

XForms Implementation of a Federated Electronic Health Record, Using a Blockchain

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Czechia



XForms Implementation of a Federated Electronic Health Record, Using a Blockchain

Electronic Health Records (EHR)

The fragmented record – repository and federated solutions

Valkyrie – a federated health record for mental health

The federated record as a blockchain

XForms Implementation of a Federated Electronic Health Record, Using a Blockchain



Electronic Health Record

TIUMACH, Orest (Mr) Born: 19-Jul-1983 (42 years) Gender: Male
Patient Id 272722822 NHS Number 262727272

Quit Administration

cityEHR

Dashboard Patient Search Patient Cohorts In-Tray Clinics Orders Registration

In Progress New Hide Events Summaries Forms Letters Pathways Ordering Prescribing Booking Show

▼ cityEHR Feature Demo (27)

- Acid Base Disorders
- Allergies and Warnings
- Bone Chemistry
- Hospital Anxiety and Depression Scale
- Laboratory Test Results
- Patient Summary
- Update Patient Demographics
- Feature Demonstration

DAS 28

Disease Activity Score (DAS 28)

DAS 68

Diagnosis

Family History

Fracture History

04-Feb-2026 - DAS 28 * Page load time:

Show ISO-13606 ☐ Show Ids ☐ Highlight Entries -- None -- Word Processor Template Demographics - Libre Office

Disease Activity Score (DAS 28)

Count Swollen Joints 3 Tender Joints 1

ESR 24

Visual Analogue Scale 3

DAS Score 3.69

cityEHR Version Number - 1.7-2026-01-31-3 User: cityEHR Administrator / cityEHR Feature Demo / en-gb Logged on: 05:09:50 Wednesday, 4th February 2026 Last logged on: 04:41:44 Wednesday, 4th February 2026

Recording Vital Signs

TIUMACH, Orest (Mr) Born: 19-Jul-1983 (42 years) Gender: Male
Patient Id 272722822 NHS Number 262727272 

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Patient Images
Body Mass Index
Bone Mineral Density
Diet and Exercise Plan
Diet and Strength Plan
Book Services
Lifestyle Assessment
Lifestyle Assessment and Schedule
Blood Pressure History
Lifestyle Scale Questionnaire

04-Feb-2026 - Vital Signs * Page load time:
 Show ISO-13606 ☐ Show Ids ☐ Highlight Entries -- None -- Word Processor Template Demographics - Libre Office
    

Vital Signs

Body Temperature	38.5	(°C)
Heart Rate	78	(beats per minute)
Respiratory Rate	18	(breaths per minute)
Blood Pressure	Systolic 125 (mmHg)	Diastolic 78 (mmHg)

cityEHR Version Number - 1.7-2026-01-31-3 User: cityEHR Administrator / cityEHR Feature Demo / en-gb Logged on: 05:09:50 Wednesday, 4th February 2026 Last logged on: 04:41:44 Wednesday, 4th



A Structured EHR, Using the ISO 13606 Standard

TIUMACH, Orest (Mr) Born: 19-Jul-1983 (42 years) Gender: Male
Patient Id 272722822 NHS Number 262727272 

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04-Feb-2026 - Vital Signs * Page load time:
 Show ISO-13606 ☒ Show Ids ☐ Highlight Entries -- None -- Word Processor Template Demographics - Libre Office
    

Vital Signs

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cityEHR Version Number - 1.7-2026-01-31-3 User: cityEHR Administrator / cityEHR Feature Demo / en-gb Logged on: 05:09:50 Wednesday, 4th February 2026 Last logged on: 04:41:44 Wednesday, 4th

Standard Representation Using HL7 CDA

TIUMACH, Orest (Mr) Born: 19-Jul-1983 (40)

Patient Id 272722822 NHS Number 26272727

In Progress New Hide Events

- Patient Images
- Body Mass Index
- Bone Mineral Density
- Diet and Exercise Plan
- Diet and Strength Plan
- Book Services
- Lifestyle Assessment
- Lifestyle Assessment and Schedule
- Blood Pressure History
- Lifestyle Scale Questionnaire

