WHITE PAPER
OPEN TELEKOM CLOUD

The European IAAS option

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Contents

Executive summary

Cloud computing is no longer the bold leap it once was. Once derided as a mere gimmick, its immense potential is now widely recognized. And it has come of age at the breakneck speed typical of the digital era. The cloud debate has likewise matured, now focusing on concrete ways to exploit the model to enhance business, on the technical nuts and bolts of implementation, and on cloud strategies.

There are currently four main items on the cloud-computing agenda. **Security concerns** stubbornly persist as the chief roadblock to adoption. But security is a whole potpourri of issues. They include not only technical parameters or the subjective belief on the part of IT decision makers that they have limited influence. A more pertinent question relates to the consequences of compliance requirements such as data privacy. Against this background, European enterprises are demanding contracts with cloud service providers that are subject to national law and to local and European data-protection requirements. EU-GDPR (General Data Protection Regulation, May 2018) increased the level of data privacy for European citizens. European data privacy will be mandatory even for EU-external cloud service providers, if they process data of european citizens.

In second place is the need for **user-friendly administration**. Experience has shown that many cloud-management tasks are left to users, who need the right skills to handle complex and unwieldy tool environments with confidence. Providers frequently hand responsibility for operating cloud-related customer service to the user organizations themselves. The same applies to technical and process-related integration issues. To a large extent, the cloud is still a do-it-yourself toolkit.

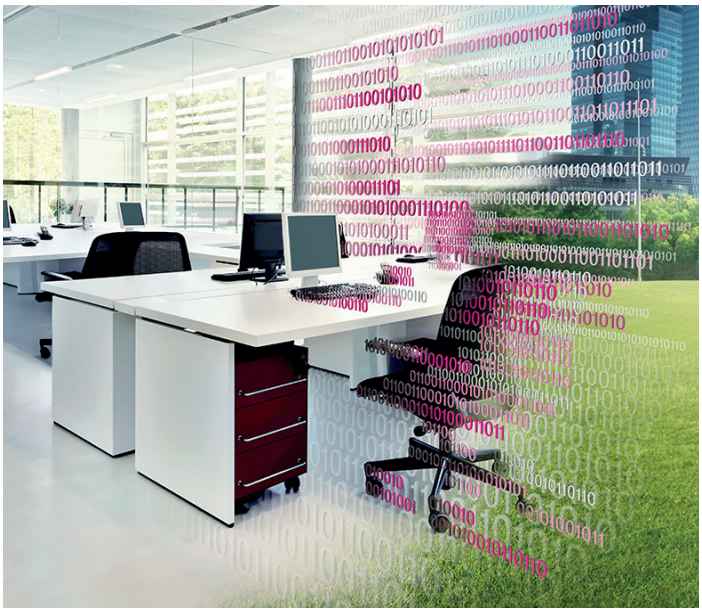
Third, the illusion that **cloud computing is always less expensive** has been replaced by greater realism. Lack of transparency and a raft of paid-for additional services—particularly network resources—make a holistic approach to cost essential. Clouds show their advantages especially in temporary usage scenarios or dynamic operations. At times customers are willing to accept the higher costs of the cloud in order to relieve themselves of infrastructure management or to achieve greater IT flexibility.

Last, cloud customers are increasingly aware of the risk of vendor lock-in should they opt for a proprietary platform.

This is the backdrop to Deutsche Telekom's launch of the Open Telekom Cloud for the European market in March 2016. It is a public IaaS from a German provider with built-in compliance. Based on the OpenStack standard, it is easy to use and competitively priced. This white paper describes the general situation regarding public clouds, with a focus on infrastructure as a service. It offers insight into the Open Telekom Cloud's architecture and outlines a number of use cases.

Setting course for digitization

Digitization evokes a wide spectrum of reactions, from overwhelmingly positive to cautious and fearful. What is clear is that no business can afford to ignore it. The trend—and its consequences—are now firmly on the agenda for executives repositioning their organizations to meet tomorrow's challenges. If half of analysts' predictions come true, society is on the brink of far-reaching change that will transform our world and rewrite the business rule book.



Digitization—A Driver of Public Cloud Adoption

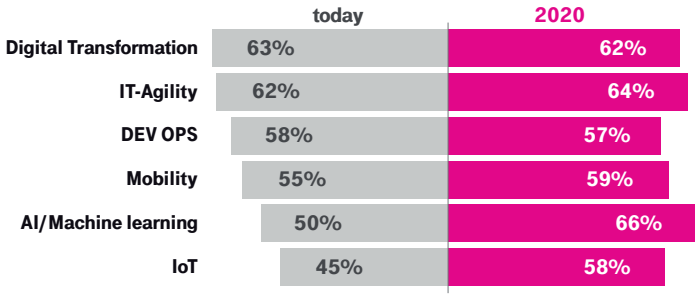


Fig. 1. How much is each of these trends or factors driving public cloud engagement?[1]

There are many aspects to digitization—both business and technical. Business aspects include data analysis that gives deeper insight into markets and customers—for better decision-making, an improved customer experience and buyer journeys, and leaner, more efficient business processes. Technical effects include greater connectivity through mobile devices and the Universe of Things, and rising data volumes and data traffic. Overall, businesses will gain ever greater customer intimacy, and time-to-market will separate success from failure as never before.

Critical factors will not only include network resources, but also compute and storage capacity. And these must be affordable, reliable and elastic. In other words, digitization cannot be achieved without cloud computing.

[1] Cloud Vision 2020: The Future of Cloud Study, 2018, Logicmonitor

Cloud on the upswing

Cloud computing is clearly gaining traction, driven by trends such as the Internet of Things, artificial intelligence, enterprise mobility, and collaboration. It forms the basis for new business models and will gradually replace existing sourcing/provisioning models. It took about ten years to replace traditional sourcing models. Research by the 451 Group shows that the tipping point was reached in 2017: In the business environment, 50 percent of all workloads are processed in clouds. In 2019, the pendulum will continue to swing towards the cloud[2]. The study of Logic Monitor referenced in Fig. 1 expects that 83 percent of all enterprise workloads will be in the cloud by 2020.

To date, businesses have generally preferred private clouds. But recent surveys indicate a move towards hybrid and public clouds—in Europe and elsewhere. April 2019 Gartner[3] projected the annual revenue for public cloud services 2019 at $214 bn. The IaaS segment grew by nearly 30 percent in 2018 to $ 30.5 billion worldwide[4]. These increases clearly show that enterprises have a huge demand for public cloud services as a means of turning business visions to reality.

The various cloud-computing service models—infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (SaaS) are associated with distinct use cases and implementation scenarios, and target differing customer groups. IaaS is cloud computing in its original form: demand-driven provisioning of raw compute and storage capacity. Resources are charged on a pay-as-you-use basis, enabling users to try out new (digital or digitally-assisted) business models quickly, without investment risk. In this respect, the cloud can lay the foundations for future business.

Easy to implement and use, SaaS accounts for the lion's share of the cloud market, although the markets for PaaS and IaaS are also sizeable: IDC[5] sees the global market for Public cloud computing at $ 210 bn in 2019. More than half of this is attributable to SaaS, while IaaS shows the largest growth. The growth of the cloud is also reflected in an indirect component, the view of data traffic in cloud data centers: it will more than triple from 2016 to 2021 (from 6 to 19.5 exabyte p.a.). Cisco expects global cloud traffic in 2021 to account for 95 percent of all datacenter traffic.[6]

IoT, Big Data and AI need Clouds

A key driver of demand for public clouds is the Internet of Things. Public clouds are highly suitable for managing the corresponding devices and securing them against vulnerabilities, and also for analyzing the huge volumes of data generated by IoT. As the Internet of Things grows, so does the cloud. In August 2018, IoT Analytics analysts found 7 billion networked items globally and projected growth to 21.5 billion by 2025[7]. Bain not only sees strong growth for the IoT market to $ 530 bn by 2021, but also points out a close correlation: Cloud service providers play an influential role as providers of IoT solutions[8]. As an example, Zion Research sees a strong increase in cloud usage for the Industrial IoT (CAGR of 26 Prozent)[9].

Big data analyses enable data-driven business models and improve decisions. Such analysis workloads are perfect scenarios for temporary cloud usage. According to a study by Vanson Bourne, 83 percent of all technology decision-makers in companies see the cloud as the perfect platform for big data workloads. 69 percent of this group want to move their complete analytics to the cloud in 2023[10].

