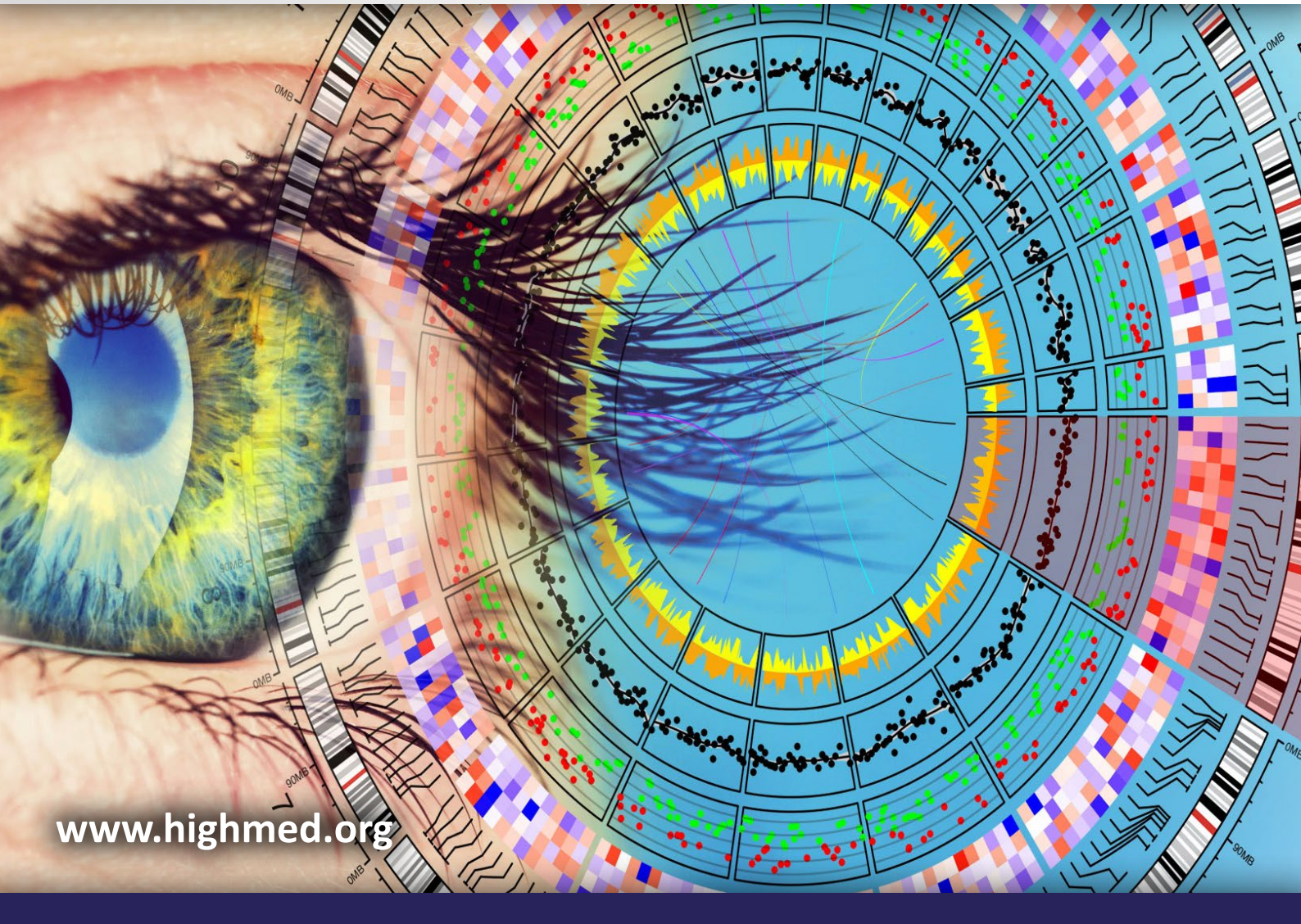
HiGHmed
Medical Informatics

*open*EHR

open data platforms in medical informatics



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MEDIZINISCHE FAKULTÄT HEIDELBERG

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MHH Medizinische Hochschule Hannover

Greetings

Prof. Dr. Annette Grüters-Kieslich
Chief Medical Director
and Chairwoman of the Board
Heidelberg University Hospital

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Dear Reader,

Along with more advanced technologies in the healthcare system comes a constantly growing quantity of health-related data for everyday clinical activities. However, the lack of uniformity inherent in the available data, in terms of quality, type and format, has emphasized the criticality of the establishment of a standardization framework.

The medical informatics consortium HiGHmed funded by the German Federal Ministry of Education and Research (BMBF) addresses this challenge and aims to develop and use innovative information infrastructures to increase the efficiency of clinical research and to swiftly translate research results into tangible and validated improvements of patient care. These aims are tightly connected to challenges to integrate and further develop solutions of innovative, internationally interoperable data integration and methods, with the intending to demonstrate their added value for health research and also patient care.

A chosen infrastructure for HiGHmed is the open source solution *open*EHR (Open Data Platforms in Medical Informatics), a creation of semantic interoperable electronic health record architecture in a vendor- and technology-neutral format. *open*EHR standardizes heterogeneous medical IT systems and the resulting dispersion of medical data in archetypes and templates. These archetypes are developed in collaboration with the international *open*EHR community, which consists of physicians, computer scientists and processing as well as standardization experts. The results are systems and tools that add value to decision-making support in day-to-day clinical practice and support research questions and will be the basis for a data-centric “app” ecosystem. These tools will reduce workload and significantly improve semantic traceability. Furthermore, model-generated code and user interfaces are an area of continuous innovation in *open*EHR and promise to revolutionize health computing.

With this brochure we would like to introduce *open*EHR to you. A platform where international CIOs, IT architects and medical informatics experts share their experiences and present their use cases for novel information system architectures based on *open*EHR.

With this, I hope that you will enjoy reading about the diverse projects featured in this brochure.

Prof. Dr. Annette Grüters-Kieslich
Chief Medical Director
and Chairwoman of the Board
Heidelberg University Hospital

Greetings

Prof. Dr. Roland Eils
Coordinator of HiGHmed
Medical Informatics Consortium Germany

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Dear Reader,

A standardized management of vast amounts of data from disparate organizations is crucial for use of big data in health-care for efficient knowledge discovery. Likewise, newly emerging paradigms as precision and systems medicine require a holistic picture of the individual patient across the health care system.

