

# A Multimodal Multi-Device Discourse and Dialogue Infrastructure for Collaborative Decision Making in Medicine

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# Outline

- The THESEUS/Medico Project.
- Need for ontology-based knowledge structure for medical data (i.e., images).
- Collaborative Dialogue-based annotation in RadSpeech.
- Conclusion and outlook.

# About THESEUS

“THESEUS is developing new semantic technologies that will be able to analyze, classify and link information based on content. Not only will computers find information with the help of key words or content fragments, as they do today, but they will also determine its significance, draw connections to other information, model it as a classification system and employ certain rules to draw logical conclusions.”

[www.theseus-programm.de](http://www.theseus-programm.de)

# Motivation in Medico

## Found Situation

- Structuring of medical reports dependent on individual preferences
- Textual and visual data is “passiv”
- Marginal supply in automatized interpretation of medical data

## Trend in clinical care

- High dependence on digitized patient information
- Growing need to store and organize patient data (health records, laboratory reports, medical images)
- Need of effective image retrieval based on the meta information that is part of the image content

# Challenge 1

How can computer be able to interpret images and to recognize by itself parallels and also abnormalities between images?

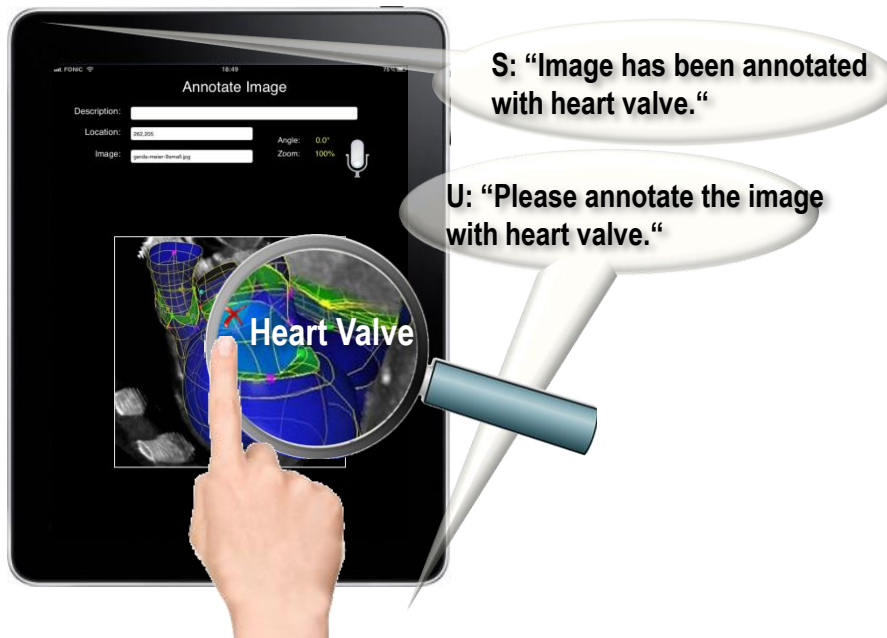
# Ontology on Medical Data

- Generate semantically enriched data (ICD-10)
- Create multi-lingual version covering at least English and German
- Represent includes/excludes in a formal manner for automatic reasoning

# Challenge 2

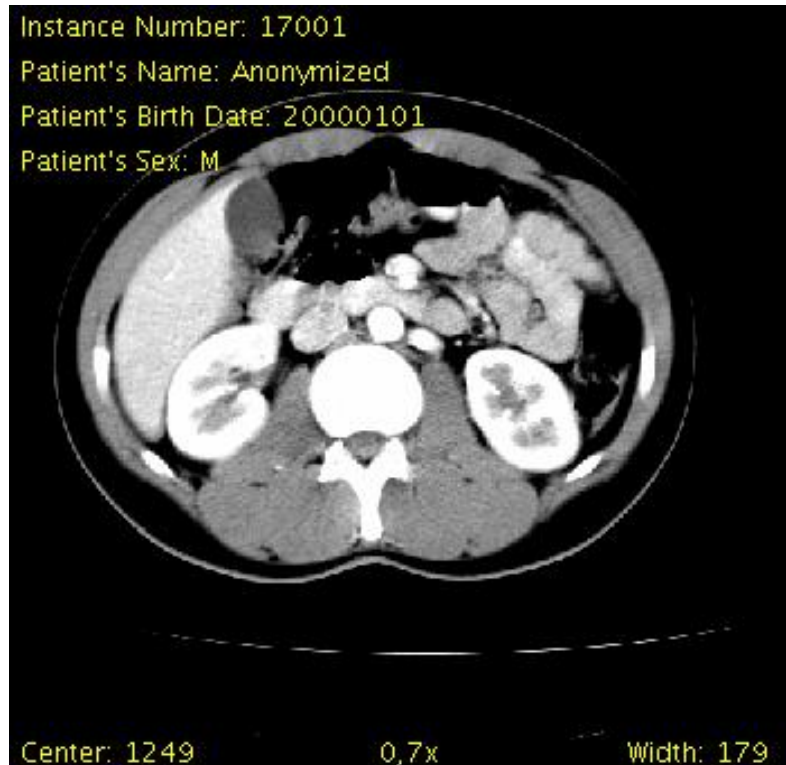
How we can easily acquire the necessary medical image knowledge that ought to be used in the software application that must be provided by the medical experts?