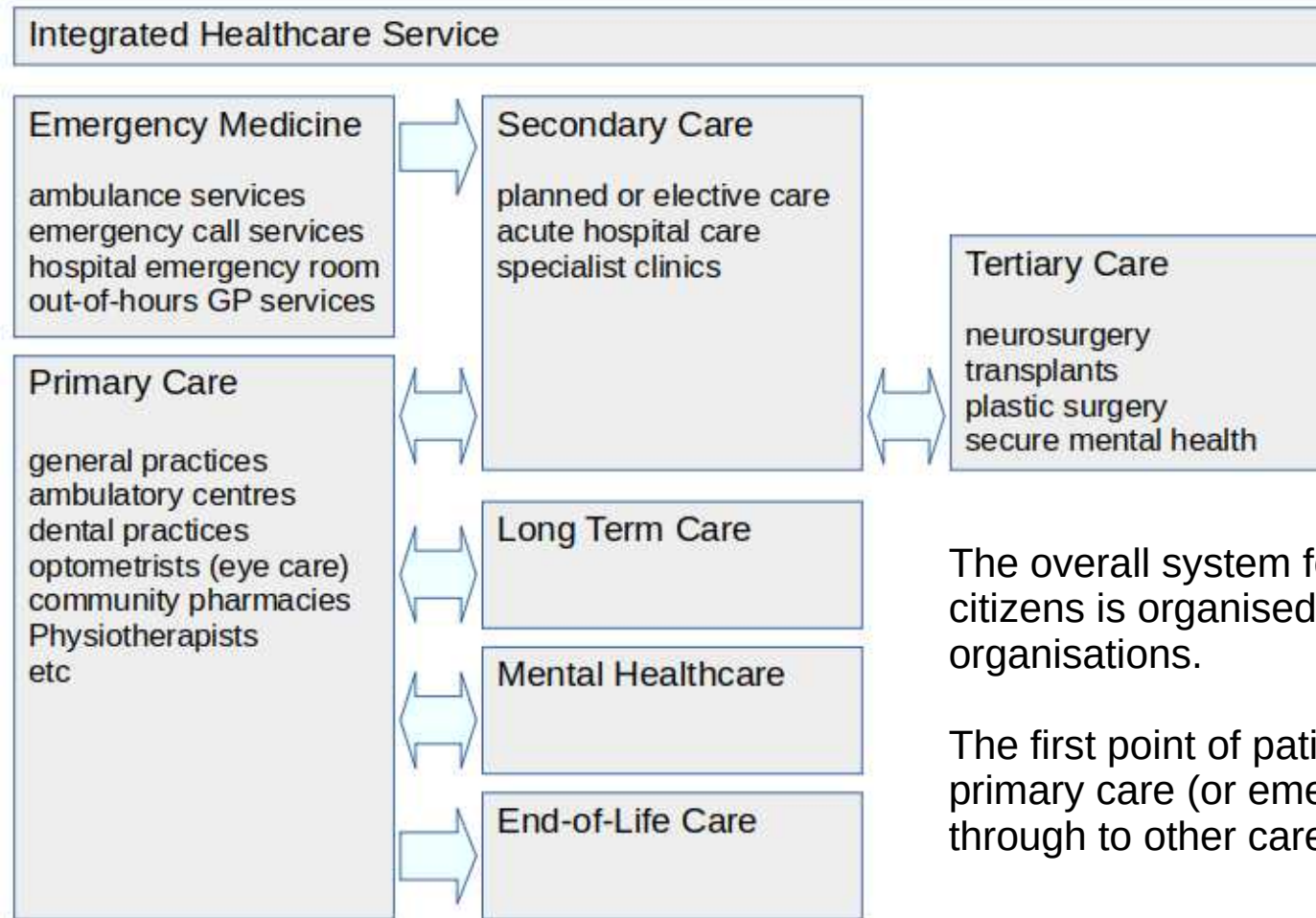
cityEHR Version Number - 1.7-2026-01-31-3 User: cityEHR Ad

