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Smart Medical Information Technology for Healthcare

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Universitätsklinikum Leipzig
Medizin ist unsere Berufung.

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UNIVERSITÄT LEIPZIG

Friedrich-Schiller-Universität Jena
seit 1558

RWTH AACHEN UNIVERSITY

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Prof. Dr. Wolfgang E. Fleig

Prof. Dr. Uli Hahn

Andreas Henkel

Prof. Dr. Gernot Marx

Volker Lowitsch

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Background

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- Long-standing cooperation in clinical research
  - Infectious diseases, intensive care medicine
- Complementary methodological expertise in
  - clinical trial research
  - epidemiology
  - medical informatics
  - systems medicine and disease modelling
  - natural language processing
- Management experience of large research clusters
- State-of-the-art intersectoral IT services for healthcare

Use cases

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HELP

Hospital-wide EMR-based computerized decision support system to improve outcomes of patients with bloodstream infections

ASIC

Algorithmic Surveillance of ICU patients to improve personalized management of care

PheP

Phenotype Pipeline, algorithms for phenotyping and NLP on EMR data

Source: UKJ (A. Schroll, M. Szabó), NVHR

Use Case **HELP**
EMR-based decision support for bloodstream Infections

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PIs:
Pletz, clinician
Scherag, biometry
Jena

- Setting: Normal wards and ICUs
- Application of EMR-based computerized decision support system to improve outcomes of patients with bloodstream Infections
- Development of **digitalized Antibiotic Stewardship** based on harmonized structured and unstructured data from diverse information systems
- **SMITH App** as user interface
- Outcomes: personalized management of bloodstream infections, reduced hospital readmission, reduced mortality

Source: UKJ (A. Schroll, M. Szabó)

Fleig, CEO, Leipzig

Use Case **ASIC**
Algorithmic Surveillance of ICU patients

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PI:
Gernot Marx, Clinician
Andreas Schuppert, Modelling
Aachen

- Setting: Intensive Care Units (ICUs) (Respiration, ARDS, Sepsis)
- Application of „**High-Performance Computing**“ for model-based, clinical decision support
- Development of **virtual patient models** for clinical research (partners: Research Centre Jülich, Bayer AG)
- **SMITH App** as user interface
- Outcomes: personalized management of ARDS, reduced organ dysfunctions, reduced mortality

Source: UKJ (A. Schroll, M. Szabó)

G Marx, Clinician, Aachen

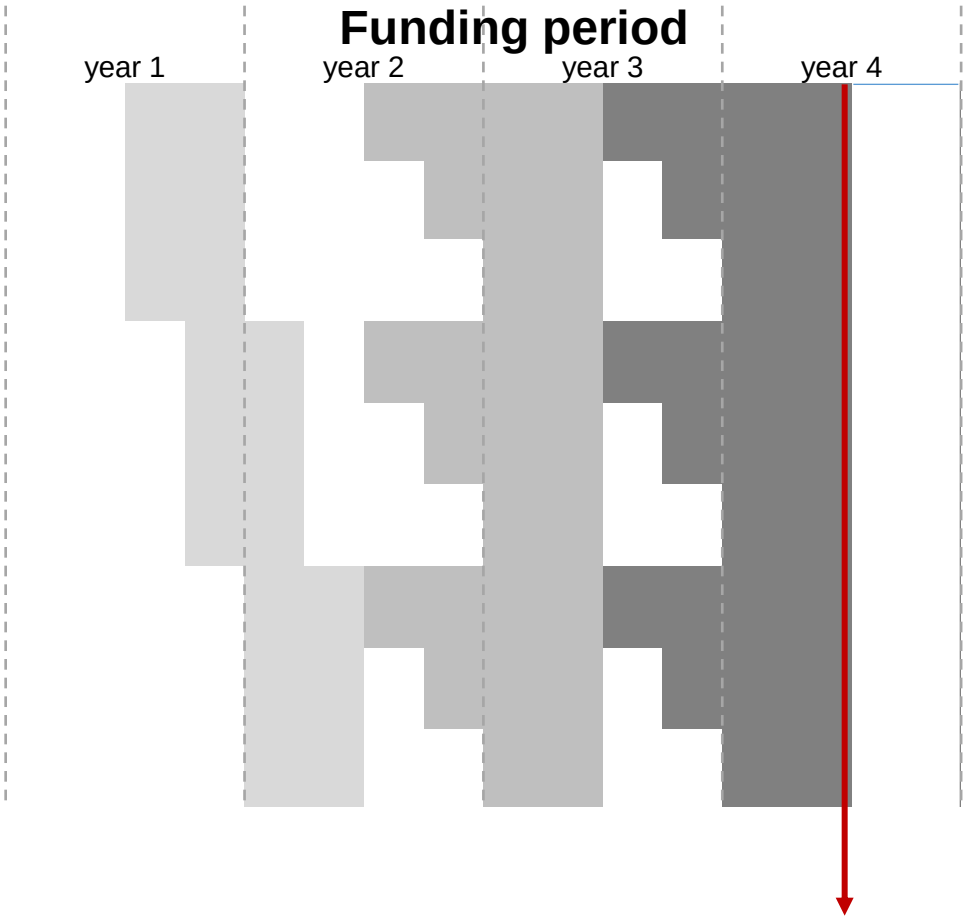
Generating Evidence

ASIC
Study design
(sequential stepped wedge designs)

control data

ASIC App (Version 1.0)

