Edge Computing
Fog Computing
Cloud Computing

INDUSTRIAL IoT DATA PROCESSING LAYER STACK

CLOUD LAYER

Big Data Processing
Business Logic
Data Warehousing

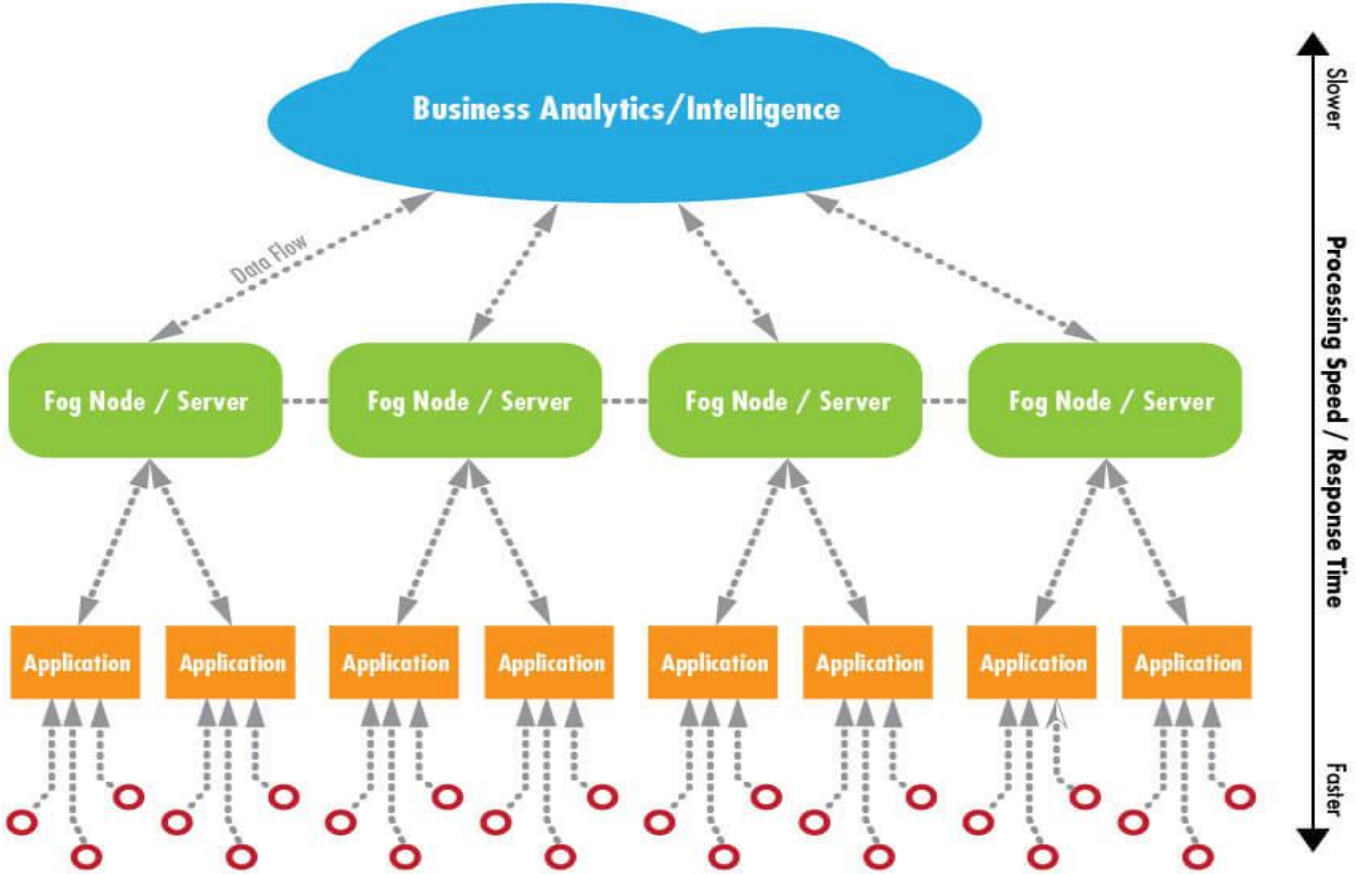
FOG LAYER

Local Network
Data Analysis & Reduction
Control Response
Virtualization/Standardization

EDGE LAYER

Large Volume Real-time Data Processing
At Source/On Premises Data Visualization
Industrial PCs
Embedded Systems
Gateways
Micro Data Storage

Sensors & Controllers (data origination)



What is edge computing?

- Edge computing is a distributed computing framework that brings enterprise applications closer to data sources such as IoT devices or local edge servers.

