Corporate Technology

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From Patients to Information and Back

How semantic technologies support this round trip

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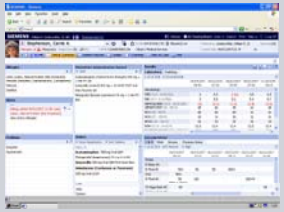
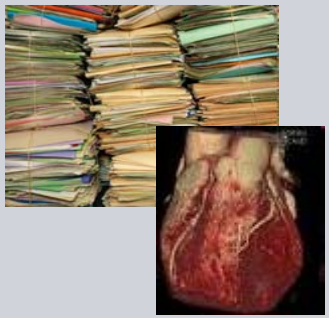
Global Technology Field Autonomous Systems

Towards information overload…





Patient Records

Activity Monitoring

Vital Data

How can we use patient information to improve quality and efficiency of medical services?

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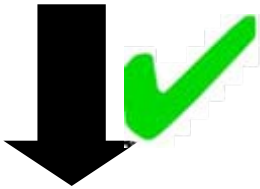
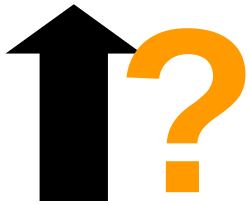
From patients to information…



…and back???



Agenda

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- Motivation
- **Semantic Technologies**
- Patient Data Management
- Ambient Assisted Living
- Summary

Semantic Technologies

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- Data Integration and Exchange
- (Semi-) Automated Monitoring & Diagnosis
- Information Retrieval & Search

↕

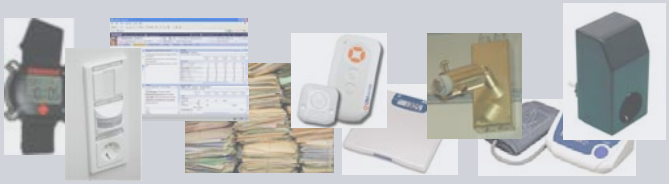
- Reasoning Methods

↕

- Knowledge Representation

↕

- Semantic Annotation



Basic Functionalities

- Automation due to formal model
- Higher relevance & precision in search applications

Logical Reasoning Algorithms

- Deductive Reasoning Methods
- Abductive Reasoning Methods
- …

Formal Domain Models

- Rule-/DL-based Models
- Incomplete / Uncertain Information
- Temporal / Spatial Dependencies
- …

Structuring unstructured Information

- Automated annotation of texts and images
- Natural Language Processing
- Ontology Learning
- Sensor Data Preprocessing / Data Fusion
- …

Agenda

SIEMENS

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Semantic Search for Patient Data Management

Data Integration and Exchange

(Semi-) Automated Monitoring & Diagnosis

Information Retrieval & Search

Reasoning Methods

Knowledge Representation

Semantic Annotation

Semantic Search

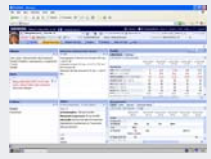
Improve relevance and precision of retrieval process through semantic query interpretation and document annotation.

Query Answering

Integrated Health Archive
(Semantically Annotated Documents)

OCR &
Ontology Learning

Image Annotation



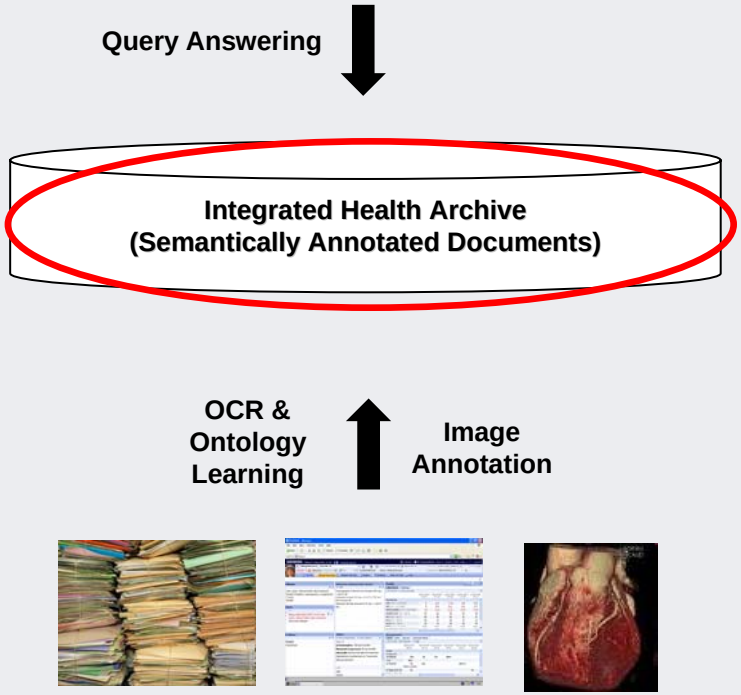
Patient Data Management

Semantic Search for Patient Data Management

How do we represent semantic annotation of documents?

Semantic Search

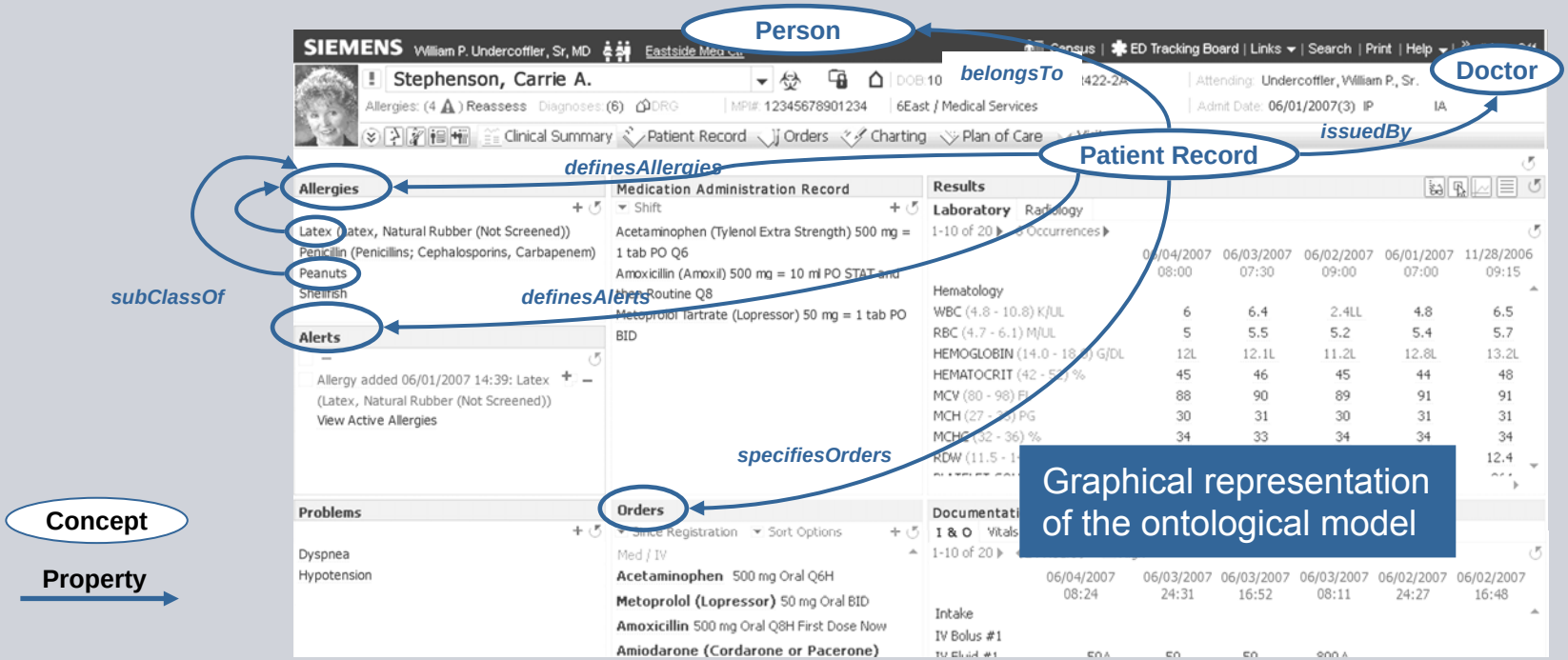
Improve relevance and precision of retrieval process through semantic query interpretation and document annotation.



