



# **Frankfurt University of Applied Sciences**

– Faculty of Computer Science and Engineering –

## **Project Cloud Computing**

LowTech GmbH

Milestone 1

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# 1 Technology and infrastructure (as-is)

LowTech GmbH as-is infrastructure:

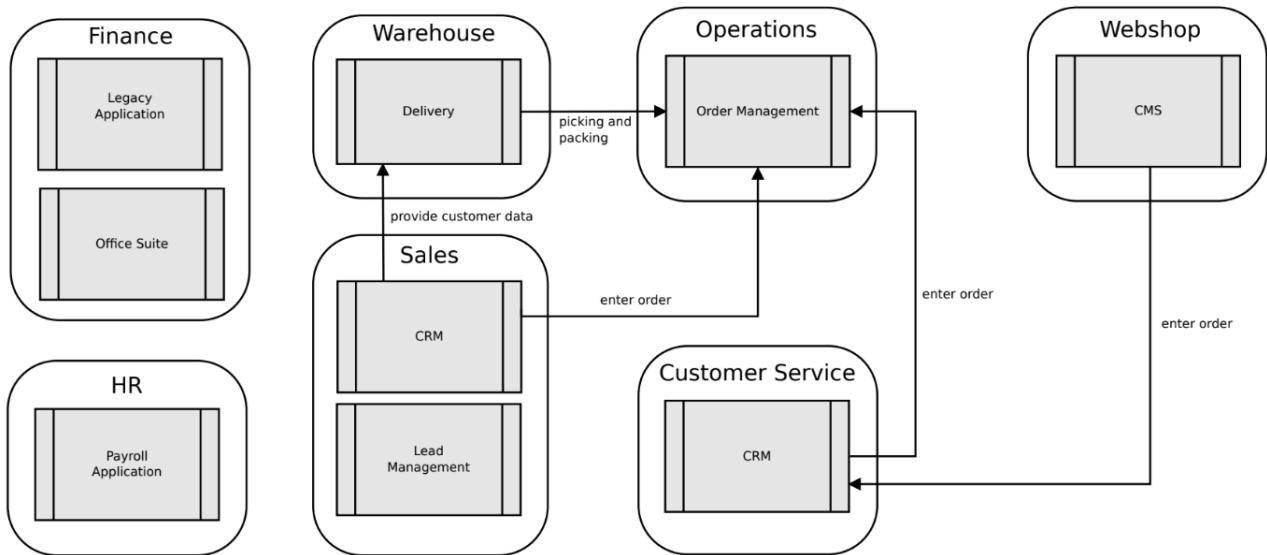


Figure 1: Application landscape of Low Tech GmbH, showing key systems and their integrations.

## 1.1 Server Resources

Table 2 shows the total server resources allocated across different departments.

Department	RAM	Storage (HDD)	Storage (SSD)	Storage (Tape Drive)
Finance	8GB	500GB	-	-
HR	8GB	2000GB	-	-
Warehouse	8GB	1000GB	-	-
Sales	16GB	2000GB	-	-
Sales	32GB	-	-	10000GB
Operations	32GB	3000GB	-	-
Webshop	128GB	-	500GB	-
<b>Total</b>	<b>232GB</b>	<b>8500GB</b>	<b>500GB</b>	<b>10000GB</b>

Table 1: Server resources allocated by department (summed up).

## 1.2 Traffic and usage (last month)

System/Service	Storage Used
Legacy Accounting Software	350GB
Payroll	1000GB
Delivery	250GB
CRM	980GB
CRM Storage	5500GB
Order Management	100GB
CMS	10GB
<b>Total</b>	<b>8190GB</b>

Table 2: Server resources allocated by department (summed up).

The infrastructure of Low Tech GmbH consists of various systems and departmental allocations, with a total of 232 GB RAM, 8500 GB HDD, 500 GB SSD, and 10,000 GB of tape drive storage. Storage utilization over the past month amounted to 8190 GB, with CRM and payroll systems being the primary consumers.

