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# VIRTUAL DATA CENTER: IMPLEMENTATION OF DCAAS USING IONOS

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**Abstract.** This paper presents the working and implementation of Software-Defined Data Centers (also known as Virtual Data Centers). The main aim of using this emerging technology based on IT as a Service architecture (ITaaS) is to give organizations the platform to work with physical-like data centers in a cloud environment, thereby providing hardware flexibility over a virtual deployment. To show the working of an SDDC platform, an online cloud service platform called Ionos, which provides a cloud-based data center, is used with the virtual servers running Windows Server 2022. This paper is written while working under Lever10 Inc, a US-based IT service company giving real-world experience building a virtual data center (VDC) for a client organization. This paper also highlights the complexity of providing DCaaS (Data Center as a Service) by showing the steps taken to construct and implement a data center and the difficulties faced while creating a VDC.

## SOFTWARE-DEFINED DATA CENTER: AN INTRODUCTION TO DCAAS AND ITS ADVANTAGES

The data center has always been a place where data is stored, accessed, processed, and used. Made up of Compute (CPU), Memory (RAM), Storage, and Networking, we were able to build systems to run applications and websites depending on the requirements and needs of the organization. The onset of cloud services, notably AWS (Amazon Web Services), gave users a reason to ditch physical data centers for an infrastructure that could run their applications without bothering about "racking and stacking physical hardware." But as front-end apps become even more accessible and commonplace, it's more critical for the back-end infrastructure to become as agile as those front-end apps [1]. Providing for the back and the front end is the responsibility of an organization's data center. Hence the need for the Software-Defined Data Center (a.k.a. Virtual Data Center) for cloud-based infrastructure.

This leads to the question of what a Software-Defined Data Center is. It is a virtualized architecture that extends basic virtualization concepts such as Abstraction, Orchestration, and Automation to all data center resources [2]. In an SDCC, "all elements of the infrastructure – networking, storage, CPU and security – are virtualized and delivered as a service."[3] It provides a full-blown data center infrastructure over a cloud service, basically a large-scale working data center in the cloud. That translates to expanding infrastructure when required, giving users a pay-as- you-go model for flexible "physical-like" data center facilities.

DCaaS (Data Center as a Service) provides these facilities, a relatively new term for a subset of ITaaS (IT as a Service). However, with cloud-based infrastructure providers (IaaS providers), you are given prebuilt or completely bare metal systems, usually only a single server or a single unit of infrastructure, without provisions for virtual networking, choices of software, and individual components. The aim of DCaaS is to use virtualization to its fullest, expanding the virtual aspect of infrastructure beyond just storage and computing solutions to big-scale data center systems, properly replacing the need for physical computing hardware while giving similar functionality and flexibility.

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It also helps administrators of an organization's systems, as they can build the data center without requiring any 3rd party workforce to run and maintain their systems through other CSPs (Cloud Service Providers).

This brings forth a significant advantage to small or medium organizations, as they have total control over their infrastructure. Start-ups or similar organizations can build their own data centers and operate with the same resources as a large-scale data center without having to build or use large-scale physical or cloud systems. DCaaS provides for all kinds of uses where users need more than one single server and need communication between different parts of the organization's infrastructure to run and deploy applications.

**VMware Architecture of a Software-Defined Data Center: The Complexity of a VDC**

As we lightly discussed earlier, data centers require compute, storage, memory, and networks. VMware, a leading organization providing SDDC virtualization options, describes the architecture of how an SDDC needs to beconstructed to run.

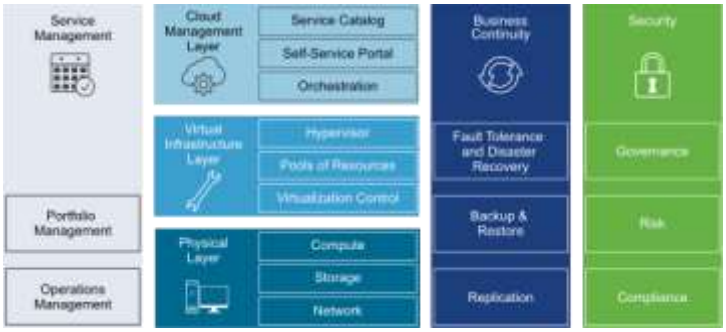


*Figure 1 VMware Architecture of a Software-Defined Data Center* [4]

