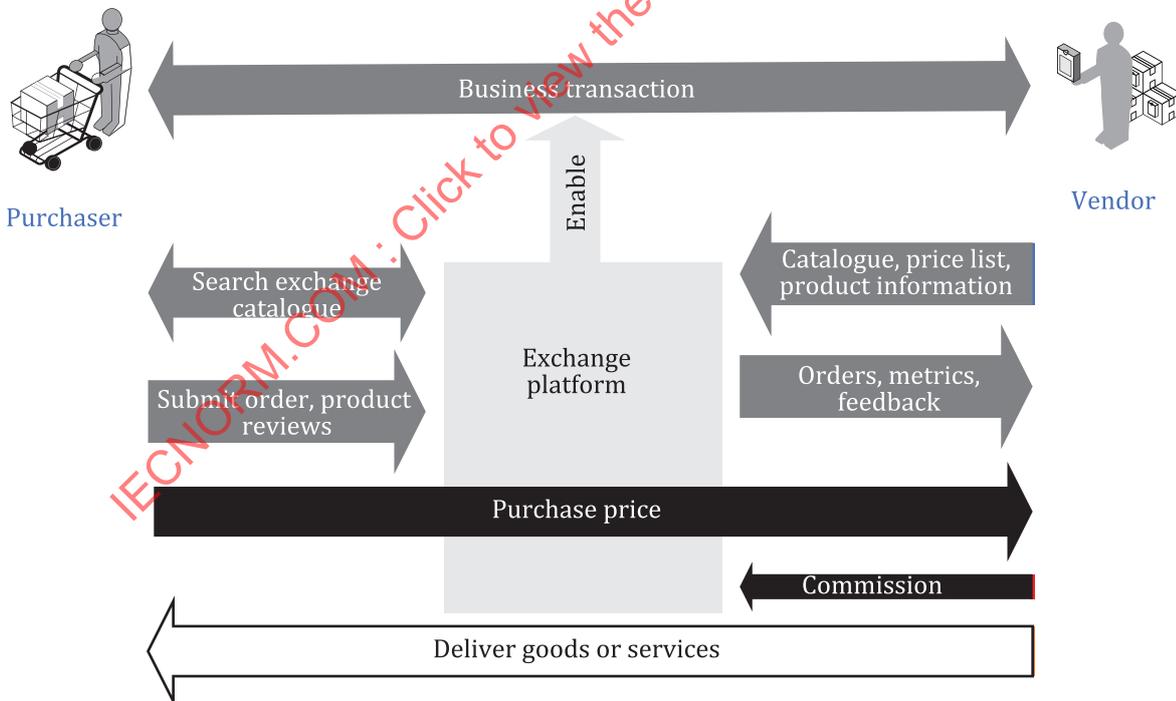

Figure 3 — Exchange platform

Exchange platforms can take a fee from each transaction. The actual transfer of payments for transactions between vendors and purchasers is usually delegated to one or more payment platforms (see 7.3.3 below) run by the same company or by a third party.

An exchange platform exists where two or more vendors offer goods or services (e.g. apps, software components, APIs) to two or more potential users of those goods or services.

An exchange platform may have rules for participation, set down by the exchange platform provider or laid out by a fourth party. Those rules may be enforced contractually or technologically or both, pro-actively, continuously or reactively, to varying degree of effectiveness. For instance, apps in a digital store can be subject to malware scanning before being offered for sale. Exchanges need not involve buying and selling: content and apps can be offered for no monetary cost, for example, in a blogging platform in which the exchange enables the dissemination of ideas, with writers offering their material and readers selecting which items to spend their time on.

Exchange platform participants potentially include a provider, rule enforcement mechanisms and authorities, safeguarding mechanisms, vendors and user/customers.

An exchange platform can include one or more recommendation mechanisms, such as to help the users navigate the available offerings, or to suggest to vendors where and how to place their goods to attract user interest. There is a spectrum of recommendation capabilities, such as highlighting new or sale items, indicating similar or complementary items, matching against wish-lists, advising based on prior activity by this user, or sharing community-based insights based on prior usage from many or all users.