- In the context of networks, the edge is the device, or the local network containing the device which communicates with the Internet.

What is edge computing?

- It is not meant to be a complete replacement of the cloud.

- Edge computing is an optimization of the cloud, instead of relying on the cloud to do all the work edge computing does the compute work on site sometimes on the edge device itself.

Edge Computing vs. Cloud Computing

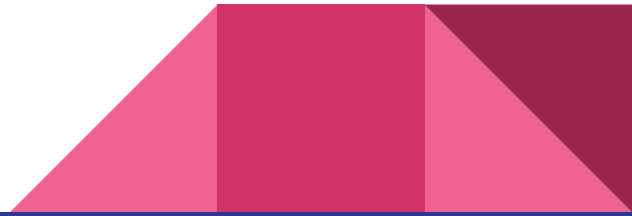
- Cloud computing relies on a central computing model that delivers services, processes and data services.

- Edge computing is a highly distributed computing model that brings computation and data storage closer to the sources of data

What is an edge device?

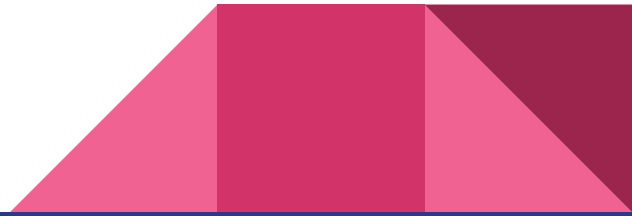
- An edge device is a device that controls data flow at the boundary between two networks.

- A common misconception is that edge and IoT devices are synonymous.
- An IoT device is a physical object that has been connected to the internet and is the source of the data. An edge device is where the data is collected and processed.



Evolution of computing

- Early computing: Centralized applications only running on one isolated computer.
- Personal computing: Decentralized applications running locally.
- Cloud computing: Centralized applications running in data centers.
- Edge computing: Centralized applications running close to users, either on the device itself or on the network edge.



How does edge computing work?

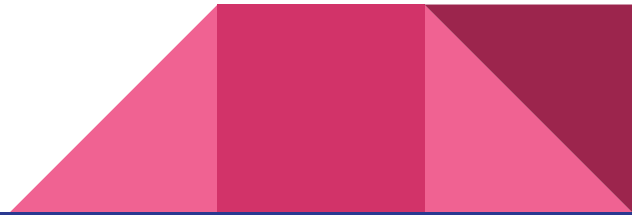
- Edge computing works by capturing and processing information as close to the source of the data as possible.

- Computing tasks may be deployed to nearby edge servers, gateway devices, edge devices might process data onboard or send the data to a smartphone for example.

Why edge computing?

- In traditional enterprise computing, data is produced at a client endpoint That data is moved across the internet, to where it is stored and worked upon by an application. Results of that work are then sent back to the client.

- The volume of data being produced by those devices and used by businesses, is growing far too quickly for traditional data centers infrastructures to accommodate.



Advantages of edge computing

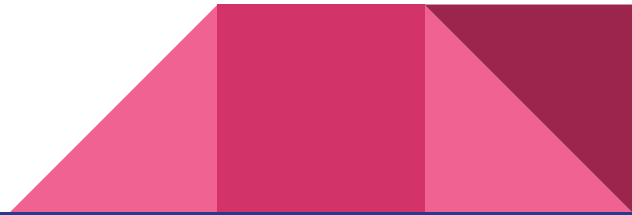
Advantages of edge computing over cloud computing:

- Reduced latency
  - By processing data closer to the source and reducing the physical distance it must travel, edge computing can greatly reduce latency.
- Speeds processing
  - Since edge devices process data locally, the information they collect doesn't have to travel nearly as far as it would under a traditional cloud architecture.
- Reliability
  - With edge devices positioned closer to end-users, there is less chance of a network problem.

Advantages of edge computing

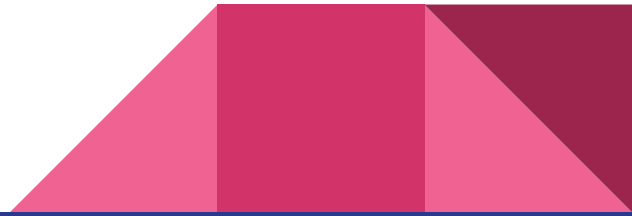
Additional advantages include:

- Autonomy
  - Edge computing does the compute work on site. Computations executed sometimes on the edge device itself and data is saved to transmit to a central point only when the connectivity is available.
- Scalability
  - Edge computing offers a cheap route that enable the scalability, and allows companies to expand their computing capacity through a combination of IoT devices and edge data centers.