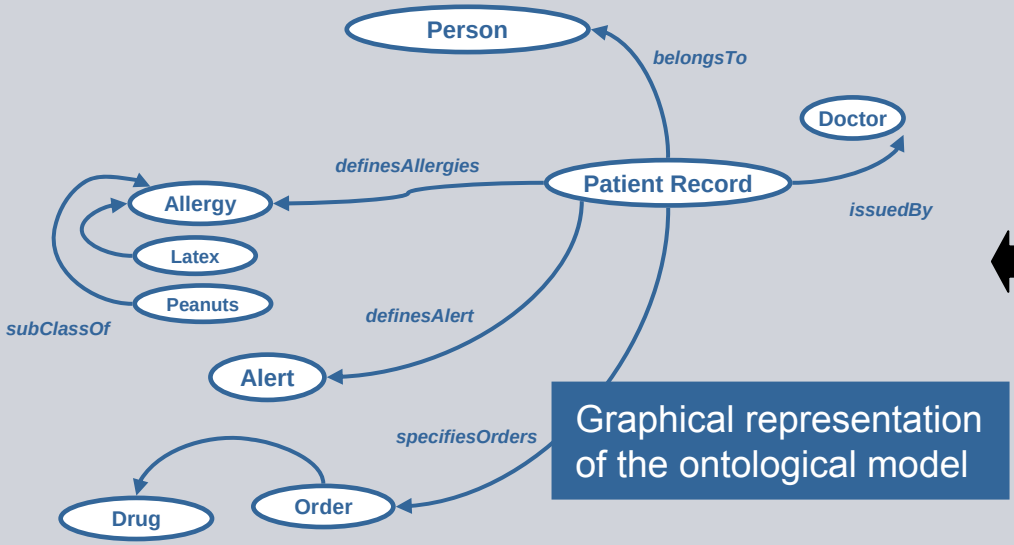
Patient Data Management

Ontologies can be used for annotating documents and images

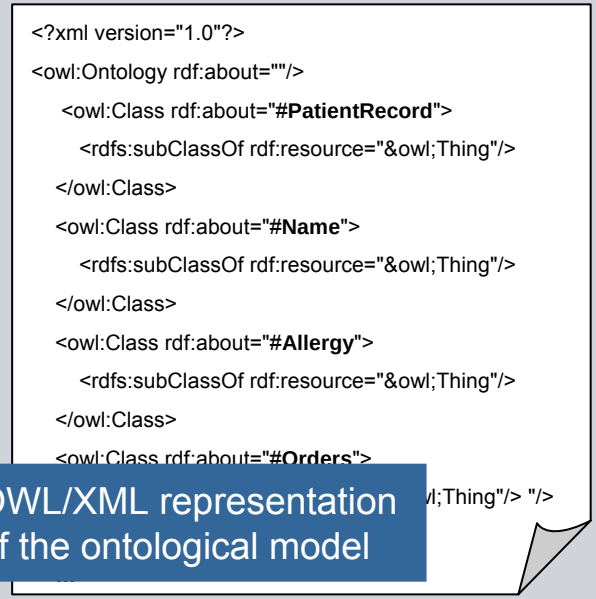
Ontology = Shared model that **formally** describes arbitrary **entities** („concepts“, „classes“) and their **interrelationships** („roles“, „properties“).



Ontology Representations



Graphical representation of the ontological model



OWL/XML representation of the ontological model

Underlying logical model

PatientRecord $\equiv =_1$ belongsTo.Person $\sqcap \forall$ specifiesOrders.Order $\sqcap \forall$ definesAllergies.Allergy

Allergy $\equiv$ LatexAllergy $\sqcup$ PeanutAllergy $\sqcup$ ..

…

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Many ontologies exist in the healthcare domain…

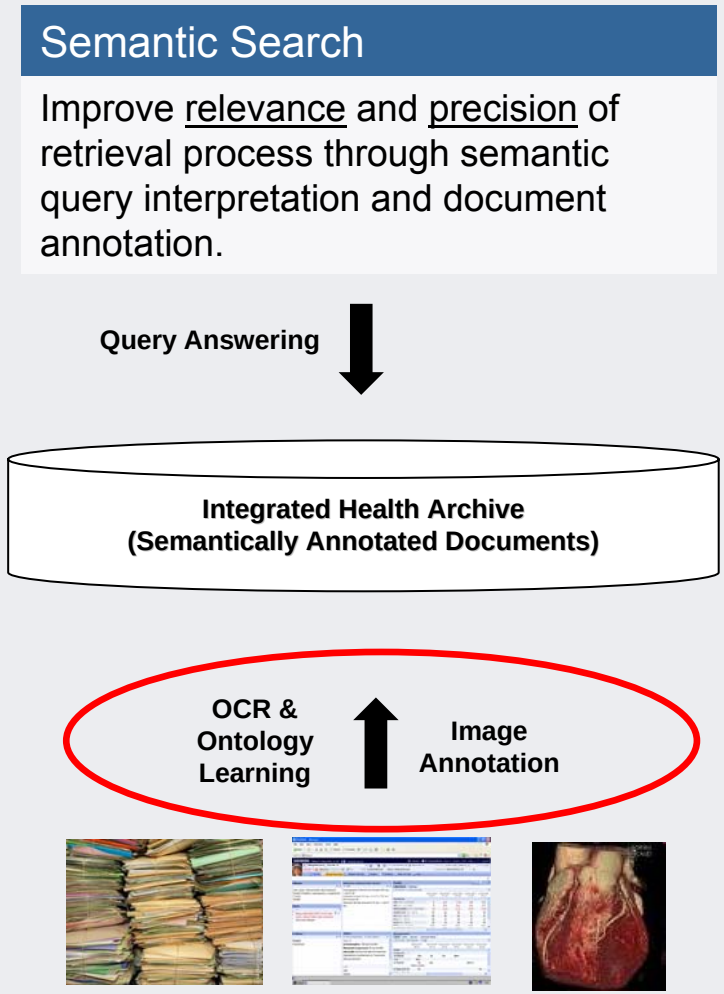
Existing Ontologies

- Medical ontologies
  - SNOMED: 379.000 Concepts, 52 Roles
  - GALEN: 2740 Concepts, 413 Roles
  - RadLex: 1500 Concepts
  - …

