Dedalus

VENDOR NEUTRAL ARCHIVES FOR THE WHOLE HOSPITAL

1. Challenges in Medical Image Archiving

Hospitals and healthcare facilities are facing an exponentially growing amount of image data that needs to be managed efficiently and securely. The fragmentation of image archiving systems leads to significant interoperability issues and hinders quick and straightforward access to important medical data. The increasing use of imaging procedures is resulting in a data flood that is pushing traditional storage solutions to their limits. Radiologists require fast and reliable access to this data in order to make accurate diagnoses.

The main challenges are the following:

- **Interoperability Issues and Data Access**

Many hospitals use different PACS (Picture Archiving and Communication Systems) that are often incompatible with each other. This complicates data exchange and retrieval, leading to inefficient workflows.

- **High Costs**

Different solutions are used for storing, managing and retrieving data, with-out any unified access. This increases operational costs and maintenance expenses, and may also result in data loss.

- **Security and Privacy Requirements**

Protecting sensitive patient data is of utmost importance. Stringent data protection laws and regulations require robust security measures and relia-ble data archiving.

Vendor Neutral Archives have thus been developed to address these issues.

2. Introduction to Vendor Neutral Archives (VNA)

Definition and Core Principles of a VNA

A Vendor Neutral Archive (VNA) is a specialized storage solution designed to store and manage medical imaging data in a standardized format, regardless of the specific imaging devices or systems used to generate these images.

Core Principles of a VNA:

1. Vendor Neutrality

A VNA can store and manage data from various imaging devices and PACS without being tied to a specific vendor. This ensures that data is stored in a standardized format.

2. Interoperability

By using open standards and protocols, a VNA facilitates data exchange be-tween different systems and departments. This eases integration into exist-ing IT infrastructures and promotes collaboration.

3. Centralized Management

A VNA provides a central platform for storing and managing all medical im-aging data, simplifying data management and facilitating access to this data.

4. Long-Term Storage and Archiving:

A VNA is designed to store large volumes of imaging data securely and effi-ciently over long periods, ensuring data integrity and availability.

Advantages of a Vendor-Neutral Approach

The implementation of a VNA offers numerous benefits for hospitals and healthcare facilities:

1. Increased Flexibility

By decoupling image storage from imaging devices, hospitals can more easily integrate new technologies and systems without having to perform existing data migrations. This simplifies the adoption of new imaging devic-es and technologies.

2. Cost Reduction

A VNA reduces long-term data management costs, by minimizing the need to migrate data when switching PACS providers. Additionally, it lowers oper-ational costs by centralizing data management and reducing redundant systems.

3. Improved Integration and Collaboration

A vendor-neutral approach enables seamless integration of various systems and fosters collaboration between departments, such as radiology, cardiolo-gy, pathology, and oncology departments. This leads to improved patient care, thanks to faster and easier access to comprehensive imaging data.

4. Security and Privacy Benefits

A VNA comes with robust security measures, including data encryption and access controls, ensuring that sensitive patient data is protected. Centralized audit trails and monitoring features enhance compliance with data protec-tion laws and regulations.

