# MEDUSA

## DELIVERABLE
## D2.2.3 Demonstrator platform

Medical Distributed Utilization of Services & Applications

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Major: Interaction
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## HISTORY

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# 1. Introduction

## 1.1 Document overview

This document describes the release of the Medusa demonstrator platform.

The Medusa system is used for demonstrations in hospitals in both France and the Netherlands.
These demonstration session are run by Medusa workpackage 1.

Chapter 2 gives a brief overview of the Medusa system. Chapter 3 decribes the functionality of the different components. Chapter 4 describes the steps necessary to configure Medusa on a client system, and the last chapter describes the steps to get started with Medusa.

Input for this document was provided by all consortium partners, especially for chapter 3.

## 1.2 Medusa overview

Medusa provides a scalable cloud based solution for distributed utilization of medical services and applications, like imaging, decision support, etc.

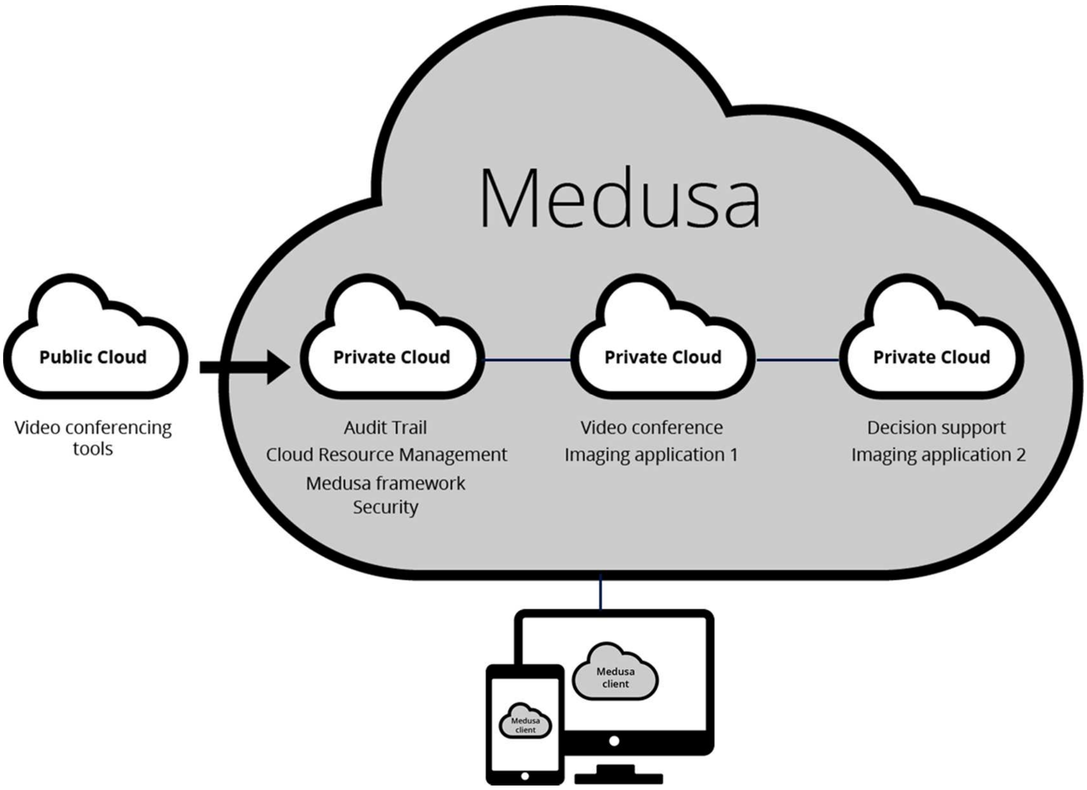


**Figure 1 Medusa overview**

Figure 1 provides an overview of the system. Medusa consists of a lot of independently running, cloud based medical applications. These applications work together in the Medusa context, and provide a collaboration environment for users. Users can work on applications simultaneously, and discuss the situation of a patient.