XML Document Viewer

Download Close

```
<ClinicalDocument xmlns:cityEHR="http://openhealthinformatics.org/ehr" xmlns:math="http://exslt.org/
<typeId root="#CityEHR:Form" extension="#CityEHR:Form:VitalSigns"/>
<templateId root="#ISO-13606:EHR_Extract:cityEHR" extension="#ISO-13606:Folder:FeatureDemo"/>
<id root="cityEHR" extension="#CityEHR:Form:VitalSigns"/>
<code code="" codeSystem="cityEHR" displayName="Vital Signs"/>
<effectiveTime value="2026-02-04T05:23:21.523Z"/>
<recordTarget>
  <patientRole>
    <id extension="272722822"/>
    <patient>
      <name>
        <prefix>Mr</prefix>
        <given>Orest</given>
        <family>Tiumach</family>
      </name>
      <administrativeGenderCode code="" codeSystem="" displayName="Male"/>
      <birthTime value="1983-07-19"/>
    </patient>
    <providerOrganization>
      <id extension="cityEHR" root="#ISO-13606:EHR_Extract:cityEHR"/>
      <name/>
```

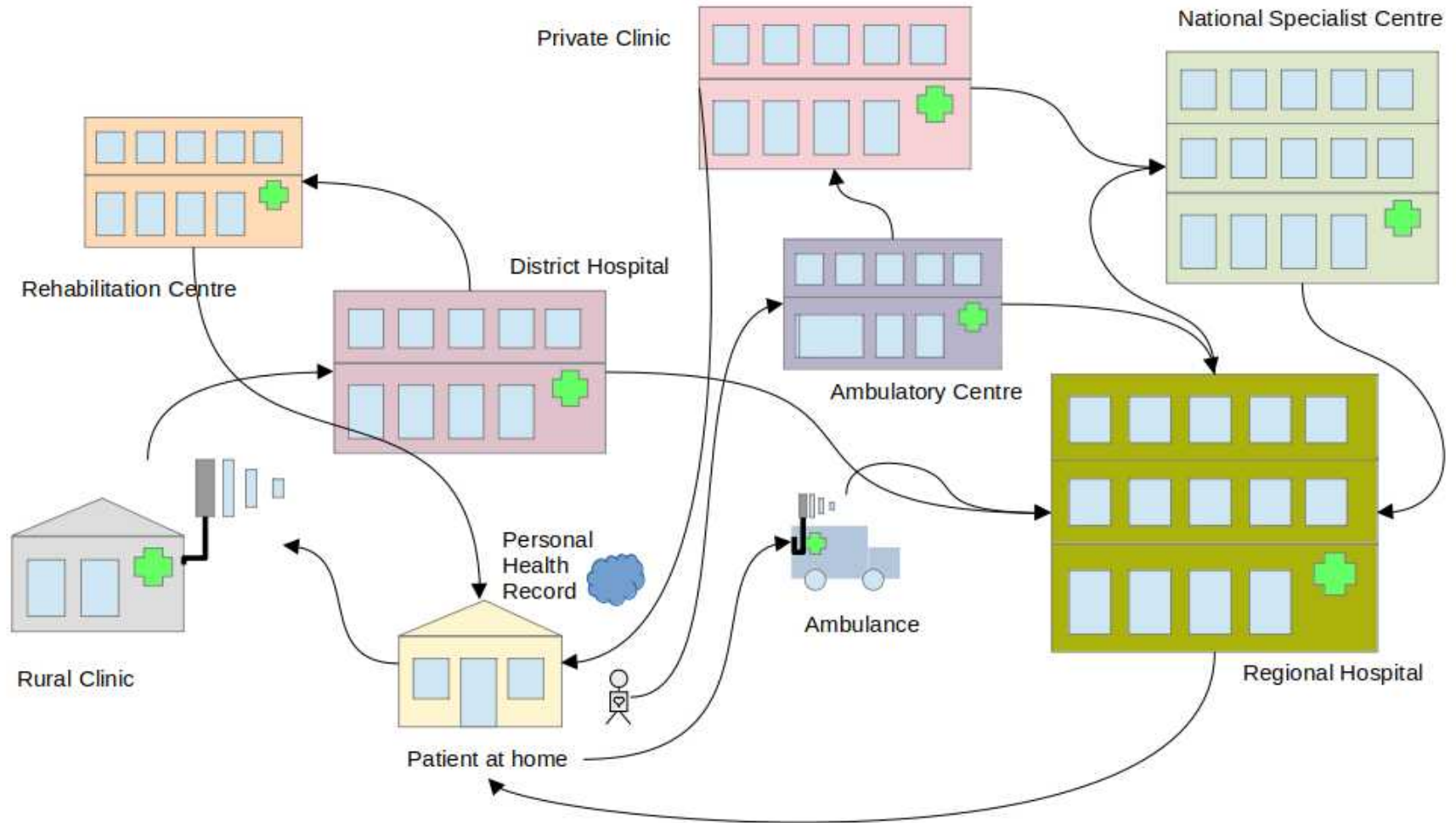
The Healthcare Delivery System



The overall system for the delivery of healthcare to citizens is organised as a set of provider organisations.

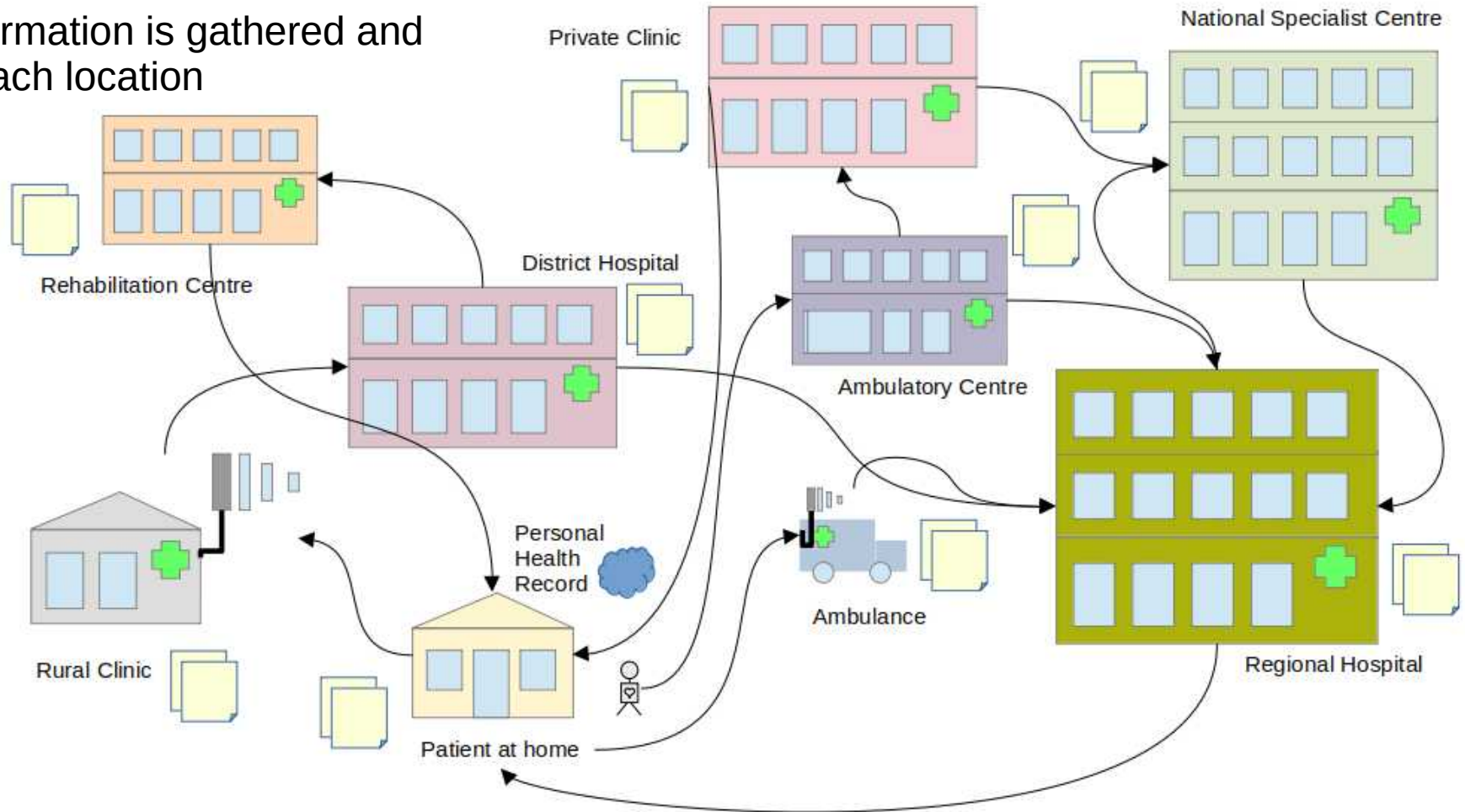
The first point of patient contact is usually in primary care (or emergency services) with referral through to other care providers.