The highly complex and diverse data originating from care, omics, clinical and biomedical research for analytics, machine learning and clinical decision support systems needs to be findable, accessible, interoperable and reusable across institutional boundaries. While the organizational framework to enable data exchange and trustful cooperation in full compliance with the patients' right of self-determination and data protection legislation is a major challenge, the socio-technical aspects of data sharing must not be neglected. Today, we find that contemporary hospital information system architectures are not well suited for data reuse within and across institutions in an economical and sustainable way. Opening up existing and avoiding future 'data silos' by implementing inter-operability standards is a prerequisite here.

Recently, open source solutions based on *open*EHR (Open Data Platforms in Medical Informatics), a semantic, interoperable electronic health record architecture, have gained traction in the United Kingdom, Norway, Slovenia, Australia and cross-boundary organizations like Eurotransplant. The primary focus of its endeavor is on electronic health records (EHR) and related systems. For HiGHmed, *open*EHR plays a vital role by enabling collaborative information management and by providing interoperable and vendor-independent data repositories. *open*EHR thus enables the use of standardized specifications across multiple sites and promotes future service-oriented software architecture and innovative system solutions in clinical care.

In this brochure we present the challenges and opportunities of *open*EHR for the healthcare system. We hope that you enjoy reading and that you will follow our enthusiasm for open data standards in clinical care and research.

Yours,
Prof. Dr. Roland Eils
Coordinator of HiGHmed
Medical Informatics Consortium Germany

*open*EHR
What is it?

In recent decades it has become clear that the value of information technology in health (often called e-health) has lagged far behind its value in other domains such as banking, process control and logistics.

Motivation

People the world over routinely and justifiably wonder why their health records don't work like their online banking does. Similarly, healthcare professionals ask why their Electronic Medical Record (EMR) systems still don't talk to each other, are so expensive, and why it is so difficult to maximize the value of the vast amounts of available health data.

There are many contingent reasons for the poor progress of IT in health relating to politics, commercial interests, and the inability to focus funding across the mixture of public and private economic sectors, but there are also fundamental causal factors at work, which if not addressed will continue to block progress. Chief among these are the *complexity of information and processes* (ultimately due to the innate complexity both of human biology and society), and secondly the fact that the focus of healthcare – the patient – routinely *moves across enterprise and jurisdictional boundaries* while expecting seamless care.

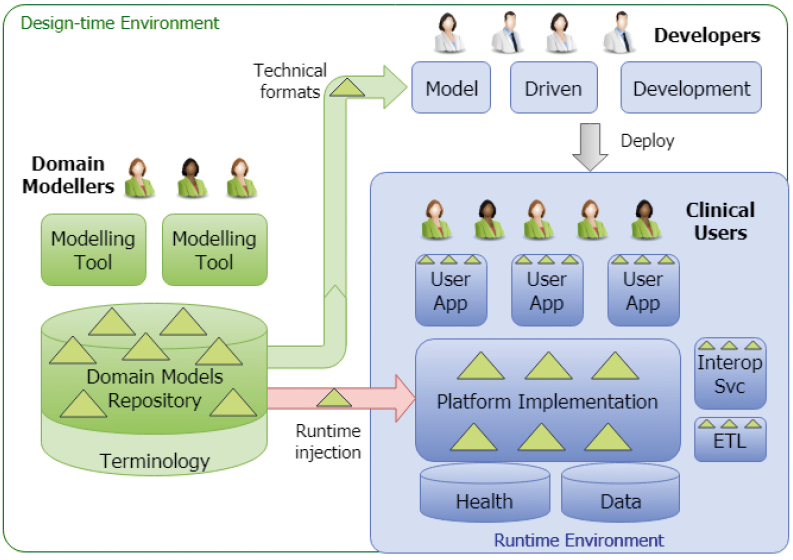
*open*EHR as a technology

***open*EHR is designed to address this need, by providing the following:**

- A multi-level framework that separates data models from domain models
- An open platform architecture that can be used to represent patient-centric health data, which are *accessed* by institutions and products but not controlled by them
- A modelling *factory* environment that continually produces computable domain models (known as *archetypes* and *templates*), developed by domain professionals, in any language
- Tools that *machine-convert* domain models into technical forms useful for developers

We can visualise an ***open*EHR technology ecosystem** that implements the above as follows:

The model-driven *open*EHR technology ecosystem



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Under this architectural approach, the entirety of the deployed software solution is based on (at design time) and driven by (at runtime) computable models of content and process created by domain professionals. Notably, the data representation depends only on the *data* model, which ensures that **physical database contents are not affected by new domain models**.

As a community-based organisation, *open*EHR undertakes three kinds of activity:

- Publishing the **technical specifications** that define both the platform and the domain models
- Developing **software** for modelling tools and repository
- Publishing **clinical models**, which act as *de facto* standards for fragments of the domain

The technical specifications include **information models for healthcare data**, including the EHR and demographics; a portable **query language**, formal languages for expressing domain content and data sets, and finally, an **open API** specification.

The *open*EHR query language represents a major innovation, which enables the writing of **model-based queries** that are independent of physical database schemas, and thus **portable across systems**. This enables a sustainable approach to clinical decision support and business analytics, which otherwise are either tied to a single database, or else have to be rewritten for every target system.

Interoperability is solved in a way common outside of the healthcare domain, which is **by machine-generation of schemas and software** components from models, rather than hand-building of message or document definitions. In a similar way, the **difficulty of application development is greatly reduced** via machine-generation of application software and UI components.

The value of using *open*EHR

An *open*EHR platform solution may be deployed in a single hospital much as any EMR solution is, but also across a city, region or whole country. It is in the latter deployments where the capability of persisting data in a patient-centric rather than institution- or product-centric fashion is realised, and **vendor lock-in is avoided**.

The separation of domain models from the technical layers qualitatively changes the software engineering economics of solutions, because it allows the platform to be built and deployed independently, with domain models being *injected at runtime*, removing one of the major sources of cost at a stroke. It also allows **domain professionals**, who know their own data and workflows, to be **in the driving seat** when specifying the semantics of Healthcare Information System solutions.

The technical advances of *open*EHR lead naturally to a **plug-and-play platform economy**, in which any vendor or developer can produce a solution component, as long as it conforms to the published data and Application Programming Interface (API) base standards of *open*EHR, and additionally, the domain content models created by the community of clinical professionals.

The use of *open*EHR also entails new f**reedom with respect to health data**: initially, it is liberated from *products and vendors*, to be owned by providers; eventually it can move to full patient ownership, with healthcare professionals as guardians – the ultimate realisation of the patient-centric EHR.

It is the goal of the *open*EHR Foundation and community to fundamentally change the quality of information technology in the service of medicine, so as to improve outcomes in clinical healthcare, public health and the value of secondary data use.