Because of the medical data, the environment is highly secure, and all access to data is authorized.

Medusa offers a combination of medical and supporting generic services. The medical applications are:

- Imaging platform (Philips)
- Imaging algorithms (AMC)
- InVitro analysis (ImStar)
- DosiSoft (DosiSoft)
- ComaSoft (PSP)
- Decision support (based on medical data)

These are supported by a couple of generic services:

- Video conferencing
- Audit trail
- Cloud resource management
- User management

## 1.3 References, Acronyms

Referenced documents

| Reference | Title |
|---|---|
| FPP | Medusa Full Project Proposal |
| D111 | Use case scenarios and User requirements |
| D211-221 | Medusa Architecture and Interface specifications |
| D543 | Reference implementation of components |

# 2. Components

Medusa is built up from the components listed in this chapter. Main functionality and innovations are described in the next paragraphs.

| Component | - Consortium partner |
|---|---|
| Framework | – Technolution |
| Cloud infrastructure | – Bull |
| Cloud management | – Prologue |
| Security | - Cassidian |
| User management | - Cassidian |
| Imaging Client | - Institute Mines-Telecom |
| Video conferencing | - Philips |
| Image analysis platform | - Philips |
| Decision support | - Sopheon |
| Algorithms | - AMC |
| Dosisoft | - Dosisoft |
| Pathfinder | - Imstar |

## 2.1 Medusa Framework

The Medusa framework is developed by Technolution

### 2.1.1 Functionality

The Medusa framework is the 'glue' between all applications in the Medusa domain.
The Medusa Web client shows all Medusa applications in a browser environment.

The framework backend is taking care of the synchronization between all the different applications: user management, video conferencing, cloud resource management, decision support, audit trail, and all the medical applications.

### 2.1.2 Main innovations

The framework provides a highly scalable mechanism which makes it possible that independent applications are working together in a completely distributed cloud environment. Applications do have specific responsibilities, varying from imaging to user management to decision support. The framework brings these applications together, and provides a platform to work seamlessly together.
The framework is used in the medical domain, but the architecture is reusable, and can be applied to any domain, for example traffic management, energy management, etc.

## 2.2 Component User Management

The User Management component is provided by Cassidian.

### 2.2.1 Functionality

The User Management (UM) module provides services to deals with users accounts and access right.

### 2.2.2 Main innovations

The UM module was designed to be flexible and customizable; therefore it provides interfaces to manage the configuration/customization of the application. The possible configurations are to:

- manage password policies,
- customize Manager interfaces (language, terminology, dictionaries …),
- manage organizational units,
- manage technical accounts,
- manage templates to make easier the creation of users with default value.

It also provides a full bench of provisioning connectors already included in the solution that could be used to provision the Information System Applications.

## 2.3 Component Security

The security component is provided by BULL, IMT and Cassidian.

### 2.3.1 Functionality

The security and transmission component provides all security services needed to offer a secure access to Medusa.
It is composed of five modules:

- The authentication module which aims at authenticating Medusa users and providing access to Medusa application without forcing the users to re-authenticate themselves on each one.
- The access control module which aims at enforcing access control for Medusa application. The module provides a role- and organization-based access policy to resources.
- The ciphering module which aims at protecting data transmitted over the network in confidentiality and integrity.
- The fingerprinting and watermarking module ensuring that the medical images have not been corrupted over time or in transit on MEDUSA network.

### 2.3.2 Main innovations

The security module provides Cloud based secure transmission including:

- Multi level encryption

- Central IAM (Identity & Access Management) solution with complex right modeling and certificate deployment
- Deployment of an Identity based Firewall to authenticate user on each security equipment
- Single Sign On from the user device to Medusa service.

It also provides two innovative content traceability and integrity proof technologies to medical uses:

- Watermarking: identifying the owner and the information leaking source
- Fingerprinting: automatic tracking of unauthorized distribution

## 2.4 Infrastructure as a Service (IaaS)

As described in the D211 " Medusa architecture and interfance specification " and D543 "Reference implementation of components", the IaaS provided by Bull is comprised of two layered subcomponents :

- The physical infrastructure : comprises compute nodes, physical storages, and network components.
- The *Cloudificator* and Cloud Management (OpenStack): transfoms the physical infrastructure in Cloud services, and provides management functions of those services.