Edge computing use cases and examples

- Manufacturing
  - Monitor manufacturing, enable machine learning at the edge to find production errors and improve product manufacturing quality.
- Farming
  - Use sensors to track water use, nutrient density and determine optimal harvest. Data is collected and analyzed to improve the crop growing algorithms
- Network optimization
  - Edge computing can help optimize network performance by measuring performance for users across the internet and then employing analytics to determine the most reliable, low-latency network path for each user's traffic.

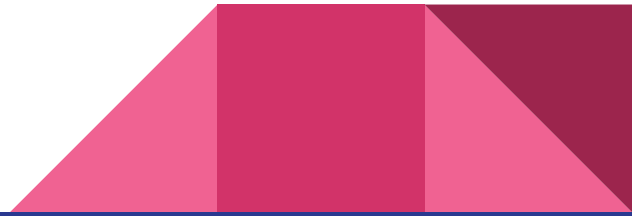


Edge computing use cases and examples

- Improved healthcare
  - The data collected from patients requires edge computing to apply automation and machine learning to access it, ignore "normal" data and identify problem data so that clinicians can take correct measures to help patients in real time.
- Transportation
  - Autonomous vehicles gather information about location, speed, road conditions, traffic conditions. This requires onboard computing so each autonomous vehicle becomes an "edge."
- Retail
  - Edge computing can help analyze the data collected by surveillance, stock tracking, sales data and other real-time business details to identify business opportunities

Challenges of edge computing

- Limited capability
  - Cloud computing brings more variety and a bigger scale of resources than edge computing which usually has a specific scope and purpose.
- Connectivity
  - Edge computing overcomes typical network limitations, but it still requires some minimum level of connectivity.
- Security
  - With the addition of more smart devices into the network, such as edge servers and IoT devices that have built-in computers, there are new opportunities for malicious attackers to compromise these devices.



The future of edge computing

- By 2025, edge compute is expected to be four times larger than cloud and generate 75 percent of the world's data.

- Technologies that will drive edge computing forward include:
  - Advances in edge hardware
  - Machine learning and artificial intelligence
  - Digital transformation
  - Connected and autonomous cars

Fog Computing

Introduction

At first, IoT sensors were storing data using Cloud Computing and When the data became very large(Big Data), cloud computing couldn’t process and transfer all this data so the problem is solved using fog computing paradigm.

The fog computing name is due to Cisco which played it on cloud computing when the clouds are high in the atmosphere, and the fog applies to the clouds near the ground down.