Author:
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Management Board, *open*EHR Foundation

*open*EHR in HiGHmed

HiGHmed – an open platform approach to enhance cross-enterprise care provision and research

Modern medicine is confronted with an unprecedented data flood arising from recent technological breakthroughs in genome sequencing, imaging and remote sensing amongst others, which are becoming part of routine clinical care at an ever increasing pace. Despite this massive increase in data sources, diversity and volume, only a surprisingly small fraction of this data is currently integrated for routine processes in clinical practice. This integration is mainly hindered by the current state of hospital information systems, which favor an application-centered approach over a collaborative and data-driven mindset, creating a vast amount of data silos. Consequently, care providers are prevented from taking advantage of a holistic view on all available data that would allow optimal diagnosis and treatment. Moreover, those data sets, which are often unique and invaluable, are not available for research purposes, thereby actively impeding progress in clinical research and the translation of cutting-edge research insights into clinical practice.

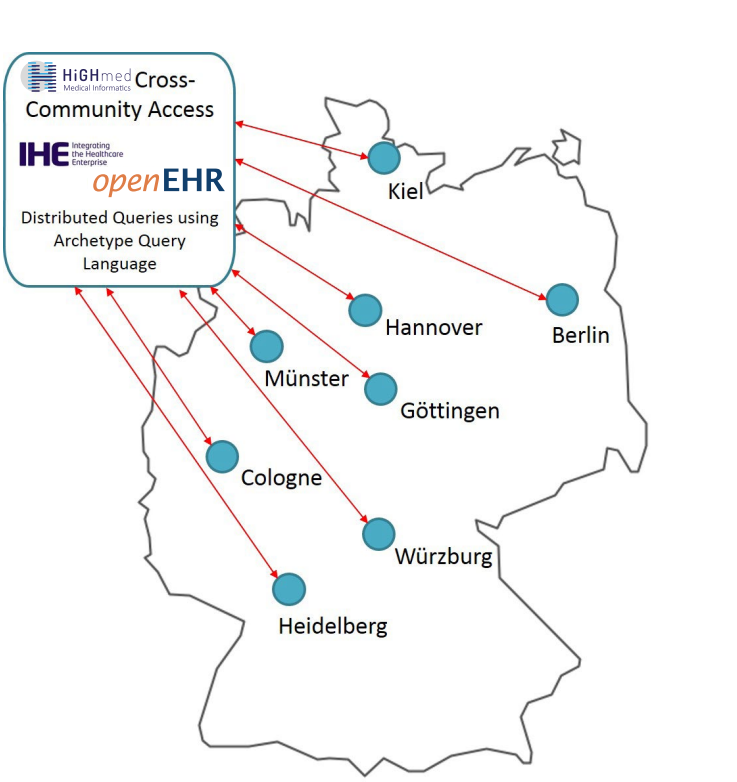
The Medical Informatics funding scheme of the German Federal Ministry of Education and Research aims at overcoming these obstacles and thereby promoting the opportunities of digitalization in medicine. By establishing integrated IT solutions, the exchange and use of data from healthcare, clinical and biomedical research across institutions and locations will be greatly facilitated. During a four-year development and networking phase, which started in January 2018, funding worth a total of about €150 million will be allocated to four consortia.

The HiGHmed consortium currently consists of the three university hospitals in **Heidelberg**, **Göttingen** and **Hanover**, and is complemented by more than 20 partners from academia and industry. The HiGHmed consortium will integrate five additional university hospitals: the University Medical Center Schleswig-Holstein, the University Hospital Cologne, the University Hospital of Würzburg, Charité – Universitätsmedizin Berlin and the Münster University Hospital, which have formally applied to join HiGHmed by the end of 2018. The HiGHmed consortium will thus significantly increase its impact in clinical care and research across Germany through the inclusion of 25 % of all German University hospitals.

Open Health Platform Approach

In HiGHmed all university hospitals will establish Medical Data Integration Centers (MeDICs) based on a generic and scalable reference architecture. This architecture is based on IHE XDS, *open*EHR and HL7 FHIR for integrating data from care, research, and external sources, which will facilitate the development of new solutions for medical data analytics and benefit clinicians, patients and researchers. A shared information governance structure between all involved clinical sites in accordance with the FAIR (Findable, Accessible, Interoperable, Reusable) principles will provide the foundation for meaningful data exchange.

The geographical distribution of participating university hospitals and their connection via the HiGHmed platform



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To demonstrate the capability of the technical design and the organizational structure, the MeDICs take the responsibility to prove the suitability of the HiGHmed approach by supporting three medical use cases in the domains of oncology, cardiology and infection control.

To achieve the aspired goals and provide a solid foundation to address the specific requirements of the clinical use cases, HiGHmed's approach includes the iterative definition of an interoperable, open health data platform specification. The following characteristics are essential to the HiGHmed platform:

1. **Open Service Models:** All specifications of the provided application programming interfaces (APIs) are openly accessible to everybody. Specifications include data security and privacy, electronic health record management and database queries.
2. **Open Information Models:** All clinical models are well defined based on established open standards. Data based on these models can be reliably processed and computed in local and distributed environments. In addition, all models are openly available in HiGHmed.
3. **Open System Specifications:** All system components and protocols are openly specified using licenses feasible for commercial and non-commercial use. This assures that every component in the system can be replaced by software from multiple vendors, including open source communities.

By providing such an open platform, HiGHmed avoids any mandatory procurement of proprietary solutions that would cause vendor lock-in. Instead, participants in HiGHmed are able to acquire relevant components from different vendors, open source initiatives or by self-development. This architecture will foster an ecosystem, based on open service interfaces and clinical models.