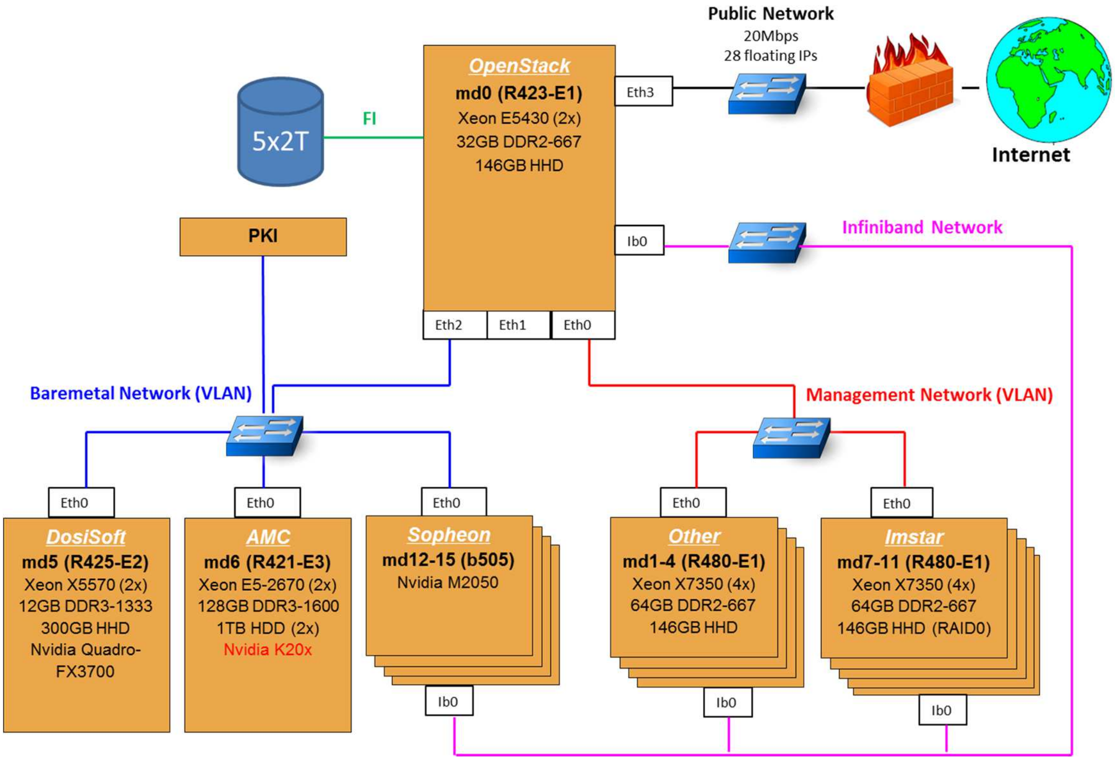


**Figure 2. Medusa IaaS**

This infrastructure is composed of two sub-infrastructures: the virtualized infrastructure and the baremetal infrastructure.
The next section describes the functions of these infrastructure as a service.

### 2.4.1 Functionality

The physical infrastructure provides following features as services:

- The virtualized infrastructure: a set of computing nodes with high frequency CPU, 48 GB of RAM, and high rate Tera Bytes disks. These nodes dedicated to non-graphical computing applications are connected via Ethernet of 1 Gb/s, thus absorbing business and control flows. In the Medusa system, a virtual machine is assigned to each application, then each couple application/virtual machine is deployed by the PaaS layer tools.
- The Baremetal infrastructure: is a non-virtualized environment composed of nodes equipped with high frequency CPU and GPU. These nodes are connected by a network interconnect Infiniband of 40Gb/s. Operating systems are pre-installed manually on these nodes dedicated to applications requiring graphical calculation.