→ Existing large taxonomies/ontologies are a big advantage of the medical domain

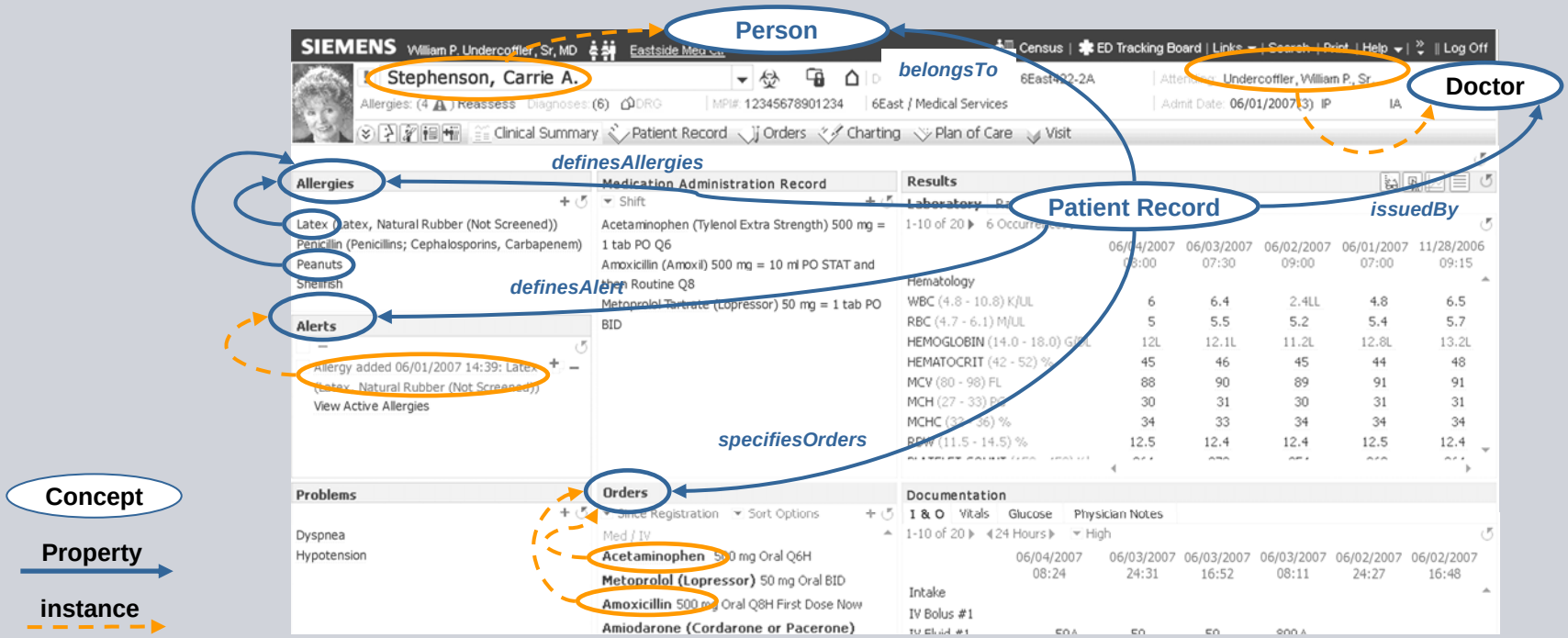
Semantic Search for Patient Data Management

How do we automatically derive semantic annotations?



Semantic Annotation

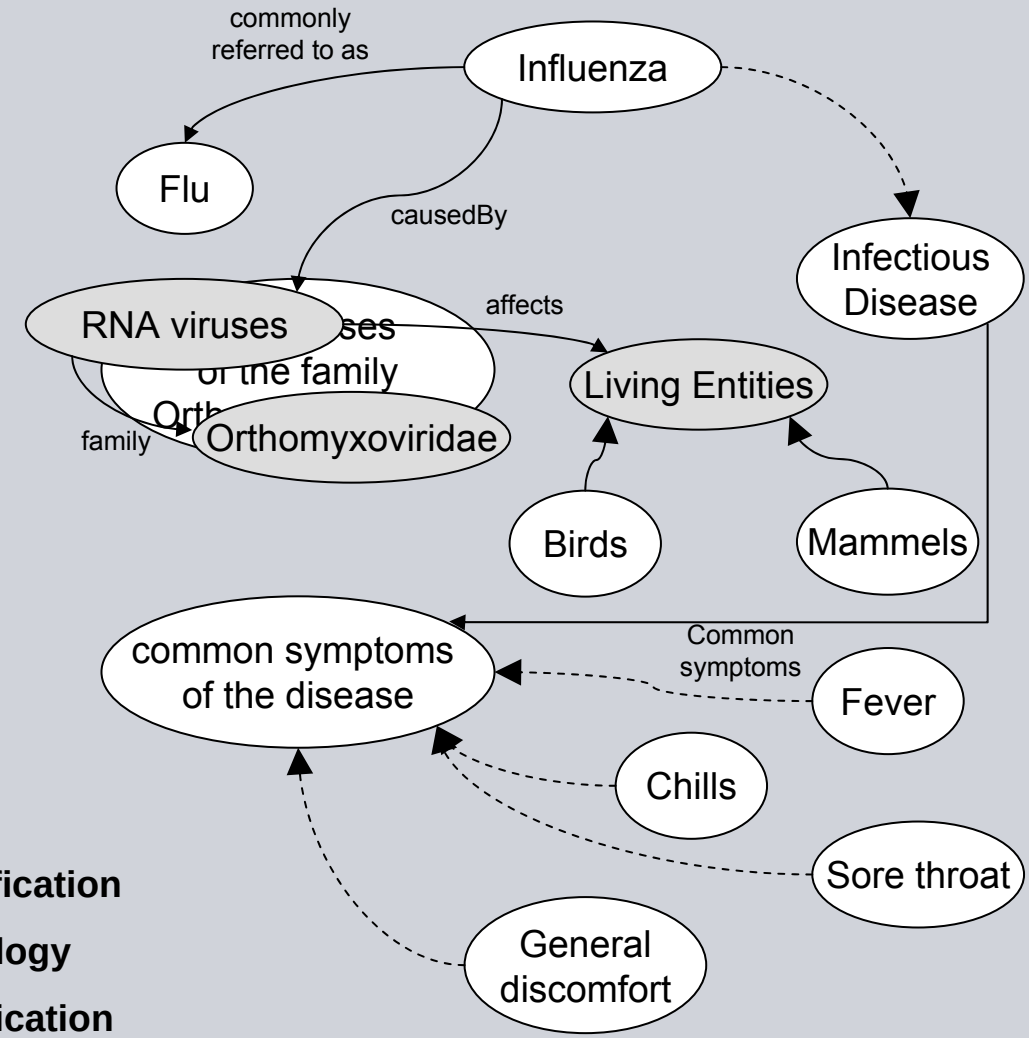
Generate structured, semantically annotated information from unstructured information such as texts