### 1.3 Power consumption)

Servers:

Type	Amount	Electricity Consumption (Per Server)	Total Consumption
Application Server	4	1000W	4000W
Application Server	1	1200W	1200W
Storage Server	1	1200W	1200W
Web Server	1	1200W	1200W
<b>Total</b>	<b>7</b>		<b>7600W</b>

Table 3: Power consumption by server type (summed up).

The calculation of the monthly energy consumption is as follows:

$$\frac{7600 \text{ W}}{1000} = 7.6 \text{ kW} \quad (1)$$

The monthly energy consumption is calculated by:

$$7.6 \text{ kW} \times 24 \text{ h} \times 30 \text{ days} = 5472 \text{ kWh per month} \quad (2)$$

Clients:

Type	Amount	Electricity Consumption (Per Unit)	Total Consumption
Clients	17	500W	8500W
Laptops	14	50W	700W
Laptops	5	1	100W
<b>Total</b>	<b>7</b>		<b>9700W</b>

Table 4: Power consumption by server type (summed up).

$$\frac{9700 \text{ W}}{1000} = 9.7 \text{ kW} \quad (3)$$

For the client energy consumption:

$$9.7 \text{ kW} \times 8 \text{ hours} \times 21 \text{ days} = 1629.6 \text{ kWh per month} \quad (4)$$

The total energy consumption per month is:

$$5472 \text{ kWh (Servers)} + 1629.6 \text{ kWh (Clients)} = 7101.6 \text{ kWh per month} \quad (5)$$

The energy demand is significant, with server usage accounting for 5472 kWh per month across seven servers, predominantly driven by application and web servers. Client devices, including 17 desktop clients and 19 laptops, contribute an additional 1629.6 kWh per month. Overall, the monthly energy consumption totals 7101.6 kWh.

## **1.4 Critical assessment)**

- **Scalability**
  - Old Hardware
  - No space for more Hardware
- **Availability**
  - No redundancy
  - No UPS (Uninterruptible Power Supply)
- **Security**
  - Only Windows Defender and pfSense
  - No Role-based Access Controls
  - Maybe lack in encryption
  - Outdated platforms and software

The current infrastructure lacks scalability, security, and high availability, falling short of modern standards. Immediate upgrades are essential to ensure system resilience, enhanced security, and capacity for future growth.

## 2 Infrastructure cloud transformation

The goal of Low Tech GmbH's cloud transformation is to modernize the existing infrastructure by transitioning to a scalable, secure, and highly available cloud environment. This will be achieved through the adoption of a hybrid cloud strategy leveraging private and colocated cloud solutions, and implementing a microservices architecture powered by Docker and Kubernetes. By embracing cloud-native technologies and open-source solutions, Low Tech GmbH aims to enhance system reliability, optimize operational efficiency, reduce costs, and enable future scalability while ensuring robust data security and compliance.

## 3 Hybrid Cloud Solution for LowTech GmbH: Private and Colocated Infrastructure

For LowTech GmbH, a **private and colocated hybrid cloud solution** offers an optimal balance between flexibility, control, scalability, and security. This hybrid infrastructure combines the benefits of a **private cloud** for sensitive applications and data with the advantages of **colocated hosting** for enhanced scalability and resource management. Such a solution aligns with LowTech GmbH's goal to modernize its infrastructure while retaining control over critical systems and data, with a view to migrating to a **public cloud** in the future.

### 3.1 Private Cloud Infrastructure for Sensitive Applications

LowTech GmbH's sensitive applications, such as finance systems, HR, and payroll data, require stringent compliance with privacy regulations and data security policies. These systems will reside within a **private cloud** environment, either hosted on-premises or in a private data center. The private cloud offers LowTech GmbH full control over infrastructure and data management, ensuring compliance with regulations like **GDPR** or **HIPAA**.

To support LowTech GmbH's ongoing modernization efforts, the private cloud will use advanced **virtualization technologies** (such as **VMware** or **OpenStack**) and **Kubernetes** for container orchestration. Kubernetes will allow the company to efficiently deploy, manage, and scale **microservices-based applications**. This approach modernizes existing legacy systems by breaking them into smaller, independently deployable services, enhancing flexibility, performance, and maintainability.