Brian Hopkins of Forrester points out that cloud usage (via subscription) for big data analytics in the cloud is growing more than 7 times as fast as on-premise usage[11a] and names three reasons for big data analyses in the Cloud:
The ever-decreasing costs of using cloud resources, the licenses for on-premise tools and the speed of innovation of the public cloud, which is rapidly adapting new technologies such as AI and quantum computing.

> **Enterprise architects must recognize that the combination of big data and public cloud is not just a trend; it is an extinction-level event for digital dinosaurs.“** [11b]

These arguments can also be applied to the operation of artificial intelligence solutions in the cloud. McKinsey[12] states that AI is traditionally trained in the cloud. Deloitte[13] sees the cloud as a driver for AI implemenatations—with improved ROI. The advisers therefore expect a dramatic upswing in AI cloud usage for 2019. 70 percent of the AI user companies will rely on the Cloud.

[2] By 2019, 60% of IT workloads will run in the cloud, 451 Research, Kaitlin Buckley, 2017
[3] Gartner Forecasts Worldwide Public Cloud Revenue to Grow 17.5 Percent in 2019, Gartner, 2019
[4] Gartner Forecasts Worldwide Public Cloud Revenue to Grow 17.3 Percent in 2019, Gartner 2018
[5] Worldwide Public Cloud Services Spending Forecast to Reach $160 Billion in 2018, According to IDC, IDC, 2018
[6] Cisco Global Cloud Index: Forecast and Methodology, 2016–2021 White Paper, updated November 2018
[7] State of the IoT 2018: Number of IoT devices now at 7B – Market accelerating, Knud Lasse Lueth, IoT Analytics, 2018 (State of the IoT & Short-Term Outlook)
[8] Unlocking Opportunities in the Internet of Things, Ann Bosche, et al., Bain, 2018
[9] Zion Market Research Cloud Computing In Industrial IoT Market , Global Industry Analysis, Size, Share, Growth, Trends, and Forecast, 2017 – 2026, 2018
[10] The State of Analytics in the Cloud, Teradata/Vanson Bourne, 2019
[11a] Move Big Data To The Public Cloud With An Insight PaaS, Forrester, Brian Hopkins, 2017
[11b] Move your Big Data into the Public Cloud, Forrester, Brian Hopkins, 2017
[12] Artificial intelligence: The time to act is now, McKinsey, Gaurav Batra et al., 2018
[13] Artificial intelligence: From expert-only to everywhere – TMT Predictions, Jeff Loucks, Deloitte, 2019

There are two main target groups for infrastructure-only services, which are particularly popular in the IT industry: strategic decision-makers such as IT directors and CIOs who are adding cloud computing to their sourcing mix, and developers/testers who create the applications. IaaS use cases do not depend on company size, but on the skills of those who manage cloud services. Other, more specific IaaS target groups are independent software vendors (ISVs), SaaS providers and systems integrators who tap into IaaS resources to create customer-specific solutions.

Reservations concerning cloud adoption

Security in all its facets—regardless of the legal or cultural space—ranks high on the list of reservations against the cloud. In a recent O'Reilly report (April 2019) [14], security and compliance challenges still achieve top rankings.

Most providers offer a high level of technical security. However, European businesses still face unresolved questions relating to compliance (as confirmed by the study by Logicmonitor). Compliance issues often hide compliance with the GDPR with regard to personal data, as well as contract drafting according to national law.

The EU-US Privacy Shield—a new legal framework for data exchange between EU and US—has been in effect since August 1, 2016. But it continues to face criticism, and as a result the recent European Commission adequacy ruling may be overturned by the European Court of Justice. Furthermore, recent developments in the USA[15] suggest that data protection, particularly for European-based users, may be weakened. By contrast, the EU's data protection reform package (EU-GDPR) raises data privacy to a commonly agreed high level on part with Germany's. All enterprises processing personal data have to be compliant with these regulations—data processors as well as data controllers—independent from the fact that they are located in the EU.[16]

Experts and analysts agree that US providers dominate the public IaaS market. Amazon Web Services, followed by Microsoft Azure and Google Cloud Platform, are the key offerings[17]. Alibaba was the only non-US provider to make it into the top league in 2019.

Forrester analyst Paul Miller notes that despite these reservations, the greater part of large European corporations uses public clouds[18]. Two main reasons for this are the simple availability without any further technical or organizational requirements and the usage-related, dynamic billing, which makes Public Cloud an interesting sourcing alternative.

A host of use cases

Putting aside the security and compliance debate, IaaS has a host of potential use cases, especially in B2B and B2C contexts. Solutions fall into three categories, subdivided by target users:

1. Infrastructure services such as virtual data centers and application hosting are primarily attractive to IT professionals responsible for data centers, while file sharing and backups increasingly address heads of user departments, too.
2. Developer-centric services include testing and development, mobile apps, the Internet of Things and Big Data/business analytics.
3. In the case of customer-centric services, IaaS resources function in the background. They are not visible to users as services per se, but enable the operation of websites and portals and are deployed for e-commerce or digital marketing. This category also includes media and content-related use cases.

An IT security use case

Dynamic IT resources are ideal for short-term or temporary usage scenarios. Koramis, a provider of IT security services for process control, automation, and industrial software, uses public-cloud resources for its projects. Based in western Germany, Koramis finds and resolves vulnerabilities in IT systems. Customers include chemical plants, mass transit operators and smart factories. Infrastructures or new software products, such as home automation solutions, are checked for potential security weaknesses using laboratory simulations.

Koramis leverages elastic IT resources to model customer systems in the Cloud. There is no need to procure hardware; the tests can be run concurrently, allowing analysis to be accelerated by employing additional virtual servers. Tasks that previously took days or even weeks can now be completed in minutes. Koramis' baseline resources comprise 16 virtual servers and four terabytes of storage. In the course of a project, up to 250 virtual servers may be required on a temporary basis. Additional resources can be provisioned from a cloud within minutes. Koramis also leverages this provisioning method for its training offerings. Previously, its instructors arrived at the customer site with a truckload of hardware. Now, all they need is a broadband Internet connection. Business-critical data is processed within a German cloud—a key criterion for Koramis customers, who are unwilling to use US-based clouds.

[14] How companies adopt and apply cloud native infrastructure, Roger Magoulas, Nikki McDonald, O'Reilly, 2019
[15] Trump has officially ended federal online privacy rules, Recode, 2017
[16] EU-Datenschutz-Grundverordnung: Das sind die Neuerungen, Astrid Ackermann, 2016 (German only)
[17] Top cloud providers 2019: AWS, Microsoft Azure, Google Cloud; IBM makes hybrid move; Salesforce dominates SaaS, Larry Dignan, zdnet, 2019
[18] Public Cloud Reaches European Mainstream, but Brexit Complicates UK Picture, Forrester, Paul Miller, 2018

General Scenarios for IAAS deployment

Top use cases for iaas services and platforms

Websites/Portals ■ Website hosting ■ Portal hosting ■ Content delivery ■ Web analytics ■ Application Performance Mgmt	**E-Commerce** ■ Store hosting ■ Marketplace integration ■ Content delivery ■ Store analytics ■ Application Performance Mgmt	**Digital Marketing** ■ Online campaigns ■ Email campaigns ■ Messaging ■ Content delivery ■ Machine learning	**Media/Content** ■ Media storage ■ Content delivery ■ Content processing ■ Machine learning	**Customer-centric**
Development/Testing ■ App testing ■ App containers ■ Mobile backends ■ Machine learning ■ API management	**Mobile Apps** ■ App testing ■ App analytics/APM ■ Mobile backends ■ Messaging/push ■ Content delivery ■ Identity management	**IoT** ■ IoT endpoint management ■ Sensor data ■ Processing and analytics ■ Machine learning ■ Messaging ■ IoT identity/security	**Big Data/Analytics** ■ Database as a service ■ Elastic data warehouses ■ Hadoop hosting ■ Sensor data analytics ■ API management ■ High Performance Computing	**Developer-centric**
Virtual Data Centers ■ Hybrid clouds ■ Private clouds ■ Autoscaling ■ Identity management ■ Virtual desktops	**Application Hosting** ■ SAP hosting ■ CRM hosting ■ ECM hosting ■ SharePoint hosting	**Backup/Archiving** ■ Backup ■ Disaster recovery ■ Archiving ■ E-Mail archiving	**File Share/Messaging** ■ File share ■ Messaging ■ E-Mail hosting ■ SharePoint hosting	**Infrastucture-centric**

Fig. 2. IaaS is versatile and different user groups can benefit. Source: Crisp Research

Further IaaS challenges

In addition to the security and compliance issues mentioned above, user organizations must overcome other challenges before they can truly benefit from public IaaS. For example, the leading IaaS providers focus on offering standard services. The infrastructure resources are complemented by self-service management services (which can give rise to additional, unexpected costs). But no advice on implementation is available, nor do providers offer any indication of the network traffic volumes required for IaaS (a further significant cost factor).