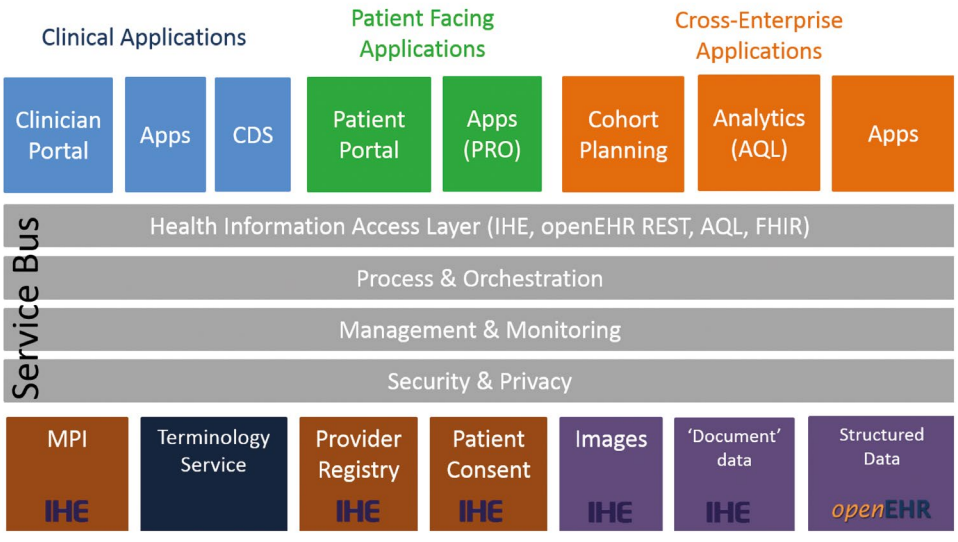
The role of *open*EHR

Within the HiGHmed platform, the management of structured medical data is of utmost importance. The availability of structured data is the prerequisite for any meaningful computation as statistical analysis, machine learning and the execution of decision support algorithms. To address the challenges regarding standardization, management and computability of structured data, *open*EHR provides several capabilities needed to achieve the aspired objectives.

Firstly, an information model governance framework, derived from the one pioneered by Norwegian Nasjonal IKT (see from page 16), helps to establish a common understanding of the data between the participating hospitals by allowing collaborative work on formal representations of clinical information models, called archetypes. The creation and curation of archetypes is driven by dedicated data stewards, a new socio-technical role

HiGHmed Platform Architecture

The core components of the HiGHmed platform are based on IHE and *open*EHR specifications. A service bus integrates the components and provides a secure and standardized data access layer. Based on the platform, an ecosystem of applications can be developed.



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within hospitals, that takes responsibility of professional long-term care of data from design to processing and sharing data for the different purposes. In close cooperation with clinical stakeholders, they drive the collaborative modelling and maintenance activities, which will establish a cross-enterprise information management resulting in a shared data dictionary.

This shared data dictionary can be used to assist the manual implementation of the semantics agreed upon within databases, and data capture forms within software systems. However, this approach will still require additional effort to integrate the data into a clinical data repository. Preferably, standardized data models can be directly incorporated within the HiGHmed platform to create new clinical and research application systems and databases. For example, interoperable clinical registries could be developed based on the capabilities of the HiGHmed platform and shared semantics.

Another important aspect of *open*EHR is the separation of data and applications. This means that applications don't use their own database layer, which then forms the typical data silo, but leverage the platform to store any structured patient data instead. Through this approach, all electronic health record data can potentially be used immediately by other clinical and research applications and for data analytics within the HiGHmed consortium. Additionally, locally developed, and highly specialized solutions can be easily exchanged between sites that have implemented the HiGHmed platform.

In contrast, building such systems in a traditional way and creating mappings to a standardized messaging interface seems neither financially sustainable nor realistic given the sparse resources of hospital IT departments. Additionally, without a platform approach, integrating newly developed applications across different sites will be burdened with high costs.

In the medium term, based on the scalable and solid architecture of *open*EHR, comprehensive and full-blown clinical application systems, like closed-loop medication management systems or patient data management systems, can be developed against the HiGHmed platform and provide standard-compliant and interoperable data "by design" and without costly mappings. Likewise, lightweight patient-facing apps can use the same data semantics to provide valuable data from wearables and patient reported outcome.

By providing a semantically-enabled data querying through the Archetype Query Language (AQL), *open*EHR offers a sound technical foundation to acquire data needed from disparate healthcare providing organizations. Queries can be directly expressed using the centrally managed models residing in the shared data dictionary. For the HiGHmed platform, this introduces a reliable and safe way to query data, deploy algorithms and develop clinical decision-support systems in a highly-distributed environment.

Outlook

While the HiGHmed platform will start with a narrow focus on the use cases, it provides a framework to extend its supported data models and functions in an open and transparent way. By connecting with international programs and initiatives, and by aiming at providing an open source implementation of the main components of the platform, we seek to facilitate the further roll-out and the proliferation of the open platform approach.

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*open*EHR in the EU
The Eurotransplant approach to interoperability

Eurotransplant has chosen ***open*EHR** as the basis for its clinical data repository as a means to enable the sharing of data across an international cooperation of hospitals, clinical registries and national authorities.

This international collaborative framework includes all transplant hospitals, tissue-typing laboratories and hospitals where organ donations take place. As mediator between donor and recipient, Eurotransplant plays a key role in the allocation and distribution of donor organs for transplantation. The mission statement and goals of Eurotransplant express the foundation's main target: to ensure an optimal use of available donor organs.

The integrity and availability of data can be improved by sharing data within the transplant process chain automatically. The system renewal project, currently being executed, should prepare the system for future interoperability between hospital and laboratory systems and Eurotransplant systems. To be more flexible the current monolithic system will be split in several applications: donor, allocation and waiting list.

System renewal

Eurotransplant develops and maintains a waiting list management, allocation and donor reporting system, that enables the 24/7 allocation of donor organs to patients on the waiting list. This 20 year old web-based system is currently being replaced in the CORE project.

Eurotransplant

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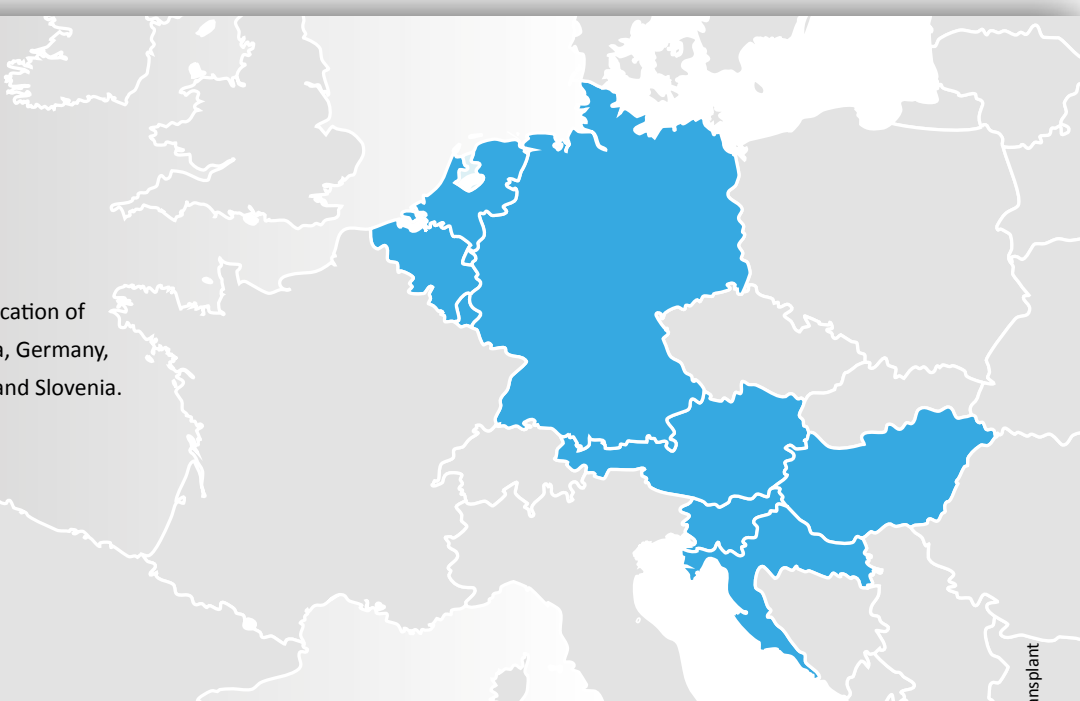
Eurotransplant member states in Europe