The Patient Journey



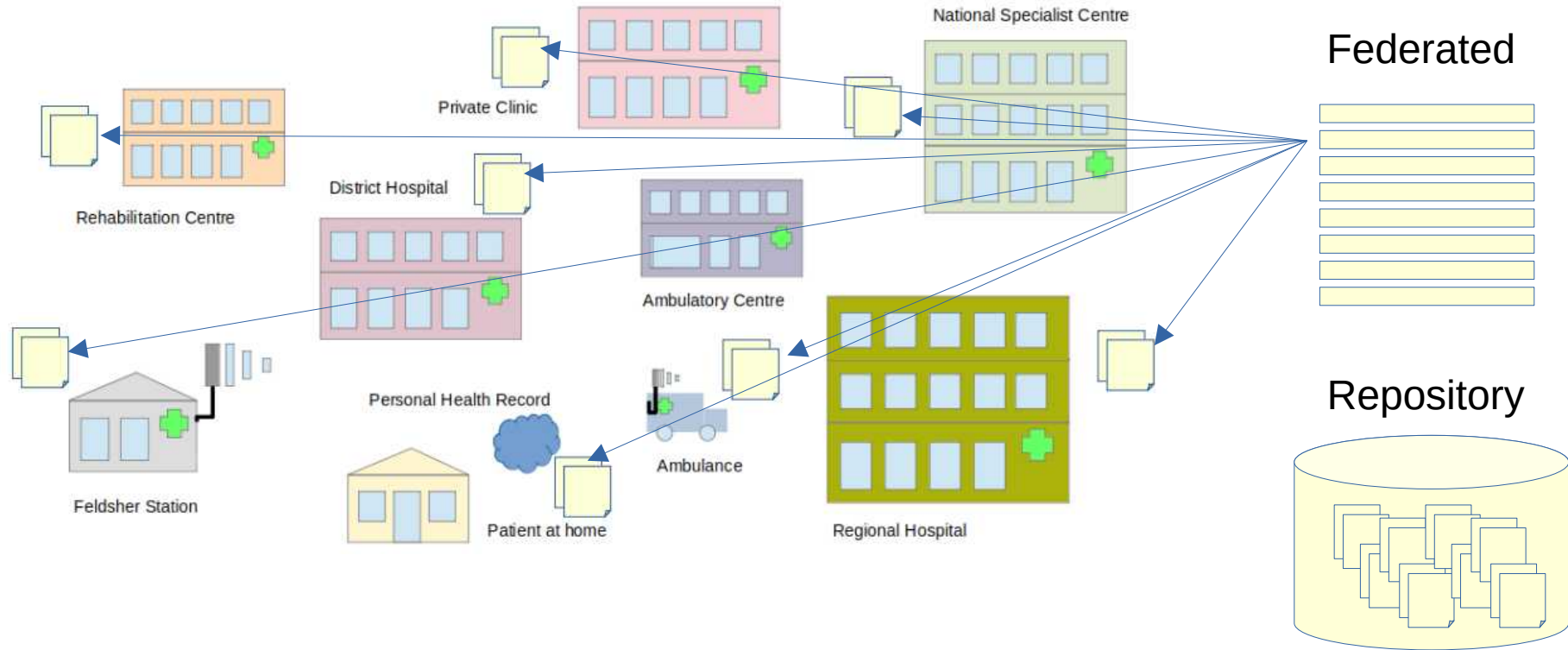
Silos of Patient Information

Patient information is gathered and stored at each location



Federated or Repository EHR

Electronic Health Record (EHR) – the complete, cradle-to-grave, longitudinal health record. Gathers together all the silos of patient information.