# RadSpeech: Multimodal Medical Annotation



- Digitize patient data by Natural Language Dialogue and Gesture
- Deployment of the Radlex taxonomy (with more than 6000 terms)
- Dialogue Framework: ODP (Ontology-based Dialogue System)
- ASR: Nuance Recognizer 9.0
- TTS: SVOX

# Dicom Header



## Study -----

→ mdo:studyID mdo:containsSeries mdo:studyDescription  
 mdo:age mdo:studyDate mdo:studyTime  
 mdo:participating

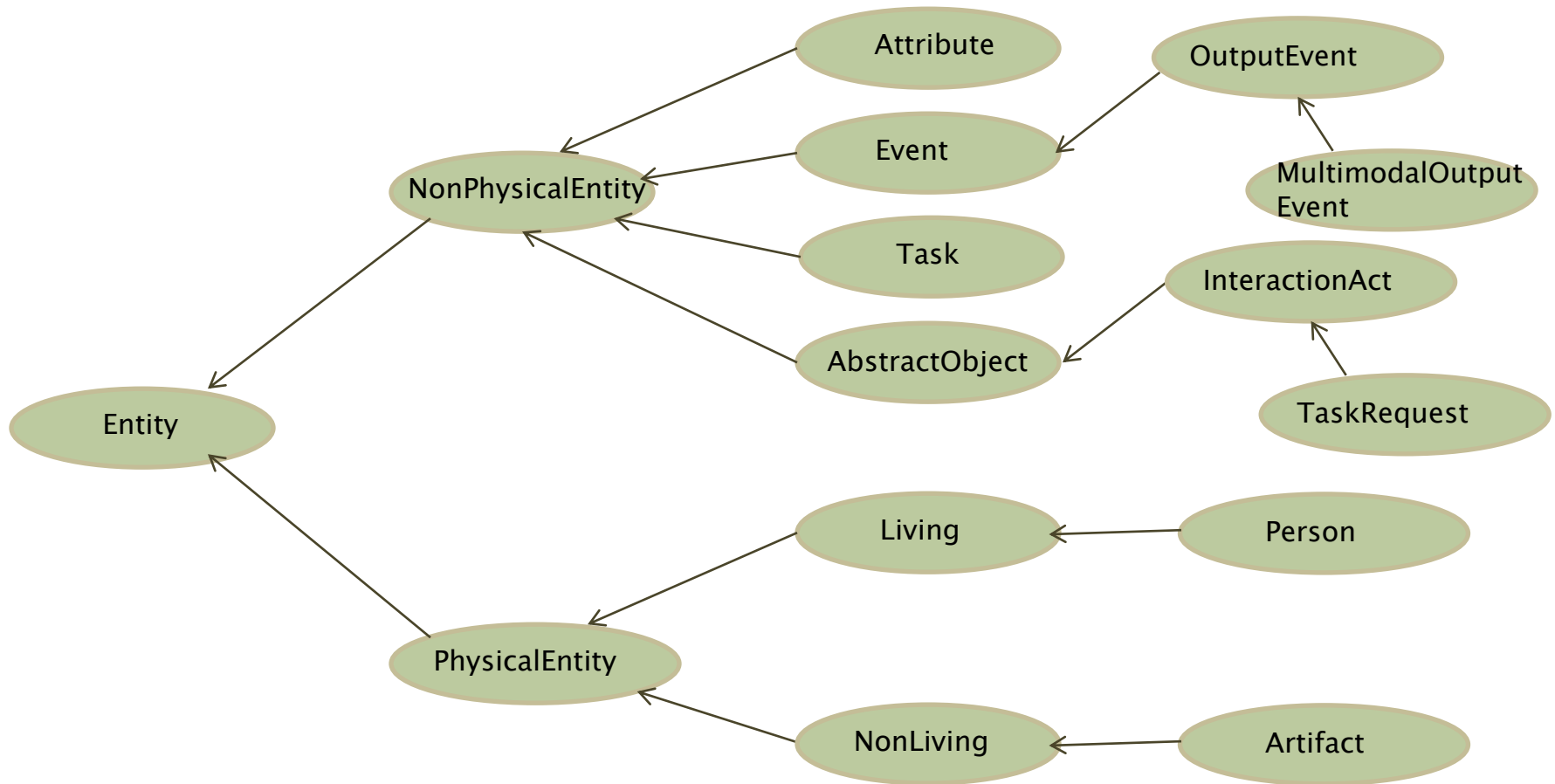
## Patient -----

→ mdo:Series: mdo:seriesInstanceID mdo:seriesDescription  
 mdo:modality mdo:containedInStudy mdo:patientPosition  
 mdo:manufacturer mdo:manufacturersModelName  
 mdo:softwareVersion mdo:protocolName  
 mdo:rotationDirection mdo:exposureTime  
 mdo:xrayTubeCurrent mdo:exposure mdo:generatorPower  
 mdo:convolutionKernel mdo:bodyPartExamined mdo:kvp  
 mdo:contains