Moreover, the main providers do not offer the integration of new services into existing IT environments, or the migration of existing workloads. As a result, projects of this kind call for the assistance of third parties with the right expertise. Another option would be for customers to develop the corresponding skills in-house. However, few companies possess the knowledge required to augment their legacy IT infrastructures with a simple IaaS option. This means introducing IaaS is a major undertaking—a far cry from the hoped-for new era of simplicity in IT.

Additional costs for network and management services and—more importantly—the problem of vendor lock-in, compel user organizations to make a conscious, strategic decision in favor of a single (possibly proprietary) platform. This should be the subject of extensive discussion, particularly if the provider appears likely to develop the platform in line with its own interests rather than users'. Should a user organization need to switch to a new platform, the transfer of huge amounts of data accumulated in the provider's storage systems will be among the biggest associated expenses.

OpenStack as a technological basis

Technological dependencies can be significantly reduced by choosing an open-source platform. OpenStack has become the established leader on the cloud computing market. It is already a highly proven offering and, backed by many major corporations, could well emerge as the long-awaited standard technology for the cloud.

OpenStack began as a joint project of Rackspace Hosting and NASA [19].Today, its community numbers more than 700 companies and 100,000 individuals (as of July 2019). OpenStack is variously referred to as a cloud management framework, a cloud computing software platform, or simply as a cloud operating system. Openstack.org describes its product as "software that controls large pools of compute, storage and network resources … managed through a dashboard or via the OpenStack API (Application Programming Interface)" [20].

The first version, Austin, was launched in 2010, while the latest, Stein, was released in April 2019 [21]. OpenStack comprises a range of components that virtualize compute resources, provision storage, and organize these into virtual networks. Another set of components provides administration functionality for users. The open-source software supports various hypervisors [22]. OpenStack is a low-cost alternative to established virtualization and cloud-management methods based on licensed software. Analysts maintain that, despite costs for maintenance agreements and software-update projects, open-source solutions—particularly in cloud computing—are less expensive than proprietary solutions.

OpenStack boasts one of the fastest-growing open source communities worldwide. The software can be used to create both public and private clouds, which facilitates hybrid strategies, too.

Analysts expect **OpenStack will gain additional traction** when cloud platform providers launch their own distributions. These are likely to offer additional management functionality that compensates for the lack of skills within user organizations.[16]

OpenStack components

OpenStack consists of a library of modules that perform various cloud deployment and management tasks. OpenStack clouds can differ as to which of the standard modules are deployed and which are replaced by alternatives. This is often the case with the Neutron networking component. Certain core modules are mandatory for all OpenStack installations, however. All components work with service APIs based on standard REST interfaces.

[19] OpenStack: Viele brauchen es, keiner versteht es - wir erklären es, Martin Gerhard Loschwitz, 2015
[20] OpenStack
[21] OpenStack: Rocky Release Schedule
[22] OpenStack, Wikipedia.de

Nova is OpenStack's core component. It manages and automates computing resources and deploys virtual machines. However, Nova depends on a virtualization technology. It interoperates with the following hypervisors: KVM, Xen, VMware, Hyper-V and Linux LXC. Nova supports horizontal scaling on standard hardware. This makes it simple to integrate computing resources into existing systems.

Glance supports the management of virtual machine images. These are installation packages comprising operating system and application software that accelerate the implementation of applications in a cloud environment. Glance can store, retrieve and re-install images on servers. Only Glance can add, delete, share and duplicate images. It can also be employed to implement backups. Stored images can be used as templates.

Cinder handles block storage, providing corresponding storage volumes and attaching them to, or detaching them from, server instances. Cinder can provide persistent storage from diverse sources, both local Linux storage and a wide array of storage platforms.

Swift is a scalable object storage system. The storage clusters it manages can scale horizontally, simply by the addition of new servers. In contrast to block storage, data in object storage is distributed across multiple storage media.

Neutron manages networks and IP addresses. It offers users a range of network models; a popular option is VLANs that segregate the virtual machines. Neutron also gives users real self-service functionality—even over their network configurations.

Keystone is OpenStack's central user administration system. It supports authentication and multiple authorization methods. For example, it is compatible with existing directory services such as LDAP.

Other modules add security functionality (Barbican), billing (Ceilometer), orchestration (Heat), support for Hadoop (Sahara), database services (Trove), dashboards (Horizon), bare-metal provisioning (Ironic), cloud messaging (Zaqar) and a file-share service (Manila).

Heat is OpenStack's module for orchestration of cloud infrastructures. Resource templates enable the generation of code for task automation based on dialogs. The Mitaka version released in April 2016 gives OpenStack users the ability to add new operating-system components via plugins during ongoing operations (with no downtime). Mitaka has improved the stability and adaptability of IT environments on OpenStack—especially large-scale environments.

Openstack Modules and Deployment Tools

Fig. 3. Developed platform, Source: OpenStack

Open Telekom Cloud

Technical infrastructure

Deutsche Telekom launched a new public cloud service in March 2016, initially focusing on the European market. Based on OpenStack, the Open Telekom Cloud enables user organizations to avoid vendor lock-in. It also meets legal requirements for IT operations, e.g. data protection and other compliance issues.

T-Systems operates the Open Telekom Cloud in three availability zones (AZ) at data centers in Magdeburg and Biere. These are twin-core, tier 3+ facilities located some 25 kilometers apart. They are connected via a low-latency, high-speed network, and therefore meet all criteria for fail-safe operations.

At the data centers, T-Systems maintains pools of commodity servers with Intel x86 architectures. Compute capacity for users' virtual machines is provisioned automatically. SATA, SAS or SSD block storage is used in line with specific I/O rate requirements. Object storage is available as an alternative. InifiniBand ist available on the platform for high-performance tasks. The underlying network uses vSwitches, eliminating the risk of bottlenecks arising in the IP fabric.

T-Systems provides users with first-and second-level support. Huawei offers third-level support by phone.

T-Systems holds comprehensive certifications validating the correct operation of the infrastructure platform, including ISO 27001 and ESARIS (Enterprise Security for Reliable ICT Services).

Moreover, the provider has obtained cloud-specific certifications such as CSA STAR level 2 Gold, BSI C5, TÜV Trusted Cloud Service, ISO 27017 and 27018. Open Telekom Cloud received a certification according to Trusted Cloud Data Profile (TCDP) 1.0 and is thus optimally positioned for (not yet existing) EU-DSGVO certification.

A health dashboard at https://status.otc-service.com/ gives users a real-time insight into the status of the platform.