Examples of exchange platforms include:

— multi-vendor retail platforms,

— ride-hailing services,

— local service exchanges, such as for gardeners, plumbers and other local tradespeople,

— "classified advertising" websites, where vendors can place small adverts and purchasers can search for them. This includes the traditional general-purpose small advertising originally carried by newspapers, and more up-market and specialised services such as those covering second-hand cars, boats and accommodation.

7.3.2   Application marketplace

Application marketplaces are a special type of exchange platform (see ISO/IEC 19944). A "store" for buying software applications or "apps" within a computer or mobile device operating system can be an instance of a two-sided software platform. Users will choose to use devices and their associated store platforms where they expect many companies to add new applications or update the existing ones, showing the presence of cross-side network effects.

Companies wishing to provide their applications through a device-appropriate "store" will have to implement it for the appropriate device type, meaning they have to write their code to run within the operating system for that device, use the APIs it provides, and in some cases also meet specific obligations (such as privacy, safety or accessibility) that go along with use of that store.

Rules around the use of such stores have implications for platform governance, the security of the device (individually and as a component in a corporate IT system), ease of use and user privacy.

Hybrid software sales models also exist that combine these approaches.

7.3.3 Payment platform

A payment platform[1] creates a multi-sided market which facilitates payments from customers (individuals/businesses) to vendors (also referred to as merchants). The payment platform can be monetized, such as by charging a transaction fee, typically charged to vendors.

NOTE   There are also funds-transfer systems that are peer-to-peer. These do not qualify as digital economic platforms since they do not create a multi-sided market.

The payment platform provides components that vendors can include in their websites, in their apps, or in their physical stores to process payments made by customers of the vendor's product or service.

The payment platform can provide a common security service to all of their constituent groups, whether they are purchasers, vendors, or banks, and can provide banks with tools that aid in their own fraud detection and mitigation processes.[2]

Some payment platforms may provide their own apps for consumers to use directly or allow for their payment functions to be embedded or in or connected to vendor or banking websites or apps.

EXAMPLE 1   A shopping website, selling their own goods, uses a "shopping cart" function provided by a third-party payment platform that enables customers to complete their purchases. The payment platform takes the payment, including any required additional security steps, then notifies the shopping website that payment is complete and the goods can be shipped.

EXAMPLE 2   A news website allows customers to pay for their subscription using a choice of third-party payment platforms rather than requiring them to provide credit card information. This allows the news site to avoid handling much personal information about their customers, simplifying their privacy compliance obligations.

As shown in Figure 4, there can be several different payment platform participant groups involved, even just for a single transaction.

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1)   Some will use the term "financial transaction platform" rather than "payment platform". However, ISO 23897:2020, 3.3 "financial transaction" applies specifically to financial instruments used between financial organisations, not to payments for services.