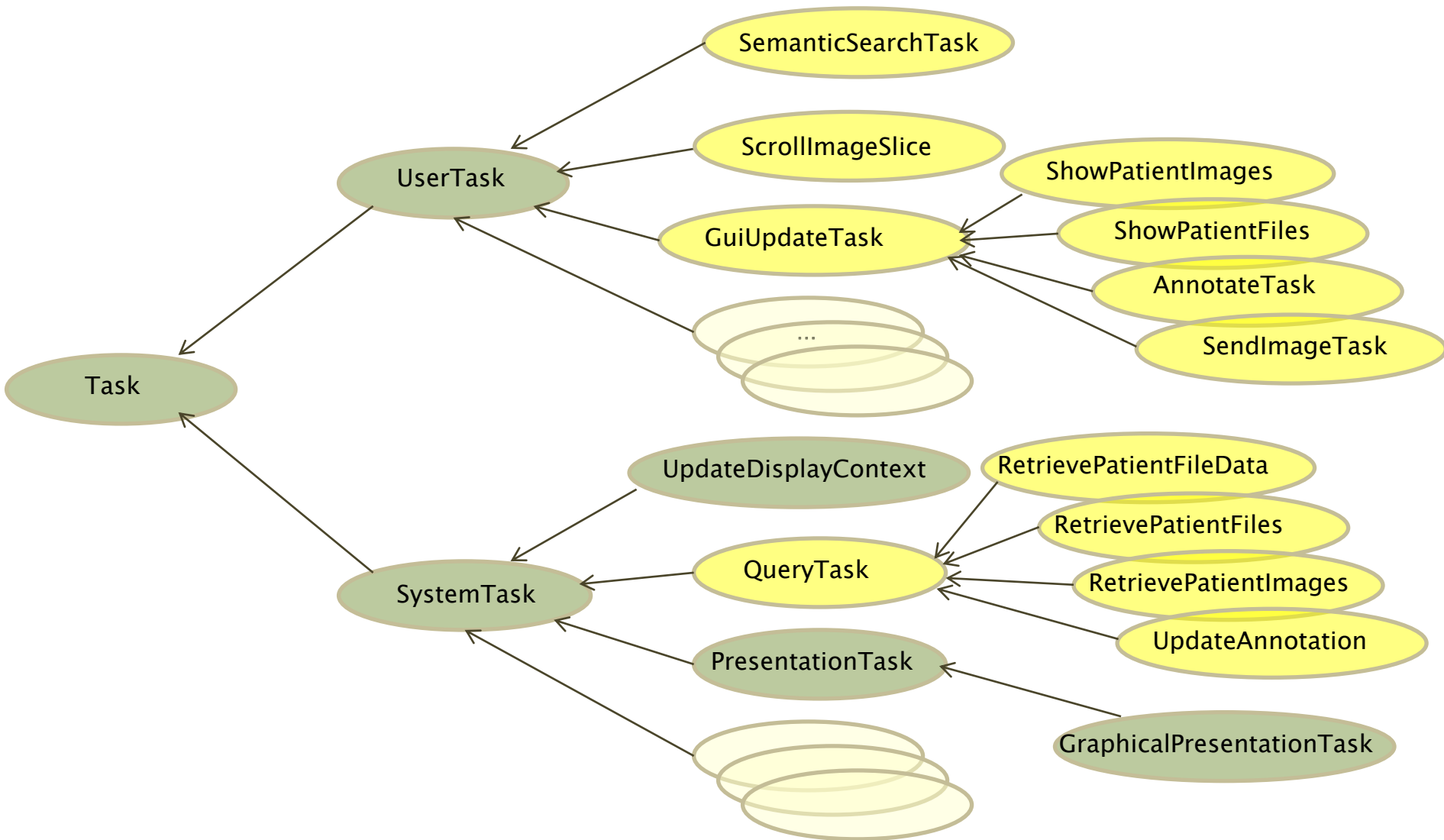
## Image -----

→ mdo:DicomImage: mdo:containedInSeries  
 mdo:sliceThickness mdo:rows mdo:columns  
 mdo:numberOfFrames mdo:acquisitionDate  
 mdo:acquisitionTime mdo:bitsAllocated mdo:bitsStored  
 mdo:rescaleIntercept mdo:rescaleSlope  
 mdo:repetitionTime mdo:echoTime  
 mdo:MRAcquisitionType mdo:numberOfAverages  
 mdo:flipAngle mdo:sequenceName

# Dialogue System's SUM



# RadSpeech's Domain



# Rule Engine of the Dialogue System

WME on the goal stack

```

1 <?xml version="1.0" encoding="UTF-8"?>
2 <object type="http://www.dfki.de/ontology/medico#RetrievePatientImages">
3   <slot name="http://www.semvox.de/ontology/odp#hasContent">
4     <object type="http://www.dfki.de/ontology/medico#Patient">
5       <slot name="http://www.semvox.de/ontology/odp#hasRefProp">
6         <object type="http://www.semvox.de/ontology/odp#RefProp">
7           <slot name="http://www.semvox.de/ontology/odp#type">
8             <value type="String"><![CDATA[def]]></value>
9           </slot>
10          </object>
11        </slot>
12      </object>
13    </slot>
14    <slot name="http://www.semvox.de/ontology/odp#surname">
15      <slot name="http://www.semvox.de/ontology/odp#firstname">
16        <value type="String"><![CDATA[Gerda Meier]]></value>
17      </slot>
18    </slot>
19  </object>

```

Activated rule

```

34 <rule name="execute-task(query)">
35   <comments>
36     Same rule as exute-task. But QueryTask is a System Task and no User Task so
37     we need this rule to fire.
38   </comments>
39   <weighting>0.5</weighting>
40   <conditions>
41     <goal name="goal">
42       <object type="comet#QueryTask">
43         <slot name="hasContent"/>
44         <slot name="hasResult"/>
45         <empty/>
46       </object>
47     </goal>
48   </conditions>
49   <actions>
50     <action type="updateWME" name="goal">
51       <object type="comet#QueryTask">
52         <slot name="radspeech#hasSource">
53           <empty/>
54         </slot>
55       </object>
56     </action>
57   </actions>
58   <function
59     name="de.semvox.odp.core.obm.framework.service.InvokeService"
60     arg1="goal"
61     result="result"
62   />
63   <action type="addWME" name="result"/>
64   <action type="deleteWME" name="goal"/>
65   <action type="push" name="result"/>
66 </actions>
67 </rule>

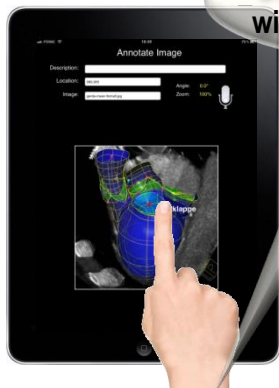
```