The Valkyrie Project

A distributed service-oriented architecture for
coordinated healthcare services

Alternative title: Distribuert tjenesteorientert arkitektur for koordinerte helsetjenester

Awarded: NOK 16.0 mill.

Source:	Research council of Norway
Project Manager:	Professor Terje Geir Solvoll
Project Number:	312492
Application Type:	Forskerprosjekt / Fornyelse
Project Period:	2021 - 2027
Funding received from:	IKTPLUSS-IKT og digital innovasjon
Organisation:	Helseforetak / Helse Nord RHF / UNIVERSITETSSYKEHUSET NORD-NORGE HF / UNIVERSITETSSYKEHUSET NORD-NORGE HF NASJONALT SENTER FOR E- HELSEFORSKNING / Nasjonalt senter for e-helseforskning
Location:	Troms - Romsa - Tromssa / Tromsø
Subject Fields:	Medisin og helsefag / Helsefag / Helsetjeneste-, helseadmforskning
Partner countries:	Canada Storbritannia Portugal

<https://prosjektbanken.forskningsradet.no/en/project/FORISS/312492>

Norwegian Centre for E-health Research
University Hospital of North Norway, Tromsø,
Norway

Valkyrie - distributed service-oriented architecture for coordinated healthcare services

Description

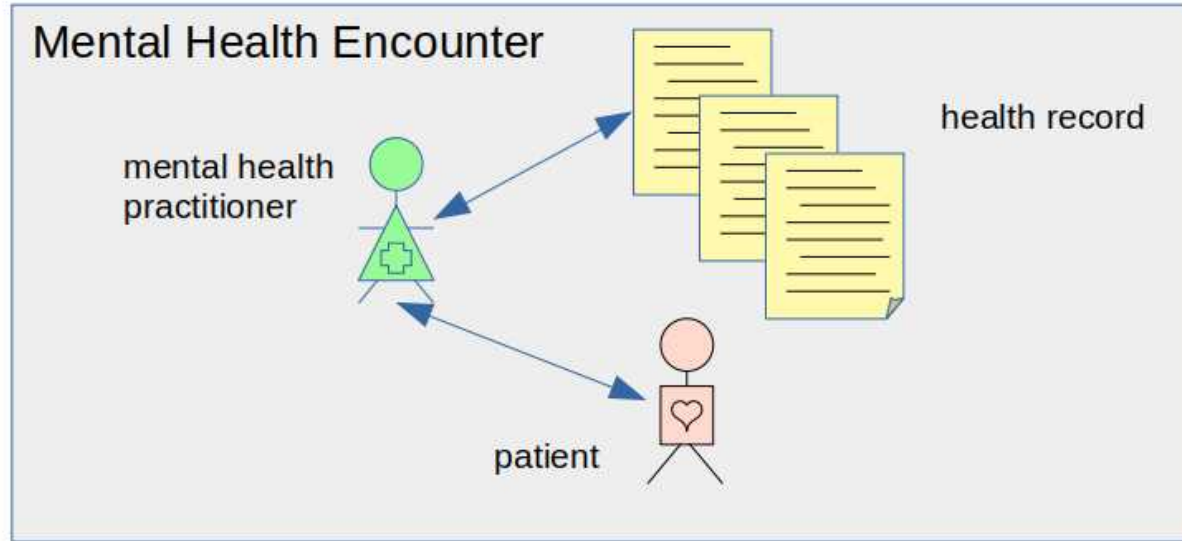
The aim of Valkyrie is to develop a technical
prototype of an ICT architecture to promote
health care services coordination.