2)   There are different roles adopted by financial institutions facilitating the transaction (see e.g. https://digital .hbs.edu/platform-digit/submission/visa-leveraging-indirect-network-effects/)
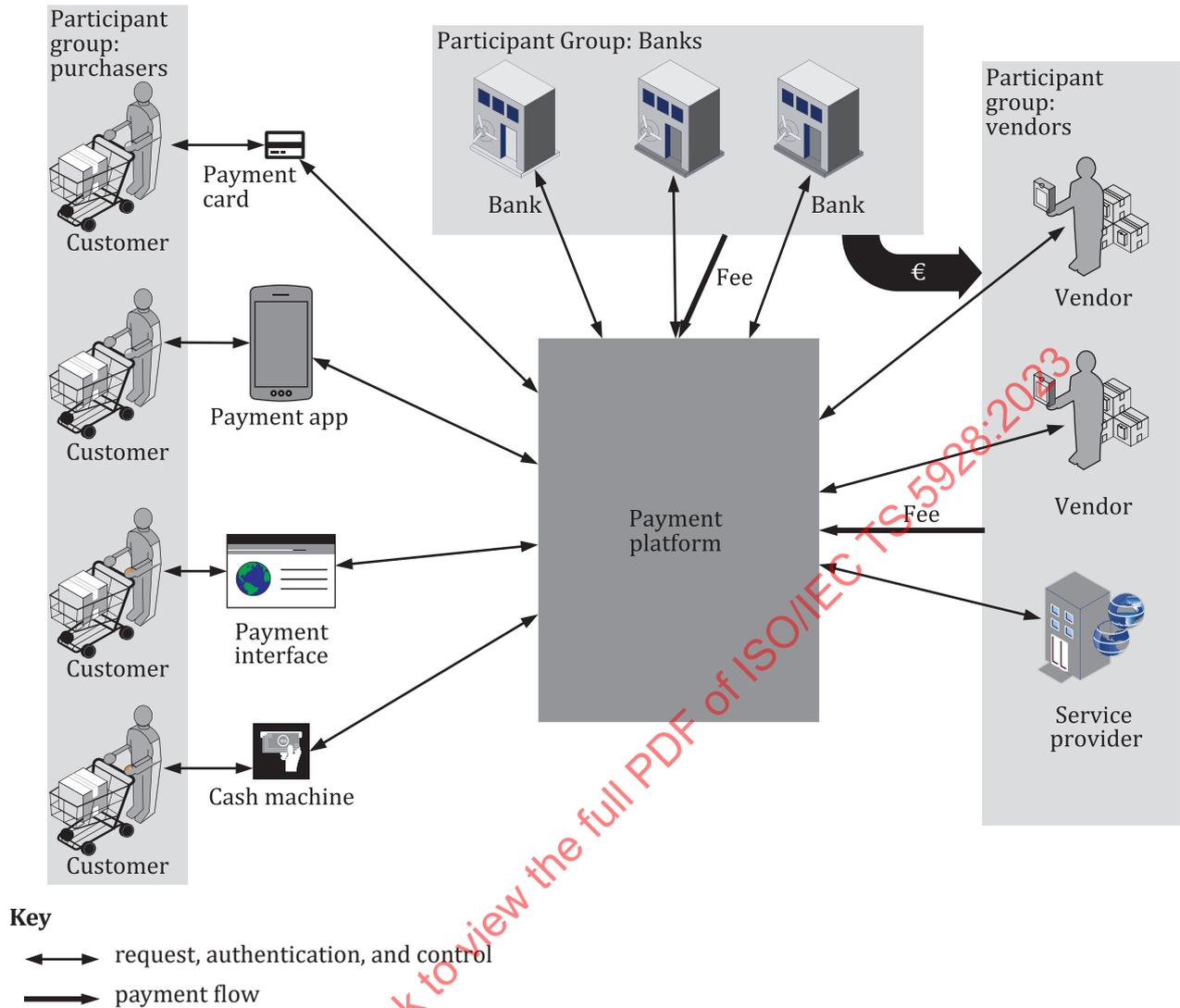
Figure 4 — Payment platform

There are strong positive cross-side network effects (see 5.3.1 above and 8.2 below) between vendors and users on the platform. For instance, customers derive more value as more vendors sign up, because the transaction service becomes more widely accepted at places where the customers shop. Conversely, vendors derive more value as more potential purchasers sign up. This appears to introduce a "chicken and egg"[3] entry barrier, since it can be difficult to attract users without retailers willing to accept a new payment platform, and it can be hard to enrol retailers unless they anticipate a demand from users. Nonetheless, new forms of payment platforms, new forms of payment, and new entrants in existing market sectors, do appear and succeed. "Chicken and egg" arguments can appear compelling, but do not always stand up to real-world scrutiny.

Typical payment platforms include:

— credit card companies

— online payment and escrow services

— mobile payment providers

— automatic teller machine networks

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3) causality dilemma

— electric vehicle charging payment networks

NOTE   In some countries, networked automatic teller machines (cash machines) can be used by customers to pay for mobile phone credit, or to pay household bills in addition to normal banking such as withdrawing cash.

7.3.4   Ad-funded platforms

An ad-funded platform is one subtype of the more general "attention funded" platform. There are other types, such as where the compensation comes in the form of an end-user's time or information they provide (such as an online marketing survey). However, this document will concentrate on paid advertising as the most important model.

The ad-funded platform serves two distinct groups: users and advertisers. It operates by aggregating users by providing a service (such as news content) and charging advertisers to display advertising to those users.

In an ad-funded platform, the advertisers value the users, and typically a platform with more users is more attractive to the advertiser. Whether the users value the advertisers varies across platforms and contexts, for instance when they are made aware of products they find interesting. In other words, cross-side network effects are present and are stronger in one direction. Users may also value other users, showing the extent of same-side network effects (e.g. on a social media network). As a result, aggregating the user side of the platform can be an important part of an ad-funded platform strategy. Advertisers typically aim to reach large and relevant groups of users. The platform charges advertisers, sometimes only when users respond positively to the ads, while users may receive access to the platform for free.