ASIC App + Expert Advisor System (Version 2.0)



Biometry
Andre Scherag

Audit

Outcome: hard clinical endpoints

Use Case PheP
Phenotype pipeline and NLP

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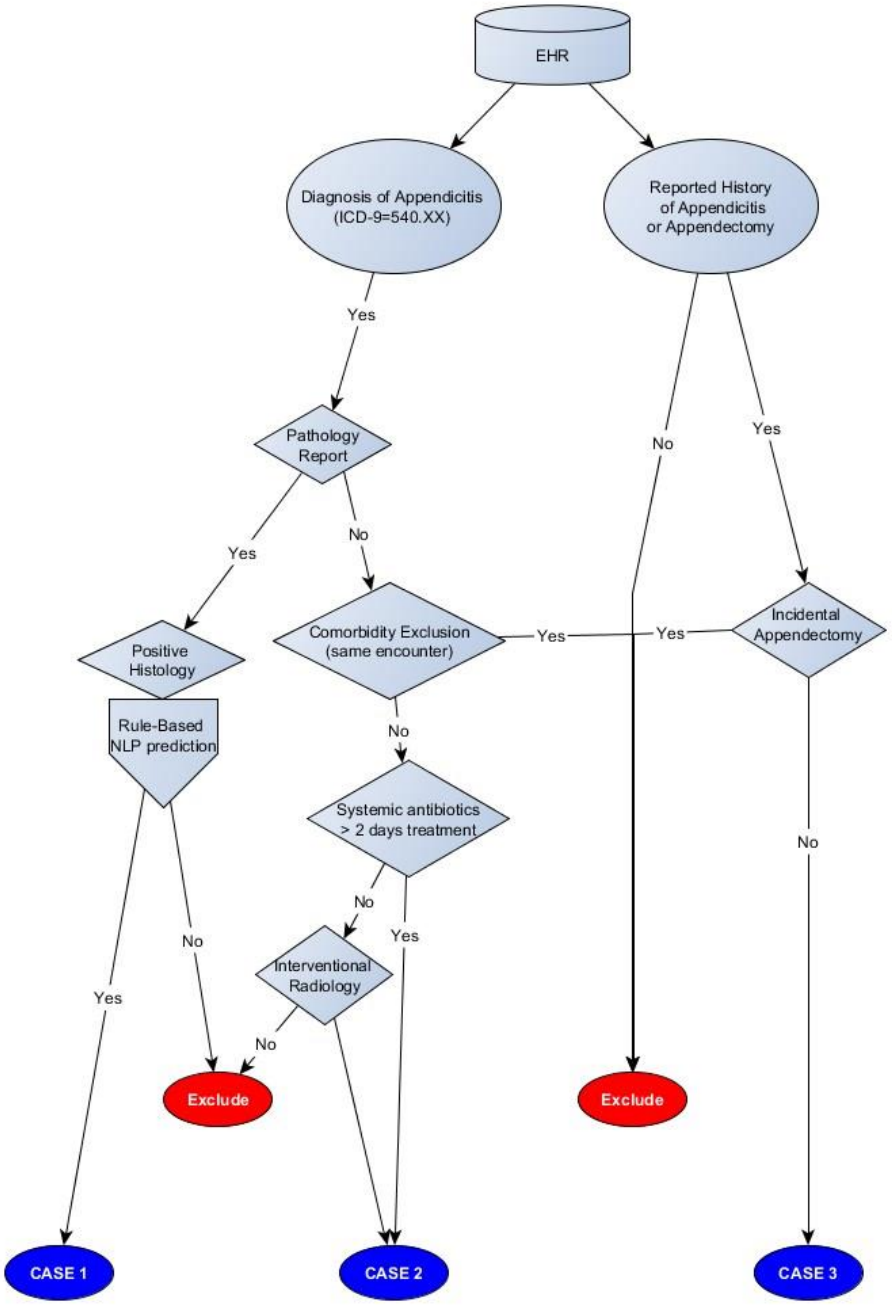
PIs:
M Löffler, classifiers & models
U Hahn, NLP

- **Algorithms for phenotyping** by using structured and unstructured data from electronic medical records (EMR) ➔ classification, annotation
- Development of
  - **a rules engine and factory and a meta data repository**
  - **a natural language processing engine and factory and text corpus**
- create a technology to automatically mine EMR and generate phenotype classifications and annotations (the uses cases are two examples)

Source: UKJ (A. Schroll, M. Szabó)

Loeffler, PI, Leipzig



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eg
Appendicitis
classifier
-Emerge -

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ormation
ealthcare

Web Table 2. Characteristics of Heart Failure Status Definitions			
HF Status	Presence of ICD9 AND positive mention of HF	Heart Failure Date	Ejection Fraction
Definite	Yes	365 day window	No EF EF <50% (HF Type = 1) EF ≥50% (HF Type = 2)
Probable	Yes (or ≥5 unique dates of either)	365- 1825 day window	No EF EF <50% (HF Type = 1) EF ≥50% (HF Type = 2)
Possible	Either or none if EF <50	Unable to assign date	any
Control	None	N/A	No EF EF ≥50