INDUSTRIAL IoT DATA PROCESSING LAYER STACK

CLOUD LAYER

Big Data Processing
Business Logic
Data Warehousing

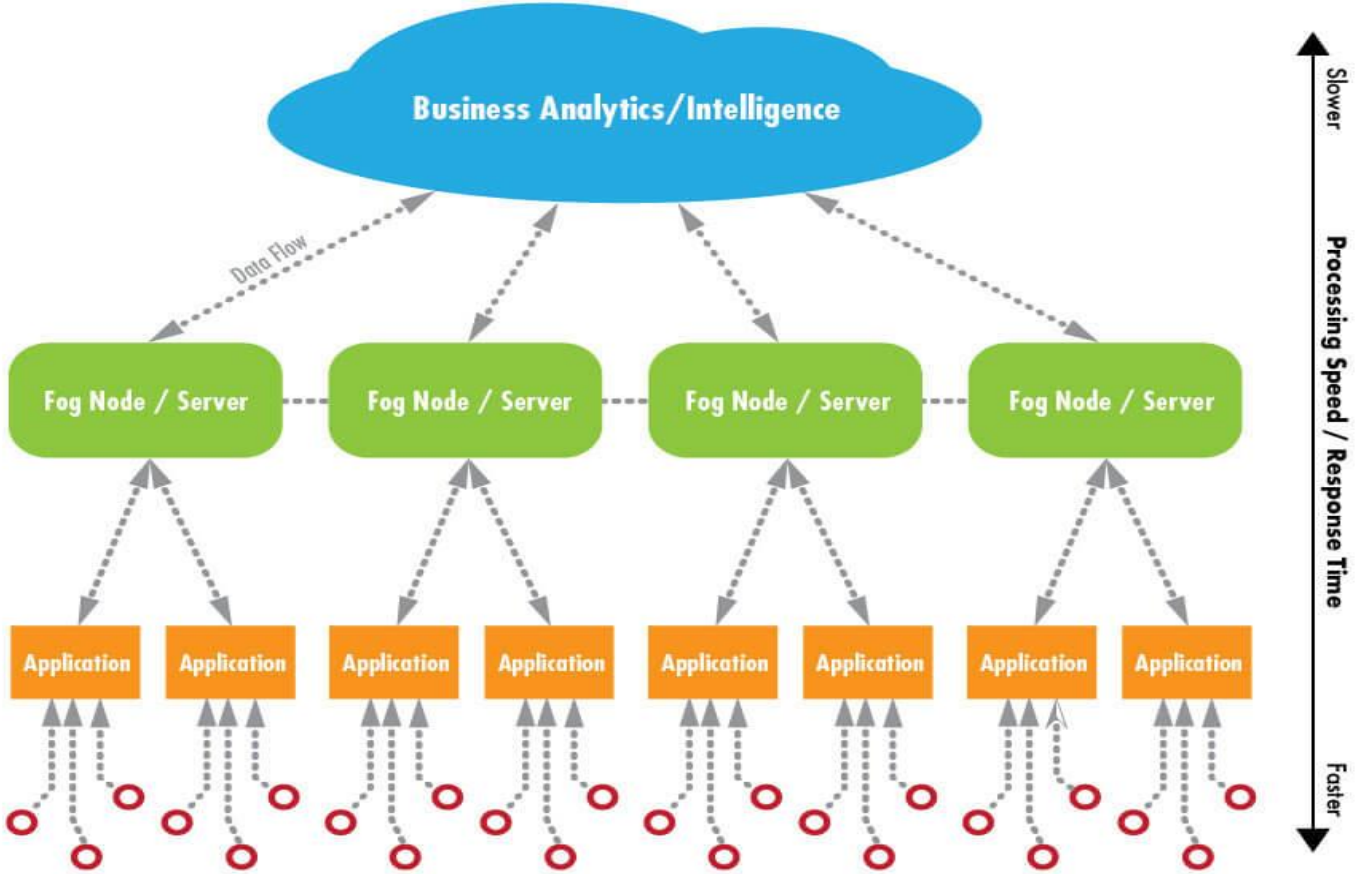
FOG LAYER

Local Network
Data Analysis & Reduction
Control Response
Virtualization/Standardization

EDGE LAYER

Large Volume Real-time Data Processing
At Source/On Premises Data Visualization
Industrial PCs
Embedded Systems
Gateways
Micro Data Storage

Sensors & Controllers (data origination)