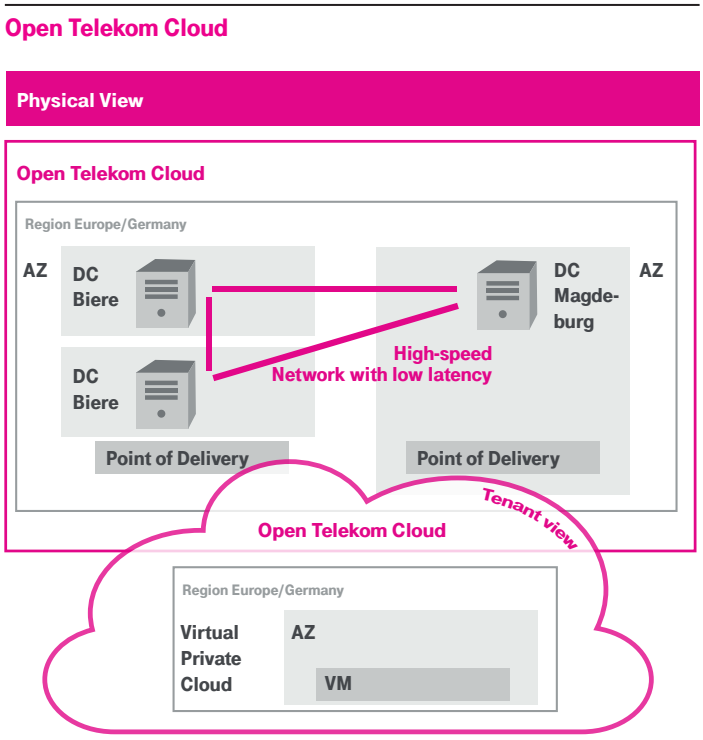


Fig. 4. The infrastructure of the Open Telekom Cloud

Portfolio

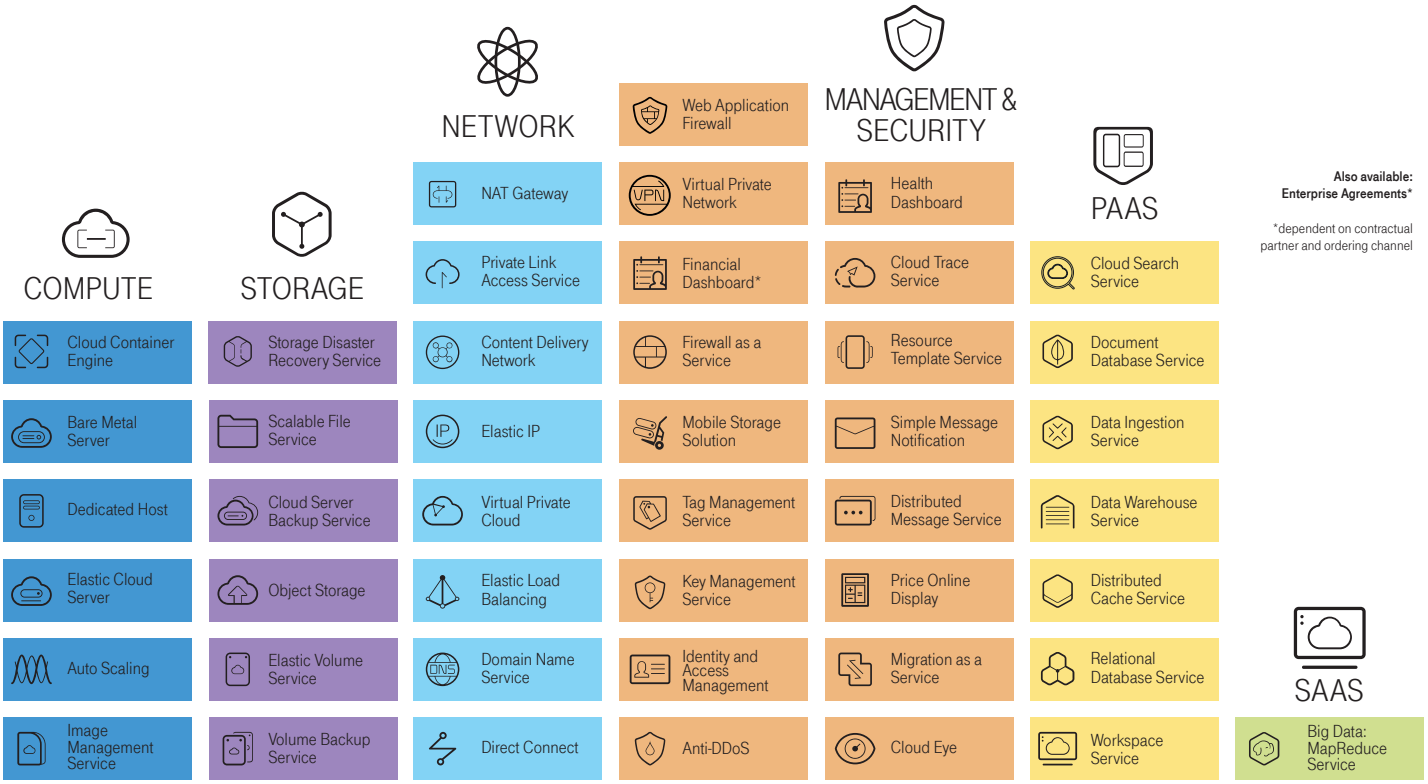


Fig. 5. Services of the Open Telekom Cloud

Network services

Network-level services comprise elastic IP service, virtual private clouds (VPC) and unified/elastic load balancing. They are deployed to segregate resources for multiple users, and as the basis for automatic scaling. The VPC service creates a separate section of the Open Telekom Cloud that is under the respective user's exclusive control. The Elastic IP Service provides the user with a public IP address for accessing this virtual private cloud. This also makes it possible to access Open Telekom Cloud resources via the public Internet. An IPSec-based VPN gateway is available for connecting a corporate network to the cloud platform.

Network connections with higher performance than usual Internet connections like Ethernet Connect and MPLS (Intras-Select) can be implemented via DirectConnect respectively Private Link Access Service. Domain Name Service and NAT Gateway are also available. Additionally Open telekom Cloud offers access to a content delivery network to boost perfomance of web sites/content.

Computing Services

The role of computing services is to provision virtual servers. Users can choose between 27 basic flavors, each with a defined vCPU-to-RAM ratio for conventional deployment scenarios. In addition, the Open Telekom Cloud provides 38 advanced flavors. These are suitable for special purposes and more specialized requirements (see below). Flavors are packages consisting of virtual CPUs and virtual RAM. The following flavor classes are available:

- **General Purpose (available vCPU/RAM ratios are 1:1, 1:2, 1:4 & 1:8)**
- **High performance** – for applications that need extremely high processing power – including InfiniBand
- **Graphical processing unit optimized** – for applications requiring a GPU (cryptography, graphics processing, CAD applications)
- **Disk-intensive** – with a local hard drive for big-data applications
- **Large Memory** –for applications with significant main-memory requirements, e.g. SAP S/4 HANA
- **FPGA** –hardware-dependent programming allows the design of highly specialized servers for top performance

Computing servers with 1 to 60 vCPUs are available, with 1 to 940 GB RAM. Users can currently choose from seven groups of operating systems: Open Linux (CentOS, Ubuntu, openSUSE), Oracle Linux, SUSE, Red Hat, Debian, Fedora, EulerOS and Windows.

As virtualization technology Xen and KVM are used. From mid-2019, the Open Telekom Cloud will focus on KVM. KVM is characterized by better support and higher performance of the flavors.

Overview of available flavors

	GENERAL PURPOSE FLAVORS (available with KVM)			
vCPU	RAM [GB]			
1	1	2	4	8
2	2	4	8	16
4	4	8	16	32
8	8	16	32	64
16	16	32	64	128
32	32	64	128	256
60	-	128	258	512

	HIGH PERF	GPU	WORKSPACE	DISK INTENSE	LARGE MEM
vCPU	RAM [GB] + additional Resources				
2	8	-	4	-	-
4	16	8 + vGPU	8 (+ 1 vGPU)	32 + 5,4 + 3,6 TB	128
8	32	16 + vGPU 64 + GPU** 64 + GPU***	16 (+1 vGPU)	64 + 10,8 + 7,2 TB	128/256
12	-	-	-	-	256
16	64, 128*, 256*	128 + 2GPU***	-	128 + 21,6 + 14,4 TB	470
18	-	-	-	-	445
24	-	-	-	192 + 21,6 TB	445
32	128, 256*	256 + 4GPU***	-	256 + 28,8 TB	940
36	-	-	-	256 + 43,2 TB	890
60	-	-	-	540 + 43,2 TB	890
	XEN/KVM*	XEN/KVM	XEN	XEN/KVM	XEN

*mit InfiniBand/KVM, **Nvidia M60 (KVM/pass-through),
***Nvidia P100/V100 (KVM/pass-through)

Fig. 6. Basic and advanced flavors for different requirements

In addition to this range of flavors, the Open Telekom Cloud offers a dedicated host that can be rented by the hour. There are six hosts available, two based on Xen, four on KVM. These hosts can be leveraged to run virtual machines on the basis of the available flavors.