Heart Failure Date Assignment Rules: Taking the cross product of all the unique

NLP-Ejection fraction

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Web Table 4. Regular Expressions* for Reporting of Ejection Fraction in Unstructured Reports	
• Calculated EF ##% • Calculated LVEF ##% • Calculated LV ejection fraction ##% • Calculated Left Ventricular ejection fraction ##% • Calculated Ejection Fraction ##% • Calculated Ejection Fraction ##%. Visual estimate ##%-##% • Estimated EF ##% • Estimated EF = ##% • Estimated EF ##%-##% • Estimated Ejection Fraction ##% • Estimated Ejection Fraction ##%-##%	• Estimated Left Ventricular Ejection Fraction ##% • Estimated Left Ventricular Ejection Fraction ##%-##% • Estimated Left Ventricular Ejection Fraction range ##%-##% • EF ##% • Ejection Fraction ##% • LVEF ##% • LVEF ~ ## - ##%Left Ventricular Ejection Fraction ##% • Visual Estimate of LVEF ##% • Visual estimate of Left Ventricular Ejection Fraction ##% • Visual Estimate of EF ##% • Visual Estimate of Ejection Fraction ##%
*The regular expression list above includes the variations identified during the algorithm validation at Mayo Clinic and Group Health and thus is not an exhaustive list of every possible combination of the use of characters such as "=" or "~".	

Natural Language Processing

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Objective: Building a nucleus for text analysis of German medical records

- **Automating** content-focused analyses
- Build up of accessible well annotated **clinical corpora** (gold standard for system evaluation, training data for machine learning of classification models)
- Development of novel, **semantics-focused software** (primarily dealing with clinical named entities, their relations, and temporal dependencies among events)
- Formation of a dedicated **NLP-pipeline** useable by the **DICes**
- **Collaboration** with leading national players in biomedical Natural Language Processing (NLP), from industry (Averbis, Freiburg and ID, Berlin) and academia (JULIE Lab, Prof Hahn, FSU Jena)

Outcome of a first corpus project

(Uli Hahn, M Loeffler)

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- **Collection** of 2,360 German-language discharge summaries from roughly 3,000 patient records (EHR) taken from the three sites involved (J: 960, L: 850, AC:550)
- **Annotation with the BRAT tool** carried out by 8 annotators across the three sites (J: 5, L: 2, AC: 1)
- **Annotation of all medication information** contained in the discharge summaries on drug name, dosage, mode, frequency, duration, reasons for administration
- **Evaluation of the quality of annotations** by measuring the inter-annotator agreement (IAA) for the 5 annotators from Jena, using a centroid F-score: drug name, dosage and frequency (.95), mode (.75), duration (.70), reasons (<.50)
- **Evaluation of a-prototype medication recognition system** using F-score: dosage and frequency (.82), drug name (.50), mode (.21), reasons (–)

PheP can be used to

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- analyse real world patient care
- search for particular phenotypes (eg CAP, genetic)
- investigate and improve EMR data quality

- Integrate systems medicine disease models into the physicians desk top (pespective emerging)
  - eg chemotherapy dosing and timing
  - based on hematotoxicity models (e:Med projects)
  - eg biomarker based treatment decisions

Model of thrombopoiesis

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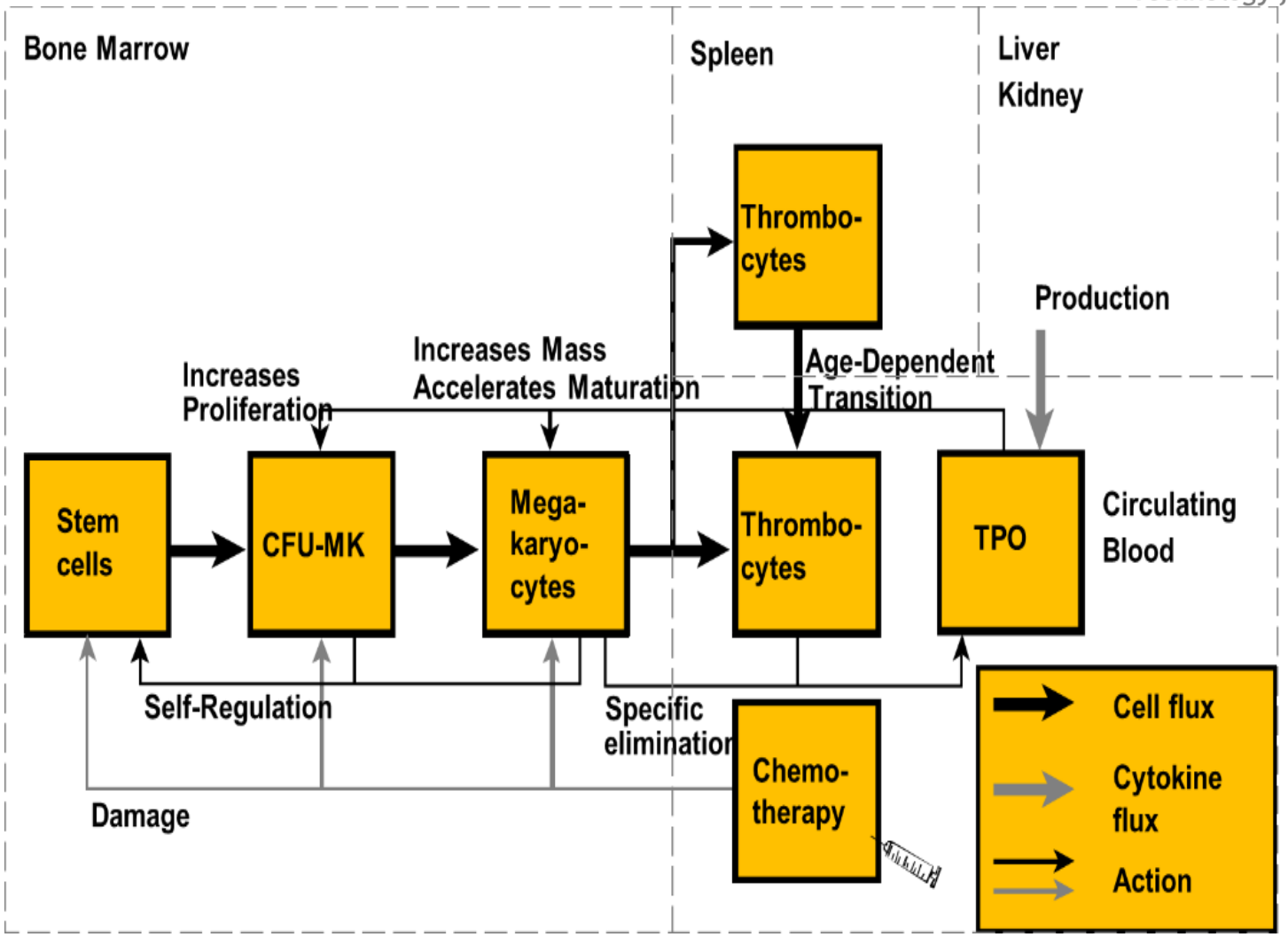