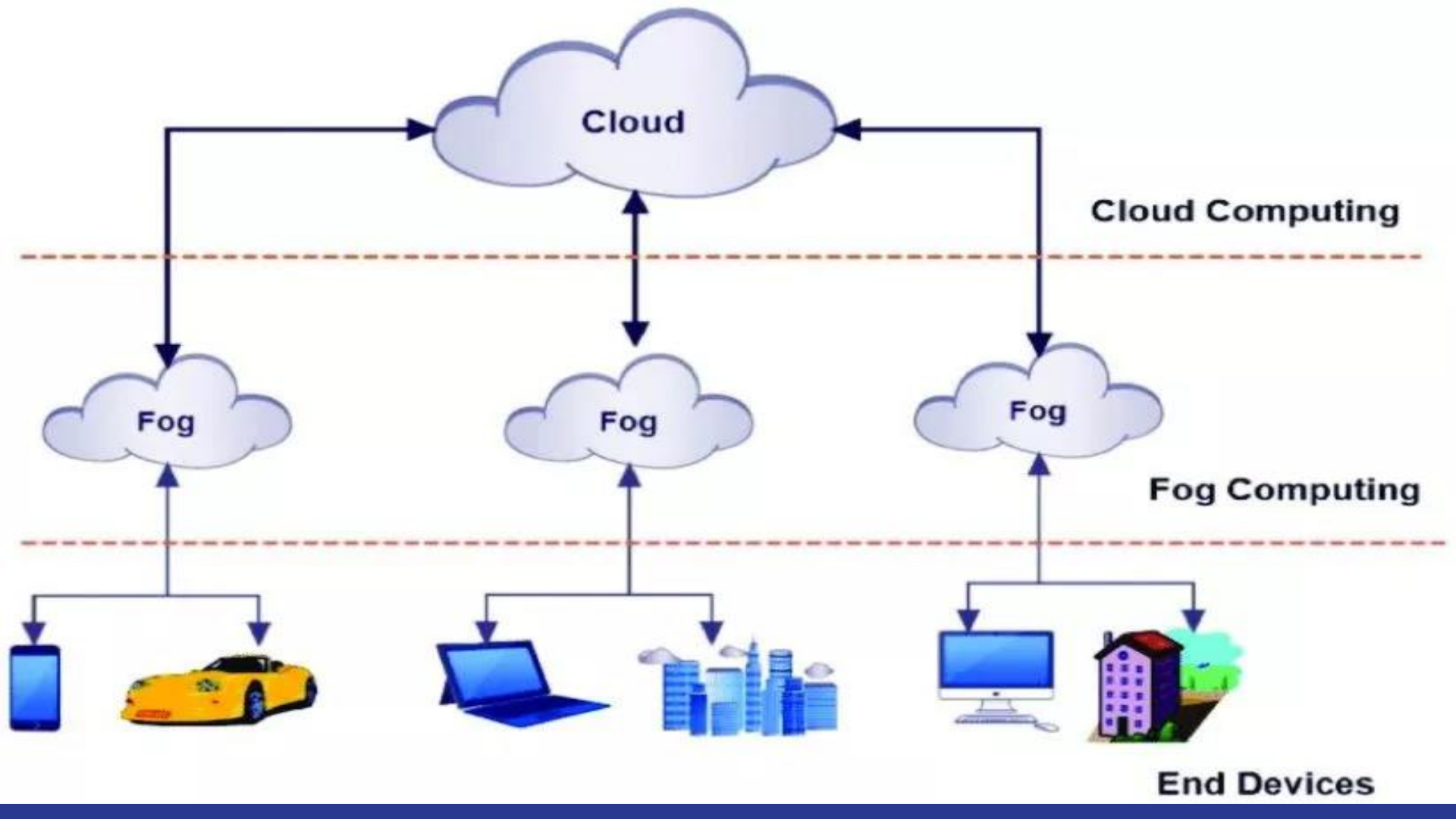


What is the Fog Computing ?

Fog Computing is a decentralized computing infrastructure in which data, compute, storage and applications are located somewhere between the data source and the cloud.

How it works?

- Fogging enables **short-term analytics** outside the cloud datacenters, while the cloud performs resource-intensive, longer-term analytics.
- Fog computing contains various devices like **fog computing gateway** (A variety of wired and wireless endpoints that contains routers and switches) which accepts data from IoT devices.
- Most sensitive data are handled by nearest fog node to end device.
- Less sensitive data are sent to aggregate node for analysis and sends the resulted decisions to the nearest node.


Cloud
Cloud Computing
Fog
Fog
Fog
Fog Computing
End Devices

Applications of Fog Computing

- **Linked vehicles:**

  Self-driven vehicles are producing a significant volume of data. The information has to be easily interpreted and processed based on the information presented such as traffic, driving conditions, environment, etc. All this information is processed quickly with the aid of fog computing.

- **Smart Cities:**

  Energy networks use real-time data for the efficient management of systems. It is necessary to process the remote data near to the location where it is produced. It is also likely that data from multiple sensors will be produced. Fog computing is constructed in such a manner that all problems can be sorted.

Pros	Cons
Reduces amount of data sent to the cloud	Physical location takes away from the anytime, anywhere, any data benefit of the cloud
Conserves network bandwidth	Security issues: IP address spoofing, man-in-the-middle attacks
Improves system response time	Privacy issues
Improves security by keeping data close to the edge	Availability/cost of fog equipment/hardware
Supports mobility	Trust and authentication concerns
Minimizes network and internet latency	Wireless network security concerns

Feature requirements	Cloud Computing	Fog Computing
Latency involved	High, depends on User to DC route	Low
Response time	Several Minutes	Milliseconds
Service Location	Inside Cloud Data Center via internet	Edge of Cloud network
Time for data storage	Months or years as per contract	Transient
Hops between user & server	Multiple	One
Location Awareness	None, need manual routing	Very local
Architecture	Centralized	Distributed
Last mile connectivity	Broadband, MPLS, Leased line	Wireless
Attach probability on data	High	Low
End to end Security	Cannot be defined or controlled	Can be defined
Nodes to collect data	Very few	Unlimited
Mobility support	Limited support	Supported

References

- https://www.winsystems.com/cloud-fog-and-edge-computing-whats-the-difference/
- https://www.jigsawacademy.com/blogs/cloud-computing/fog-computing-applications
- https://www.youtube.com/watch?v=BsfaiYNbCJ0&list=PLExIbkpRI1eWLY_wOvUPY2IJsmyh0-b9b&index=3
- https://www.researchgate.net/figure/Simulator-tools-for-fog-computing_tbl4_341426513
- https://www.investopedia.com/terms/c/cloud-computing.asp
- https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20210[illegible]-1