Note that some ad-funded services may also offer a "premium" version of the service where the user pays the platform for additional services or products, or to avoid advertising.

It's also important to understand the distinction between an *ad-funded* platform and an *advertising* platform. The latter is really a form of exchange platform, which forms a bridge between those wishing to place advertisements for their products, and the various websites and other locations where the ads will be shown to the end-users.

Figure 5 below shows a relationship between these two types of platform. Exactly what information is exchanged between the two platforms (on the mid-grey arrows) will vary by the contract between the businesses, and in many cases also due to the regulations that apply in the relevant jurisdiction(s).
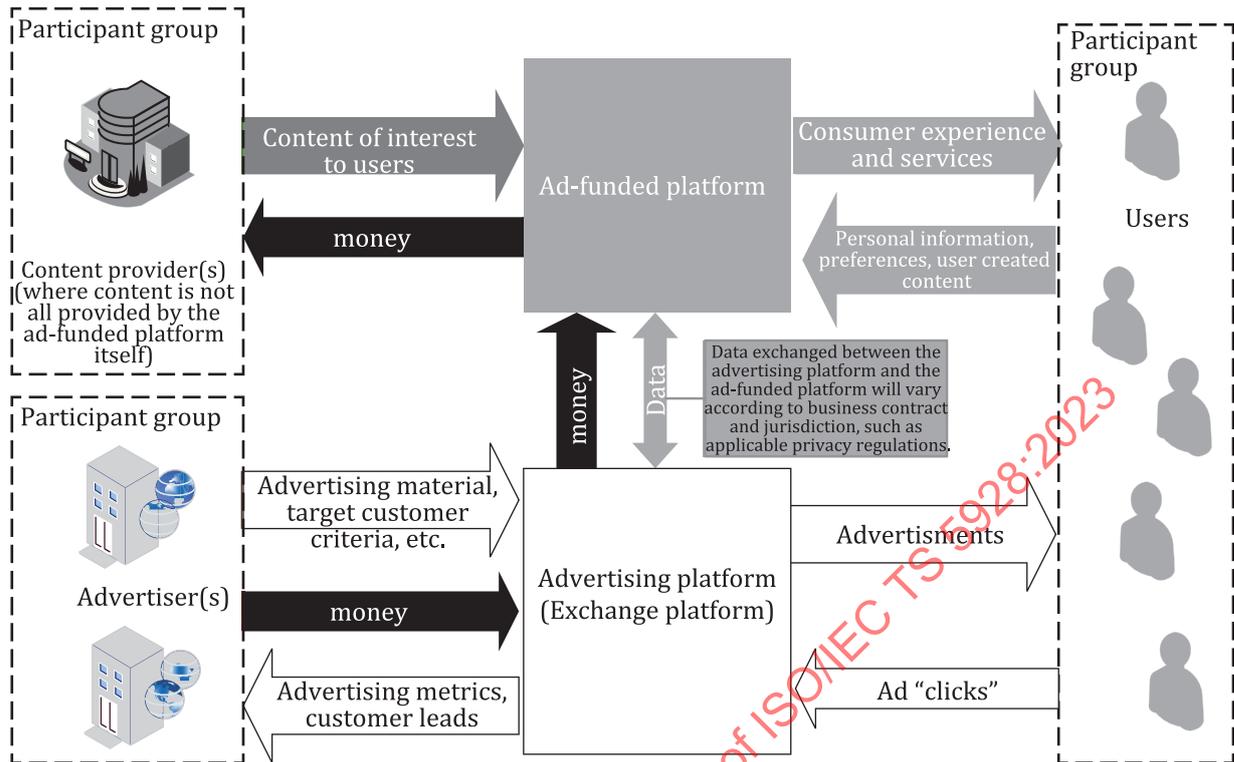
Figure 5 — Ad-funded platform

There are ad-funded instances for each of the following kinds of online service and for many other types of online service:

— search engines

— social media networks

— product or service review sites

— classified advertising sites

— online news websites

— online map services

— travel and holiday booking websites

— music streaming services

EXAMPLE   A music streaming service, which monetizes the "free" version via advertising, and provides a better experience if the user pays a subscription. From a strategic point of view, having both a free and paid subscription helps the platform to price discriminate according to the users' willingness to pay, while at the same time increasing the user base, which is important in the presence of network effects.