Remote storage: both Virtualized and Baremetal infrastructures are sharing a high performance remote storage of tens of Tera Bytes through an infiniband network.
On the other hand, the *Cloudificator* and Cloud management component provides the following fucntions:

- Self-service automated provisioning
- Service catalog
- Charge Back, relying on metering from Ceilometer
- Capacity management
- Performance management
- Configuration and change management
- Lifecycle management
- Orchestration of deployment

### 2.4.2 Main innovations

The main innovation of Medusa IaaS is the ability to fit heterogeneous requirements of application, in terms of networking, computing, storage, and management, thus fulfilling requirements of the demonstrators.
For example, application requiring GPU computation would dynamically be deployed on nodes equipped with GPU.
Operating system requirements are also met dynamically on deployment time.
Moreover, the IaaS dynamically and transparently adapts to changes in application requirements at running time.

## 2.5 Component Cloud management

The Cloud management component is provided by Prologue.

### 2.5.1 Functionality

All software components composing the MEDUSA system are deployed on a Cloud infrastructure. Their deployment is managed by the Cloud management layer, which runs as a back-end service.
The Cloud management platform orchestrates the allocation and release of resources on the Cloud provider's infrastructure, and acts as an intermediary between the client environment and the Cloud resources. It also oversees the lifecycle of the deployed resources, ensures their availability and scalability, and links the legacy applications from the virtualization server back to the collaboration framework's client environment, all that in a security-aware implementation.
At the core of the Cloud management layer lies the Cloud broker component that selects Cloud resources and services according to customer requirements (technical, operational, regulatory). The Cloud management engine can provide

monitoring functionalities and reporting derived from the logs of events, warnings, and errors generated during operation.

### 2.5.2 Main innovations

The main innovation of this component reside in the fact that it can translate technical requirements for computing, storage, network, and security resources identified for each MEDUSA application into machine-readable code used by UiC-B engine to provision resources. In addition, business, and policy requirements of applications can be defined, and the definition of requirements is in a general-purpose, extendible, and reusable format. Adding or customizing an application in the MEDUSA system is therefore a simple procedure.
In addition, Cloud management seamlessly manages custom scalability and life-cycles of virtualized legacy applications that are initially implemented for single user/single machine operation.
The Cloud management platform is designed according to the Service-Oriented Architecture model, and invoking functionalities on this platform is possible through the REST API that it offers.

## 2.6 Component Imaging Client

The Imaging Client component is provided by IMT.

### 2.6.1 Functionality

Imaging Client component provides three independent functionalities.
First, it is a kind a glue allowing for legacy, non-cloud developed applications to included into the MEDUSA framework; actually, the Imaging Client main functionality is to ensure the virtualization in cloud of any legacy application, without either additional development or modification of their codes.
Secondly, it provides the collaboration functionality over non-collaboration applications; here again, the codes of the non-collaborative applications is not changed; instead, a collaboration layer, independent with respect to the application but including the medical best practices is featured. This virtualization layer deals with both collaboration message exchanges and application personalization according to the actual user profile/role.
Finally, the Imaging Client also ensures the multi-terminal access to legacy application.

### 2.6.2 Main innovations

The imaging client comes across with three-folded innovations, at methodological, functional and technical levels.
First, at the methodological level, the Imaging Client combines a full multimedia approach to open-source, open-standard instantiation. Secondly, at the functional level, the cloud virtualization and collaboration are granted for each and every

legacy application, without any restriction in its operating system or typology and imposing any constraint on the user device. Finally, note the technical gains (bandwidth and CPU saving) with respect to state-of-the art competitors (as assessed in the related MEDUSA deliverables in WP5).

## 2.7 Image Analysis Platform

The Medusa Image Analysis Platform is developed by Philips.