Ontology

- <http://www.dfki.de/ontology/comet#QueryTask>
- <http://www.dfki.de/ontology/medico#RetrievePatientFileData>
- <http://www.dfki.de/ontology/medico#RetrievePatientFiles>
- <http://www.dfki.de/ontology/medico#RetrievePatientImages>
- <http://www.dfki.de/ontology/medico#UpdateAnnotation>
- ▶ ● <http://www.semvox.de/ontology/odp#ResourceTask>
- <http://www.semvox.de/ontology/odp#SlotToFillTask>
- <http://www.semvox.de/ontology/odp#StoreResult>
- <http://www.semvox.de/ontology/odp#UpdateContextGrammar>

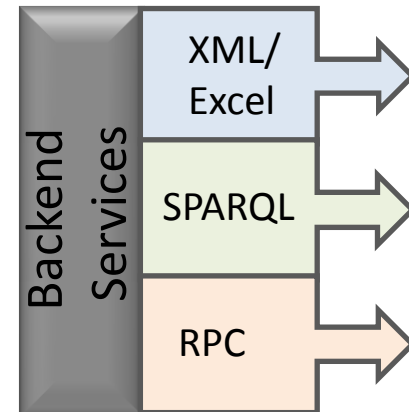
## User Hypotheses

U: "Please annotate the image with heart valve."



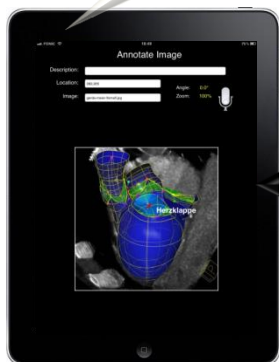
### Interaction Manager

- Handle Touch Events
- Handle Task Request
- Execute User Task
- Execute System Task



S: "Image has been annotated with heart valve."

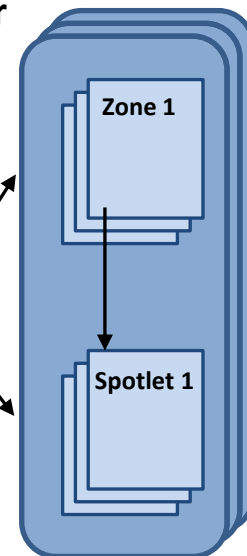
## System Feedback



### Presentation Manager

- Integrate System Task
- Integrate User Task
- Model GUI presentation
- Integrate Output Event

### Display Context Manager



```

<object type="radspeech#ImageInputEvent">
  <slot name="odp#hasContent">
    <object type="medico#ImageAnnotation">
      <slot name="medico#medicospotlet"/>
    </object>
  </slot>
  <slot name="odp#isSselected"/>
  </slot>
  <slot name="medico#annotation"/>
  </slot>
  <slot name="odp#hasContent">
    <object type="medico#ImageAnnotation">
      <slot name="medico#medicospotlet"/>
    </object>
  </slot>
  </object>
</slot>
<slot name="comet#yCoordinate">
  <value type="Float">
    <![CDATA[190]]>
  </value>
</slot>
</pre>

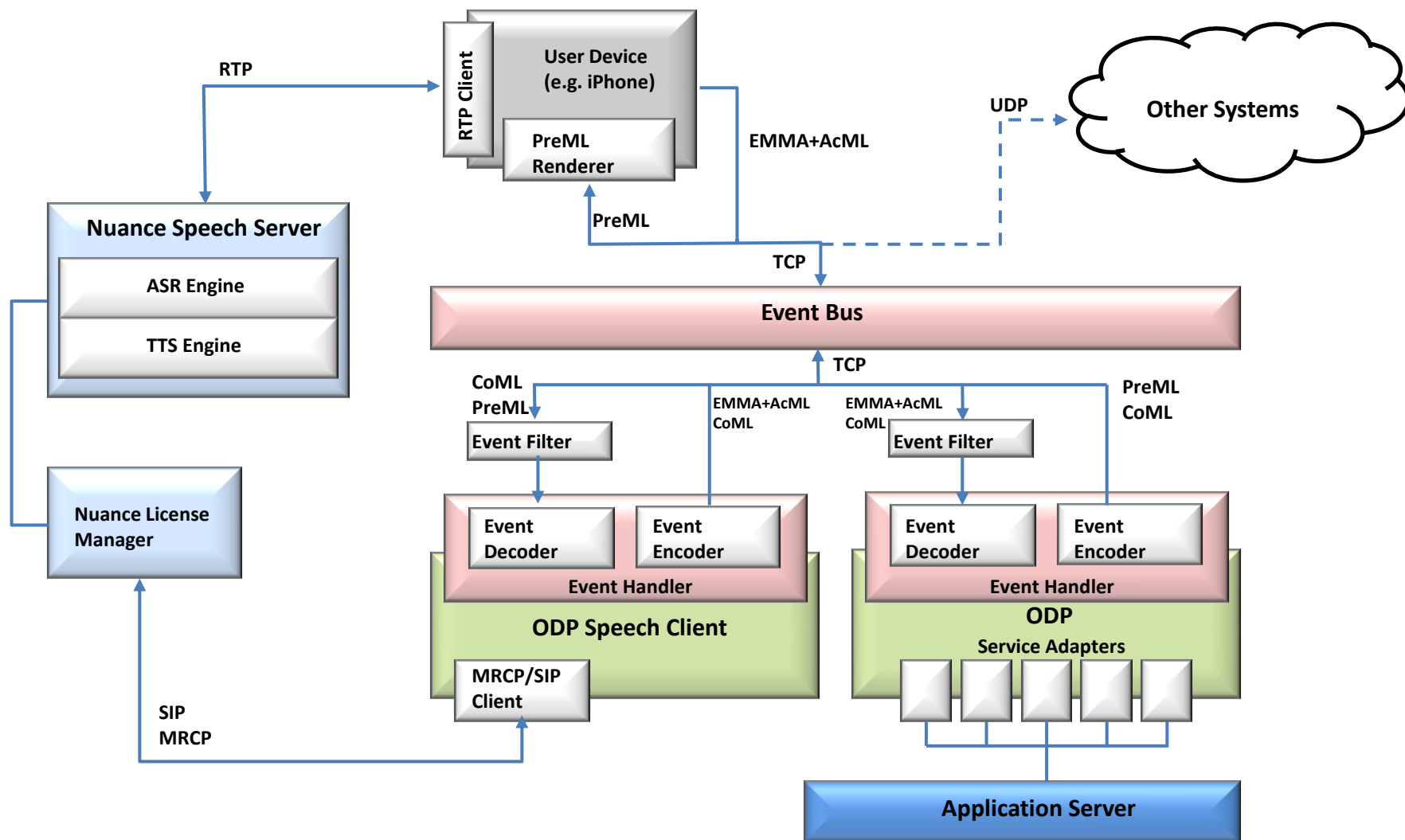