### 3.2 Colocated Hosting for Scalability and Flexibility

In the context of **colocated hosting**, LowTech GmbH will deploy its physical servers in a **third-party data center** while retaining control over the hardware. This solution enables the company to scale its infrastructure efficiently, ensuring that hardware needs for high-demand workloads (such as the **Sales** and **Operations** departments) are met without the burden of managing an internal data center. Colocated hosting also improves resource allocation, as it provides more flexibility than a purely on-premises solution, allowing LowTech GmbH to manage infrastructure without significant upfront capital investments.

By combining both private cloud and colocated hosting, LowTech GmbH can expand infrastructure capacity on demand. This hybrid model provides **high-performance computing** for specialized applications while leveraging the physical security and networking benefits of a colocated data center.

### 3.3 Hybrid Cloud Architecture: Integration of Private and Colocated Infrastructure

In the **hybrid architecture**, the private cloud will host **core applications** and sensitive data, while colocated servers will manage resource-intensive or overflow workloads. Key features of this hybrid solution include:

- **Infrastructure as a Service (IaaS):** Both the private cloud and colocated hosting will use an IaaS model, enabling LowTech GmbH to provision virtualized servers dynamically. The private cloud will handle core operations such as finance and CRM, while the colocated infrastructure will support high-demand applications or data overflow.
- **Microservice Architecture:** LowTech GmbH's legacy applications will be decomposed into microservices, enhancing scalability and flexibility. For example, the **CRM** and **Order Management** applications will be broken down into independent services, deployed across both the private cloud and colocated infrastructure as per performance and security requirements.
- **Containerization with Kubernetes:** Both the private and colocated environments will use **Docker containers** orchestrated by **Kubernetes**. Containers enable efficient, portable deployment of services, and Kubernetes ensures the seamless management of microservices across both infrastructures.
- **Data Integration:** To maintain seamless data flow between the private cloud and colocated infrastructure, tools like **APIs** and **service meshes** (e.g., **Istio**) will be employed. This ensures that data consistency and communication are maintained across both environments, allowing LowTech GmbH to integrate legacy systems with modern cloud-native applications.
- **Disaster Recovery and Business Continuity:** The colocated infrastructure will play a critical role in **disaster recovery** (DR). It provides a geographically redundant backup for the private cloud, ensuring that critical applications and data remain available even in case of infrastructure failure. LowTech GmbH will also leverage **backup solutions** to protect important business data, further securing the organization's business continuity.

### 3.4 Security and Compliance for Sensitive Data

A hybrid cloud solution allows LowTech GmbH to retain tight control over sensitive data, addressing security and compliance concerns while benefiting from the flexibility of cloud technology:

- **Data Encryption:** Encryption will be applied both in-transit and at-rest to protect data. Sensitive financial and HR information will remain within the private cloud or colocated servers, with strict controls to prevent unauthorized access.
- **Access Control:** The private cloud and colocated hosting will implement **role-based access control (RBAC)** and **identity and access management (IAM)** solutions, ensuring that only authorized users have access to sensitive applications and data.



- **Network Security:** Both private and colocated infrastructures will utilize **virtual private networks (VPNs)**, **firewalls**, and **intrusion detection systems (IDS)** to safeguard against unauthorized access, ensuring the security of LowTech GmbH's critical systems.

### 3.5 Scalability and Flexibility in the Hybrid Cloud Model

The hybrid cloud solution provides LowTech GmbH with the flexibility to scale its infrastructure based on business needs:

- **Scalability:** The private cloud will handle core operations and sensitive applications, while the colocated infrastructure will scale to meet fluctuating demands, particularly for workloads in **Sales, Operations**, and other high-performance departments. By colocating servers, LowTech GmbH can easily increase its capacity without significant upfront investments.
- **Flexibility:** The hybrid solution allows LowTech GmbH to optimize its workloads based on performance, security, and regulatory requirements. For instance, sensitive data can be maintained in the private cloud or colocated servers, while less critical workloads can be offloaded to the public cloud as needed.