Overview Dedicated Hosts with KVM-Hypervisor

DEDICATED HOSTS	SOCKETS & CORES	CPU	HARDWARE
General Purpose (s2-Large)	2 à 22	144 vCPUs	Intel® Xeon® Processor Gold 6161 (30,25 MB L3 Cache, 2,2 GHz) Memory: 704 GB
General Purpose (C3)	2 à 18	60 vCPUs	Intel® Xeon® Processor Gold 6151 (24,75 MB L3 Cache, 3,0 GHz) Memory: 256 GB
Memory Optimized (M3)	2 à 18	60 vCPUs	Intel® Xeon® Processor Gold 6151 (24,75 MB L3 Cache, 3,0 GHz) Memory: 512 GB
General (s2-Medium)	2 à 12	72 vCPUs	Intel® Xeon® Processor Gold 5118 (16,5 MB L3 Cache, 2,3 GHz) Memory: 328 GB

Fig. 7. Technical specifics of Dedicated Hosts based on KVM

In addition to virtual machines and dedicated hosts, the Open Telekom Cloud also offers bare metal resources. They can be used either with or without a user-defined virtualization layer. Above all, bare-metal resources deliver improved speed for highly processor-intensive applications.

Overview Bare Metal Server

	COMPUTE-OPTIMIZED	GPU-ACCELERATED	HIGH-PERFORMANCE	MEMORY-OPTIMIZED	MEMORY-OPTIMIZED
CPU	2 x 8 core Intel Xeon E5-2667 v4	2 x 14 core Intel Xeon E5 -2690 v4	2 x18 core Skylake Xeon Gold 6151 V5	4 x 24 core Broadwell Xeon E7-8890 v4	4 x 24 core Broadwell Xeon E7-8890 v4
RAM	256 GB	512 GB	192 GB	2048 GB	4096 GB
GPU	-	8 x P100	-	-	-
Netz	-	100G IB*	100G IB*	-	-

*Infiniband

Fig. 8. Technical specifics of Bare Metal Servers

Computing services can be combined with other services, such as auto scaling (scaling of resources in line with workload), or an image service. Images are preconfigured operating systems (including drivers), with optional applications. The Open Telekom Cloud provides preconfigured system images, but user-defined ones can also be created and stored for rapid access. For this purpose, all flavors are allocated fixed SAS, SATA or SSD block storage.

The Cloud Container Engine (CCE) enables the use of containers on the Open Telekom Cloud. Kubernetes is used. CCE not only utilizes virtual machines but bare metal servers as well.

Storage Services

The Open Telekom Cloud offers three basic storage solutions: block and object storage as well as Scalable File Service. Object-based data storage is accessible via the Internet using HTTP or HTTPS protocols, and is independent of specific compute resources. Data is not physically stored in a single contiguous block. Free storage capacity is used in line with requirements. Object storage is an affordable option for long-term retention of large data volumes. Object storage can accommodate files of up to 5 TB in size. Object storage is available in three classes, in accordance with data usage needs: cold, warm, and standard. Cold OBS is suitable for data that needs to be saved but is only seldom processed (typically once a year). This option does not support real-time access. There is a choice of three classes of data recovery/extraction. Warm storage offers the same specifications as standard OBS, but is intended for data that is accessed approximately once monthly. Standard OBS offers rapid access to data that needs to be processed frequently and directly, for example by means of big-data tools. In other words, users can choose the storage method that best suits their data usage.

It comes complete with the native OpenStack API Swift and native S3 API, a web management dashboard, a cloud storage service web client, and a software development kit for the user organization.

Block storage is persistent storage attached to the compute resources as a **virtual drive**. Unlike conventional hard disk arrays, this storage service stores identical copies on multiple storage nodes to retain the data permanently. Between 40 GB and 32 TB of block storage can be selected, and up to 40 virtual drives can be attached to one compute instance.

Overview block Storage

	COMMON I/O (SATA)	HIGH I/O (SAS)	HIGH I/O (SAS BOOSTED)	ULTRA-HIGH I/O (SSD)	ULTRA-HIGH I/O (SSD BOOSTED)
Max. IOPS per EVS disk	1.000	3.000	3.000	20.000	30.000
Max. throughput per EVS disk	40 MB/s	120 MB/s	550 MB/s	320 MB/s	1 GB/s
Average response time	10 ms - 15 ms	6 ms - 10 ms	6 ms - 10 ms	1 ms - 3 ms	1 ms

Fig.9. Block storage is offered in five different performance levels.

A **Volume Backup Service** (VBS) offers additional protection for block storage resources. Data on local systems and storage devices is backed up by the snapshot method, enabling rapid restoration. Block storage comprises separate pools for the various classes (SSD, SATA and SAS).

Scalable File Service (SFS) is based on OpenStack's Karbor. SFS is an easy to use network storage, similarly to a NAS (network attached storage). SFS scales automatically with the amount of data, even regarding bandwidths. Access speed is higher than using a standard object storage.

Storage Disaster Recovery Service (SDRS) allows real-time replication of data across two availability zones. This enables failover/failback scenarios.

CLOUD MANAGEMENT

Cloud resources are either accessed via the **cloud console** or directly, by means of the APIs provided (native OpenStack or other, special-purpose APIs). Customers can employ a dashboard to manage compute and storage resources, and images. Cloud Eye and a financial dashboard ensure transparency, giving users information on active resources, consumed quantities and costs incurred at any time. If myWorkspace is implemented, users are assigned administrator accounts for managing their resources. Further users within a given organizational unit are created via this type of account. Subsequently, an identification and authentication service provides secure sign-in and identification of these users. Accounts also support the definition of quotas to limit resource usage to a specified maximum. This helps organizations to avoid exceeding budget thresholds.

Moreover, when the virtual machines, etc. are activated, the price is displayed on-screen for complete cost transparency. The cloud trace function allows users to automatically generate log files that record all changes to resources. This is especially useful for auditing purposes. There is a distributed messaging service (DMS) and a simple message notification (SMN) service, both based on API calls. Furthermore, the SMN function can be employed to send SMS text messages or emails to external contacts. Migration-as-a-service (MaaS) and HEAT/resource templates are two Open Telekom Cloud management services that simplify data transfer and resource orchestration.

Security services

The Open Telekom Cloud optionally provides encryption for block and object storage. In addition, a central system is in place for the management of Open Telekom Cloud public access keys.
There is also an **anti-DDoS** security service that detects distributed denial of service attacks aimed at crippling web addresses on the public Internet. It also actively responds to such attacks, safeguarding the availability of applications running in a cloud. Anti-DDoS protects the public IP address, ensuring that applications operated on the Open Telekom Cloud are not affected by criminal activities designed to overload servers—such as challenge collapsar attacks, UDP and SYN flooding. The service performs security filtering at the firewall on data traffic over public IP addresses.

Platform services

A relational database service (RDS) that supports mySQL, PostgreSQL and Microsoft SQL Server is also available. RDS provides powerful monitoring functionality, delivering visibility into the status of VMs and comprehensive performance reports for data management purposes. Standby databases can be created (in addition to the primary database) to ensure high availability. Up to five read-only replicas can be added for each database cluster, enabling rapid access.

Redis, named Distributed Cache Service, and MongoDB, named Document Database Service, are also available.

Open Telekom Cloud's workspace service provides five flavors (two of them including integrated vGPU) in the form of virtual desktop infrastructures. The virtual desktops provide encryption and 2-factor authentication. They can also be implemented on Dedicated Hosts to use licenses that already exist in-house.
A Data Ingestion Service allows the transfer of large amounts of data, a Data Warehouse Service cross-analyses of various existing databases.

Extended scope of services: hybrid clouds

The cloud computing model has existed in principle for more than a decade. But in this time, expectations have changed. There is still interest in plain-vanilla on-demand virtual machines and storage. However, users now want additional services that ensure greater convenience, and suites that offer not just IaaS but also PaaS and SaaS. Cloud vendors are therefore continuing to evolve their offerings.

One of the hottest topics among users in 2018 has been hybrid clouds and the management of multi-clouds.[23] Multi-cloud environments consist of multiple autonomous cloud solutions, each operating in isolation for a clearly delineated functional scope. Hybrid clouds, by contrast, entail the integration of diverse IT components with the aim of modelling an entire or partial business process. This has to take account of a variety of cloud types (private, public, community), and also more traditional IT installations. OpenStack facilitates this task. Since 2018, a hybrid Open Telekom Cloud model is available that allows users to implement their own private installations alongside the public Open Telekom Cloud. Thus hybrid models can easily be realized.