```

<preml-radspeech:presentation
  xmlns:preml-radspeech="http://www.dfki.de/markup/preml-radspeech"
  preml-radspeech:new="true"
  preml-radspeech:width="10.0"
  preml-radspeech:x="253.0"
  preml-radspeech:y="253.0" />
</preml-radspeech:presentation>

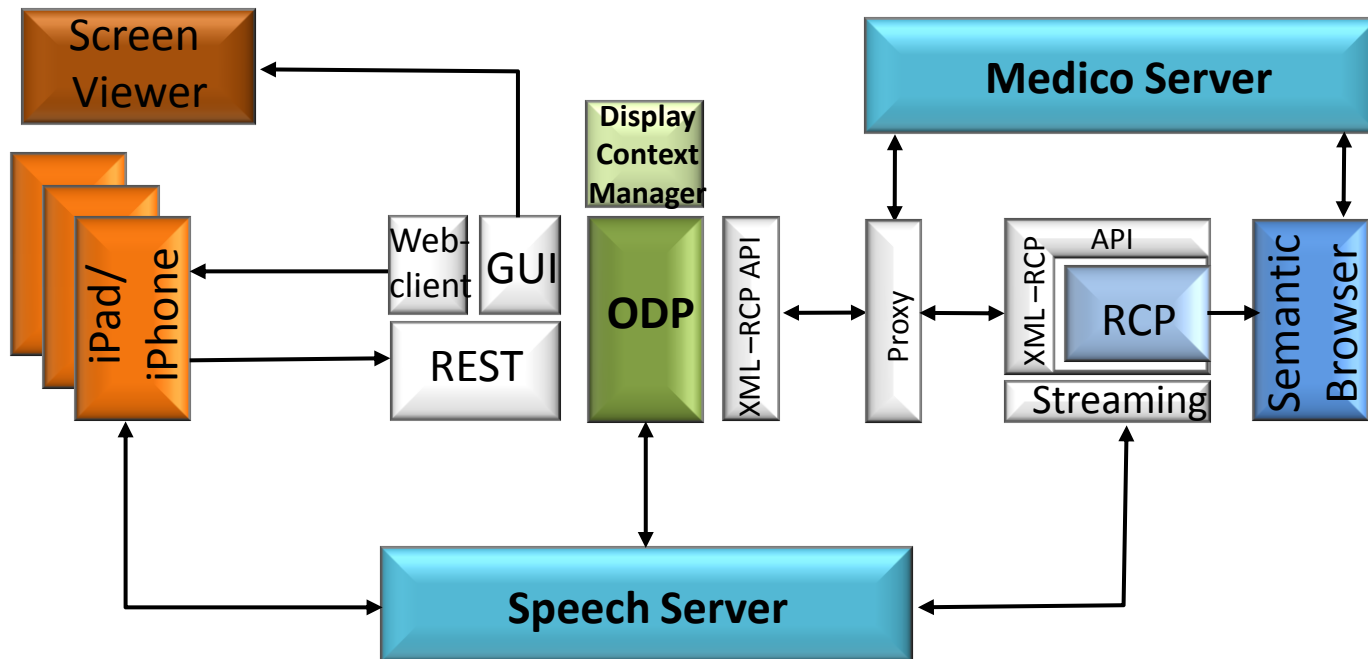