### 3.6 Future Migration to Public Cloud

The hybrid cloud infrastructure will serve as an intermediate step towards a full **public cloud migration**. As LowTech GmbH moves to a public cloud in the future, the hybrid architecture will provide the necessary flexibility for gradual adoption. By leveraging **containers** and **microservices**, applications will be made portable and cloud-agnostic, allowing LowTech GmbH to migrate workloads to public cloud platforms like **AWS, Azure, or Google Cloud Platform (GCP)**. This approach ensures that LowTech GmbH maintains control over sensitive data during the transition while still benefiting from the scalability and cost-efficiency of the public cloud.

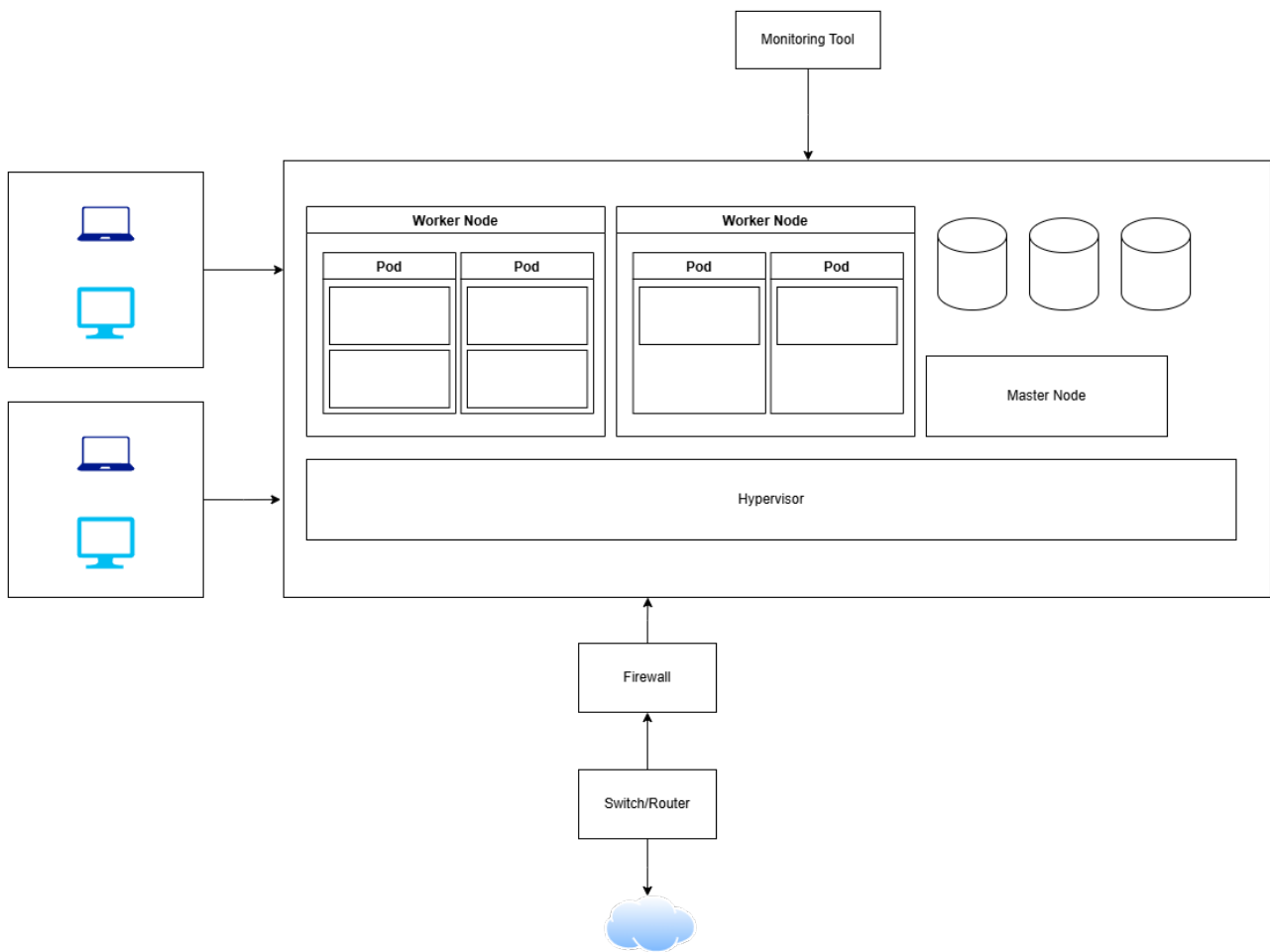


Figure 2: Kubernetes Cluster

## 4 Hardware and Software Components for New Infrastructure

### Hardware Components

- **Servers:**
  - Virtualized Servers (for Kubernetes Nodes)
  - Application Servers (for microservices deployment)
  - Storage Servers (for data storage needs)
  - Web Servers (for web application hosting)
- **Networking Equipment:**
  - Switches (for intra-data center communication)
  - Routers (for external connectivity)
  - Firewalls (for network security)

- Load Balancers (for traffic distribution across services)
- **Backup Devices:**
  - Backup Servers (for storing backups of applications and databases)
- **Storage:**
  - SSD Storage (for high-performance applications)
  - HDD Storage (for archival or less demanding workloads)
  - Network Attached Storage (NAS) (for shared access and backups)
- **Colocated Data Center Infrastructure:**
  - Colocated Racks (for housing physical servers in third-party data centers)
  - Cooling Systems (for maintaining optimal operating conditions)
  - Power Supply Units (UPS) (for ensuring uninterruptible power supply)

## 4.1 Software Components

- **Operating Systems:**
  - Linux (e.g., Ubuntu, CentOS, RedHat - for running Kubernetes nodes and containers)
- **Virtualization and Containerization:**
  - Docker (for containerizing microservices and applications)
  - Kubernetes (for container orchestration and microservices management)
  - OpenStack (for managing private cloud infrastructure)
- **Networking and Security:**
  - pfSense (for network security, firewalls, and VPN setup)
  - Intrusion Detection Systems (IDS) (for network security monitoring)
  - VPN Software (for secure remote access)
- **Backup and Disaster Recovery:**