Consisting of 3 layers, we have the physical, virtual infrastructure, and cloud management layers. The cloud management layer deals with cloud-based services, i.e., features not delivered by a regular data center. Service Catalog enables cloud admins to control distribution, ensure internal compliance, and increase discoverability for solutions within an enterprise [5]. The self-service portal is accessed to configure infrastructure, and orchestration deals with the automation of tasks and processes run on the infrastructure. The virtual infrastructure layer has a hypervisor (software that enables the sharing of physical compute and memory resources), the resources, and the control over virtualization. This is usually managed in vSphere, a VMware virtualization platform. Then there exists the physical layer, which we discussed earlier.

There are other services provided by VMware SDDC- business continuity, security, and service management. Configuring and running the infrastructure is done through the VMware vSphere and vCenter client applications. This whole infrastructure must be run on AWS, Google Cloud, or another cloud service provider to be considered a cloud-based data center. That involves configuring the cloud service as well as building the VMware virtualization. In 2019, VMware added support for Kubernetes, a container orchestration platform for applications on its vSphere platform. A container is a software package that holds all the necessary dependencies, software, and OS to run an application in any virtualized environment. Kubernetes, first presented by Google in 2014, introduced orchestration features (to automate tasks needed to manage operations) across multiple hosts. This meant that Kubernetes could have large-scale structures over which multiple container-holding applications could run.

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This made the SDDC Infrastructure very complex, primarily when complex business-grade applications are run through containers requiring the need of multiple administrators and third-party service providers. Managing resources, containers, and servers, load balancing, and automation through VMWare become a mammoth task, making an SDDC architecture worthwhile for only larger organizations and companies who want to shift their current complex data center to the cloud. For smaller users and organizations, solutions to find the sweet spot between flexibility and complexity were sparse, thus making implementation harder.

Harder-to-implement services, however, permanently lose out to companies that can provide a solid infrastructure to users in an easy-to-use way. The two examples of CSPs we shall discuss are AWS LightSail and Ionos.

## Ionos vs. Amazon LightSail: The Tale of VDC and VPS

In 2016, Amazon Web Services announced the initiation of LightSail services, intended to compete with major VPS providers at the time. VPS- Virtual Private Servers are virtual machines sold by a cloud/ internet hosting service. A virtual private server runs its own copy of an operating system (OS), giving customers superuser-level access to the OS, so they can install any software that runs on that OS. Similar to a dedicated physical server, it costs much less but shares the underlying physical hardware with other VPSes, which may lead to lower performance, depending on the workload [6]. LightSail provides a VPS with configurable prebuilt virtual servers offering amounts of compute in vCPUs (virtual CPUs), memory, storage (SSD+ HDD), and OS images. Using the web app, you can configure a Linux server or a Microsoft windows server. However, a VPS is a single server and a single instance, so does that qualify as a Software-Defined Data Center?

The simple answer to that is no. A data center requires "networking" between multiple servers. That is a virtual data center's essence and an essential feature. As for differences between a VPS and VDC, a VPS is used for hosting sites, business files, and media, but a virtual data center hosts multiple virtual servers. The connection and integration between more than one virtual server make a virtual data center. This is, unfortunately, not a feature that AWS LightSail possesses. However, leading CSP Ionos has a trick up its sleeve.

Ionos started its virtual data center services in the mid-10s, providing a unique tool for creating and configuring virtual data centers called the Data Center Designer (DCD). Users can use the DCD to connect various virtual elements to create a complete hosting infrastructure, as with a physical data center. [7]