Example: Semantic annotation of patient record

Semantic Annotation from Texts: Simple Example

Influenza, commonly referred to as the flu, is an infectious disease caused by RNA viruses of the family Orthomyxoviridae, that affects birds and mammals. The most common symptoms of the disease are chills, fever, sore throat, muscle pains or general discomfort.



Ontology learning steps:

- **Part of speech tagging**
- **Apply patterns for concept label identification**
- **Complete taxonomy from domain ontology**
- **Apply patterns for relation label identification**

Semantic Annotation from Texts

Examples of basic linguistic methods

Available Tools

Basic Linguistic Processing: Many free and commercial tools available

- GATE (Univ. Sheffield)
  - http://gate.ac.uk/
- Alvey Natural Language Tools (Univ. Cambridge, Edinburgh and Lancaster)
  - http://www.cl.cam.ac.uk/research/nl/anlt.html

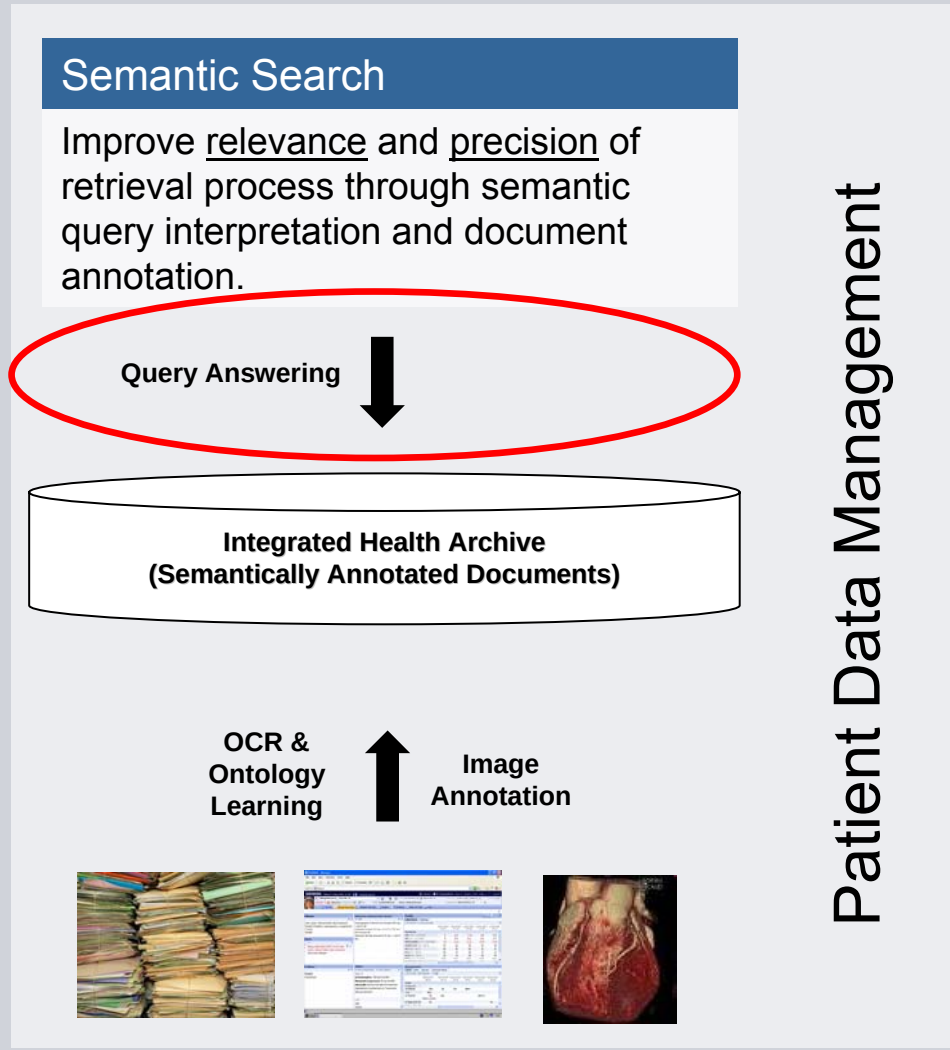
Term/Taxonomy/Relation Extraction

- Text2Onto (Univ. Karlsruhe)
  - http://ontoware.org/projects/text2onto/
- OntoLT/RelExt (DFKI)
  - http://jatke.opendfki.de
  - http://olp.dfki.de/OntoLT/OntoLT.htm
- OntoGen (JSI, Ljubljana)
  - http://www.textmining.net
- ASIUM (Univ. Paris)
- OntoLearn (Univ. Rome)
  - http://www.dsi.uniroma1.it/~navigli/

Paul Buitelaar, Philipp Cimiano, Bernardo Magnini: *Ontology Learning from Text: Methods, Evaluation and Applications* Frontiers in Artificial Intelligence and Applications Series, Vol. 123, IOS Press, July 2005.

Semantic Search for Patient Data Management

How do we understand the user information need?