Valkyrie will work to reduce the gap in
relevant patient health data availability
between health care services in different
levels. Patient-centric pathways will guide our models to make the relevant patient
health data available to the relevant health professionals.



<https://ehealthresearch.no/en/projects/valkyrie-distributed-service-oriented-architecture-for-coordinated-healthcare-services>

Federated EHR for Mental Health



The mental health encounter (as in any clinical encounter) requires interaction between the patient and the practitioner, with access to the patient's health record.

Fragments of the health record can be found in primary care systems, acute hospital systems and specialist mental health systems.

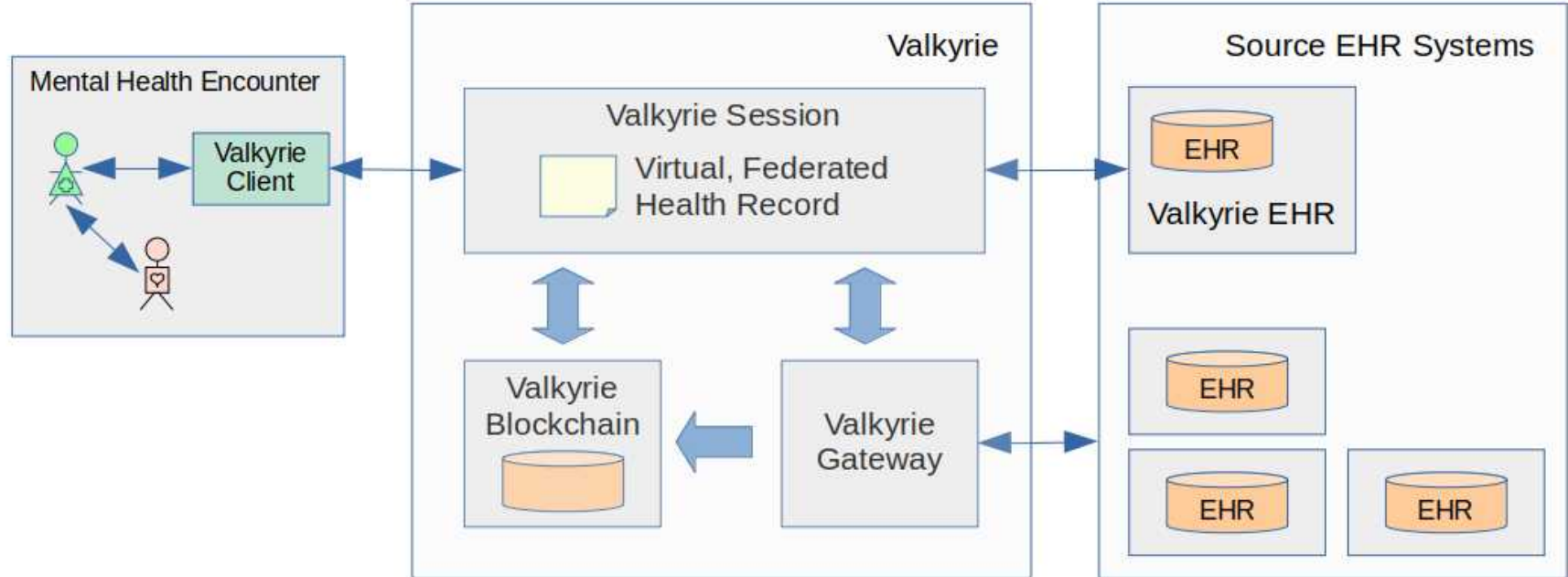
Although Norway has an advanced eHealth infrastructure, there is no integrated view across these information silos.

This is the usual scenario in any country.

