Edge

- → Cloud-Edge Continuum
- → Digital Twins
- → Actual real-time data streams
- → Run code anywhere
- → Robotic Automation

Edge-oriented Technologies

Edge computing covers a broad spectrum of technologies from internet of things (IoT) sensors to robots and extended reality (XR) devices. It is not surprising that there are many interesting trends happening across these technologies. To put it simply, edge computing refers to all networked technology outside centralised data centres as part of the so called edge-to-cloud continuum or digital continuum. In recent decades, and even today, there is a shift from on-premises computing, such as local data centres and self-owned infrastructure, to computing in the public clouds of Amazon, Google and Microsoft. On the other hand there is also an increasing push against big-tech and hence in favour of self-owned infra. In this sense, we could say that conventional edge computing is in decline. As generic computation and IT services move to the cloud, more specialized computational and technical solutions shift towards the edge. Indeed, the two developments are not actually opposed, as most of the edge-oriented trends depend on an integration with cloud services. Moreover, the boundaries between cloud and edge are not as clear in practice. Cloud computing refers to on-demand access to compute resources, such as virtual machines, storage and applications, over the internet. In this sense “cloud”is a delivery model for compute services.

In this section we see definite evidence of a growth in edge computing. Drivers of these developments are better wireless networking, such as 5G and in the near future 6G, and specialized and/or cheaper hardware. Crucially some, if not all, of the trends listed in this section include a cloud component. This is because the progress in edge computing is made possible by advancements in cloud services. Finally, please note that while technically XR technology is also a big part of edge technology, we have dedicated a separate section to this topic because XR is such a large field with many exciting developments.

TREND #1

Cloud-Edge Continuum

More computation will take place on the edge because edge computing can provide extra security and privacy, increase service availability, reduce network latency and save energy. Although it could also pose an extra security risk if not properly implemented. As computational processes shift away from centralized clouds to mobile devices and sensors, a new paradigm emerges in which workloads will be scheduled on a continuum from the cloud to the edge-based solutions, depending on their requirements. This paradigm requires a new infrastructure that connects edge users with each other and with various cloud providers, making it easy to integrate services independent of their location.

See also: Computing Continuum

How IoT is helping to create smart university campuses

There are many ways IoT can be used to improve both student services and the sustainability and security of the campus. Examples are a 3D holographic model to teach architecture, an interactive method of teaching Mandarin with the use of robots, and interactive information booths.

open example

Public values

Autonomy	Privacy
Justice	Transparency | Sustainability | Trustworthiness of information, content, data and systems
Humanity	

Readiness WATCH PLAN ACT

Drivers

#Connectivity #Decentralization #Privacy #Power efficiency

Utilisation of mobile edge computing on the Internet of Medical Things: A survey

The internet of medical things requires the streaming of large amounts of data that need to be analyzed in real-time. These requirements are expected to be satisfied by mobile edge devices with 5G capabilities.

open example

Why autonomous vehicles will rely on edge computing and not the cloud

In situations where data needs to be analysed as quickly as possible, such as with driving cars, the computation occurs on the edge. When you are in a moving vehicle, and this vehicle relies on computing for its essential functions, you need to have your compute as close to the data as possible, which is what edge computing is about.

open example

Want a connected home without a cloud? Get smarter sensors

Privacy conscious people are starting to use edge devices to create smart homes without relying on the public cloud. By putting machine learning on a sensor, engineers can build devices that don't need an internet connection for basic tasks.

open example

IMPACT

On the campus, in the classroom and in labs, more edge devices will be encountered. Privacy considerations in both education and research will require certain processes to run on edge devices instead of the cloud, for example in smart surveillance systems and in health research.

Researchers will rely on a combination of edge computation and cloud services to reach their goals. One of the challenges in future research will be to determine where on the edge-cloud continuum a certain computation should take place.

TREND #2

Digital Twins

Public values

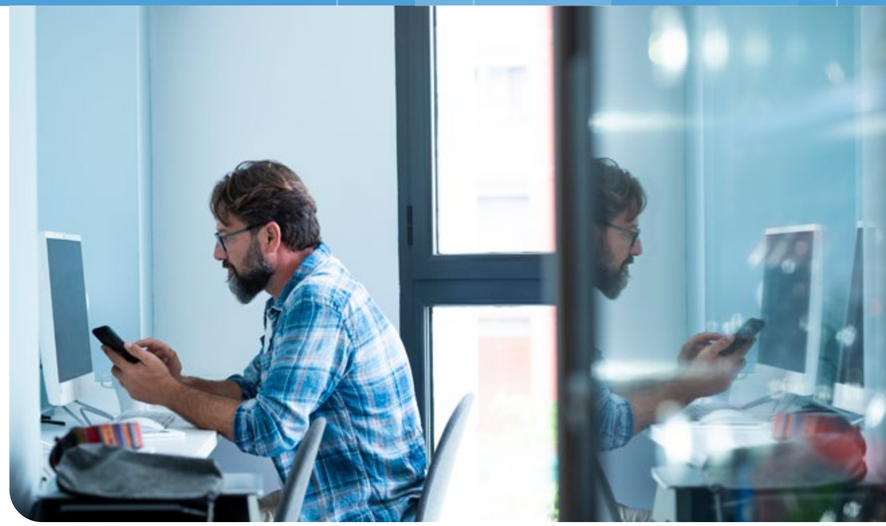
Autonomy	Privacy
Justice	Transparency | Trustworthiness of information, content, data and systems
Humanity	