8   Impact of platform characteristics on participant behaviour

8.1   General

The inter-connectedness of platform participants within the service, both within their own platform participant group and with those in other platform participant groups, can affect the behaviour of platform participants in various ways. This clause explores some of these phenomena.

8.2 Network effects

As described in 5.3.1 above, network effects arise from the quantity of participation by other participants in a platform. These effects arise in several different forms, differentiated by the "side" of the other participants and by whether the effect is positive or negative.

8.2.1 Positive network effects

A positive network effect exists where the use of a service becomes more attractive as the number of participants increases.

8.2.1.1 Same-side positive network effects

As described above, this can apply within the same participant group. For instance, if family members, friends, and celebrities become active on a specific social media network, that network becomes far more interesting and attractive for other participants to also join rather than an alternative without the same people of interest to them. This is known as a "same side" network effect.

8.2.1.2 Cross-side positive network effects

In contrast, a "cross-side" network effect arises when there is a correlation between the value attributed to the system and the number of members of a *different* participatory group.

EXAMPLE 1   An Exchange platform that offers goods from a much larger pool of vendors is going to be more attractive to purchasers looking for a product, especially if the product is substitutable and they don't care too much exactly which vendor will be supplying it.

EXAMPLE 2   A streaming media service that carries movies and television from a wider variety of studios and production houses.

8.2.2 Negative network effects

While less common, *negative* network effects can sometimes arise where large numbers of participants make the service *less* attractive to new participants.

EXAMPLE 1   Social networks that become less interesting to young people once their parents begin using them (the "no longer cool" factor)

EXAMPLE 2   Exchanges with so many similar vendors on them that potential customers find it difficult to determine the offers that are most relevant to their search. This can arise when the products are largely substitutable, perhaps even identical, and the difference between them may be subtle and hard to determine (such as the quality of customer service). Examples could include motor vehicle insurance offers, or other competitive utilities such as telecom and electricity.

EXAMPLE 3   Streaming media services where content owners such as studios decide they would rather offer their own streaming platform than continue to pay commission to a streaming company that is also carrying numerous content offerings that compete with their own.

8.2.3 Impact of network effects

Network effects are a natural consequence of individuals and organisations seeking to optimise their experience and their opportunities. As such these effects can create a significant market entry hurdle for new platforms. Nonetheless, new products, services and platforms and new entrants in existing market sectors, do appear and succeed. "Chicken and egg" arguments and concerns about the potential adverse impact of network effects can appear compelling, but do not always stand up to real-world scrutiny.

8.3 Customer inertia

Many users (even businesses) develop subconscious loyalty to specific services and may seem reluctant to try alternatives that can be available. This can be due to familiarity with the service and its user interface, or simply because it doesn't occur to them to look anywhere else.

Also, any change of service provider implies some degree of risk to a business customer, which introduces a reluctance to make casual or rapid changes without good business justification, even where a slightly cheaper or more suitable alternative may be available.

This is not unique to digital services. Many people will go first to their most familiar supermarket for their needs, and only look elsewhere when something is not available or is clearly cheaper or better elsewhere.

Companies use tools such as loyalty cards to deliberately increase this customer inertia.

8.4 Stickiness

Stickiness arises when a participant has made some significant investment of money, time, or effort into a digital service, especially where this investment grows constantly over time. Changing to a competitive service becomes challenging if that past investment will be lost, or will require substantial new investment to reach a parity of service offering.

Causes of stickiness can include but are not limited to:

— networks of contacts (people and businesses) built up over time

— content that has been uploaded (such as photographs), especially where the raw uploads have been "enhanced" within the platform, such as edited versions, timelines, tagging of people appearing in photos and lists of "likes" and "shares"

— interconnections created between items of content

— activity logs that have historical value to the participant (e.g. places visited, books read, game progress and scores)

— records of payments

Portability of cloud service customer data can mitigate stickiness to some extent, however certain types of cloud service derived data that is valued by the participant, such as social network connection data, can be governed by privacy regulations (such as consent of many other people) and thus remain unavailable for porting to another service.