Query Answering: Interpretation of Keywords

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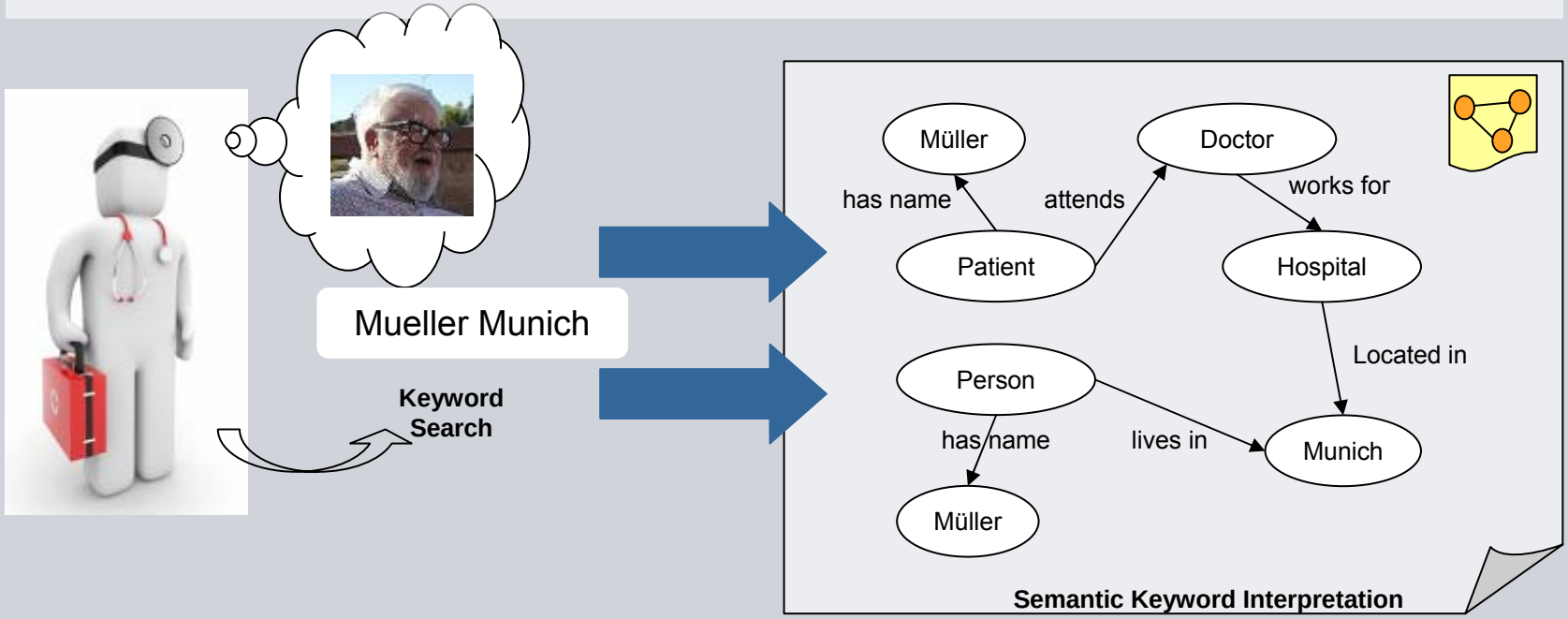
Identify user‘s real need

- Linguistic analysis of query (Word Sense Disambiguation, etc.)
- Context (other queries/tasks)
- Rewrite query (e.g. synonyms)

→ Map query to the source schemata (e.g. select shortest path)



Query Answering:
Iterative user-based query refinement

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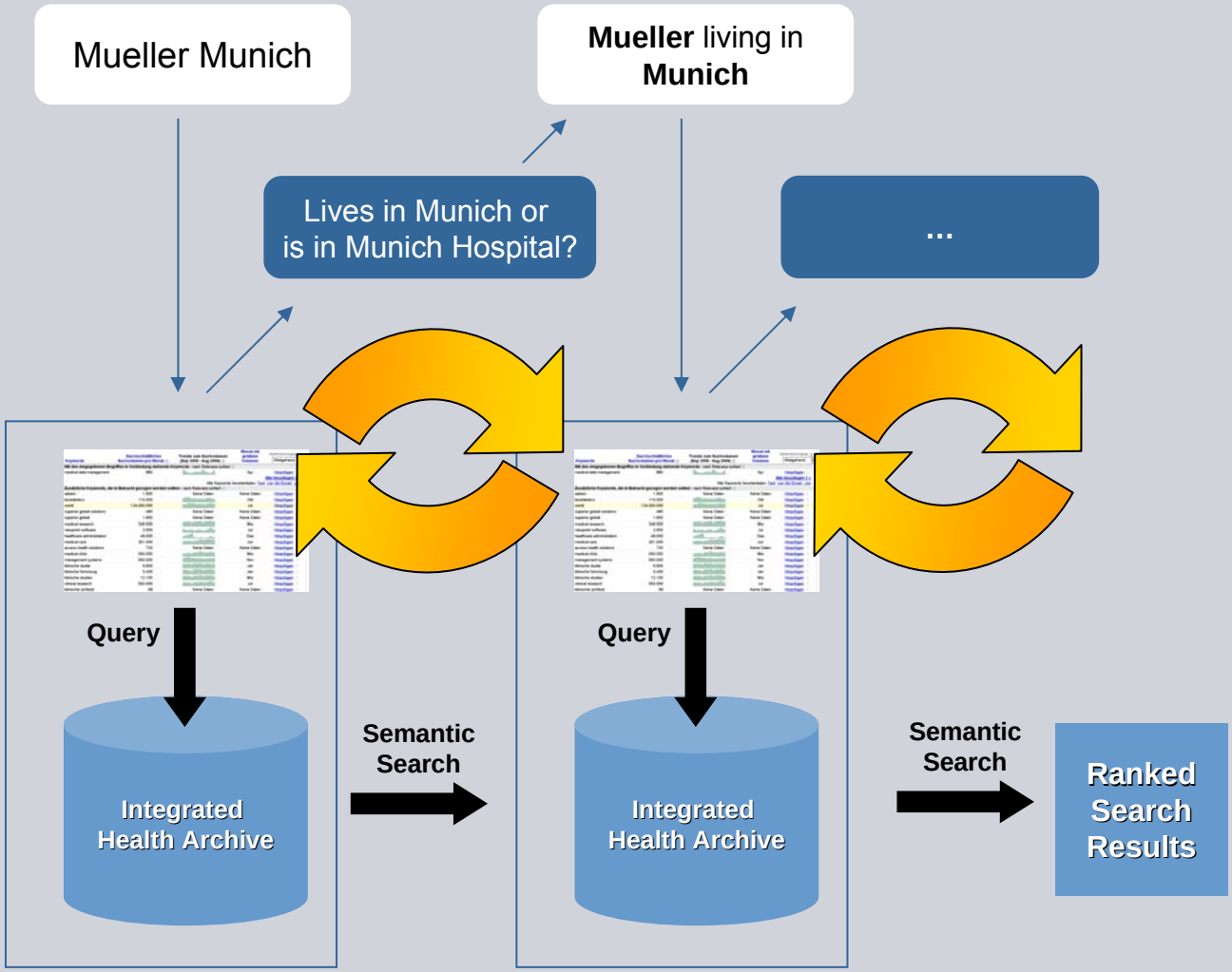

Proactive Search

- Assist the user in specifying the query
- Questions disambiguate keywords in query
- Avoids trail & error approach