### 2.7.1 Functionality

The Image Analysis Platform provides an application building framework allowing partners to quickly and efficiently build new clinical applications. This framework consists of a rich set of tools that provide a rapid prototyping environment.
Next the Image Analysis Platform provides a comprehensive set of image processing routines which can be used for algorithm development. These algorithms can then, using the Algorithm Plugin Framework, be plugged into the developed applications.

### 2.7.2 Main innovations

The extensible frameworks provide the possibilities to seamlessly integrate best of breed algorithms in the Medusa environment enabling best possible image processing in all circumstances. The integration into Medusa provides additionally a scalable hosting environment. Main innovations in Medusa are semantics based image compression, use case specific image processing, image processing as a service, high performance image processing and information integration.

## 2.8 Video Conferencing

The Medusa Video Conferencing is developed by Philips.

### 2.8.1 Functionality

The Video Conferencing component provides video conferencing, screen sharing and chat between the collaborating users in a Medusa session.

### 2.8.2 Main innovations

The functionalities in the video conferencing are delivered by integrating standard components in the Medusa Framework and Medusa Architecture. The integration of these components with the Medusa collaboration, user management and session scheduling provides an secure integrate workspace optimized for clinical usage. The main innovation of the Video Conferencing components is the optimization and integration for use in the medical collaboration domain.

## 2.9 Advanced image processing algorithms for stroke patients

The advanced image processing algorithms (AIPAs) are provided by the AMC. This algorithms are implemented as plugins for the open processing prototype platform (OP³), or the Image Analysis Platform from Philips.

### 2.9.1 Functionality

Different algorithms have different types of medical image data as input. The different types of medical images are: non-contrast computed tomography (ncCT), computed tomography angiography (CTA), and computed tomography perfusion (CTP). **Error! Reference source not found.** shows the sequence and timing of the imaging and of the main image analysis steps, which consist of:

- hemorrhage quantification, ASPECTS score calculation, and infarct volume calculation from ncCT;
- movement compensation and analysis from CTP;
- ASPECTS score calculation and thrombus detection from CTA.

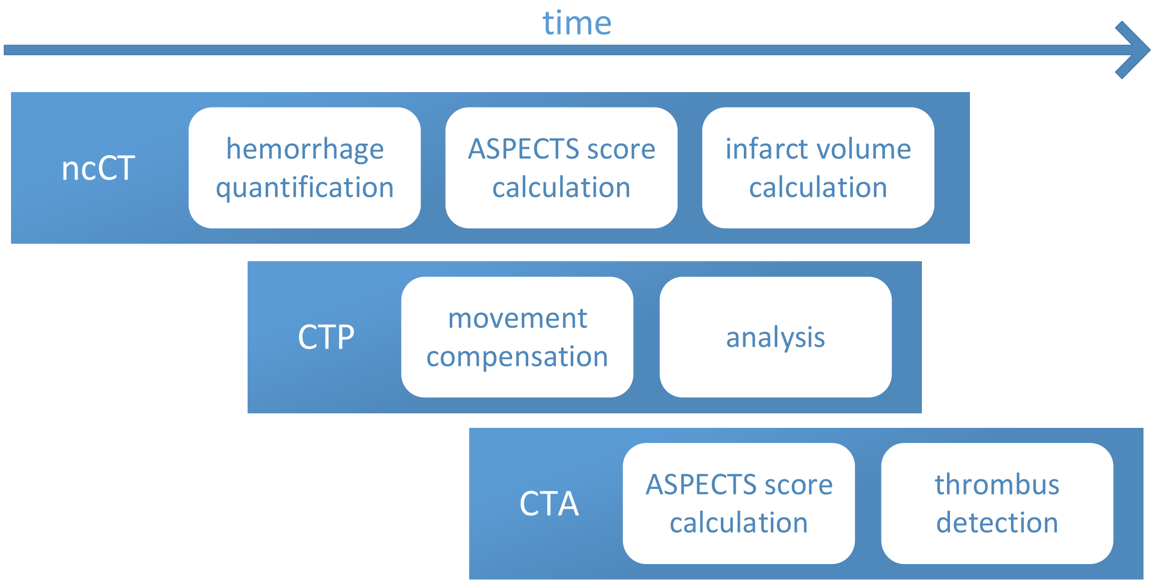


**Figure 3. Schematic overview of the sequence and timing of imaging and main image analysis steps for the stroke use-case from a user point of view.**