Hematotoxicity BEACOPP 14

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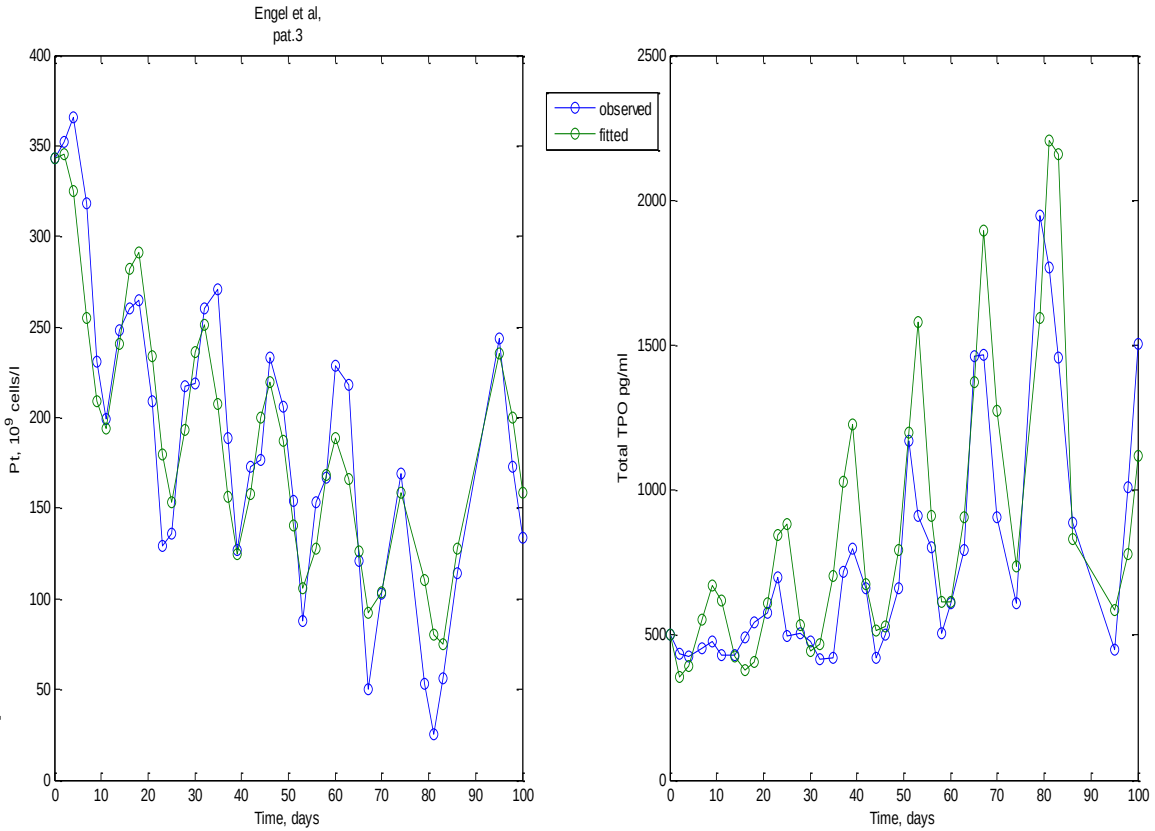
Use model for prediction



Data Integration Centres - Generic Concept -

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University Hospital (UH) | **Medical Faculty (MF)**

Steering Board
- CMO & CIO (UH)
- Dean & Scientists (MF)

Promoting clinical institutions (usage):
- Anaesthesiology and Intensive Care (ASIC, HELP)
- Microbiology (HELP)
- Hygiene (HELP)
- Clinical Chemistry
- …

Promoting regulatory institutions
- Ethics Committee
- Data Security Representative
- Legal Services

Data Integration Centre
(organisational unit of UH)
Head of DIC
- Data Trustee Service
- Data Transfer Service
- Health Data Space Mgmt.
- IT-Systems Management