5. Scalability and Future-Proofing

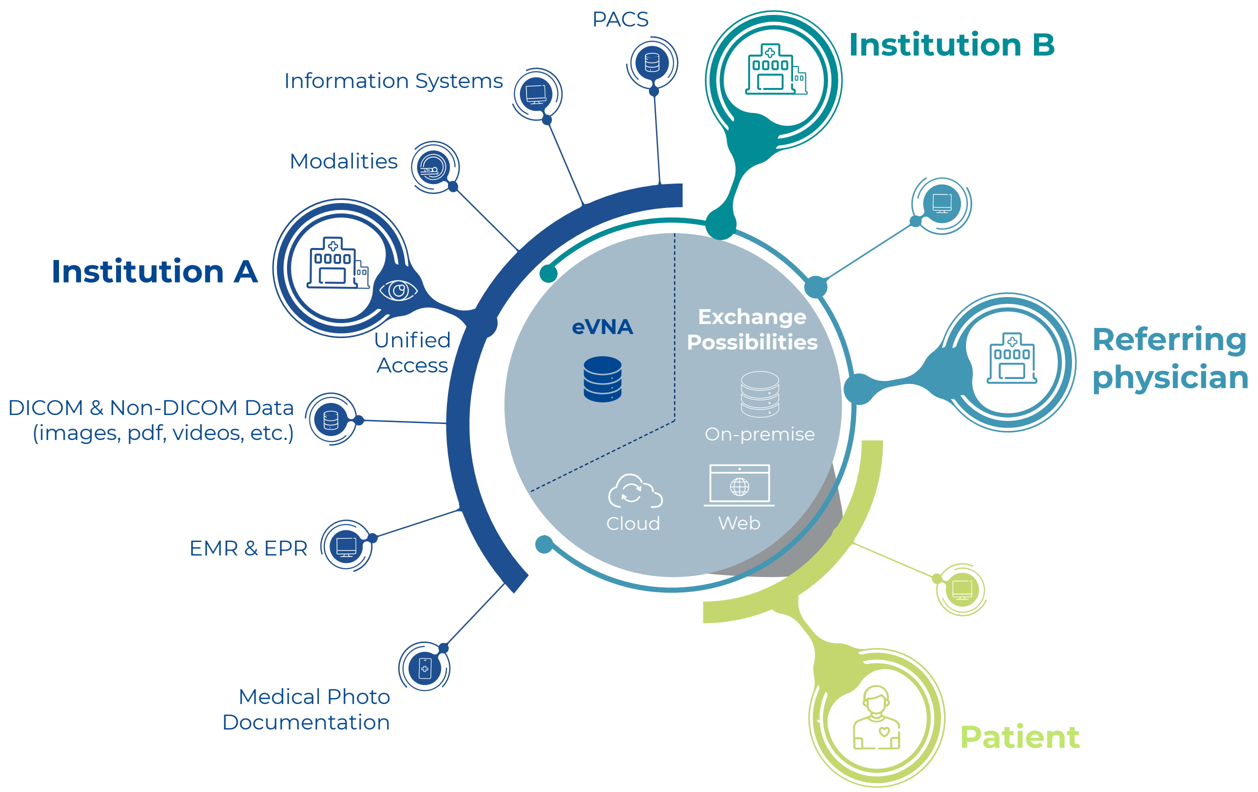
A VNA is scalable and can keep pace with the growth of imaging data in hospitals and healthcare facilities. It is also future-proof, as it can be contin-uously developed and adapted to new standards and technologies.

By implementing a VNA, hospitals and healthcare facilities can significantly im-prove the efficiency of their imaging data management, reduce operational costs, and enhance the quality of patient care.

3. DeepUnity eVNA: The Core Element of an Enter-prise Content Strategy

Functionality and Components

DeepUnity eVNA is a modern VNA solution designed to meet the challenges of to-day's healthcare landscape. It offers a scalable and flexible architecture that seam-lessly integrates into existing IT infrastructures.



DeepUnity eVNA is built on various components to achieve maximum efficiency for administrative and imaging operations. The DeepUnity Viewer is provided to re-trieve data from the eVNA. The solution is based on a new technological stack: Kubernetes.

Kubernetes is an open-source container orchestration system for automating the deployment, scaling, and management of containerized applications. It groups the containers that make up an application into logical units, in order to simplify man-agement and discovery. Containers are a virtualization technology in computing that separates applications from one another, including their runtime environments.

Kubernetes provides several advantages:

- **Accelerated Time-to-Market**

Kubernetes and containers provide users with homogeneous development, testing and production environments, helping to automate deployment. This results in significant benefits, such as convenience and speed in deliver-ing new releases.

- **Portability**

Kubernetes and containers ensure that applications function largely inde-pendently from their environment.

- **Improved Stability and Availability**

Kubernetes provides a higher level of automation, leading to greater robust-ness – meaning less effort is required when it comes to incident manage-ment and troubleshooting. Kubernetes additionally includes integrated self-healing capabilities.

- **Optimized Costs and Reduced Effort**

Kubernetes allows for optimal packing density of different container-based applications, leading to more efficient resource utilization. This reduces in-frastructure costs. Infrastructure components and stacks can also be reused, which significantly reduces personnel efforts.

Integration into Existing Hospital Infrastructures

DeepUnity eVNA supports a wide range of communication protocols and data formats, enabling smooth integration with existing systems such as PACS, RIS, and EHR. To ensure data-level independence, a single, standards-based repository is provided, which grants easy access to all imaging data.

The Dedalus platform leverages cutting-edge development methods and relies on modern architectural components like Kubernetes, which enables cost-effective installation and supports both on-premise and cloud deployments. Public, private, and hybrid cloud models are supported. As such, the platform guarantees inde-pendence from hardware and infrastructure components.

To ensure that DeepUnity eVNA supports multiple departments, disciplines and architectures, both scheduled workflows and on-demand workflows are supported. DeepUnity eVNA is also able to store both DICOM and non-DICOM data, such as JPEG, PDF, MPEG4, TIFF, PNG, and more.

The solution manages incoming imaging data from various departments, loca-tions, companies and so on, in separate storage groups. Access control is managed by assigning permissions based on roles.