### 2.9.2 Main innovations

The main innovations brought by the AIPAs are the automated extractions of parameters that can help radiologists in choosing the most effective treatment for the acute stroke patients. This is only possible because the automated processing is fast enough to produce results in a time that is compatible with the restrictions of an acute patient. Apart from that, the validation and development of these automated methods, together with the possibility of correlating their quantitative results with patients outcome, are also unique characteristics provided by the AIPAs.

## 2.10 Application for the computer-assisted in-vitro diagnostic

The application for the computer-assisted in-vitro diagnostic, Pathfinder PathoScan, is developed by Imstar.

### 2.10.1 Functionality

The application included the following functionality inside the framework:

1. On the digital images of the slides with appropriately coloured histological slices or cell spreads, detect the cells (or other objects of interest). That is, determine the contours of all these objects.
2. Characterize the cells. That is, evaluate the relevant parameters for every cell (surface, labeling optical density, shape indices etc.).
3. Classify the cells. That is, basing on the cell characterization parameters, assign the class to every cell, such as ‘Normal’ and ‘Abnormal’.
4. Review and validate the classified cells and establish the diagnostic. Only this step requires user interaction (other than identifying user and slide). To accomplish this step, the instrument presents the objects considered in the analysis to the scorer, tracking down the numerical results to the original image.

The pp1-3 can be accomplished using the distributed parallel image processing system running on multiple VMs in the cloud.

### 2.10.2 Main innovations

The main innovation of the Pathfinder PathoScan is the ability to provide the high level of the automation of the whole in-vitro diagnostic process. The system modules for slide digitization, image processing, analysis, review and diagnostic are tightly integrated in the single application ensuring the bi-directional data flow between different phases of the diagnostic process. Further, the system includes wide range of customized processing protocols, covering many application areas in the domain of cancer diagnostic.

## 2.11 Component Contouring for Oncology

The component contouring for oncology is provided by DOSIsoft.

### 2.11.1 Functionality

The component Contouring for Oncology is a software application dedicated to the review and the analysis of image series from the Nuclear Medicine to aid in diagnosis, therapy response and contouring in the scope of oncology.
Based on the detection and segmentation of tumors on functional imaging modalities (PET, SPECT), this application includes a set of tools specific to oncology, for the review of image series for the diagnosis of cancer but also for tumor quantification and response assessment of the patient over the course of the treatment.
On the other hand, the inclusion of the functional modalities in treatment planning system for radiotherapy is also addressed by the application to help radiotherapists to delineate the volume of interest (tumors) to irradiate.

### 2.11.2 Main innovations

The application provides the following main advantages:
- Provides user-friendly tools for the simultaneous examination of multiple fused imaging modalities;
- Offers original methods for segmentation of tumors using functional and anatomical modalities;
- Improves the identification and precise delineation of tumors;
- Performs the monitoring treatment and facilitates adaptive processing;
- Guides the treatment decisions;
- Exports the contour files to TPS for treatment plans implementation in radiotherapy.

## 2.12 Decision Support

The Decision Support component is provided by Sopheon.

### 2.12.1 Functionality

The Decision Support System (DSS) receives real-time patient data via the Medusa cloud and applies rules that specify the conditions for sending real-time notifications to the users in a given collaborative session.
The Decision Support System receives data from:
- one or more sensor devices that capture real-time patient data (heart rate, blood pressure, respiratory rate)
- real-time patient data generated by an image post-processing application of Medusa.

The DSS imports rules from a protocol management system (Accolade) that is used to create, officially approve and publish medical protocols. The Protocol Management System comprises a Rule Editor allowing health care professionals to define a set of decision support rules that can be automatically converted into executable code for the DSS. The selection of one or more medical protocols in a given collaboration session determines which set of rules is to be applied.