User support in addition to self-services

On-demand infrastructure services are generally only provisioned and managed via low-cost online channels. User self-services play a significant role in these delivery models. In addition to the usual self-service functions, the Open Telekom Cloud offers consulting services. A consulting website directs experts and beginners to the service packages that best meet the needs of their use cases. Other basic services, such as the hotline, are included in the package prices.

In addition, Deutsche Telekom and T-Systems also ffer the services of the Open Telekom Cloud via direct sales with personal sales contact people. Enterprise agreements (Silver, Gold, Platinum) also allow companies to order additional premium support. The Platinum agreement includes an enterprise dashboard that gives users complete transparency about the consumption of resources at cost rates that differ from the list prices. The Enterprise Dashboard is also available as a stand-alone solution.

Companies who wish to incorporate the Open Telekom Cloud into their standard **sourcing mix**—rather than using it **for specific purposes**—can take advantage of in-depth consultations with enterprise architects. T-Systems also offers project-specific transformation and migration services through its systems integration organization.

Mobile Storage Solution (MSS) is available for importing large amounts of data. Synology NAS devices can transport 100TB of data to the cloud computing center. The physical transport saves bandwidth and drastically reduces time for copying data.

[24] State of the Cloud Report, RightScale, 2018

Use cases

A key strength of open platforms is that they enable the multi-cloud or hybrid-cloud scenarios that businesses need—scenarios that will shape the cloud landscape in the years to come. At the same time, enterprises must always weigh up the extent to which existing applications can or should be migrated to the cloud.

Migragting to the cloud

Typically, corporate IT environments include a wide range of legacy software that has been employed to model core processes, with very little modification, for a great many years. This can include standardized ERP solutions, office packages, more recent Web applications or even cloud-native systems.

Their **suitability for cloud migration** will vary considerably, depending upon generation and architecture. However, migration does not necessarily mean that the application will be transferred to a cloud-native architecture. The simplest approach is to lift and shift from a dedicated platform to a dynamic one—primarily to make savings.

Transferring cloud-native applications between multiple infrastructure clouds is the most straightforward task of all—as they have been designed from the outset to run on dynamic infrastructures. In other words, there are no static relationships—and all instructions required are already within the application itself.

Migration tools can be deployed to move applications between clouds, e.g. to cut costs, to secure better service levels or achieve greater security. A typical migration scenario comprises the transfer of an application from the development to the production platform, with Docker containers emerging as the standard method of doing so.

The Open Telekom Cloud achieves this by means of the Cloud Container Engine, based on Kubernetes containers. Open-standard clouds simplify transfer still further. Proprietary clouds, by contrast, often necessitate additional steps. And if applications use provider-specific services, transfer will not be possible. Nevertheless, the migration of this type of software is associated with far less effort and expense than is the case for legacy applications—which require resolution of issues related to DevOps application management, availability and horizontal scalability. Applications may need to be completely redesigned before they can be ported to a cloud platform.

The most obvious scenario for cloud-based application operations is Web applications or SaaS. Creatieve Koppen, an innovation management agency based in Rotterdam, The Netherlands, operates an online application that supports the development of new business ideas within teams. Application load fluctuates greatly in line with demand. Operation in a public cloud allows the agency to auto-scale IT resources to ensure a consistently positive user experience.

Octopus AG, a Swiss startup, operates an SaaS offering for the management of Microsoft licenses on the Open Telekom Cloud. Service providers can harness the software to automatically generate reports on the number of licenses being used, and how they are being used. The solution enables efficient software asset management, and requires high scalability.

But public clouds can also, contrary to widespread perceptions and prejudices, support enterprise-class applications. For example, the Open Telekom Cloud can host SAP systems for sandboxing, testing or training purposes. The provisioning of infrastructure resources from the cloud is also ideal for large, memory-hungry systems, such as SAP S/4 HANA, that are being used for short-term tasks, such as training. Traditional delivery models simply cannot match the cloud in terms of speed of deployment and cost/benefit.

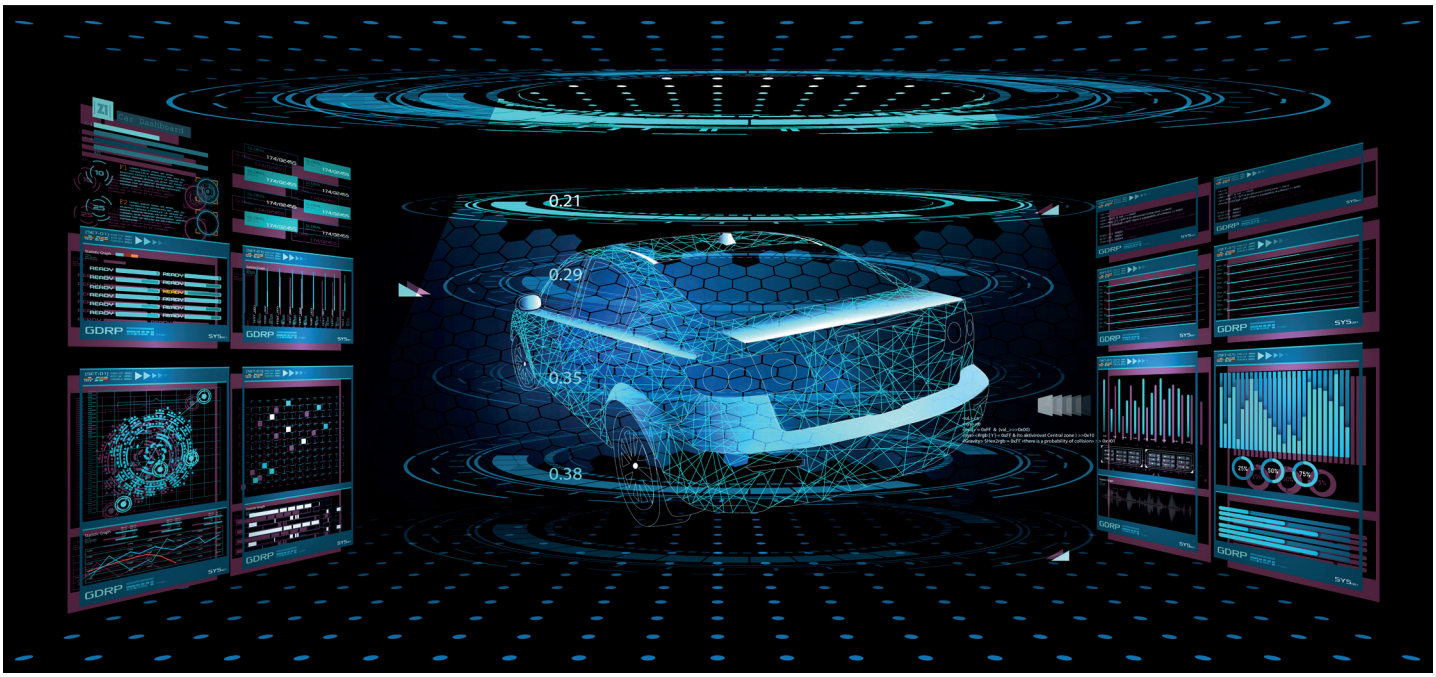
Public cloud resources are also ideal for archiving entire SAP systems (or other established business systems). JIVS on the Open Telekom Cloud makes it possible to "mothball" data and corresponding applications. This makes sense, for example, in banking when data needs to be retained within context to answer questions posed by regulatory bodies. Maintaining an operational system that has no direct business benefit is prohibitively expensive, but the data needs to be stored within its framework of reference to be useful. Transfer of the entire system to a public cloud is a way of resolving this dilemma—and making large savings.
Public cloud resources are also ideal for transferring systems to the cloud within the scope of a dedicated migration project.