9 Observations and conclusion

Economists use a definition of the term "platform" in the context of two-sided or multi-sided markets.

Technologists use the term "platform", with a variety of related and well-understood interpretations, including as a descriptive aspect of system and application architectures, for technology products and services that are used as building blocks by other developers, and to describe the functionality of business and customer-facing products.

There are also other discipline and sector-specific definitions of the word "platform" that are used in contexts that overlap with the uses by economists and technologists.

This clash of terminology between economists, engineers and others arises because the engineering use of the term "platform" in technical settings, for example, to represent layerings, system architecture elements and other structured engineering perspectives (including the use in Cloud Computing with respect to IaaS and PaaS) dates back many years. This terminology is deeply embedded in numerous national and international standards around the world. Hence, it cannot be changed simply for disambiguation purposes. Similarly, although the economic use of the word "platform" may be more

modern, it is so deeply ingrained in economic discourse that halting the use of the word "platform" in that setting is also infeasible.

This need not cause confusion if the context in which the term platform is used is clear.

It is therefore recommended that writers of standards, specifications, and other documents dealing with "platform" issues should avoid the ambiguities associated with broad references to the terms "platform" or "digital platform" by explicitly articulating the context and intended meaning when using that term.

Annex A
(informative)

Illustrative taxonomic hierarchies

A variety of distinguishing criteria can be used to support descriptions of digital services. Where these constitute a multi-dimensional space, for example, because they provide orthogonal partitions of the collection of items, visual representations of the structure of that space are possible, either using a taxonomy diagram or via other information presentation techniques.[4] Tree-structured taxonomic structures rely on the sequencing of the underlying distinguishing criteria, which offers opportunities to implicitly signal higher importance of some criteria relative to others.

Figure A.1 presents one possible example of a taxonomy for digital services. While this example begins by considering the distinction between one-sided and two or multi-sided markets, other approaches are also possible and relevant.

In devising and producing such visualizations, care needs to be taken not to confuse the reader by over-emphasising one criterion without providing alternatives.
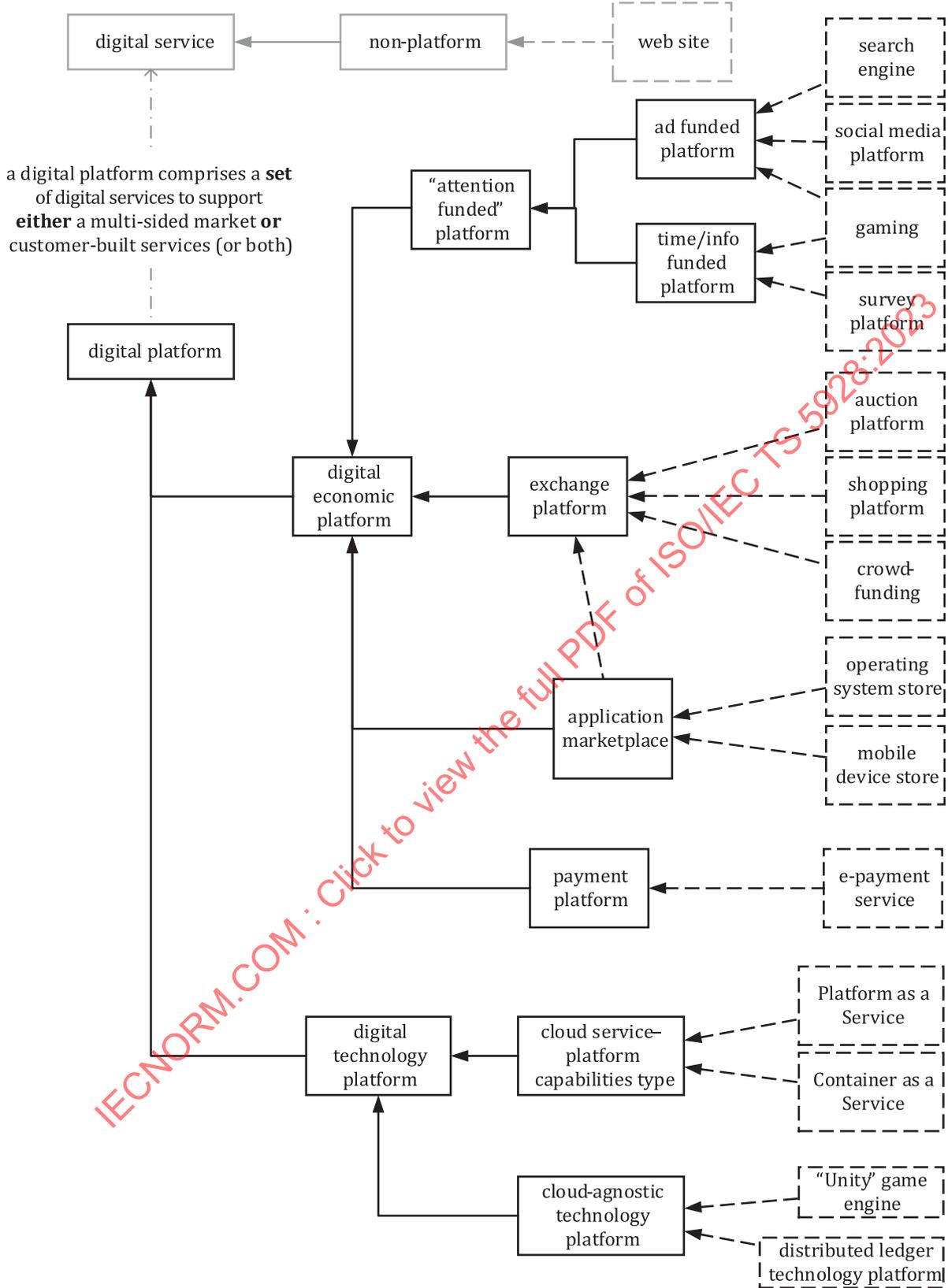
EXAMPLE 1   For market analysis and economic impact purposes, it would be possible to root the taxonomy in the funding-model criteria (e.g. distinguishing between various forms of payment made by users, or funding received by providers). In Figure A.1 this distinction is relegated to a lower level of the hierarchy.