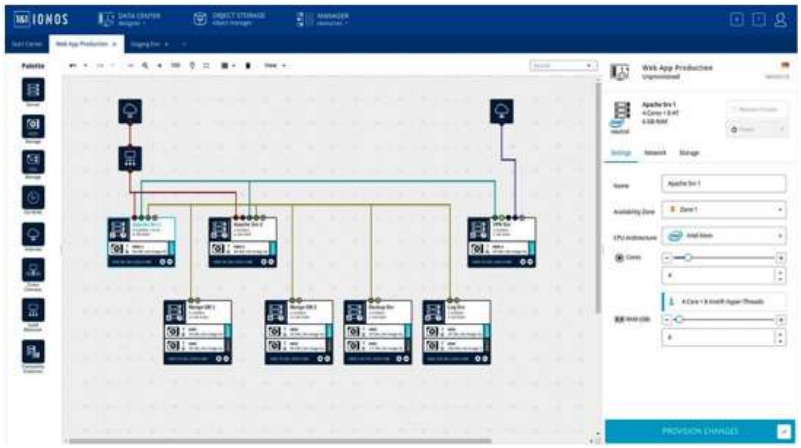

*Figure 2 Ionos DCD*

The DCD helps visualize the schema of the infrastructure, displaying servers as rectangular blocks carrying the specifications (such as the name and the size), displaying networks as lines drawn between nodes connected to each server and a network block, and displaying storage systems connected to the server blocks.

Being a very intuitive solution, this was patented by Ionos to provide users with features they knew from an actual data center. The user gets the opportunity to design, configure and provision its IT infrastructure entirely intuitively without the need to configure a hypervisor [8]. This solution is also not overly complicated to configure

while still being flexible, making it an easier task for system administrators. However, system administrators have two roles to play in the construction and implementation of Ionos' SDDC, one being the administrator of Ionos' DCD and its services (Managing IP, Kubernetes, Servers, Virtual Infrastructure, etc.) and the other being the administrator of the machine, its OS, and its applications. This is similar to the role of an administrator of a physicaldata center. This similarity makes Ionos perfect for explaining SDDC Infrastructure, as it can be easily configured and visualized.

## IONOS DATA CENTER DESIGNER

To access the DCD, use the URL https://www.dcd.ionos.com. This is a different link from other Ionos services.

- **Dashboard**: The DCD provides users with multiple virtual data centers and visualizations of overall resources used according to the cloud service plan. Users have access to menus, notably the designer, object manager, backup console, and resources manager, to configure and customize data center objects.
- **Data Center Designer:** This web app console gives users an interface to build multiple VDCs.
- **Palette and workspace:** The palette houses all the VDC components and virtual machines. Drag and drop the components in the workspace to create the infrastructure.
- **Inspector pane and Context menu:** The inspector pane is located on the right side of the workspace. It allows the configuration of each virtual machine. The context menu is accessed by right-clicking a virtual machine.

### Virtual Machines

As stated above, virtual machines (VMs) are available in the palette to be dragged and dropped into theworkspace. Each individual machine can be configured.

- **Server:** A virtual private server that behaves like a physical server. Currently configurable up to 12 cores (dual hyper thread for intel processors) and 48GB of RAM. You can configure virtual network interface cards and storage in server-mounted SSDs and HDDs (which are stored in Ionos' inbuilt NAS).
- **Cube:** A cloud cube is a VPS that comes with NVMe storage (directly attached storage to the server, which has speeds over 2000 Mbps). These are slightly restricted as compute, ram, and direct access storage are expandable only per configuration templates. Each template varies by processor, memory, and storage capacity [7]. Templates start from sizes S(1 vCPU, 2GB RAM, 50GB NVMe) to 4XL(16 vCPU, 64GB RAM, 1280GB NVMe). Cubes are also built using the system-on-chip architecture, tightly integrating compute, ram, and storage, increasing performance.

 

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### Data Center Components

Data Center Components are essential physical components required to run a virtual data center.

- **Compute:** Compute is a server's computing power (processing power). It can be configured by listing the number of CPU cores. For multicore applications, the number of cores is directly proportional to the application's performance. Compute can also be measured in vCPUs, and a single vCPU's performance is roughly equal to a virtualized CPU core. Ionos data center only uses vCPUs for cubes, and the other VMs use virtual cores.
- **Memory:** Memory in the server is provisioned by virtually partitioning physical ram on Ionos' physical servers. We can configure up to 128GB per server and 64GB per cube.
- **Storage:** Storage in Ionos is stored separately on a NAS (network-attached storage). They provide three kinds of NAS storage- HDD, standard SSD, and faster SSDs. Cubes, however, use direct attached storage, which is faster than premium SSD NAS.
- **Networking:** Networking is done by virtual Network Interface Cards, which are attached to a VM, and NIC nodes are connected directly to the internet, gateway, or another server. VLAN cables are configured by drawing a line between the server's NIC node and the virtual machine's destination.
- **ISO images:** Ionos offers various ISO images for Windows and Linux servers. Users can easily mount the Ionos ISO or the user-specified ISO to the direct-attached storage or the main storage connected to the server.