Manage growing volumes of data with cloud storage

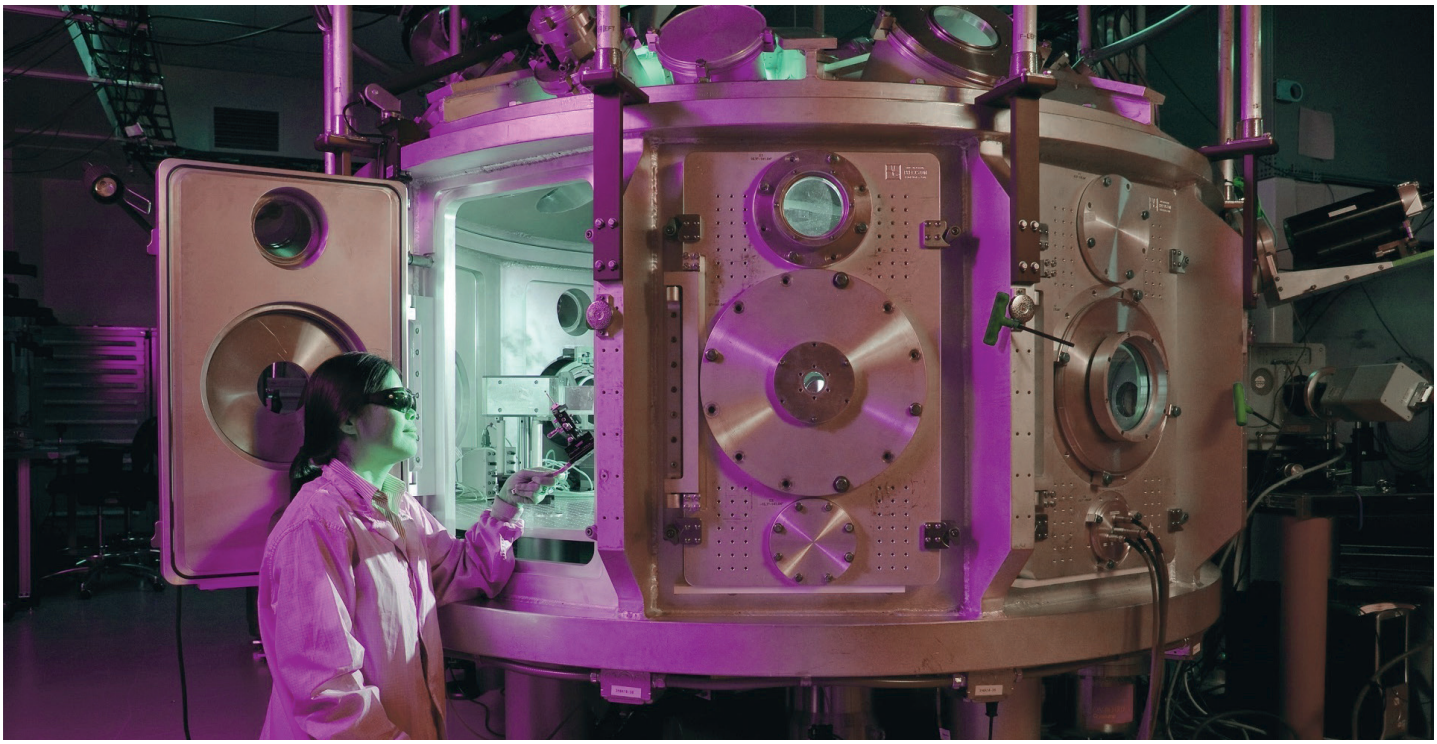
Business process of many types already generate significant volumes of data—data that must be retained for reasons of compliance, for big data analytics, or which users simply wish to archive for their own reasons. In particular, significant data is produced by communications systems. For example, emails, although often seen as yesterday's technology, continue to be extremely popular, with 281 billion being sent in 2018 alone.[24] Then there is the data that collects on intranets and collaboration platforms—and is seldom deleted. And media industry companies, by the very nature of their business model, must archive huge amounts of data for print, video and audio.

Those are the more traditional sources. New, almost inexhaustible, generators of data include connected cars, predictive maintenance solutions, and the Internet of Things. The quantity of data is skyrocketing. It is the raw material of future business models. And it requires huge, readily-available storage capacity.

In hybrid scenarios, production systems can be operated in-house—but the data is maintained in a storage cloud that expands in line with demand, acting either as the primary repository or as back-up. The use of public clouds eliminates the need for designers and administrators to develop and manage their own storage resources—which do not, in any case, generate competitive advantage. There is also no call for regular upgrades to new hardware, or for the maintenance of corresponding in-house skills.



[25] E-Mail Statistics Report 2018 - 2022, The Radicati Group, 2018



Aircraft manufacturers must retain engineering, design, image data and statistics for approximately 30 years after the final model in question has been decommissioned. Moreover, component documentation must be kept for at least 25 years. As a result, many terabytes of data have to be stored purely for reasons of regulatory compliance, but without any operational benefit. This data can be placed in low-cost "cold" object storage in a public cloud—reducing the load on production systems while fulfilling reporting obligations.

Public clouds for high-load applications

Beyond operations for simple applications, there are applications that bring classic cloud deployments to their limits. Typical examples of such applications are high-load scenarios in science and research or the processing of huge amounts of data (big data). The European Organization for Nuclear Research in Geneva (CERN), for example, is constantly setting new benchmarks with its particle physics experiments when it comes to processing large amounts of data. At an early stage, the institute recognized the potential of cloud technology and the benefits of OpenStack. In 2016, together with a dozen other top European research institutes, the CERN launched an initiative to build a European science cloud, the Helix Nebula Science Cloud.
The Open Telekom Cloud went through the entire selection process and was tested with several varied workloads. These included the processing of particle physics experiments at CERN itself (Atlas, CMS and Alice) and the Super KEKB in Japan (Belle 2), the big data analysis of cancer data (PAN-CANCER) for the EMBL (European Molecular Biology Laboratory) and simulations for the COMPASS project (Common Muon and Proton Apparatus for Structure and Spectroscopy).

The use of the Open Telekom Cloud supplements the internal resources of the institute in order to better manage peak demands. At the same time, scientists are achieving improved transparency about the resources used.

Other high-load scenarios include simulation tasks in the automotive industry and the up-and-coming discipline of bio-informatics. The latter faces a systemic challenge: the performance of genetic analysis sequencers is outstripping the pace at which IT resources can be made available. Moving to the cloud offers a way forward.

Artificial Intelligence as a cloud topic

In addition to requirements for high-performance computing, clouds can also be used excellently for another cutting-edge topic: artificial intelligence (AI). Artificial intelligences can optimize a multitude of application scenarios across industries and across processes—or take on elaborate and monotonous work.

When training artificial intelligence based on large amounts of data, there are temporary requirements for large and/or high-performance computing capabilities. After training the AI, it can be operated permanently as an integral part of processes in marketing, sales, production, service etc. Further optimization of the neural networks („learning“) can take place during operation permanently, selectively or periodically in the cloud backend.

For temporary training of AI cloud resources are the ideal fit. The necessary computing resources do not have to be acquired, but can be rented as needed for training and projects. The cloud gives users the opportunity to work with cost-intensive, high-performance resources without having to purchase them themselves. The cost of resources provides an excellent basis for developing an own pricing model towards the end customer.