Use and Access Committee

Promoting IT-infrastructure
- UH-IT Departments

Promoting research institutions (methods):
- Medical Informatics (PheP)
- Biometry & Epidemiology (PheP)
- Centre for Clinical Trials
- Biobank
- Computer Science (PheP)
- …

Cooperating SMITH partners (methods & usage)
- IT industry
- NLP industry / provider
- External users / consortia

Data Integration Centres

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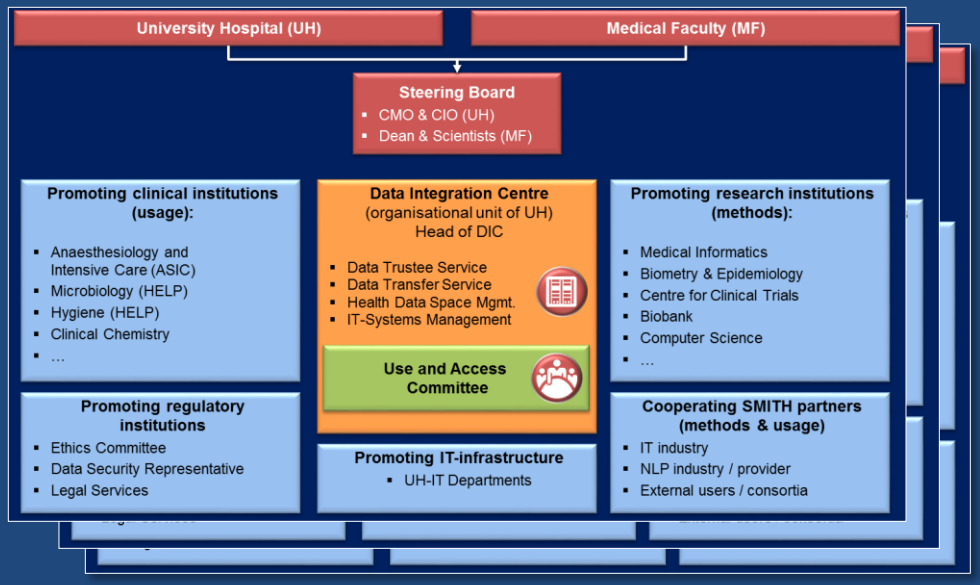

Heads of DICs

UH Aachen

Dr. Silke Haferkamp

UH Jena

Dr. Danny Ammon

UH Leipzig

Dr. Thomas Wendt

Technical Standards for Data Integration

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IHE Integrating the Healthcare Enterprise

- PIX / PDQ
- ATNA
- BPPC / APPC
- XDS
- XCA
- XUA

HL7

- CDA
- FHIR
- CQL

Medical Terminologies

- SNOMED-CT
- LOINC
- ICQ/OPS
- IHE-D Value Sets

SMITH DIC – Architectural Aspects - Communication -

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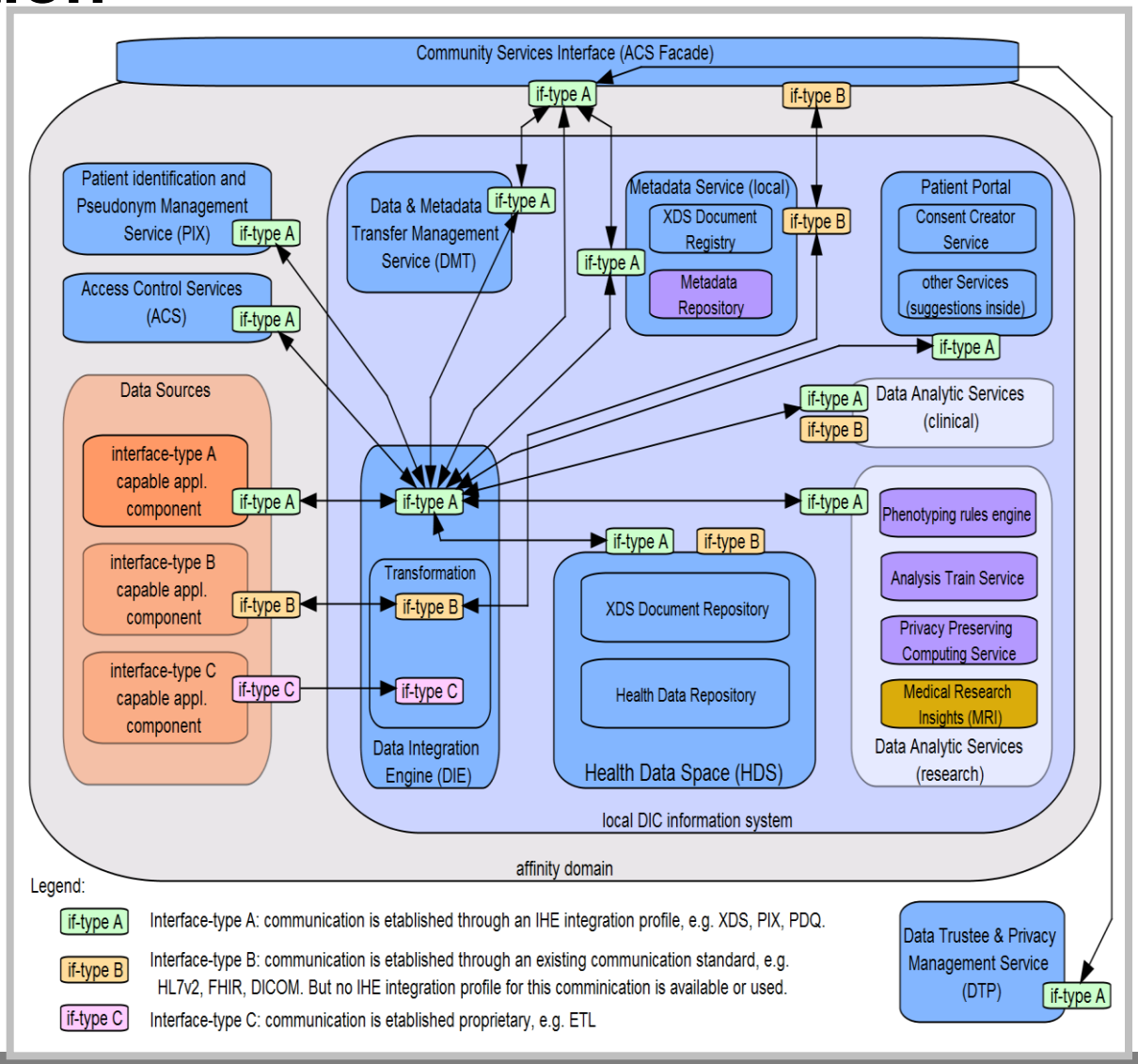
Health Data Repository