Metadata

There are several ways to manage metadata:

- **Metadata provided via HL7**

DeepUnity eVNA supports receiving HL7 ADT and ORM data. HL7 ADT is typically used to provide metadata at the patient level, while HL7 ORM is used to provide metadata related to procedure orders. The latter is also used to create the Modality Worklist. The details are stored in the eVNA database.

- **Metadata provided via DICOM**

Every DICOM object contains metadata about the captured images, as well as patient and study details. This metadata is stored in the DeepUnity eVNA database.

- **Metadata tags as provided when storing native NON-DICOM objects**

This data is also stored in the DeepUnity eVNA database.

Lifecycle Management

To allow administrators to configure lifecycle management rules based on various aspects, such as data object sources, specialties etc., a web-based administration interface for the eVNA is provided. This interface allows to define multiple rules based on a number of metadata tags stored as part of a study, such as AE-Title, ModalityInStudy, PatientAge, among others.

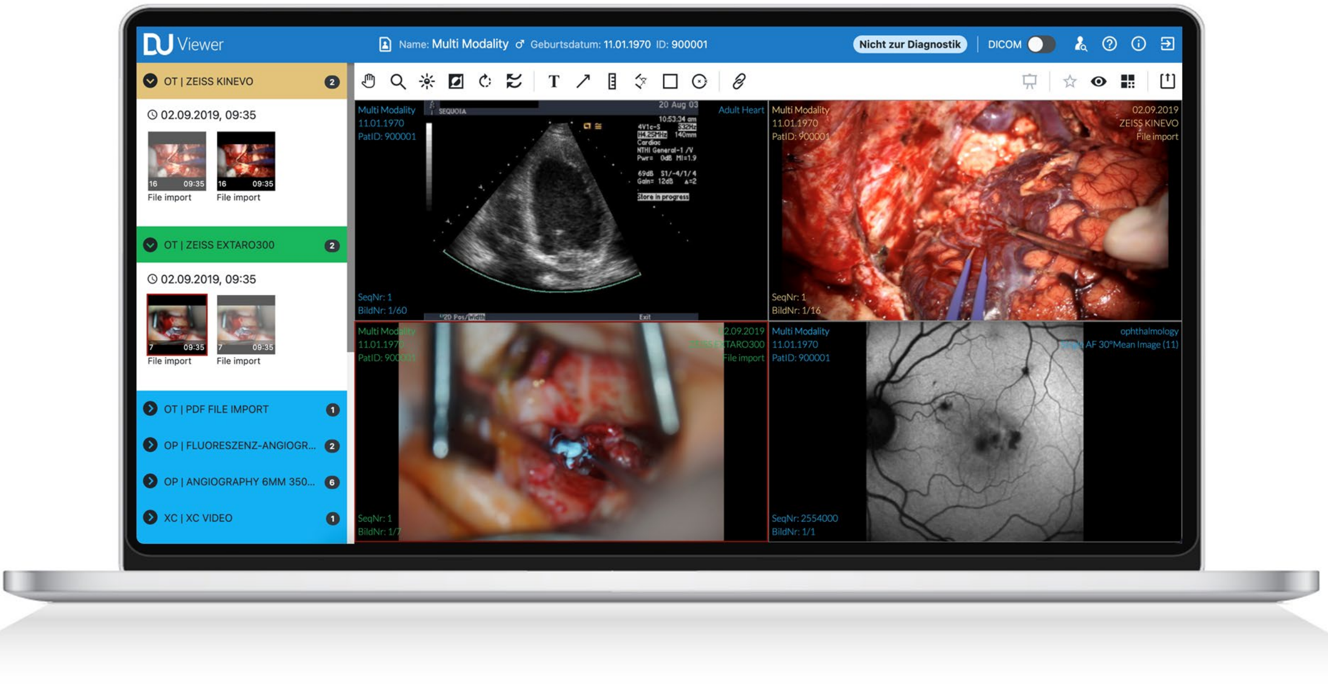
Various rules can be configured to define:

- Where the data should be stored (move/copy rules to different file system groups)Proxmox is planned.
- How long the data should be retained for (retention rules)
- When the data should be forwarded (forwarding rules)
- When the data can be deleted (deletion rules)

This allows for a granular definition of lifecycle management.

Viewing Capabilities

End users (clinicians, etc.) have access to the DeepUnity Viewer, a fully web-based viewer that requires no storage space. It allows medical staff, both inside and out-side the hospital, to access patient studies. The viewer can also be seamlessly em-bedded into the EMR (Electronic Medical Record), providing access to the entire medical imaging documentation. The viewer offers seamless access to all content, whether DICOM or NON-DICOM, through a single user interface.



Security and Privacy Measures

All functions/features within the Dedalus eVNA have been developed in strict com-pliance with legal requirements, such as auditability, document authenticity (right of inspection), data protection (ISO IEC 27001 and GDPR), Electronic Information Preservation/LTANS (ISO 14641-1), and IDW-880/ISAE-3000.