Eurotransplant is responsible for the allocation of donor organs in Austria, Belgium, Croatia, Germany, Hungary, Luxembourg, the Netherlands and Slovenia.



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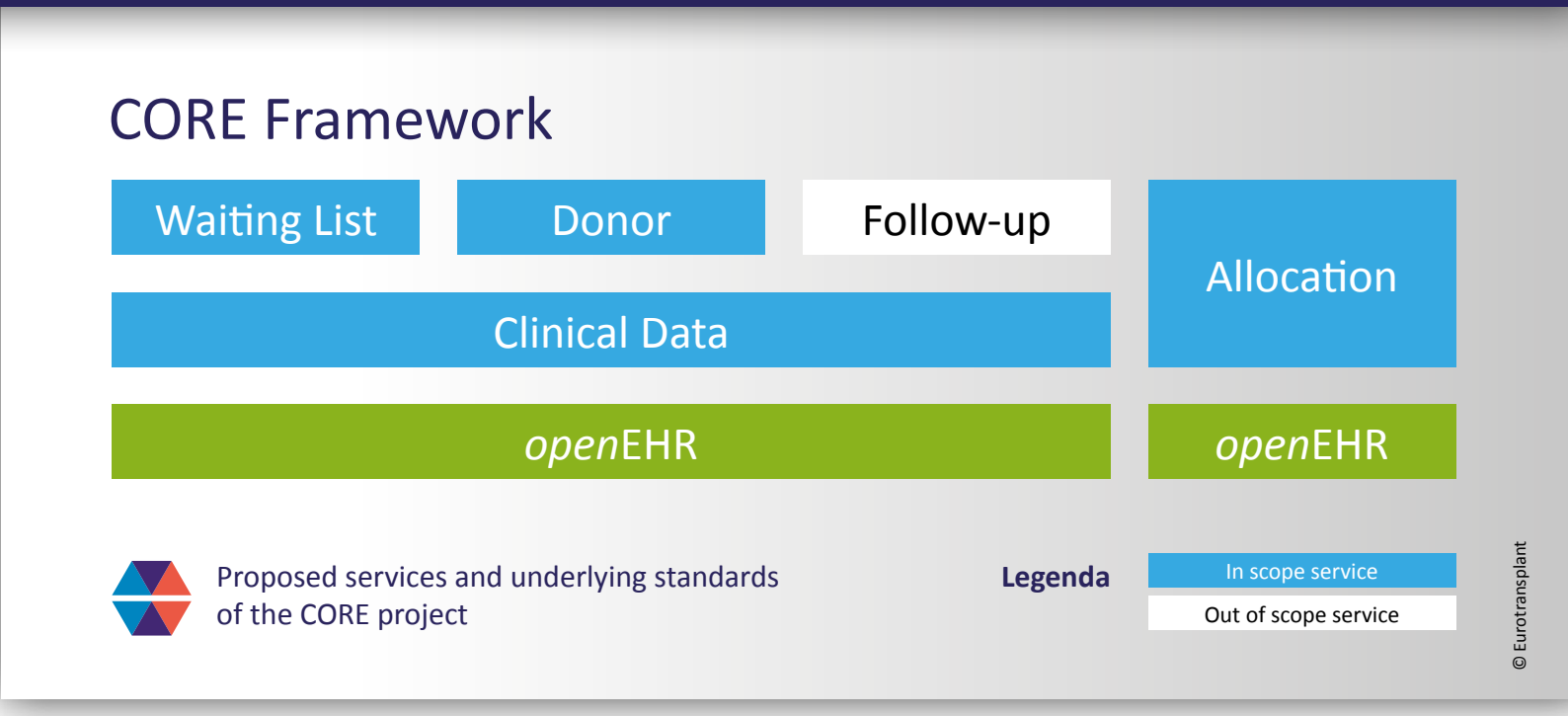

Interoperability

Eurotransplant shares the challenges of interoperability in many ways with hospitals or care regions, albeit on a larger geographical scale. Over a hundred transplant centers, immunological laboratories, national competent authorities and international registries communicate with Eurotransplant on a daily basis. Within these institutes many different systems (hospital, lab and smaller feral information systems) from different vendors using different messaging standards (from HL7/FHIR to CSV file export/import) would need to interoperate with Eurotransplant to be able to automatically share data.

The variety of different systems and messaging standards is challenging, but the differences in content of a message are perhaps the most significant hurdle. To add to the complexity, Eurotransplant systems are not well aligned with the hospital systems. Clinical data is scattered over several process domains (kidney, heart, liver etc.). This means that the same data fields, for instance creatinine test results, are redundantly stored in five different domains. With the CORE project we will underpin both the waiting list and donor application with *open*EHR, which means they can share clinical concepts, but will have a use case specific application. What clinical data needs to be gathered and shared also depends on national legislation and processes within the 8 member states.

Clinical data repository

The Eurotransplant strategy for modernizing systems is an iterative approach. Firstly, we will prepare our systems by lowering boundaries for interoperability. Secondly, we will use messaging standards that are available and used within institutes that want to connect to Eurotransplant.

Eurotransplant decided to create a clinical data repository based on *open*EHR. *open*EHR (openehr.org) is an international clinical standard that is managed by a worldwide community of physicians and clinical informaticians with the aim to develop flexible health systems.

Eurotransplant is developing a clinical data repository (Think!EHR™ by Marand) based on *open*EHR archetypes and templates. Archetypes are building blocks of clinical data (e. g. blood pressure as a laboratory result) that are described in such detail that they comprise all possible data points needed to store them for all use cases. We create templates that comprise several archetypes restricted to only those data elements needed for our domain or application specific use cases. Templates can implement the different national and process requirements without data being redundantly stored. As the clinical data repository is agnostic for the processes and uses *open*EHR archetypes, clinical data is effectively separated from the process domains to better align data with clinical systems.