Other components include a virtual gateway, an internet gateway, and a load balancer to manage networking loads. The advantage of building a VDC is that components such as cables, power supplies, motherboards, and mounting drives do not need to be configured, as these features are inbuilt into the hypervisor.

## BUILDING A VDC: THE PROCEDURE

To practice and learn the configuration of a VDC for free, you can also head over to https://cloud.ionos.com/data-center-designer and click on "start the live demo." Delete the demo data given.

### Administration of Ionos and Billing Systems

Administration in Ionos is pretty simple; users can be configured from the DCD as administrators and added to the DCD. This gives those users access to configure and work by adding and configuring servers in the DCD. However, administrators cannot configure more than the allotted resources provided (depending on the billing plan of the provisions made). With DCaaS services, administrators get both the roles of configuring the virtual hardware as well as the software of the system. This is a huge advantage, as systems can be configured through and through as per the administrator or organization's requirements.

### Creating the Servers and Configuring Components

- **Internet access-** Drag the internet access component from the palette. It acts as the virtual gateway between the data center and the internet.
- **Server-** Drag a server into the workspace. Configure the RAM and Compute from the inspector pane. Intel CPU architectures have two hyper threads per core, which gets displayed as two cores in a VM.
- **Storage-** Click on the storage tab and add a virtual SSD/HDD as your boot drive. You can also drag the storage components from the palette and drop them onto the server.

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- **Iso images-** You must select an ISO image while configuring your storage. Click on the desired ISO from Ionos or insert your own image after uploading it through FTP. Ensure to give a root password (also used as the administrator password).

Repeat the process for the other servers to be created. Click on provision changes to save and run.

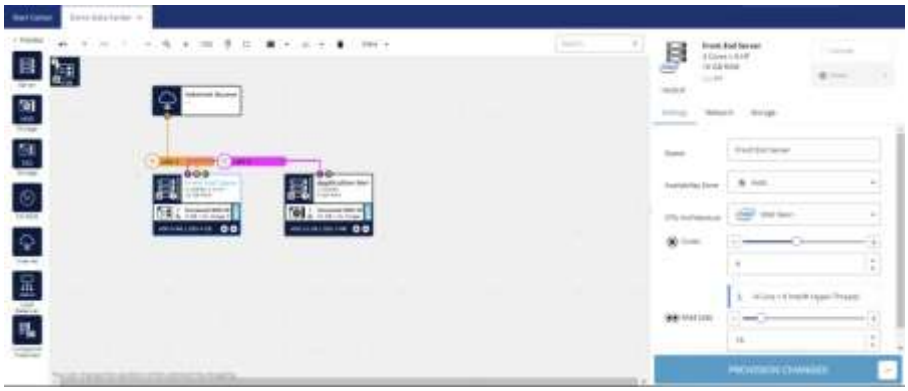

*Figure 3 Ionos Demo Data Center*

### Virtual Networks and Using Resources Manager to Configure IP

- **Create a NIC**- Configure the NIC through the network tab in the inspector pane or click the icon to add a NIC. You can configure the DHCP and Firewall if required.

*Figure 4 Creating a NIC*

- **Connecting virtual LAN**- Drag the node (color-coded according to the NIC) from the server to another server to create an internal network and to the internet access component to connect the server to the internet. Your virtual LAN is ready.
- **Custom IP**- Configure the IP through the resource manager (unavailable in demo mode). You will need a custom, static, and reserved public IP to access the server remotely or to use the server for hosting purposes.

## AN ACTUAL USE CASE SCENARIO

### Client Requirements

Business organizations usually use VPSes to run heavy business applications. Such was the case when a client requested Lever10 for a server to run LinkedHelper, a LinkedIn automation tool, and CRM software that requires running on windows/Linux and cannot be run through a container. LinkedHelper provides more than just automation: finding the right employees, contacting the target audience, and building a sales funnel with the help of a refined keyword search [9]. LinkedHelper automates the collection of data by setting up a single automated instance per LinkedIn user. However, our client had over 20 users who needed to be set up to collect data for multiple departments with different needs.