- Central persistency for structured clinical data
- FHIR interface

Medical Research Insights

- Analyze patient data to verify or develop research hypotheses
- Identify candidates for studies



Roll-out Concept

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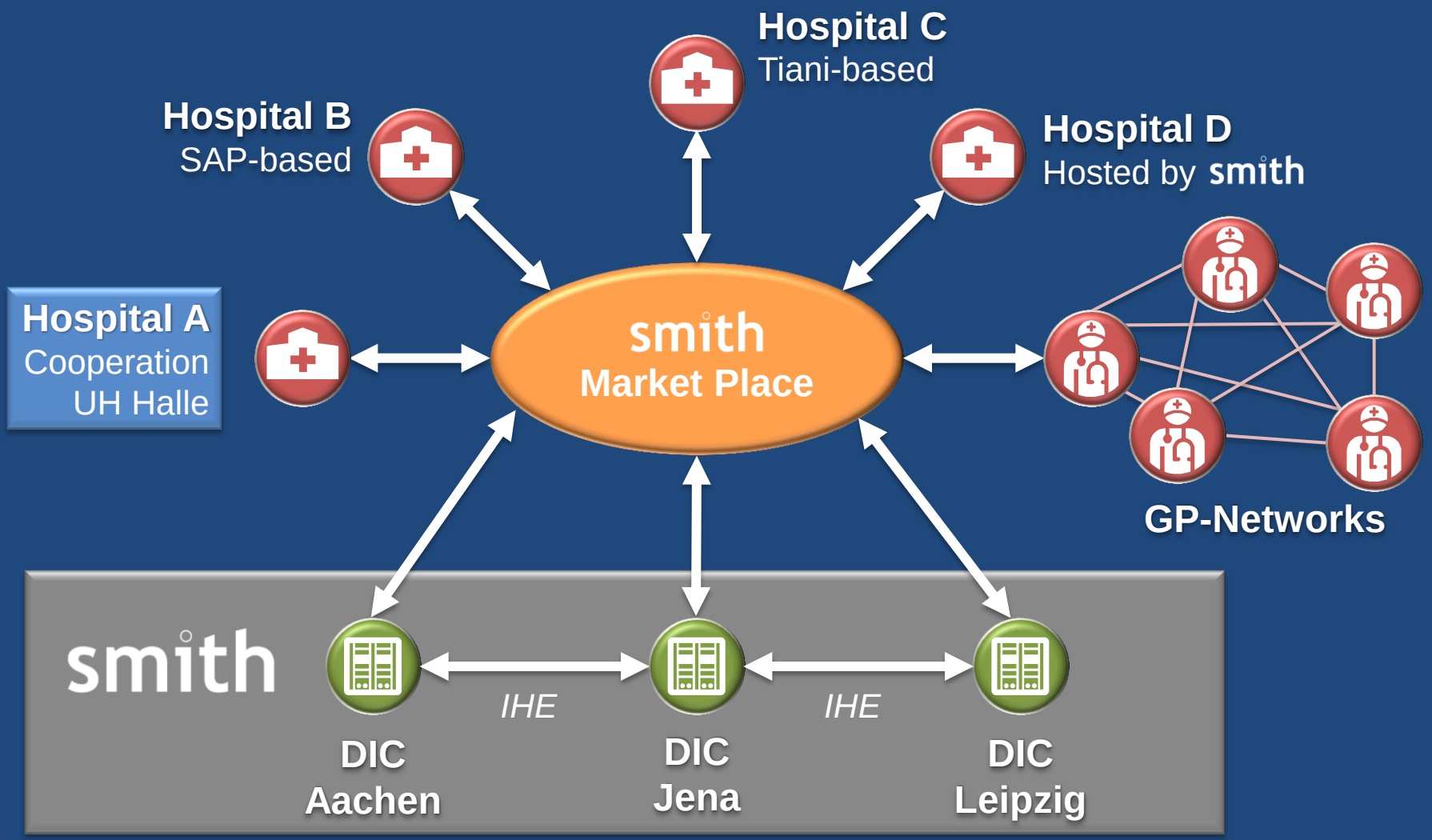