We will publish those archetypes and templates so feral information systems and registries can align their data. In a second step we will chose one or more messaging standards to communicate with hospitals and laboratories, using the clinical data repositories “open” API to easily map the data for the messages. Eurotransplant believes that having a clinical data repository with a strong focus on data semantics will help us overcome future (perhaps even yet unknown) challenges in interoperability.

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Eurotransplant

*open*EHR in the UK
The 'open platform' revolution

The National Program for IT (NPfIT) in the English National Health Service (NHS) was implemented in 2002 to make the NHS more technologically advanced, but after 10 years and almost £10bn the project was scrapped. A brief flirtation with open-source solutions only confirmed that contemporary health IT solutions (open or closed source) stay largely siloed in their clinical data design and face impossible barriers to emerging as sustainable and integrated products.

Even in the professional IT space the drive for 'health apps' via central innovation funding often simply generated a plethora of interesting but isolated products, merely adding to the existing pot of 'feral' health IT systems, typically found by the hundreds in any hospital portfolio and with hardly any connection to each other, or the main hospital system.

Pioneered by groups like HANDIHealth, with support from NHS Digital Code4Health and the Apperta Foundation, thinking emerged that building full-stack, siloed applications, whether open or closed source, was not going to build the transformative ecosystem required, in spite of improving exchange technologies like HL7 FHIR.

In contrast, an open platform approach would provide a comprehensive but semantically coherent clinical dataset, normally only available to single-vendor systems but could also do much of the 'heavy lifting' required around national connectivity, terminology services, connectors to legacy systems etc, that would normally have to be done by each application individually. In this thinking, reduced cost of development and ownership and re-deployment on new technology is as significant as increased interoperability.

The principles are well set out in 'Defining an open Digital Platform' published by the Apperta Foundation which has also brought together a collaborative clinical community to help develop the clinical archetypes and templates which power UK-based systems, ensuring close alignment with national interoperability efforts such as INTEROPen/FHIR.

While some UK health providers continue to look to the large US system vendors, a growing number are starting to procure and deploy open platform type ecosystems, whether because of budget constraints, a desire to avoid vendor lock-in of data, or to provide a more tightly integrated ecosystem of new-breed applications.

The exemplars

The 'Best of Breed' strategy – NHS Plymouth

NHS Plymouth is a large hospital provider whose IT strategy has been built around a 'Best of Breed' approach, using traditional integration technologies to move a limited set of data between different applications in its portfolio, including a home-built clinical portal/workflow service now called SeeEHR. The NHS Plymouth Clinical Information Officer (CIO), Andy Blofield talks plainly about the architectural challenges of maintaining and extending the best-of-breed approach with traditional integration and that the budget available for IT falls well short of that needed to license a full-blown 'legacy vendor' Electronic Patient Record (EPR). The trigger for Plymouth to adopt an *open*EHR-based open platform was the need to procure an electronic prescribing system, the chosen product being Marand OPENeP, which runs on an *open*EHR Clinical Data Repository (CDR), using internationally available clinical content. This was quickly integrated into the SeeEHR environment and work has already started on building other applications to run on the *open*EHR CDR, including an allergies record, eObservations and Discharge Summary preparation. NHS Plymouth are also working in partnership with local academic / innovation organisations as they see the enormous potential for this new approach to stimulate the local IT economy. Plymouth will increasingly use HL7 FHIR to connect legacy systems and those which are not *open*EHR-enabled, a mixed economy, maximising the power of each.

The 'Bi-modal strategy' – NHS Salford

In contrast to Plymouth, NHS Salford has a long established relationship with the US vendor AllScripts which successfully provides the core EPR functionality required by their highly digitised hospital service but which proved less able to respond

A growing group of leading NHS trusts in and around London have begun making use of *open*EHR to capture and manage genomics data as part of the high-profile 100,000 Genomes Project.

© Digital Health Insider

to new clinical requirements, new demands for applications and the growing interest in patient engagement via wearable devices, Patient Recorded Outcome Measures (PROMs) etc, either from a cost or time basis. Salford decided to procure and deploy an *open*EHR CDR, to sit alongside the Allscripts EPR as an 'innovation hub' for emerging projects such as nursing pre-assessment, patient respiratory disease monitoring and Renal PROMs collections. Other future expected applications include clinical registries and departmental systems. This bi-modal approach to enterprise software development was first described by Gartner in relation to ERP systems, recognising that their monolithic architectures, whilst performing an ongoing stable and valuable service, were insufficiently agile to meet the rapidly evolving needs of ERP customers, such that it was becoming necessary to run 'innovation teams and platforms' in parallel. This 'bi-modal' approach is reflected in NHS Salford where a good understanding has been reached between Allscripts and the CDR team, as to the best balance between 'stable' and 'agile'.

The 'Research / Registry Strategy' – North Thames Genomics Centre Genomics England

As part of the NHS England 100,000 Genomes project, a number of 'Genomics Centres', (local collaborations of hospitals), which are responsible for the collation and curation of cancer and rare disease phenotypics, have decided to adopt *open*EHR as the basis for their local but federatable harmonised datasets. A full set of *open*EHR archetypes and templates has been developed to align with the Genomics England (GEL) dataset, and work is ongoing to import data from 14 London hospitals into individual CDRs. Several other Genomics Centres including North-West London, West Midlands and Manchester are actively pursuing the same approach. Although the CDRs' prime purpose is to furnish GEL reports, some of the hospitals are investigating the potential to use them for other purposes e. g. for operational or other registry use.

Conclusion

The examples described demonstrate the steady emergence of *open*EHR-based projects around the UK with a varied approach to deployment and capacity building.

The market remains at an early stage but is now evidenced by procurements by a number of Trusts and by real deployments. There are of a number of other pending deployments and bids for national funding which include significant commitment to open platforms based on *open*EHR.

The 'open platform revolution' has begun.

Author:
Ian McNicoll
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*open*EHR in Slovenia
A medication management system and electronic healthcare record

University children's hospital Ljubliana (UCHL) is the first hospital based on ***open*EHR** to achieve HIMSS EMRAM Stage 6 certification.

A response to our work on this project:

"Physicians and nurses can spend more time with patients, because we have switched from time-consuming, paper-based processes for prescribing, medication administration, and pharmacist reviews to electronic medication management. We have improved safety, minimised errors, and increased the transparency of medical treatment. Additionally, communication within medical teams has improved as well."