The DSS executes the rules in real time: when the real-time patient data matches the conditions specified in a rule, the corresponding notification is sent to the collaboration session in the Medusa portal.

### 2.12.2 Main innovations

An important innovation in the Decision Support component is the integration and real-time interpretation of multiple heterogeneous data sources ranging from vital sign sensors to advanced image processing output, communicating through the Medusa cloud. This is especially valuable in the Acute Trauma use case. First of all, sensor applications ensure the real-time and continuous transmission of sensor data from the ambulance to trauma specialists in the hospital. This enables to detect trends in the patient's condition, which is currently not yet possible. Second, the real-time interpretation of these data supports a more specific and objective diagnosis (based on legally approved medical protocols).
The Protocol Management System is a back-end system that also runs in the cloud. Alldecision support rules are defined in the context of medical protocols that is authored, managed and approved by medical professionals.
Other innovations concern the Rule Editor embedded in the Protocol management System: it is highly configurable (without requiring IT intervention) and it has been expanded with the ability to define ranges and trends.

# 3. Installation

All Medusa applications are installed in a cloud environment.
The medusa system can be accessed via the url:

https://cymid-rp.cybersecurity.cassidian.com/

In order to be able to logon, the client system must be equipped with user certificates. These certificates are issued by the Medusa administrator to specific users, on a specific device, and must be loaded in the browser certificate store.

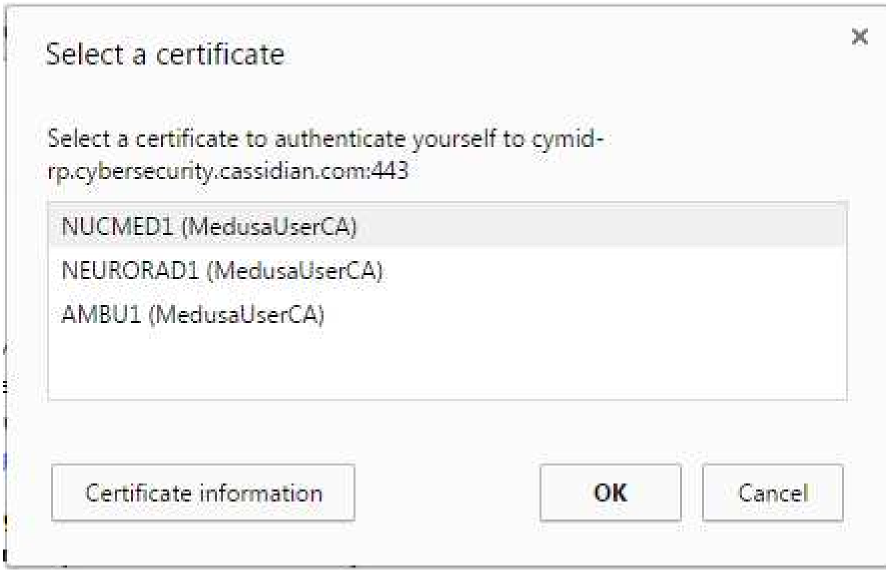


**Figure 4. Selection of correct user**

After selecting a certificated, the user logs on, and can start a session. No further configuration of the device is required.

Medusa can be used on devices ranging from tablets till high-end computers.

# 4. User guide

**Step 1. Logon**
The user logs on, by starting an internet browser and selecting the certificate installed on his system.