Running a business application called linked helper requires a lot of resources. While the real-world readings of these requirements were much lower than the documented requirements of

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LinkedHelper, the client required around four users to be run simultaneously, and we had to provide for that request.

*Figure 5 Application Requirements* [9]

If the client's requirements increased, we would need to tear down the VPS we built and create a new server. This iswhere using a VDC became beneficial; all that had to be done was to add more servers to the same cluster, thus sharing the same resources, such as the public IP, to access the server.

**Using Windows Server on an Ionos Cube**

- **Using a Cube** – After calculating the requirements of windows and LinkedHelper, we settled on a cube( dueto the faster direct attached NVME storage) that provided at least 6 cores. This prompted our choice of the XL cube, which gave us 320GB storage, 6 Cores, and 16GB RAM.
- **Provisioning the server-** Windows Server 2022 was selected as the disk image (from Ionos' images as theyare easy to configure and have no glitches), the network was configured, and the server was provisioned.

*Figure 6 Provisioning a Cube*

- **Using Ionos Console-** To access the server OS, we need to use the cloud console run by Ionos. It is prolonged and has high latency, but that is the only way to access the server till Remote Desktop Servicesare enabled. As control and other keys do not work, use the console to send key binds to access the server.

*Figure7 Ionos Console*

- **Adding the DHCP server roles and configuring the IP through windows-**Using Server Manager on windows, click on add new roles and features and configure the DHCP roles. The server will need to restart to enable the roles, following which the IP needs to be changed in windows to match the reserved IP set through Ionos to access the server publicly and use Remote Desktop Services.

Important points to note- Other roles can also be easily configured through Server Manager; however, if there is any problem with the configuration of roles, the server requires a restart. Do remember never to shut down the server, or any server in Ionos, as the whole server will need to be reprovisioned.

**Remote Desktop Services to Access the Server**

Like all servers, users and administrators need a platform to access the server. Besides being user-intuitive, Windows provides easy-to-access remote desktop features for users to connect and use the

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server with low latency and no glitches (which is why we chose Windows as our OS instead of Linux). You need a static and public IP to use remote desktop features. Enable all the required roles below and use the windows remote desktop connection app (preinstalled on any windows PC) with the IP address, username, and password. Refer to the Windows documentation to learn about Remote Desktop Services and configure your CAL (client access license). [11]


*Figure 8 Remote Desktop Services*

## Creating Users, Costs vs. People

To create a user, run lusrmgr.msc and create users there. Add the user to the remote desktop group role to give users access to remote desktop features. Administrators get remote desktop features by default.

Unfortunately, the question still does remain. "How many users need to be created for the data center." Too many users increase server provisioning costs due to more RAM requirements. So, we had to test the limits of the server. And this is what we observed-

- **RAM and CPU usage peaks** – We observed that RAM peaks only when users log into windows. For every user logging into the remote desktop, the RAM usage can peak at 70%, which is why the client's users were instructed to log in only one at a time. By doing this, we did not have to provide more RAM.

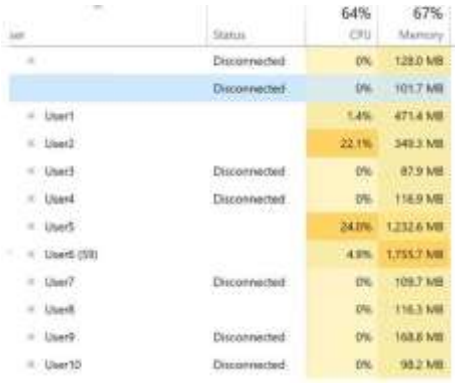


*Figure 9 Usage Peaks*

- This prompted our decision to use an XL cube, as it had adequate performance and could take the workload if used according to instruction.

## Future Possibilities and Improvements to the VDC

As we built the server using Ionos' data center infrastructure, expanding the total number of users beyond the current requirement of 20 users would be as simple as adding one more server/cube that can be provisioned for more users to be added. In the future, we can also add a load balancer if required when there are more than two servers.

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## CONCLUSION

Virtual Data Centers are the present and the future of cloud computing. We showed how DCaaS, a relatively new technology, benefits smaller organizations by providing more resources with data center features such as networking and multi-server deployment. Using the cloud service provider Ionos, we were also able to highlight the importance, working, and implementation of a virtual data center. This technology will be used for various purposes for years to come.

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