Rajko Kenda, CMO

University Children's Hospital Ljubljana

- 220+ beds
- 10 specialties, including paediatric ICU and surgery
- 14 ICU beds, 4 operating theatres, 5 recovery beds
- 650 users; 230 current Think!Clinical™ users
- 60,000 outpatient patients/year
- 6,000 inpatient encounters/year
- teaching & research activities

Vision

In 2009, and in accordance with its stated goals of "safe, high-quality, and standardised care", University Children's Hospital Ljubljana decided to transition into a modern, paperless, electronically supported healthcare institution. They wanted a system which would prevent vendor lock-in, and support the high interoperability of vendors, technologies, and applications. UCHL envisioned a modern, mobile solution, and fit-for-purpose apps with a high level of security, all of which would streamline collaboration within medical teams and with patients, and not restrict the hospital's ability to innovate in the future.

Open platform approach

Instead of relying on a traditional monolithic solution, or a best-of-breed approach, the hospital chose an open platform approach based on *open*EHR. Building upon the vendor-neutral,

University Medical Centre Ljubljana

With about 200 beds, University Children's Hospital Ljubljana (UCHL) is the largest paediatric hospital in Slovenia, and an approved member of the European Reference Network (ERN) for rare diseases. It is part of University Medical Centre Ljubljana (UMCL), which employs more than 8,000 people and is one of the largest hospital centres in Central Europe.

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clinical data repository Think!EHR™, the next generation clinical information system Think!Clinical™ was developed. It provides key functionalities and modules, such as electronic prescribing and medication management, nurse care planning, Computerized Physician Order Entry, clinical documentation, workflow management, flow charts, integration of medical devices, and ICU management.

All patient information is stored centrally in an *open*EHR format, and independently of the applications that created the data. This means that all information will remain available for the lifetime of the patient, regardless of the IT solutions that might be deployed in the future, and that any newly deployed application will be able to directly access all the data necessary in order to provide high quality treatment. By ensuring that patient data will not be lost, regardless of any future evolution of the system, patients can be confident that medical teams will always have the key details necessary to make the right decisions regarding their care.

Today, processes and workflows have been optimised, are completely electronic, and are supported with built-in decision support. Automatically generated reports and task lists help medical team members reflect on any issues and improve collaboration for even the most complicated medication management scenarios and processes – including some which are not supported in paper-based systems.

Furthermore, by relying on OPENeP – a closed loop medication management system – UCHL is now completely paperless and fully supports closed loop medication management in all ten wards of the hospital, including the paediatric ICU (PICU). Delays and disconnects, which were inherent in handwritten, faxed, or phoned orders, have now been either minimised or completely eliminated, and all relevant information is digitally stored and easily accessible to anyone involved in the care process.

Facilitated data analytics

By using an open platform, reusing data for research purposes is much easier. As every data point is explicitly modelled using archetypes, everything is available for analytical queries performed by the Archetype Query Language (AQL). Also, data can be easily exported using nightly scheduled export jobs to dedicated business intelligence tools. Through the platform approach, the extensive costs for data integration can be minimised, or avoided all together.

HIMSS Analytics EMRAM Stage 6

In 2017, University Children's Hospital Ljubljana was successfully certified as Stage 6 in accordance with HIMSS Analytics international standards. According to HIMSS, "this eight-stage (0-7) maturity model measures the adoption and utilisation of EMR functions required to achieve a paperless environment that harnesses technology to support optimised patient care." By implementing a closed loop medication management system, a sophisticated electronic medical record, and clinical decision-support systems, this hospital information system is the first in the world to achieve Stage 6 certification based on an open platform approach.

Jörg Studzinski, director of Research and Advisory Services at HIMSS Analytics, validated the hospital according to EMRAM Stage 6 standards on-site, and had the following impression: *"This collaboration between hospital staff and their software vendor has worked extremely well. The hospital has received a comprehensive software solution with a high level of functionality, designed in a way that meets the needs of the clinicians. Due to the use of open standards, the hospital also has the ability to integrate, migrate, or share medical data in the most flexible and yet secure manner – not only with established or large organisations, but also with niche-solution providers, or start-up companies."*

The hospital's EMRAM Stage 6 certification confirms that such *open*EHR-based solutions have matured and can meet even the highest requirements, while at the same time providing the benefits of open platforms, such as preventing vendor lock-in.

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*open*EHR in Norway
High quality information models for all e-health initiatives

Norway has a growing ecosystem of ***open*EHR**-based applications from several vendors, as well as a national archetype modelling and governance program coordinated through Nasjonal IKT.

History

Norwegian clinicians have been using electronic health records since the 1990s. In 2002 a Norwegian hospital, as the first hospital in the world, removed all paper based text documentation. As of 2018, several vendors are making the transition from mainly text based electronic health records to modern structured health records with decision and process support.

Two parallel and independent factors led to the Nasjonal IKT archetype governance program and the use of *open*EHR in Norway.

First, the hospitals tasked Nasjonal IKT with doing several feasibility studies about common information models in the late 2000s and early 2010s. Second, in 2010 DIPS AS chose and demonstrated *open*EHR as the information framework for their next generation e-health platform; DIPS Arena. These two initiatives started completely independent of each other, and both concluded that *open*EHR was the only real contender as a specification for specifying and governing common clinical information models, and for building an open e-health platform.

Organization of the Norwegian healthcare sector

The Norwegian health sector is organized under two different government ministries. The Ministry of Health and Care services is responsible for the hospital sector, and manages healthcare through the subordinate Directorate of health and Directorate of e-health. The Ministry of local government and modernisation is responsible for primary and aged care, through the 422 municipalities.

Hospitals are organized in four regional health authorities, which get their mandate and financing through the Ministry of Health. Primary care doctors are mainly private practices working for the municipalities, while aged care mainly operates as public services by the municipalities.

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Archetype governance program

The archetype governance program is a collaboration between Nasjonal IKT, the public hospitals of Norway and the software vendors. Nasjonal IKT provides centralized coordination of the modelling effort, hospitals provide domain experts to decide the semantics of the models, and the vendors provide implementation requirements and expertise.

The goal of the governance program is to offer high quality information models for all e-health initiatives in Norway, in order to facilitate information reuse, exchange and comparability in both primary and secondary use scenarios.

The governance program collaborates closely with the international *open*EHR Foundation Clinical Models Program, which has proved to be beneficial for both parties in terms of both quality, reuse, and rate of development. Using this collaboration method, models developed in one locality can be jointly reviewed across multiple locations and languages, and reused across the globe. This method will be further strengthened the more governance programs join the international collaboration.

The standardization processes employed are untraditional in the sense that they use specialist online tools and short, iterative review rounds instead of meetings. This approach is crucial in order to get clinicians to participate in archetype reviews, as it is significantly less time consuming and more agile than traditional standardization approaches. As a result, more than 50 % of review participants are healthcare professionals that see patients in their daily work.