**Step 2. Select session, or attend running session**

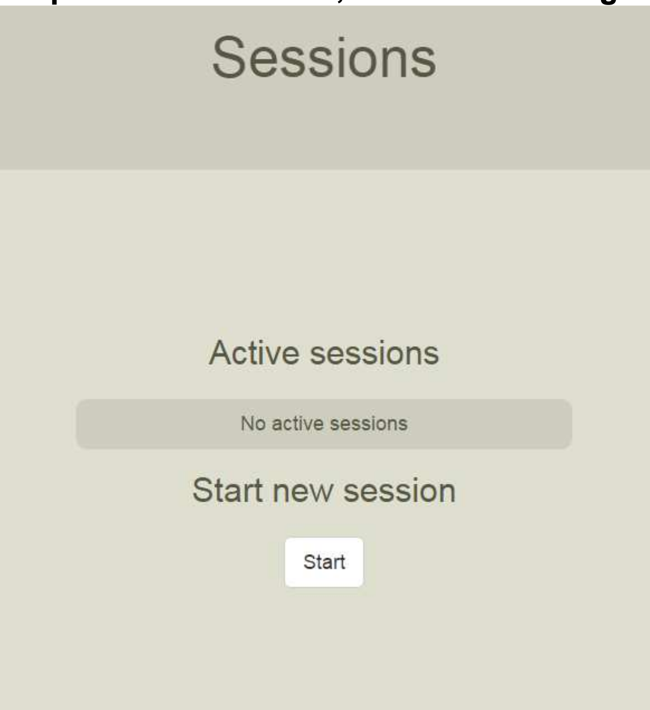


**Figure 5. Medusa start screen**

If a user is invited for a session, the session will be visible on this screen, and the user can join the session. If no sessions are listed here, the user can start a new session by pressing the 'Start' button.

**Step 3. Main screen**
After starting or joining a session, the main screen is shown. A set of default applications is shown. These default applications depend on the role of the user logged on.


**Figure 6. Medusa main screen**

Each application has a separate tab.
On the right, a collaboration part is visible.

**Step 4. Select additional applications**
When clicking on the ‘Configuration’ button in the upright corner of the screen, the configuration dialog is shown. The configuration screen shows a list of all available applications.

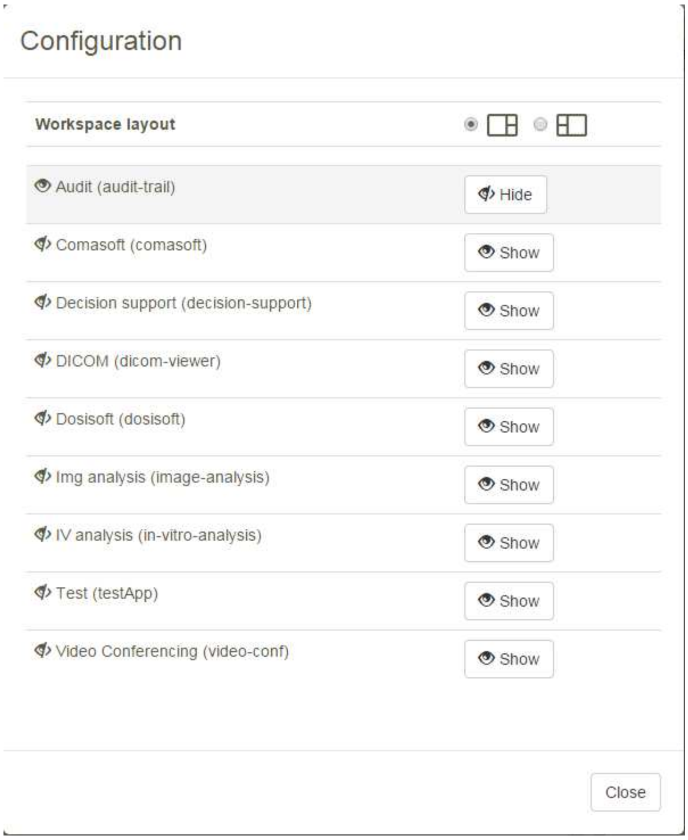


**Figure 7. Select applications**

**Step 5. Work with applications**
After selecting applications, the applications become visible on different Tabs. The applications are automatically focused on the selected patient.


Figure 8. Example of Medusa application

# 5. Conclusions

This document describes the availability of the Medusa demonstrator platform and how to use it.
The demonstrator platform can and will be used to evaluate Medusa functionality as described in Workpackage 1 (for example as described in D111, Use case scenarios and User requirements)