  - Backup Software (e.g., Veeam, Bacula - for application and server backups)
  - Cloud Backup Solutions (for offsite backup storage)
- **Monitoring and Logging:**
  - Prometheus (for system and application monitoring)
  - Grafana (for visualizing metrics and performance data)
  - ELK Stack (Elasticsearch, Logstash, Kibana - for centralized logging and analytics)
- **Database Management Systems:**
  - MySQL (for relational data storage)
  - PostgreSQL (for relational data storage with advanced features)
  - MongoDB (for NoSQL data storage)

- **Cloud Management:**

- OpenStack (for managing the private cloud infrastructure)
- Kubernetes (for managing containerized applications and microservices across clusters)

## 5 Energy Consumption and Cost Considerations

As LowTech GmbH transitions to a hybrid cloud infrastructure, energy consumption and cost efficiency are critical factors. The new infrastructure focuses on reducing both server and client energy demands while maintaining performance and scalability.

### 5.1 Servers

In a Kubernetes-based environment, energy consumption depends on hardware efficiency. To optimize power usage:

- **Energy-efficient hardware:** Using modern servers, such as ARM-based processors, reduces energy consumption.
- **Dynamic resource allocation:** Kubernetes scales workloads based on demand, minimizing idle power usage.
- **Data center efficiency:** Colocated data centers provide optimized cooling and power management, reducing overall energy costs.

These measures help keep server-related electricity costs low while maintaining performance.

### 5.2 Clients

Switching from traditional desktops to energy-efficient mini PCs and laptops can significantly reduce electricity consumption:

- **Mini PCs:** These devices consume less than 30W (often under 15W), are priced under €500, and are more than capable of running cloud applications.
- **Laptops:** With power usage ranging from 15W to 50W, laptops are efficient for cloud-based tasks.

By adopting mini PCs and laptops, LowTech GmbH can reduce the energy consumption of client devices, leading to lower electricity costs and environmental impact.

### 5.3 Cost Summary

By utilizing energy-efficient server hardware, Kubernetes for dynamic resource allocation, and switching to mini PCs and laptops for clients, LowTech GmbH will reduce operational costs. These energy-saving strategies will ensure that the company maintains a balance between cost-effectiveness, scalability, and environmental sustainability.