NASJONAL IKT

Nasjonal IKT is the Norwegian public hospital sector's main collaboration arena for information and communication technology.

DIPS

DIPS AS is the leading supplier of e-health systems to Norwegian hospitals.

WebMed

WebMed is an *open*EHR based EHR system for GP doctors and specialists outside hospitals. Developed by Fürst, the largest medical laboratory in Norway.

Pasient Sky™

PatientSky is the leading and innovative supplier of e-health systems to the Norwegian primary health care domain. We deliver an open e-health platform together with PAS and EHR.

Ecosystem

DIPS, Fürst and PasientSky are the three most prominent Norwegian vendors using *open*EHR as a sturdy technical and semantic platform for building their systems.

Patients move between healthcare providers and data are stored in different e-health systems. The current messaging platform is too difficult to expand, and too expensive to maintain. A shared information model is a requirement for making safe and effective patient journeys from primary care and into the hospitals and back.

*open*EHR was chosen by the vendors because of the well-written specifications. The archetype modelling approach facilitates the fundamental idea that healthcare professionals should teach the system about healthcare, and not the other way around. *open*EHR provides a reference model which allows for runtime extension of the system, archetypes for advanced clinical modelling, a rule based language for decision support and recently also a specification for vendor neutral clinical processes.

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German *open*EHR User Group
Building a community

While HiGHmed is certainly the largest German project using ***open*EHR**, there is a growing number of research projects and companies interested to use its capabilities to address their interoperability challenges.

However, the *open*EHR specification is comprehensive and requires some clinical informatics skills and development capabilities. Hence, there is growing demand to exchange the expertise and experience gained through different projects in Germany.

For this reasons, the HiGHmed symposium on 18th of June in Heidelberg, Germany marks the founding date of the **German *open*EHR User Group**.

Amongst other things, the user group will supply the following purposes:

- Serve as starting point for interested parties by providing contacts to German and international users and projects
- Provide an overview on the German activities on its website
- Create and distribute information and educational material – online and offline
- Organize annual meetings to exchange experience and connect users
- Provide a mailing list to enable discussions and community support
- Give feedback to the *open*EHR Foundation regarding the further development of the specifications
- Help coordinate archetype modelling activities within the (German) *open*EHR community
- teaching & research activities

The *open*EHR User Group will start its activities as informal association to avoid unnecessary costs and complexities. Eventually, after having established a vivid community, we aim to transform the user group to an official German chapter of *open*EHR. This way, political and professional representation of the community will be ensured. Then, contributing to established national interoperability meetings, such as the *Interoperabilitätsforum*, will be aspired.

See **www.*open*EHR.de** for further information and join the open platform movement!

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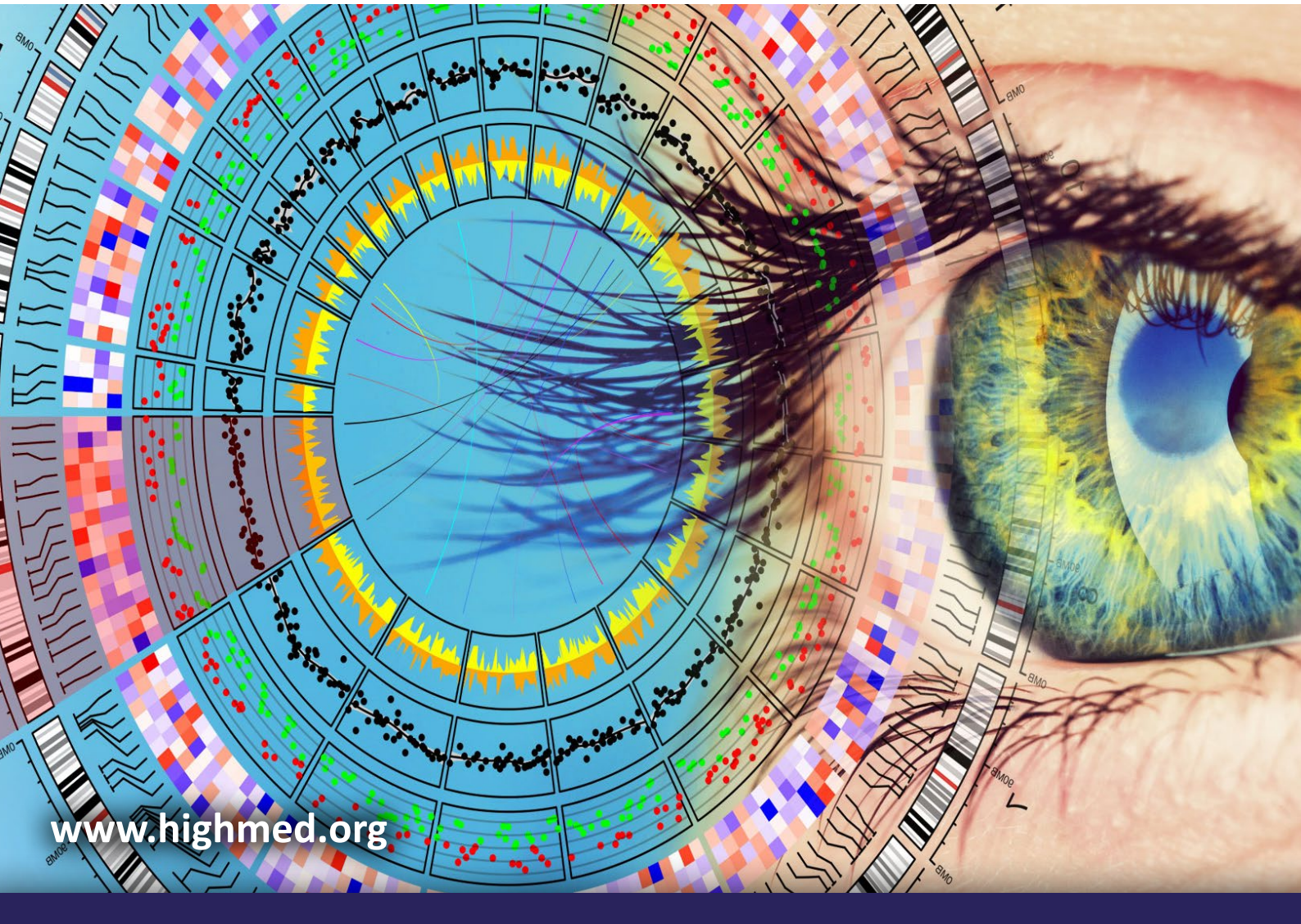

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