EXAMPLE 2   A third alternative could be to follow some regulatory initiatives and begin with a simple categorisation of the purpose of the digital service, and also distinguish by scale.

A market regulator or market surveillance authority may need to consider cost of entry, cost of participation and cost of exit for customers as well as producers, and in digital settings the economic cost to users may or may not be directly financial. As an alternative, investment of effort in prior learning, or anticipated or actual effort expended during task execution, may influence user actions. Similarly, benefits to the user of network effects in product suites can influence decisions about which online tool to use to perform a task, and barriers to switching (through the need to re-learn different user interfaces, or data portability difficulties) may be significant issues for a given problem perspective.

Difficult to assess factors, such as intuitiveness or initial attractiveness of a user interface may be significant factors in determining whether or not product switching is feasible or likely between products, such as games consoles, text editors, browsers or search engines. Such factors may even, in practice, prove more important in a market dynamics analysis than the marketing budgets and product awareness-raising capabilities of providers. In addition, these taxonomic structures and representations are not fixed in time. Platforms also morph and evolve continually, in incremental ways. What is one platform today, occupying a specific position in a taxonomic structure, may appear to be a new platform tomorrow, in a different category. Incremental change can lead to apparently sudden state shifts (catastrophic change in the mathematical sense defined by Catastrophe Theory).

EXAMPLE 3   A hit video game developer provides a product attractive to users. Such a company certainly benefits from network effects within its own community of players but does not generally bring together distinct groups of participants (unless the game has additional elements such as third-party transaction, advertising or development capabilities). On the other hand, game console providers often act as platforms, serving both third-party game developers who create games and users who wish to play video games. Players benefit from a wider selection of games, while publishers benefit from a larger and more active population of players. In addition, consoles may support in-game purchases, upgrades, sequels and ad support (for sister games at least, in the form of trailers). Similarly, the technology tools (e.g. rendering engines, storyboarding tools) and libraries (e.g. physics engines) used to build and run games form their own ecosystems with multi-sided market elements. These tools often make it easier to develop cross-platform games, thus increasing the reach of game developers while to some extent undermining the network effects of the console makers.

a digital platform comprises a **set** of digital services to support **either** a multi-sided market **or** customer-built services (or both)

Key

⬅—— sub-category

⬅– – – example(s) of