Summary: Semantic Search for Patient Data Management

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State of the art

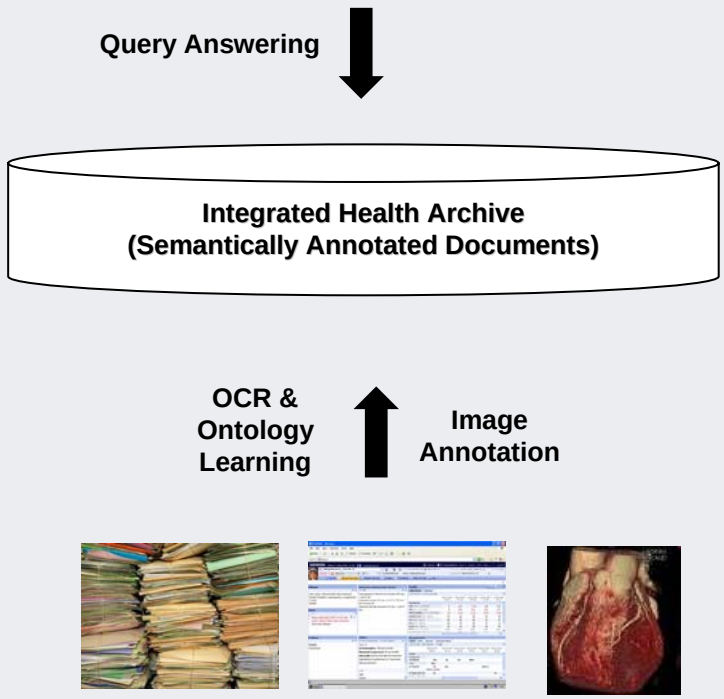
- Semantic annotation of patient records and semantic query interpretation can be used for improving patient record retrieval
- Rather mature semantic search engines available (TrueKnowledge, Powerset, Hakia,…)
- Medical ontologies/taxonomies already available (SNOMED CT, GALEN, RadLex)

Future Challenges

- Scalability for huge health archives (approx. 10^6 concepts, terabytes of data)
- Robustness of semantic annotation approaches (for texts, images, etc.)

Semantic Search

Improve relevance and precision of retrieval process through semantic query interpretation and document annotation.



Patient Data Management

Agenda

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- Motivation
- Overview: Semantic Technologies
- Patient Data Management
- **Ambient Assisted Living**
- Summary

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Situation Understanding for Ambient Assisted Living

Decision Support

(Semi-) Automated Monitoring & Diagnosis

Information Retrieval & Search

Reasoning Methods

Knowledge Representation

Semantic Annotation

Ambient Assisted Living

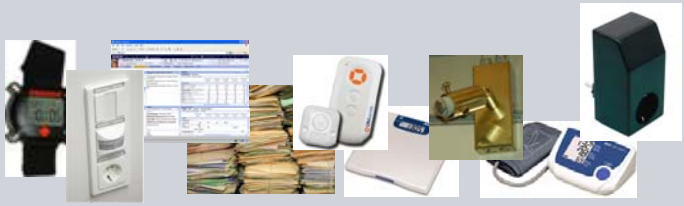
Monitor vital parameters and behavior of patient in order to recognize critical situation as early as possible.

Short-term Situation Understanding

Long-term Behavior Monitoring

Patient Monitoring Data

Event Identification



Body-worn and ambient sensors

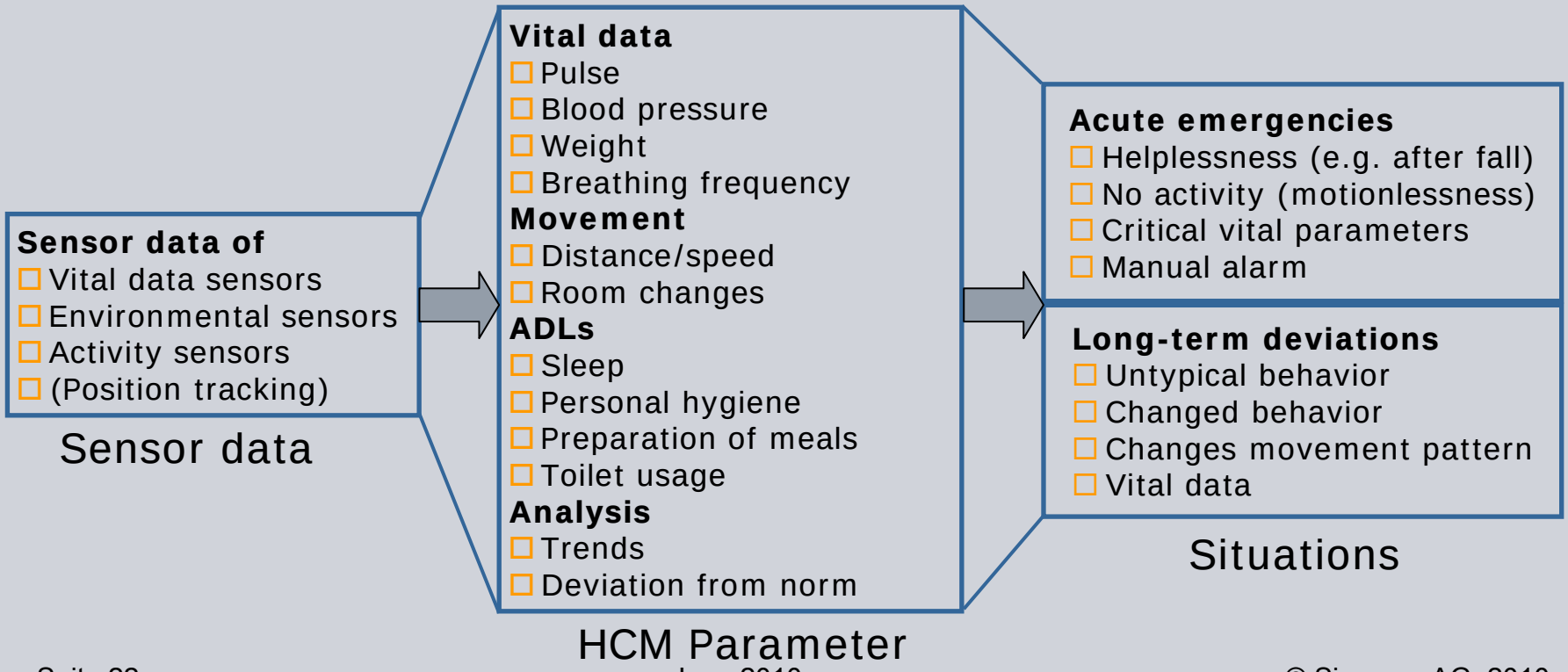
Ambient Assisted Living

Automated detection of critical situations

EU Research Project EMERGE

EMERGE: Emergency Monitoring and Prevention

Partners: Fraunhofer IESE (Coordinator), Westpfalz Klinikum Kaiserslautern, Siemens, Microsoft EMIC, Art of Technology, Demokritos, e-ISOTIS, Bay Zoltan Foundation