```


```

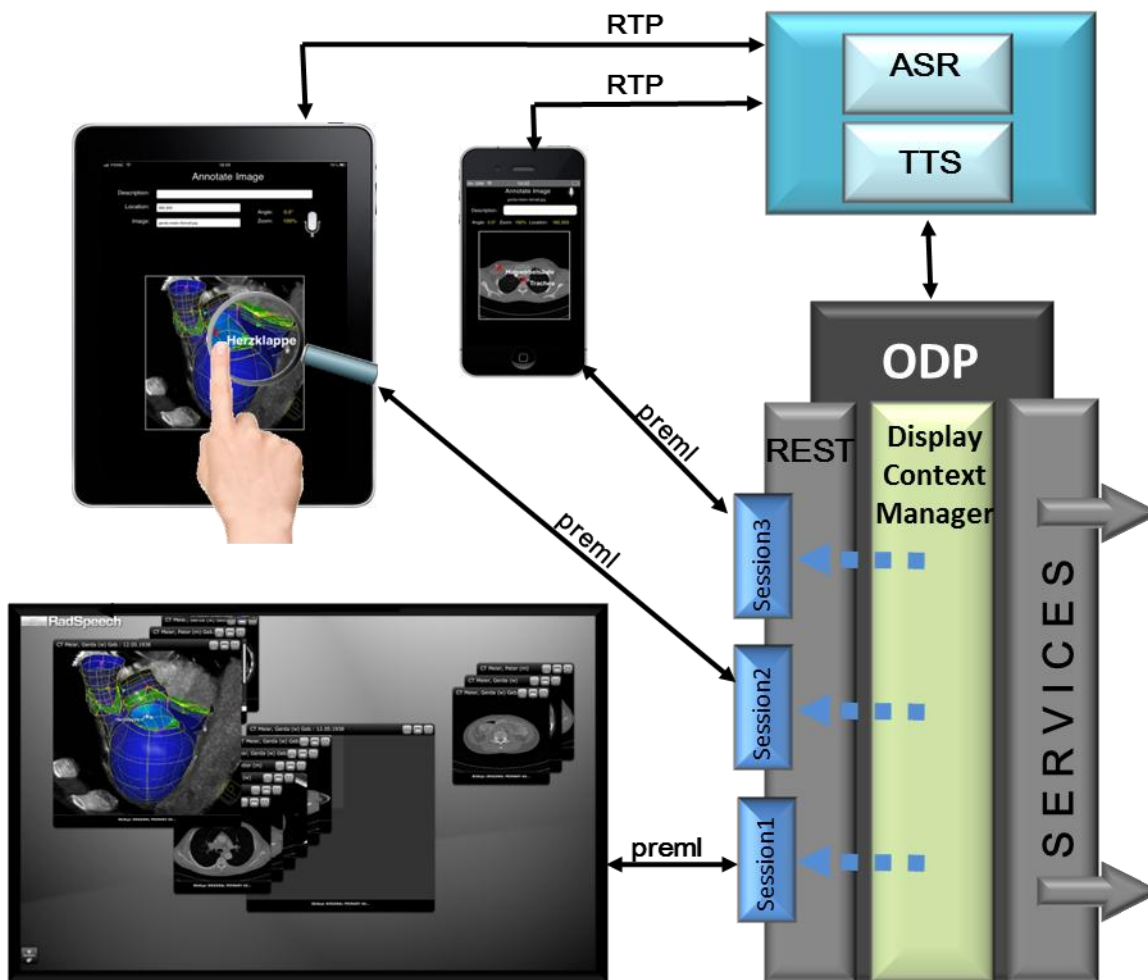
# ODP's System architecture

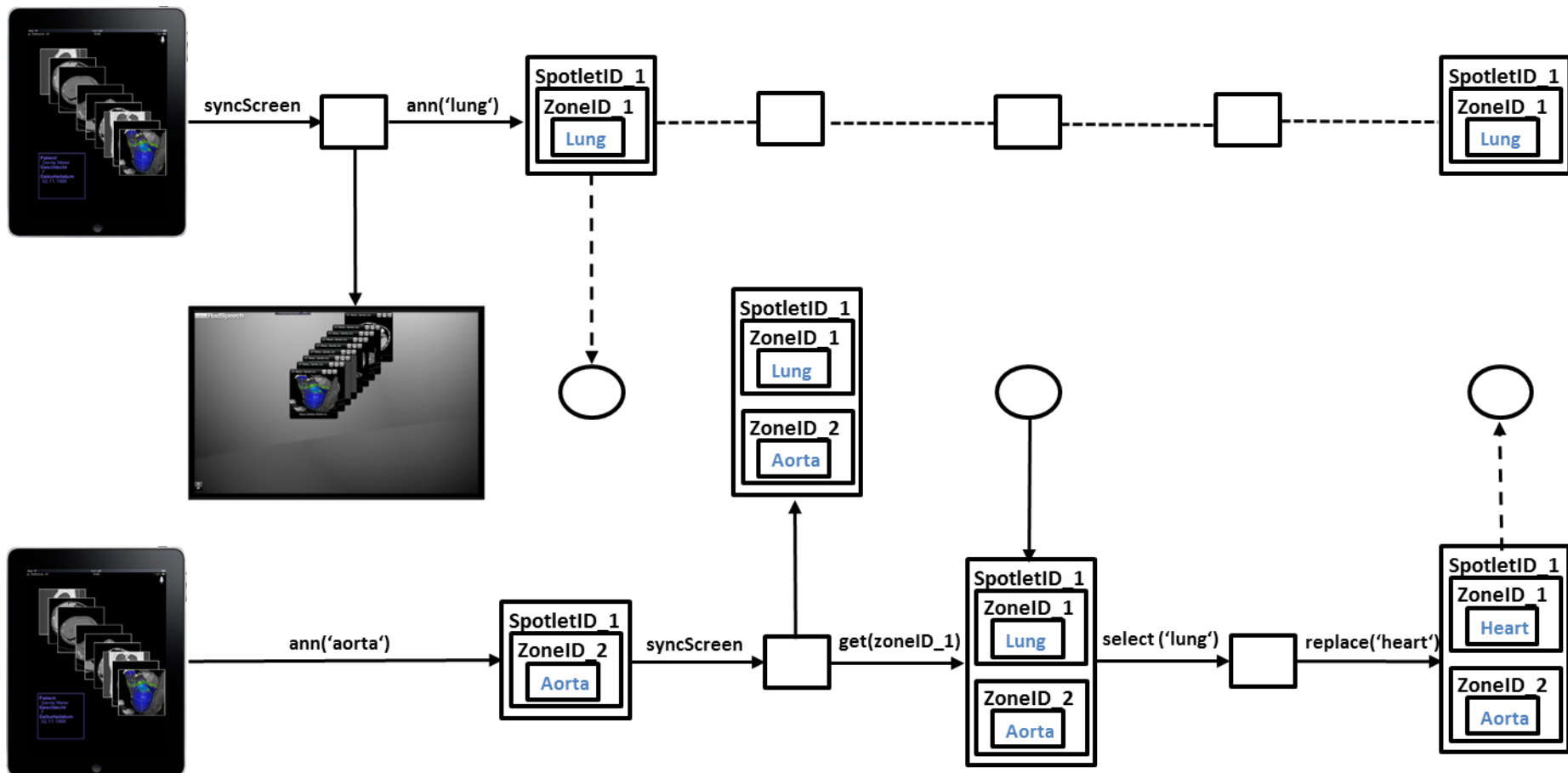


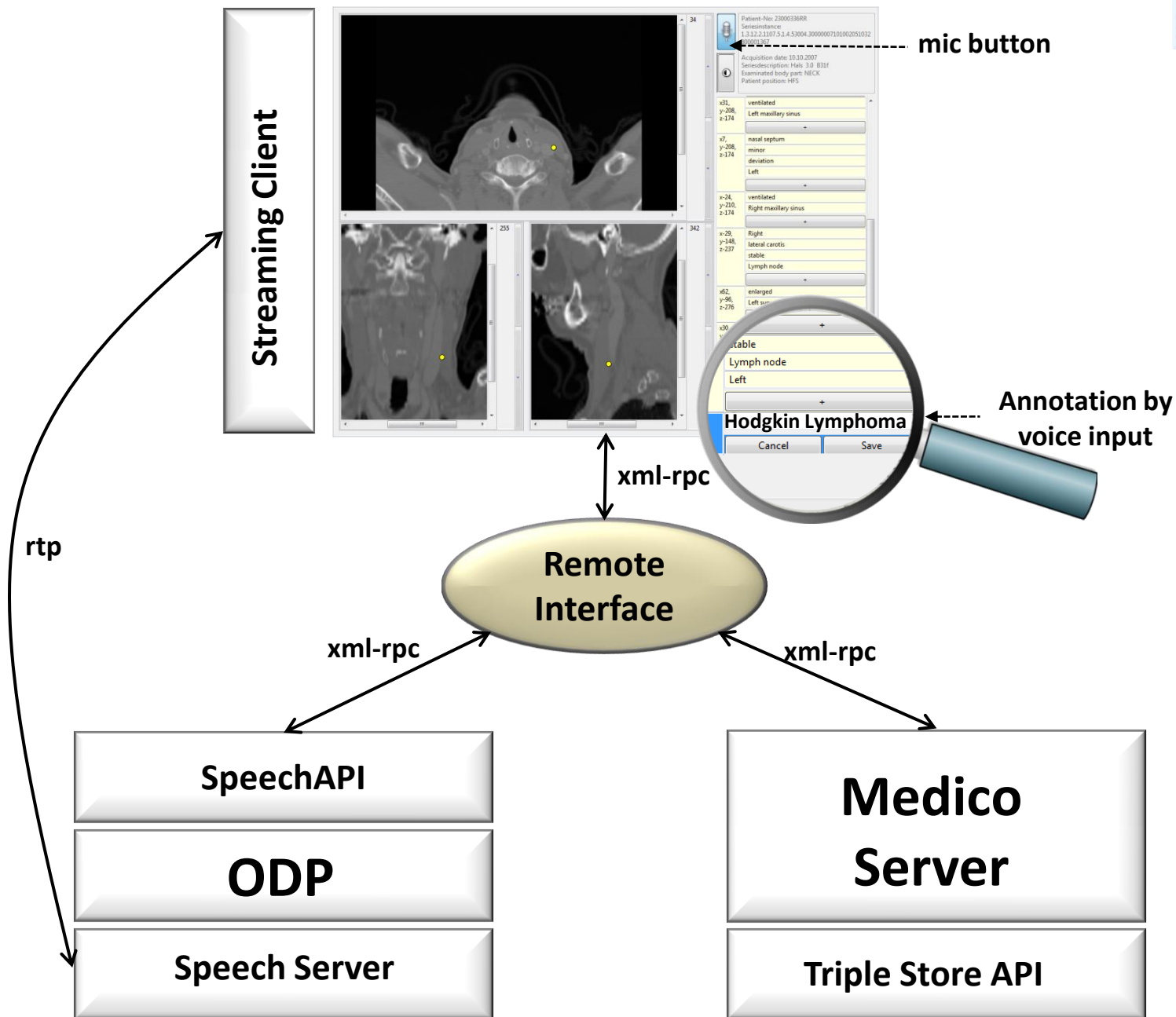
# RadSpeech Platform 1



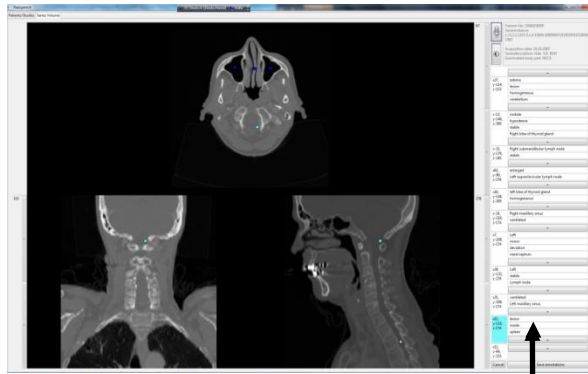
# RadSpeech Platform 2







# Semantic Search

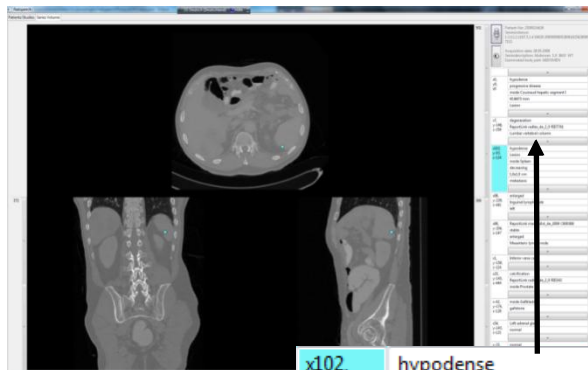


|                         |        |
|-------------------------|--------|
| x11,<br>y-116,<br>z-174 | lesion |
|                         | inside |
|                         | spleen |
|                         |        |