Readiness WATCH PLAN ACT

Drivers

#Connectivity #DigitalEconomy

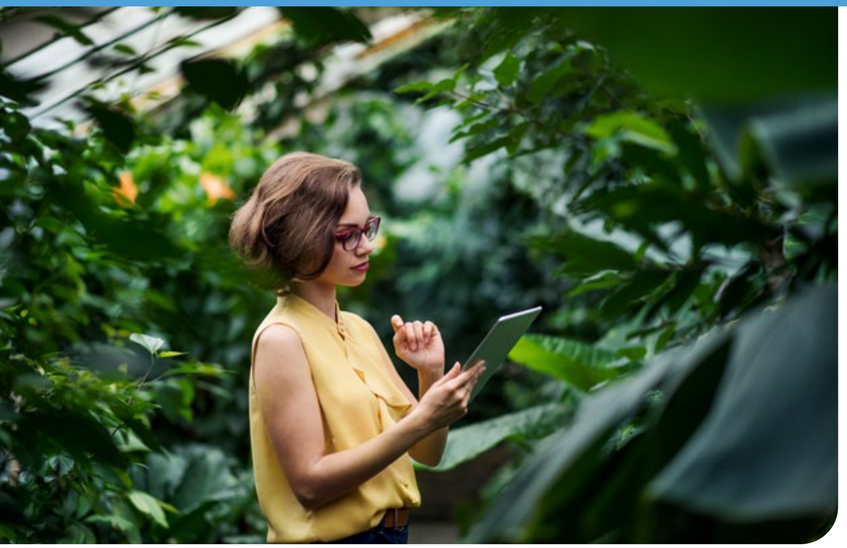
A digital twin is a real-time virtual model of something in the real world, like a spacecraft or a supply chain process. A digital twin of a critical infrastructure could be a virtual representation of a power plant, for example , that includes data from sensors, simulations, and historical performance data. With information from sensors and systems, a digital twin receives constant feedback from its physical twin. Digital twins allow us to study a real-life object or process through simulations or tests that would otherwise be physically impossible or too costly. Another advantage is that each physical object or process can have its own digital twin. Therefore, the digital twin can account for different contexts and developments. This trend builds upon the growth in edge computing and real-time data streams.



Simulia living heart

Simulia is a digital twin of a living heart that can be used to study heart defects and diseases, as well as test the efficacy of medical devices. The model comprises, among other features, a dynamic, electro-mechanical simulation, a blood flow model and a complete characterisation of cardiac tissues.

open example



Destination Earth

Destination Earth is an initiative by the European Union to create digital twins of the earth combining various data sources, artificial intelligence and high performance computing. The digital twins will be used to study the effects of climate change as well as strategies for mitigating and adapting to it.

open example

Digital Tomato Twins

Researchers in Wageningen are using digital twins to study the impact of sustainability measures on tomato crops. The 'Virtual Tomato Crops' receive feedback from actual tomatoes growing in a greenhouse.

open example

Digital twin: Empowering power systems with real-time training and predictive simulation

In the energy sector, digital twins are used for training and simulations of power systems that would be too risky and costly in the real world. Digital twin technology allows for effortless collaboration and the application of real-time insights, helping to streamline diagnostics and troubleshooting.

open example

IMPACT

Digital twins are a useful approach for researchers to study real world phenomena, especially when it is difficult or costly to study these systems or processes otherwise. Using this approach will require training in digital twin technologies.

In education, digital twins can be used to simulate job scenarios that an intern would normally not get access to, for example operating a power plant or making management decisions. In fact, some universities may turn themselves into digital twins in the metaverse, so-called 'metaversities'.