Data protection and patient security, in accordance with the GDPR, are supported in the Dedalus solution in the following ways when implemented with the Dedalus Viewer and eVNA:

1. Access Control (Identity and access management for users)
2. Role-Based Access Restrictions (Restricting access to specific us-ers/studies/departments)
3. Checksum-Based Data Integrity Verification
4. Information Lifecycle Management (ILM) (e.g., WORM with setting a reten-tion period)
5. Certificate-Based Encryption
6. High Availability and Fault Tolerance
7. Centralized Logging of User Activities via ATNA Auditing

Implementation

Solution and Infrastructure Architecture

The architecture is tailored to hospitals' specific requirements. Here is an **example**:
Three virtual Linux machines (VMs) deployed in a VMware environment:

- Application VM
- PostgreSQL Database VM for ECM)
- PostgreSQL Database VM for DICOM Services

Running on VMware provides cost-effective high availability at the hardware level and protects the application from server failures. If a physical host server fails, the virtual machines are automatically restarted on another server host within minutes.

In addition to the VMware solution, which protects the virtual machines from phys-ical server failures, Kubernetes attempts to automatically restart affected applica-tion workloads in the event of an unplanned failure.

The storage is based on block device storage. All storage resources are located on fully redundant disk subsystem, controller, and data path components. The disk-based long-term archive (LTA) is by default based on NFS or S3 storage.

The three virtual server components can be installed in the customer-provided vir-tualized VMware environment (e.g., stretched ESXi cluster) using an Open Virtual Appliance (OVA) image file.

Server Hardware Requirements

The following section summarizes the minimum requirements for the server VM.

VM#1 – Application Server DCM & ECM

Compute & Storage	Medium (M)	Large (L)
CPU	App: 14 core (10 + 4)	App: 22 core (14 + 8)
RAM	40 GB RAM (24 + 16)	56 GB RAM (32 + 24)
OS & Cluster Storage	340 GiB in total	
Short Term Storage ECM	Small / Medium / Large: 1024 GiB	
Short Term Storage DICOM	1-2 months (depending on the product)	
Long Term Archive ECM (NFS or S3)	Small: 5000 / Medium: 10240 / Large: 15000 GiB	
Long Term Archive DICOM (NFS or S3)	Size depending on DCM production	

VM#2 - PostgreSQL Database ECM (OVA)

Compute & Storage	Medium (M)	Large (L)
Version	PostgreSQL 13/14/15	
CPU	4 vCPU	6 vCPU
RAM	8 GB	16 GB
OS & DBMS App	vDisk 1: OS 100 GiB	vDisk 1: OS 100 GiB
Database ECM	vDisk 2: Db data 300 GiB	vDisk 2: Db data 400 GiB
Db Backup	vDisk 3: ~1.5 x DB Size	vDisk 3: ~1.5 x DB Size

VM#3 - PostgreSQL Database DICOM Services (OVA)

Compute & Storage	Medium (M) (Up to 100K Ex./yr)	Large (L) (Up to 200k studies /year)
Version	PostgreSQL 13/14/15	
CPU	4 vCPU	8 vCPU
RAM	32 GB	48 GB
OS & DBMS App	vDisk 1: OS 100 GiB	
Database	vDisk 2: Data & Index • Diagnost: 8 GiB • DCM Srvs.: 12 GiB per 1TiB vDisk 3: Arch/Logs 100 GiB	vDisk 2: Data & Index • Diagnost: 12 GiB • DCM Srvs.: 12 GiB per 1TiB vDisk 3: Arch/Logs 150 GiB
Db Backup	vDisk 4: ~1.5 x DB Size	vDisk 4: ~1.5 x DB Size

The eVNA application server component is installed on an Oracle Linux operating system (OS). The OS is provided in the form of an Open Virtual Appliance file. The OVA file contains all the files associated with the virtual machine. Therefore, the installation requires a VMware ESXi environment that has not yet reached 'End of General Support' according to the VMware support matrix.

The eVNA platform requires access to publicly available repositories where con-tainer images for the DU Solution applications are provided as well as updates for the platform (Kubernetes, Linux, etc.). Internet access outside of the documented repositories is not necessary.

Constant access to these repositories is required - for instance, if a node in the clus-ter fails, if an application restarts or if similar events occur, a container image may not be present in the local cache, and it will need to be downloaded ad hoc.

Third-Party Products and Tools

The following table provides an overview of the software stack, including third-party products and tools:

- Installation and Updates
- Configuration & Logging
- Monitoring/Dashboards
- Security, Network / Load Balancing
- User Authentication
- Support for LDAP, ORBIS DB, etc.
- Multi-Factor Authentication
- Message Broker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