localhost:8080/MedicoServer/?c=lesion,inside,spleen,AND,patient age,GREATER,40

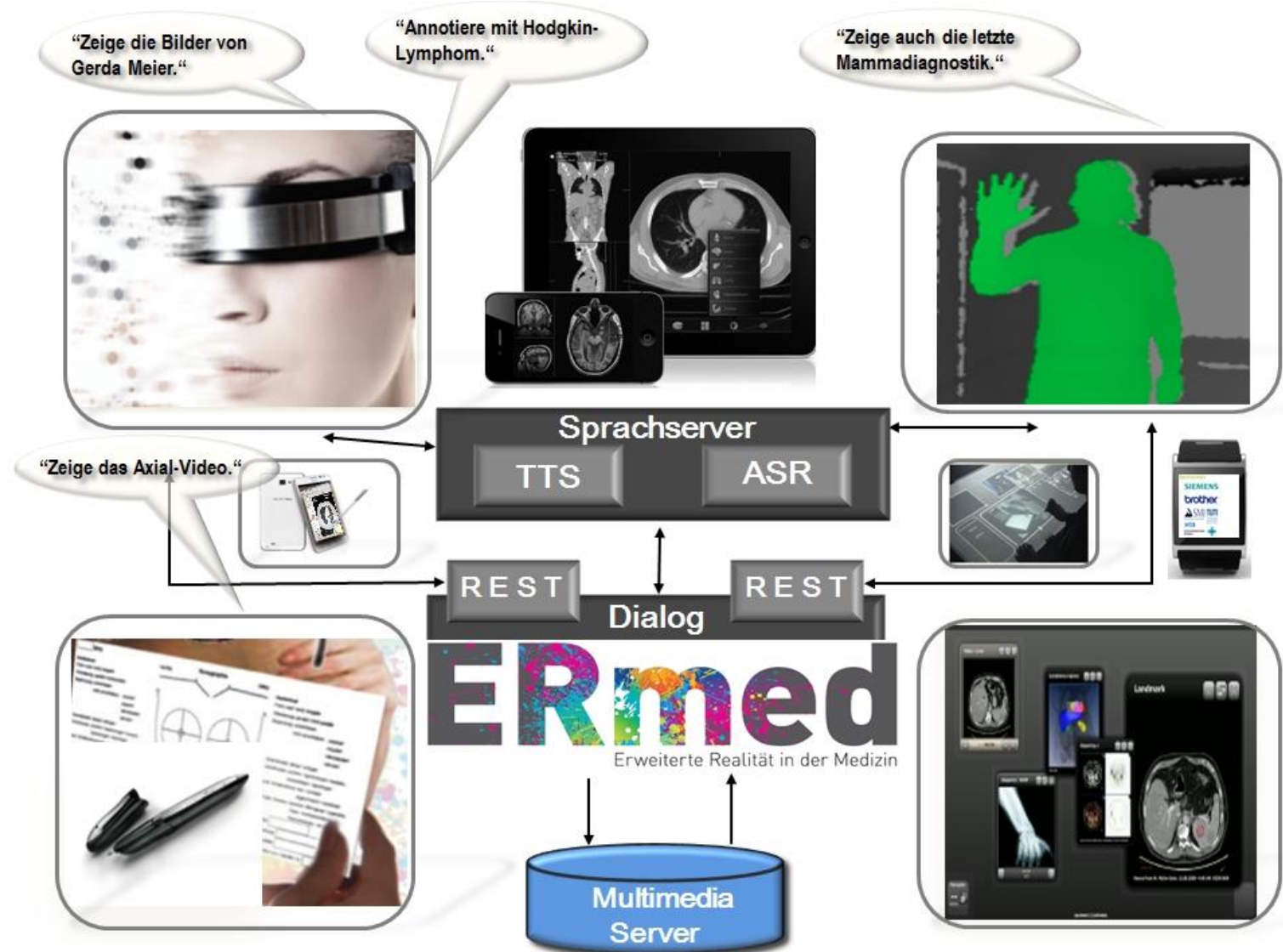


|            |            |               |            |
|------------|------------|---------------|------------|
| hypodense  | Lesion     | inside Spleen | decreasing |
| 1,6x1,0 cm | metastasis |               |            |



|                         |               |
|-------------------------|---------------|
| x102,<br>y-93,<br>z-124 | hypodense     |
|                         | Lesion        |
|                         | inside Spleen |
|                         | decreasing    |
|                         | 1,6x1,0 cm    |
|                         | metastasis    |

# Augmented Vision



# German Hightech Award



- Make dialogue-based radiology image reporting possible
- Reduce turn-over times and annotation errors
- Facilitate structured reporting
- With the iPad's FDA approval, a breakthrough for mobile medical imaging, especially in U.S., can be expected. With RadSpeech, we aim to build the next generation of intelligent, scalable, and user-friendly mobile semantic search and image annotation interfaces for the medical imaging domain.

# Conclusion and Outlook

- We enabled fast data acquisition within the medical finding process.
- We provided a extendable Dialogue Server Architecture.
- We provided a mobile dialogue system setup dedicated to real world situations in the radiologists daily routine.
- We will explore usability of dialogue-based systems in a collaborative context.
- Three typical clinical scenarios that are of interest for analysis of clinical knowledge requirements:
  - The clinical reporting process;
  - The patient follow-up treatment (i.e., monitoring the patient's health condition and the development of the disease);
  - The **clinical disease staging** and patient management.

# Questions?

Thank you!