Interpretation of Human Behavior enables Services for Ambient Assisted Living

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Assistance Services



Short-term Situation Understanding
- Activity Recognition
- Emergency Detection

Long-term Behavior Monitoring
- "Untypical" behavior
- Changes in activity patterns

Information Integration and Interpretation

Knowledge Base

Human Capability Model

Vital data
- Pulse rate
- Blood pressure
- Body weight, …

Behavior parameters
- Activities of Daily Living
- Physical Activity
- Motion, …

User Model

User Information
- Medical pre-conditions and deficits
- User specific reference values

Body-worn and ambient sensors




Rule-based Situation Understanding

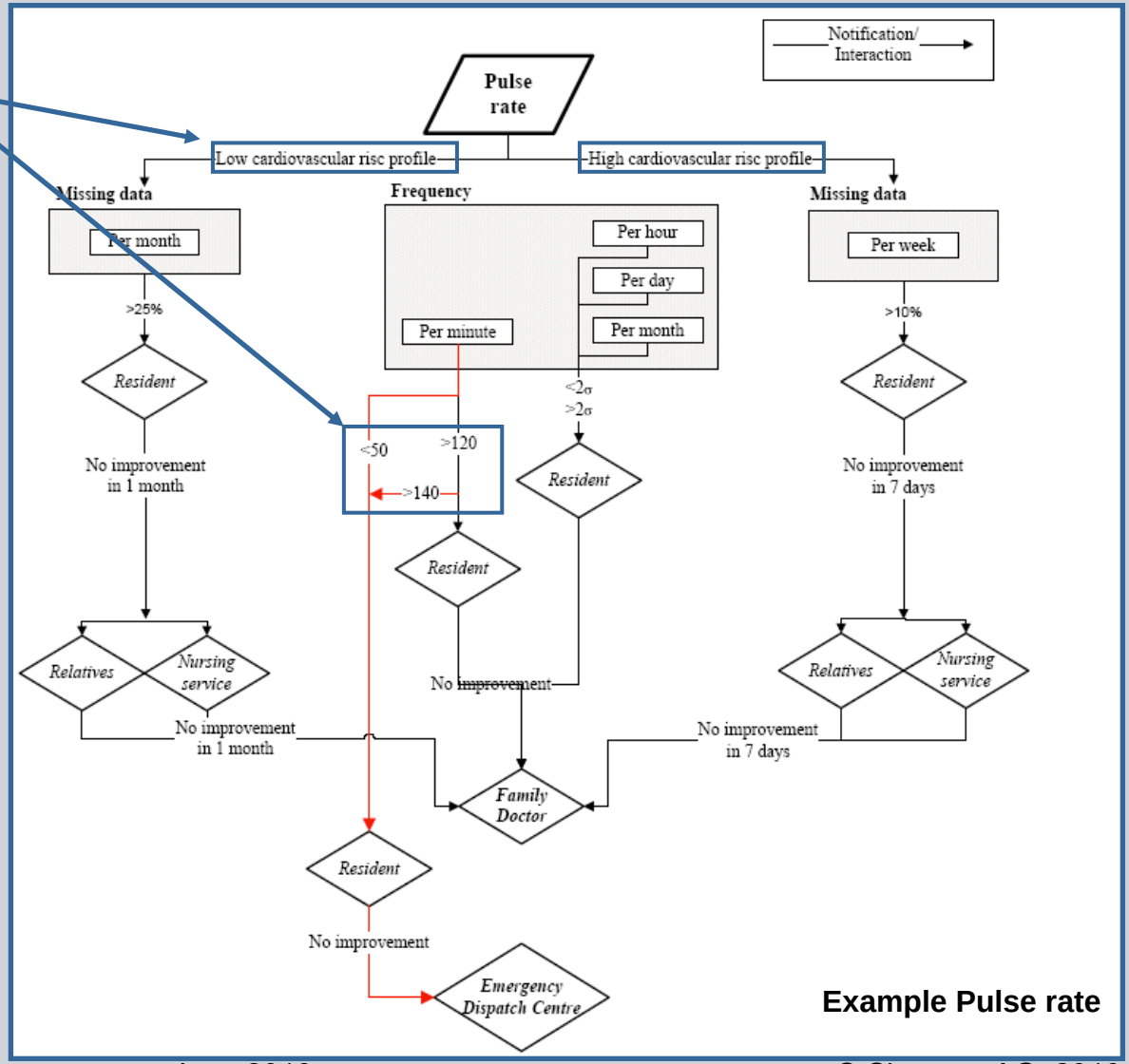
Customized through User Model

Rules describes how

- Acute critical situations
- Long-term deviations

are derived from

- Vital data
- Activities of daily live
  - Sleep (day, night)
  - Personal Hygiene
  - Toilet Usage (day, night)
  - Prep. Meals
  - General Mobility



Example Pulse rate

Rule-based Situation Understanding: Dynamic thresholds

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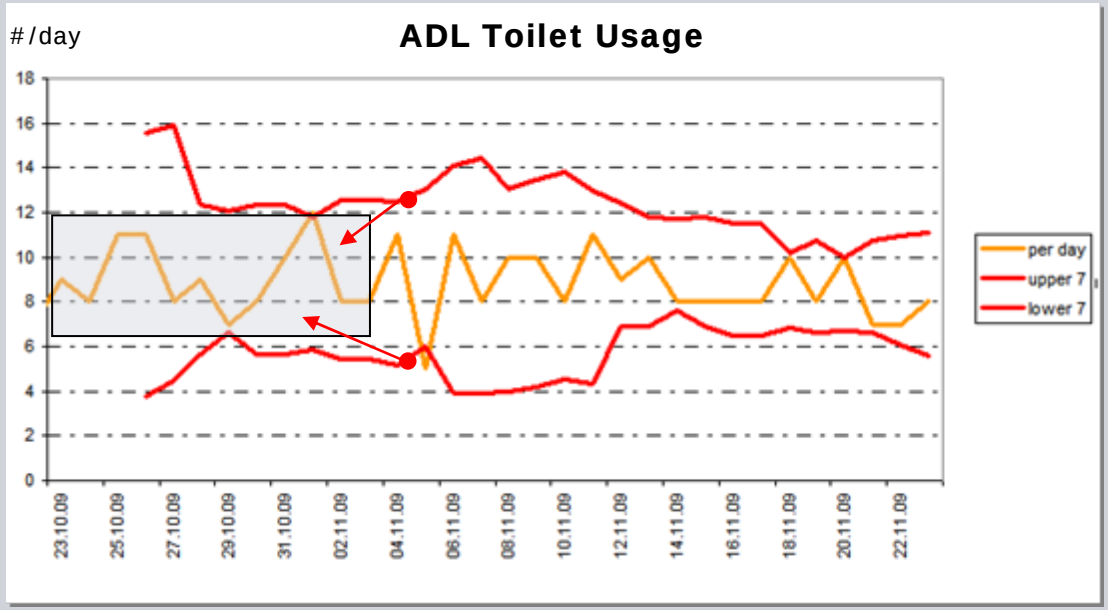
Activity of daily live assessment