SMITH Market Place – Structure & Cooperation with industrial partners

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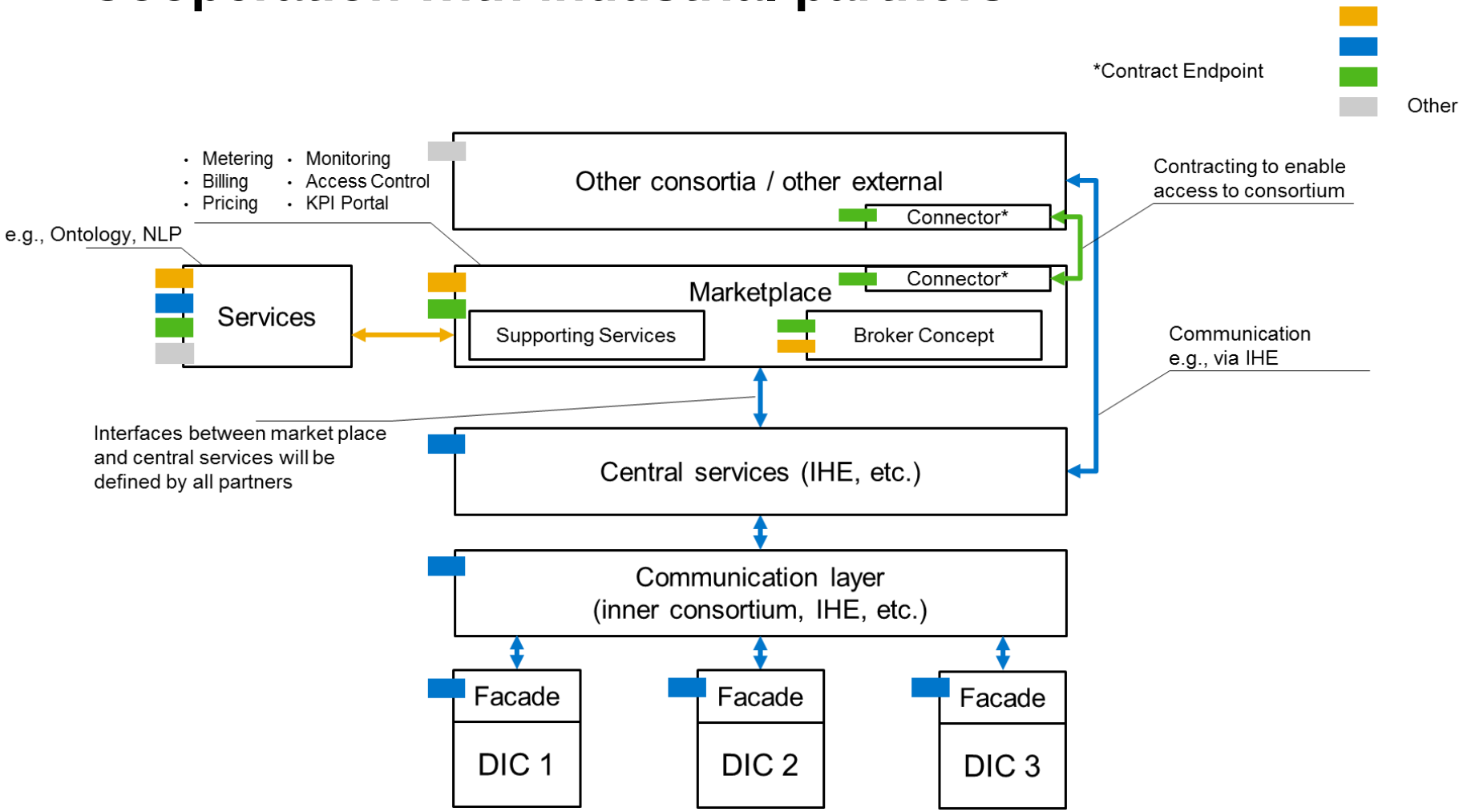

Partnerships & Cooperations

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CISCO
DIC network and security technology

märz
IHE-conform data integration (configuration and support)

SAP
implementation of marketplace

bvitg
general cooperation

Healthcare IT Solutions
EPR / roll-out

averbis text analytics
NLP procedures and terminology server (use case PheP)

ID Information und Dokumentation im Gesundheitswesen
text analysis and metadata classification (DIC)

BAYER
reference data (use case ASIC)

HL7
mutual advancement of communication standards

TIANI SPIRIT
IHE-conform data integration (development and implementation)