TREND #3

Actual real-time data streams

Public values

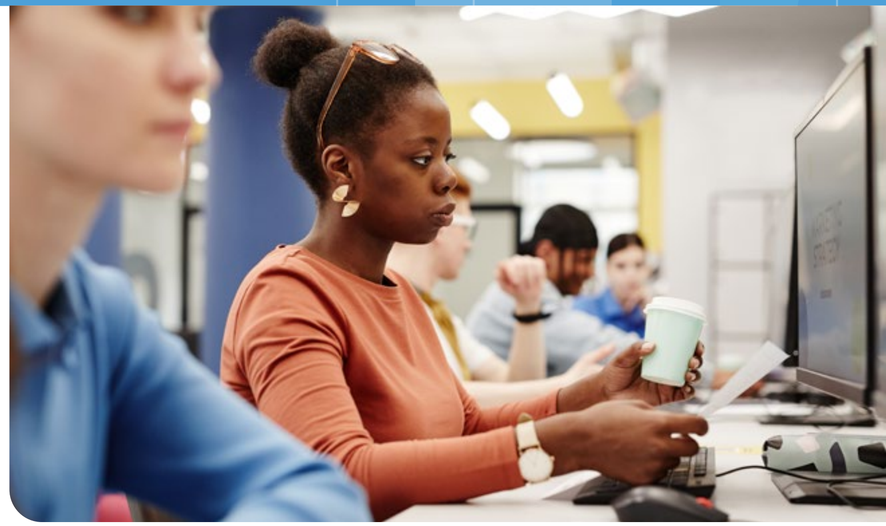
Autonomy	Privacy | Freedom of choice
Justice	Transparency | Trustworthiness of information, content, data and systems
Humanity	Health, well-being

Readiness WATCH PLAN ACT

Drivers

#Smart living #Connectivity

Three technological advancements are providing the ideal conditions for real-time data streams: 1) better and smarter networking due to 5G/6G connectivity, high-frequency, optical wireless and AI network orchestration; 2) the integration of various data sources both from the edge and traditional IT systems; 3) cloud services specialising in data streaming. These real-time data streams can be used in real-time analytics to yield better insights into what is happening in the present. Industry is using real-time analytics in its supply chains, manufacturing processes and finance to make better decisions. Soon, real-time data will become a part of education and research too.



What can real-time data analytics do for higher education?

Universities are starting to use real-time data analytics to track student progress and design curricula. Real-time data collection tools have huge implications for higher education, from campus network management and fast-action security protocols to student safety and academic success.

open example

Real-time attention span tracking in online education

Researchers are using image processing and machine learning to track the attention of students in real-time during online education. This allows for real-time feedback for both students and organisation, which may in the end increase the overall performance of students as well as the teaching standards of the lecturers.

open example

Demand for real-time data visibility in the logistics sector will boom

In logistics, real-time data streams help businesses to make better predictions and decisions with regards to their supply chain. With live logistics data, smart factories can plan just-in-sequence supply chains, warehouses can improve productivity, and retailers will be able to provision shelves better.

open example

IMPACT

Real-time data can be used to keep track of the educational progress and mental health of students. If a student is predicted to be at risk, a teacher can intervene directly. In the classroom, real-time data analytics can give educators instant feedback on their teaching methods. One potential risk of this trend is that the autonomy of students and staff is compromised.

Researchers can make use of real-time data streams for many research purposes. For example, AI/ML models can be trained and assessed on a constant flow of data and remain up-to-date for longer periods.

TREND #4

Run code anywhere

Public values

- Autonomy
- Justice — Accessibility | Equal opportunities
- Humanity

Readiness WATCH | PLAN | ACT

Drivers

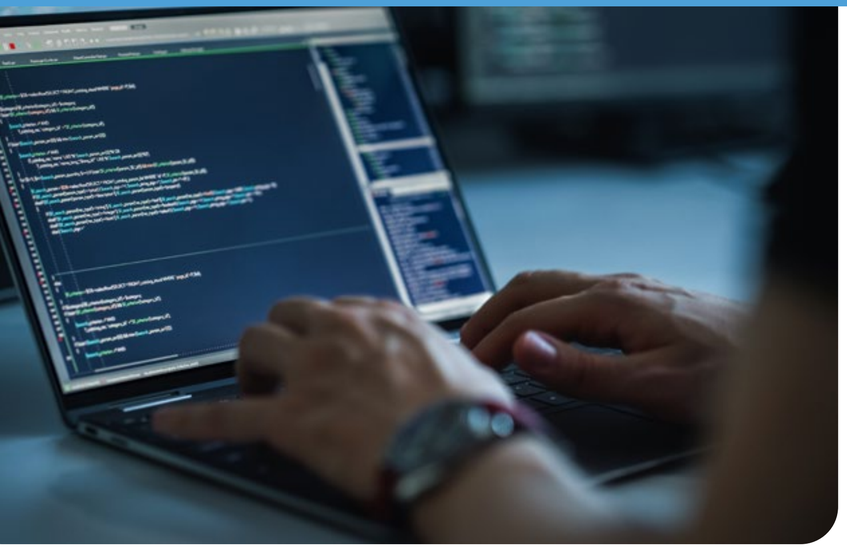
#Decentralization #Automation #Gender balance in STEAM #Open science