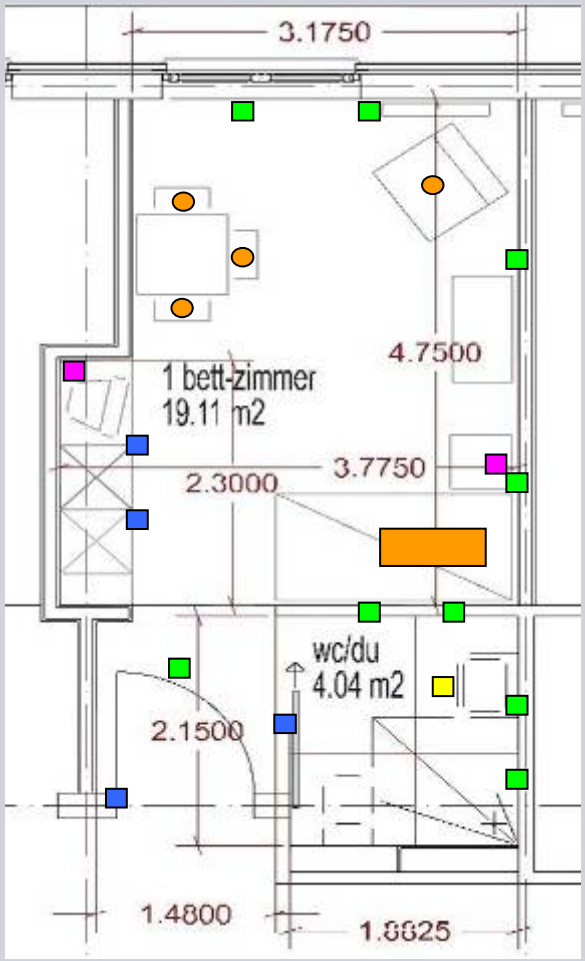
- Example: Parameter “Toilet Usage”
- Daily measure (orange)

Personalized region of normality (red)

- Calculated dynamically
  - day -> last week
  - week -> last month
  - month -> last half year
- Upper limit
- Lower limit



Project EMERGE: Field Trial & Evaluation



- Power
- Pressure
- Contact
- Presence

- Duration: 09/2009 – 11/2009
- 2 test apartments at a retirement home (Westpfalz Seniorenresidenz in Kaiserslautern)

Field Trial:

- Four types of sensors
- Emergency detection with rule-based formalization of Human Capability Models (10 parameters, ~120 rules)
- Implementation of movement monitoring component

Results are currently evaluated…

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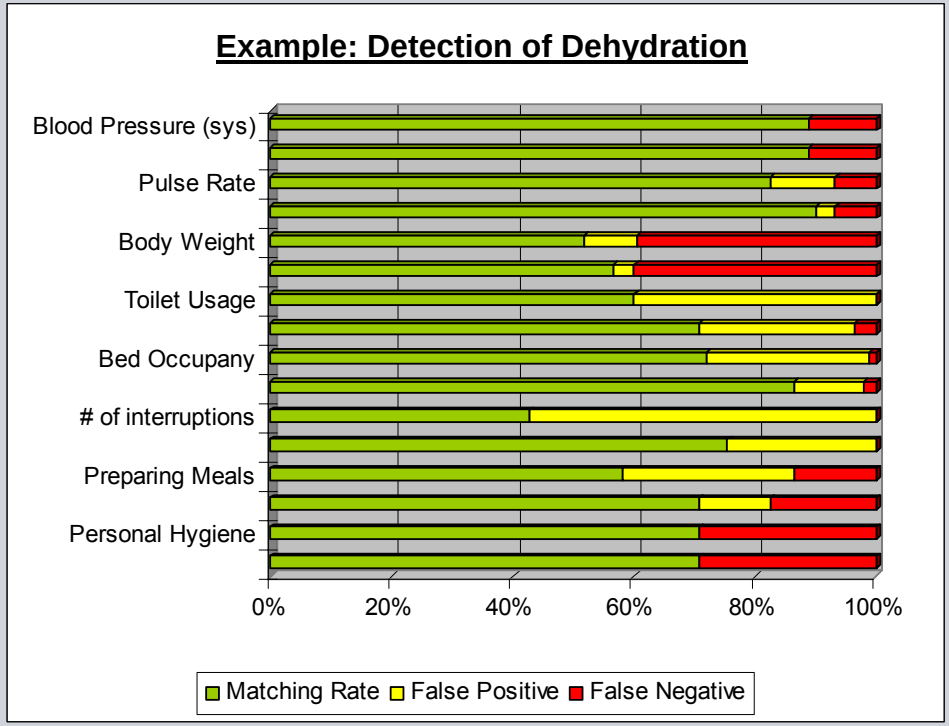
Evaluation of Human Capability Model

Simulation of persons with different defects over 250 days

Comparison of expected alarms set by non-biased physician to alarms provided by HCM assessment



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Situation Understanding for Ambient Assisted Living

State of the art

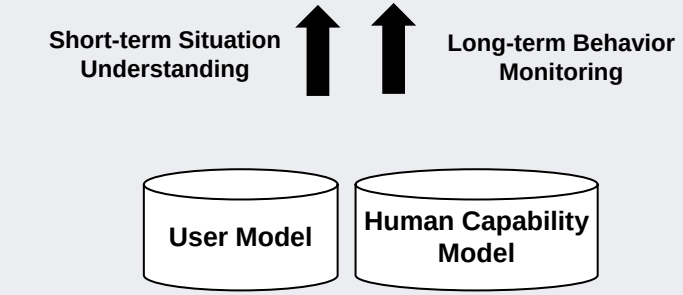
- Level of maturity: First prototypes available
- Monitoring of “simple” situations
- Evaluation phase to be continued

Future Challenges

- More complex and robust situation understanding algorithms
  - Leverage combinations of sensors
  - User-specific and activity-specific parameterization of rules
- User acceptance requires minimal number of false positives and negatives
- Legal regulations (privacy,..)

Ambient Assisted Living

Monitor vital parameters and behavior of patient in order to recognize critical situation as early as possible.



Body-worn and ambient sensors

Ambient Assisted Living

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- **Summary**

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Summary

- Information overflow in healthcare systems can be addressed by leveraging semantic models
- Semantic Search
  - increases precision and recall of patient record retrieval
- Rule-based patient monitoring
  - automates the recognition of critical situations and thus enables faster response on emergencies

…and back???

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Thank you for your attention!

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