comuny
high-performance computing

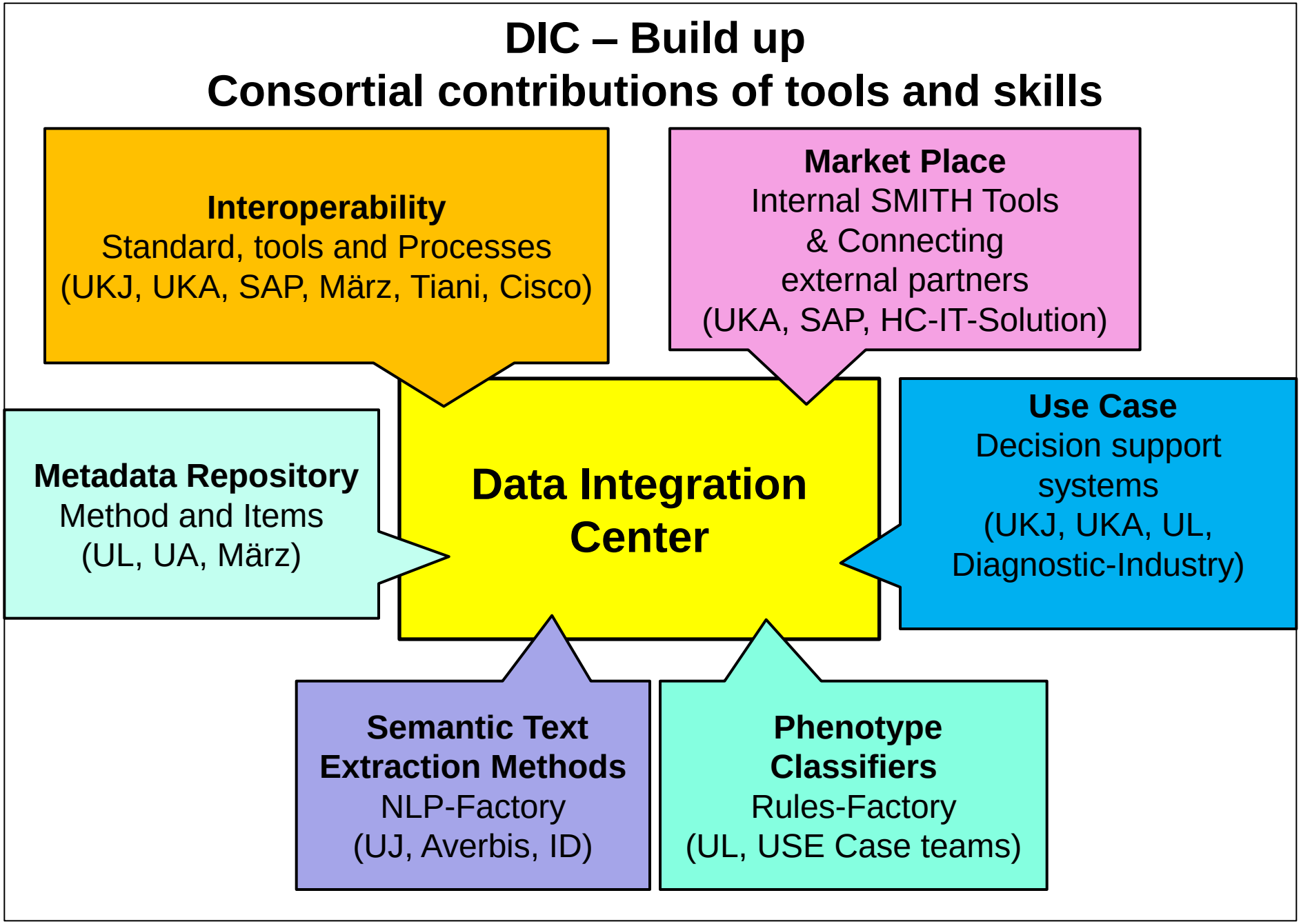
evimed
Industrial Data Space Medical Data Space

JÜLICH FORSCHUNGSZENTRUM

Fraunhofer ISST

AOK PLUS · TK · CGM · VISUS · D·M·I ARCHIVIERUNG · careliance · MEDECON Telemedizin GmbH
general cooperation

DIC – Build up
Consortial contributions of tools and skills



Overarching timelines

Interoperablility:

1 - 18 Initial set up of interoperability in DIC

19 - 30 Interoperablility implemented in DIC

Clinical use cases:

19 First patient in use case control cohorts

30 First patient in use case interventional cohorts

42 Recruiting closed and analysis performed

Roll out:

19+ Starting add DIC build up

42 DICs active, 2 hospitals, 3 GP networks

Education

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Curricula for students:

PI: Alfred Winter

- 3 new BSc/MSc programs
  - „Data Science“ (Aachen),
  - „Medical Data Sciences“ (Jena),
  - „Biomedical and Health Informatics“ (Leipzig)

- 1 international postgraduate MSC (Aachen, International Academy)

MSC Curricula

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	D1	D2	D3	D4	D5	D6	D7	D8
Ac	●	●	●	o	×	●	●	×
J	●	●	●	×	×	●	●	●
L	●	o	●	●	●	●	o	o

● Addressed by existing program
o Partly addressed by existing program
× Needed

D1	Basics of medicine and principles of medical decision-making in diagnostics and therapy.
D2	Basics of molecular biology, bioinformatics and computational biology.
D3	Statistical foundations of medical research and evidence-based medicine.
D4	Architecture of complex information systems for medical research and care.
D5	Management of complex information systems for medical research and care.
D6	Representing and modeling medical information and knowledge (incl. ontologies).
D7	Managing and processing medical signal/image data.
D8	Accessing, managing and mining biomedical big data.

Table 9-1:

Education

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3 Additional Professorships

- Leipzig (W3 Medical Data Science; 2017)
- Jena (W2 2018)
- Aachen (W3 2018)

Beitritt zum SMITH-Konsortium

Wir sind grundsätzlich offen für Beitritte von Standorten, die unsere Vorgehensweise zu DIC, Interoperabilität und Use Cases nachvollziehen wollen.

Wir bitten solche Standorte um eine schriftliche Bekundung

Wir werden dann

- Kontakt aufnehmen
- zu einer Informationsveranstaltung am 3.Nov einladen
- dann die Vorgehensweise zu einem gemeinsamen Antrag abstimmen

Danke für die Aufmerksamkeit