In the fields of software development and IT operations, developers are finding solutions for running the same code reliably in different environments. Starting with virtual machines and continuing with containerised applications and serverless functions, this trend moves towards separating code from the infrastructure it runs on. As this trend progresses, the number of devices and cloud platforms that can run the same code will increase significantly. At the same time, the technology will gradually operate independent of the underlying infrastructure and allow for smarter scheduling decisions on the cloud-edge continuum.

CNCF reports record Kubernetes and container adoption

In companies, the use of containerized application and container orchestrators, such as Kubernetes, are quickly becoming standard practice. Gartner predicts that 70% of organizations will run containerized applications by 2023.

open example



Leveraging containers for reproducible psychological research

Researchers are becoming aware of the benefits of containers for reproducible research and open science. In psychology, the use of containers may be an important step to solve the replication crisis.

open example

Singularity (Apptainer) containers improve reproducibility and ease of use in computational image analysis workflows

In high performance computing, Singularity (Apptainer) containers, as opposed to Docker containers, are used for easier and reproducible workflow. Singularity containers do not need root access to the host system to run and are therefore widely adopted on HPC clusters.

open example

Using containers to enable AI at the edge

Containers are also used to deploy AI models, even on edge devices. This innovation exemplifies two converging trends: proliferating AI use cases at the edge of the network and increasingly heterogeneous infrastructures that include hybrid cloud platforms powered by containers and Kubernetes.

open example

IMPACT

This trend will mainly impact the way researchers do their work. They can reliably run the same algorithms and models on their laptop, on a supercomputer, in the cloud or on the edge, wherever the need and/or resources are present. These technologies also increase the reproducibility and shareability of their research and will benefit the open science movement. To take advantage of this trend, however, researchers will need to become familiar with DevOps processes and technologies or rely on IT departments and new platforms to facilitate adoption.

TREND #5

Robotic Automation

Public values

Autonomy	
Justice	Equal treatment | Transparency | Democratic control
Humanity	Safety | Personal development

Readiness WATCH PLAN ACT

Drivers

#Automation #Gender balance in STEAM

Robotic automation takes place on a hardware and software level. Physical robots have been a part of manufacturing for a while and single-purpose robots for private use, such as lawnmowers, are also becoming more common. Still, robots are not as omnipresent as we would have expected a decade ago. This will change with general-purpose robots that can operate in various contexts and with the rise of robots-as-a-service companies. On the software side, robotic automation is also steadily progressing. For instance, robotic process automation is taking over repetitive desktop work and chatbots are used to automate customer service.

Cloud labs: where robots do the research

Companies are creating remote labs where robots conduct experiments for researchers. The benefits of ‘cloud labs’ are that lab research becomes more affordable, reliable and reproducible.

open example

Cobots

Cobots, short for collaborative robots, are designed to be programmable and work safely alongside humans. Safety is provided by sensors, that make a cobot go into safety mode when interrupted.

open example

Are the robots coming for white-collar jobs?

Robotic processes are automating the work of white-collar workers like physical robots are disrupting manufacturing. The question is how this will change future jobs. Jobs that may be (partly) replaced by robotic automation include lawyers, legal secretaries, accountants, translators, marketing managers and real estate agents.

open example

The rise of robots-as-a-service

Robots-as-a-service companies are making it easier for businesses to get started with robotic automation without prohibitive capital expenses. This change to the robotics business model may radically transform markets and the future of work.

open example

IMPACT

In both education and research, people will need to learn how to work with both physical and virtual robotic automation. In certain fields, students will need courses on working with robots in their future jobs. On the administrative side, robotic process automation is likely to be used for routine tasks, so staff can focus on the creative and strategic aspects of their job instead. In laboratories, certain tasks and experiments can be delegated to a collaborative robot onsite or a robot in a cloud lab. Besides automation of processes, we will see a growing interaction with robots in the daily life of a student, teacher, researcher, etc.

More about Edge

Contact

Erik Kentie
Program manager Edge-Cloud Continuum
erik.kentie@surf.nl

Tim Kok
Software Engineer
tim.kok@surf.nl

David Šálek
Advisor Data Processing
david.salek@surf.nl

Contributors

Maarten Zweers
Aaron Ding
Alexandru Iosup
Fernando Kuipers
David Groep

Continue reading

more info

communities