Video analysis with AI from the cloud

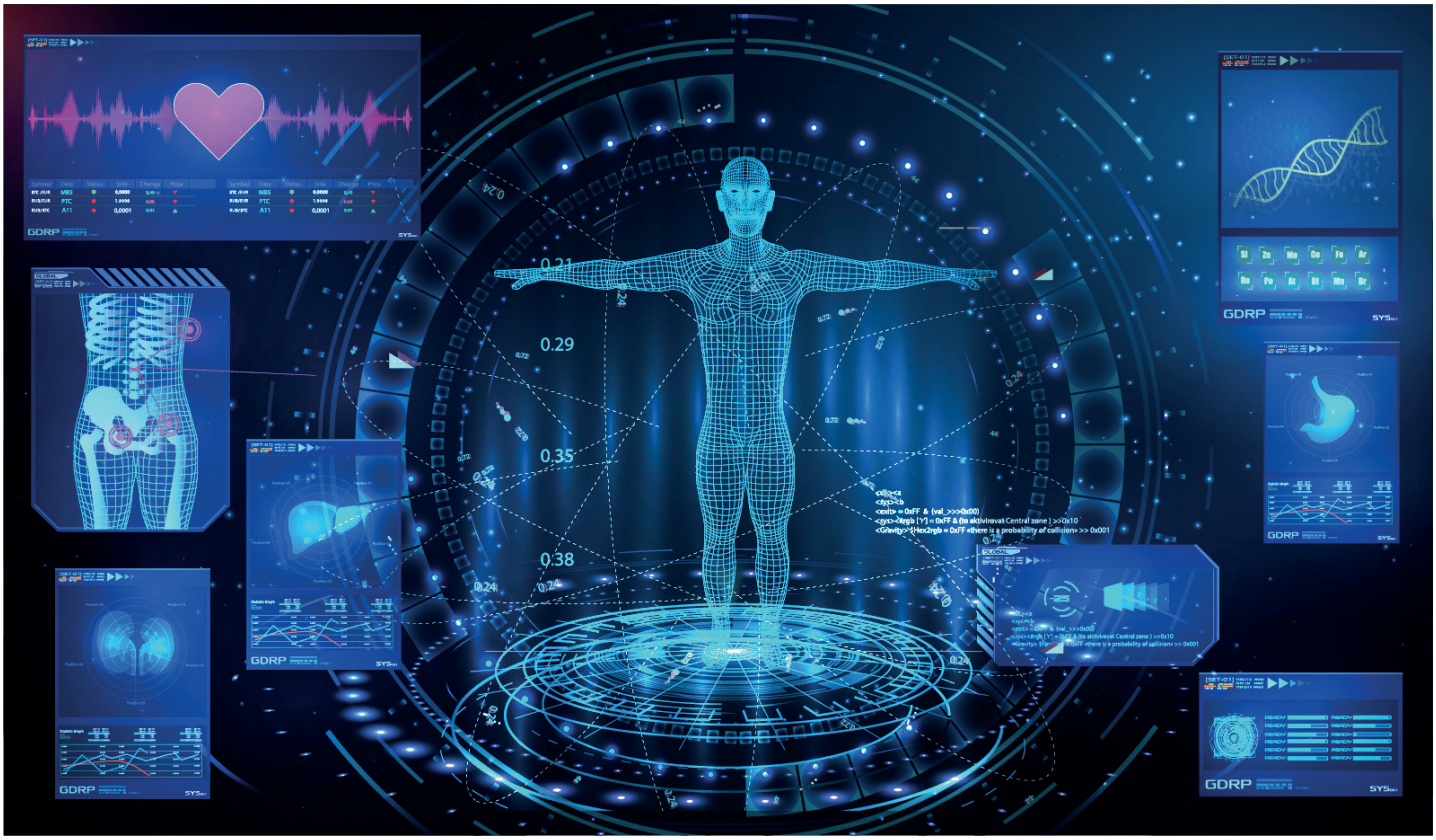
Raypack provides a cloud-native video analytics software that first needs to be trained on a matching model. The artificial intelligence is trained with an Nvidia V100 flavor. After successful training, the model is used as needed for the automated tagging of video sequences. This allows, for example, video archives to be indexed without manual effort, or rotten fruits in vegetable deliveries to be automatically identified before they enter the market.

Sales efficiency through artificial intelligence

Where are the best customers? The start-up DATALovers from Mainz has developed a service based on artificial intelligence that supports the work of sales and increases efficiency through intelligent search.

„Every searcher will find what he is looking for on the Internet,“ says Andreas Kulpa, CEO and one of the founders of DATAlovers. „The trick is to filter out really relevant information from the flood of data.“ That‘s exactly what the AI of the Rhineland-Palatinate founders can do. First, the algorithm receives information from existing customers of the company. These include criteria such as company size, number of employees, industry and location of existing customers. With this information, the artificial intelligence creates a statistical twin, a kind of digital sample customer, which serves as a template for the search process. Then the AI scours the Internet for companies that match the template - and thus finds potential new customers for the client.

The results are tailor-made target customer lists. This way, sales people receive only few, but promising results. They have to address fewer companies, but the closure rate is still significantly higher. The KI service also saves the sales department its own time-consuming research. DATALovers uses around 60 virtual machines from the Open Telekom Cloud for its solution. Depending on the order situation, it can be up to 120—for example, when a comprehensive crawl is pending, in which the artificial intelligence crawls the database for potential target customers.



Increase process efficiency with AI from the cloud

boot.AI uses its artificial intelligence to optimize various business processes. For example, the supply chain for logistics companies, the service for restaurateurs or the costs of administration at service companies. The company's AI analyzes data and processes. Based on the analysis, suggestions for potential improvements are made. From time to time, boot.AI customers value a high level of security and data protection. Therefore, the company switched to the Open Telekom Cloud. Among others, boot.AI uses bare metal servers with Nvidia graphics cards (2 x 14 processor cores, 512 GB RAM and eight P100 Nvidia graphics cards) to create neural networks. The Graphic Processor Units allow the simultaneous processing of millions of datasets without first loading them into the main memory. In addition, boot.AI benefits from the Document Database Service (DDS) based on the NoSQL database protocol MongoDB. The service is available directly from the cloud and automatically scales when data is added or removed. boot.AI only pays for the capacities that the start-up company actually uses.

Cancer detection with artificial intelligence

Radiologists often analyse several thousand images from magnetic resonance imaging (MRI) every day. And, of course, their patients expect the greatest possible concentration at all times during diagnosis so that no errors occur and nothing is overlooked. The founders of the start-up company Fuse-AI have developed a solution that helps doctors diagnose cancer. The aim is to make the work of radiologists easier with a computer-assisted second opinion and to make the bottom line diagnoses more reliable and accurate. The MRI images are transmitted in encrypted form via the Internet to the Open Telekom Cloud for analysis: The intelligence from the cloud marks conspicuous features, provides images with meta information and then sends them back to the doctor. The corresponding computing capacities are made available for the respective job, which are switched off again after the analysis has been completed. This provides exactly the resources required for fast analysis. The costs are thus based on the analyses actually generated.

Outlook

IaaS services provisioned from the public cloud are the future, and the foundations for this future are being laid right now. Companies that fail to embrace the digital era will be left behind. The global and European public-cloud IaaS market is growing fast, with no end in sight. And it is creating the basis for higher-quality PaaS and SaaS offerings.

Public-cloud IaaS provides user organizations with simple, cost-effective, on-demand access to infrastructure resources that can be deployed in a variety of scenarios.

The Open Telekom Cloud marks Deutsche Telekom's entrée into the public cloud market. As a German-based provider, the company is subject to strict national and European legislation and governance. This could be considered a burden. But it is of advantage to Open Telekom Cloud users. Deutsche Telekom is able to offer a comprehensive service package that guarantees robust data protection—as a German provider, with German-based data centers, and European service management. TCDP 1.0 certification of Open Telekom Cloud proves conformity with the new European data privacy that came into force in 2018. As a result, companies that have, until now, displayed reticence toward public cloud services for compliance reasons, can now take the plunge with good conscience. The Open Telekom Cloud comes complete with data protection, without the user organization having to implement specific mechanisms of its own.

The offering meets the needs of companies with strict security and compliance requirements—but it also addresses price-sensitive and dynamic businesses looking for simple, low-cost and rapidly available resources—in order to develop and test new applications, explore new business ideas or to find fast and lasting answer to resource needs.

Moreover, Deutsche Telekom offers a variety of consulting options to user organizations intending to make the Open Telekom Cloud an integral part of their IT landscape in the longer term. The company has a broad systems integration skillset, encompassing cloud computing, process expertise and in-depth knowledge of multiple industries. This is exactly the support that many European customers need in order to take the leap into cloud computing.

The Open Telekom Cloud from Deutsche Telekom creates a versatile basis for digitization projects in all sectors. In addition, this IaaS creates a platform for further PaaS and Saas offerings. The Open Telekom Cloud has already established firm foundations—with Akamai and a Hadoop/MapReduce suite. And to support hybrid environments, the Open Telekom Cloud offers resources available for private models. This will simplify the generation of hybrid clouds within burst scenarios.

CONTACT

T-Systems International GmbH
Market Intelligence
Uli Kunesch
Fasanenweg 5
70771 Leinfelden-Echterdingen
Germany
Email: Uli.Kunesch@t-systems.com

PUBLISHED BY

T-Systems International GmbH
Hahnstraße 43d
60528 Frankfurt am Main
Germany

www.t-systems.com

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