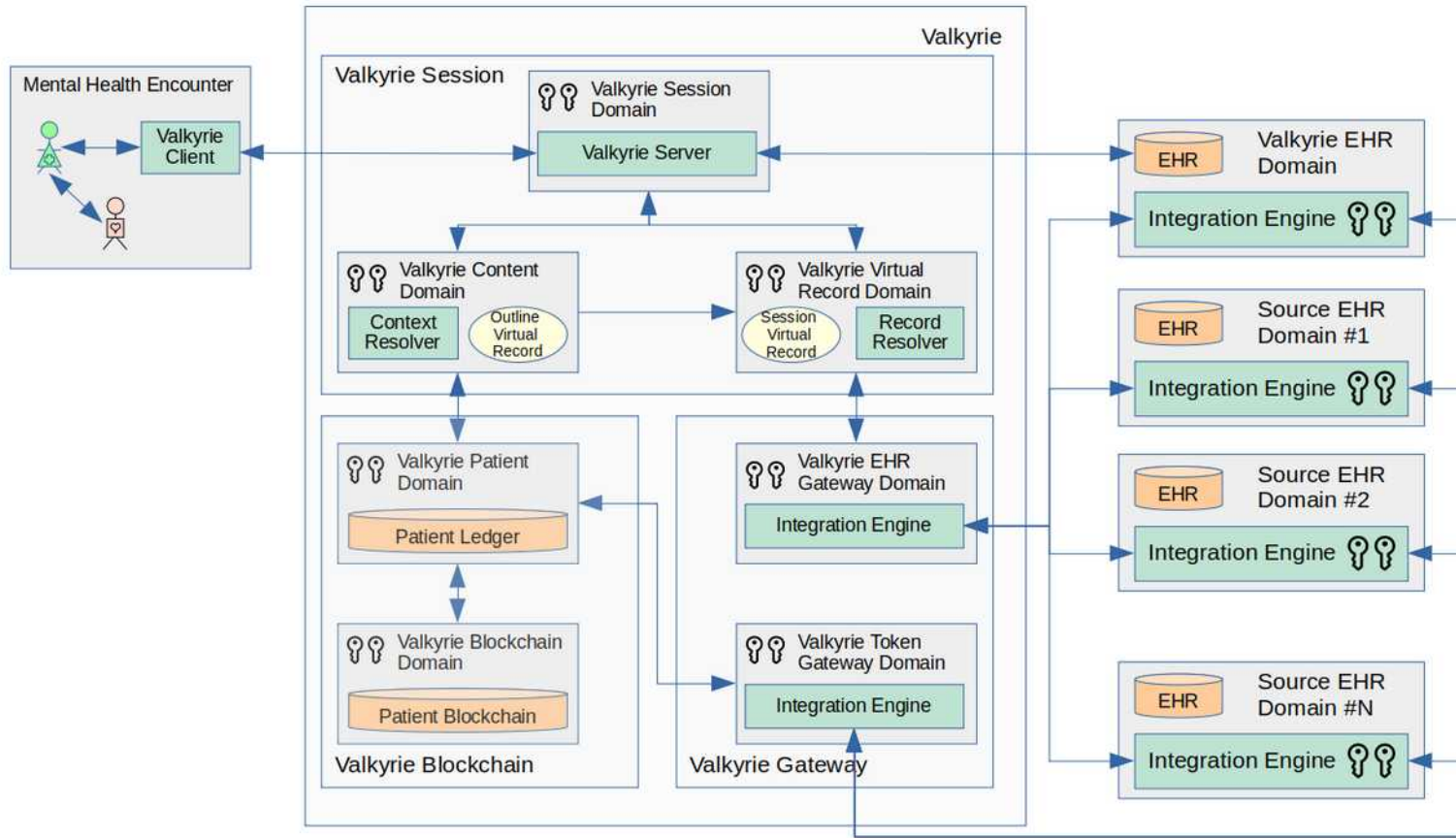
The Valkyrie Architecture

The Valkyrie Architecture is designed to provide mental health practitioners with access to the full patient record, regardless of where fragments of the record are stored.

Access must be secure and transitory – no patient information can be cached in Valkyrie between sessions.



Valkyrie Security Domains



Source EHR systems generate an Encrypted Token each time a health event is recorded.

The token is passed to the Valkyrie Gateway and then through a series of Valkyrie Domains

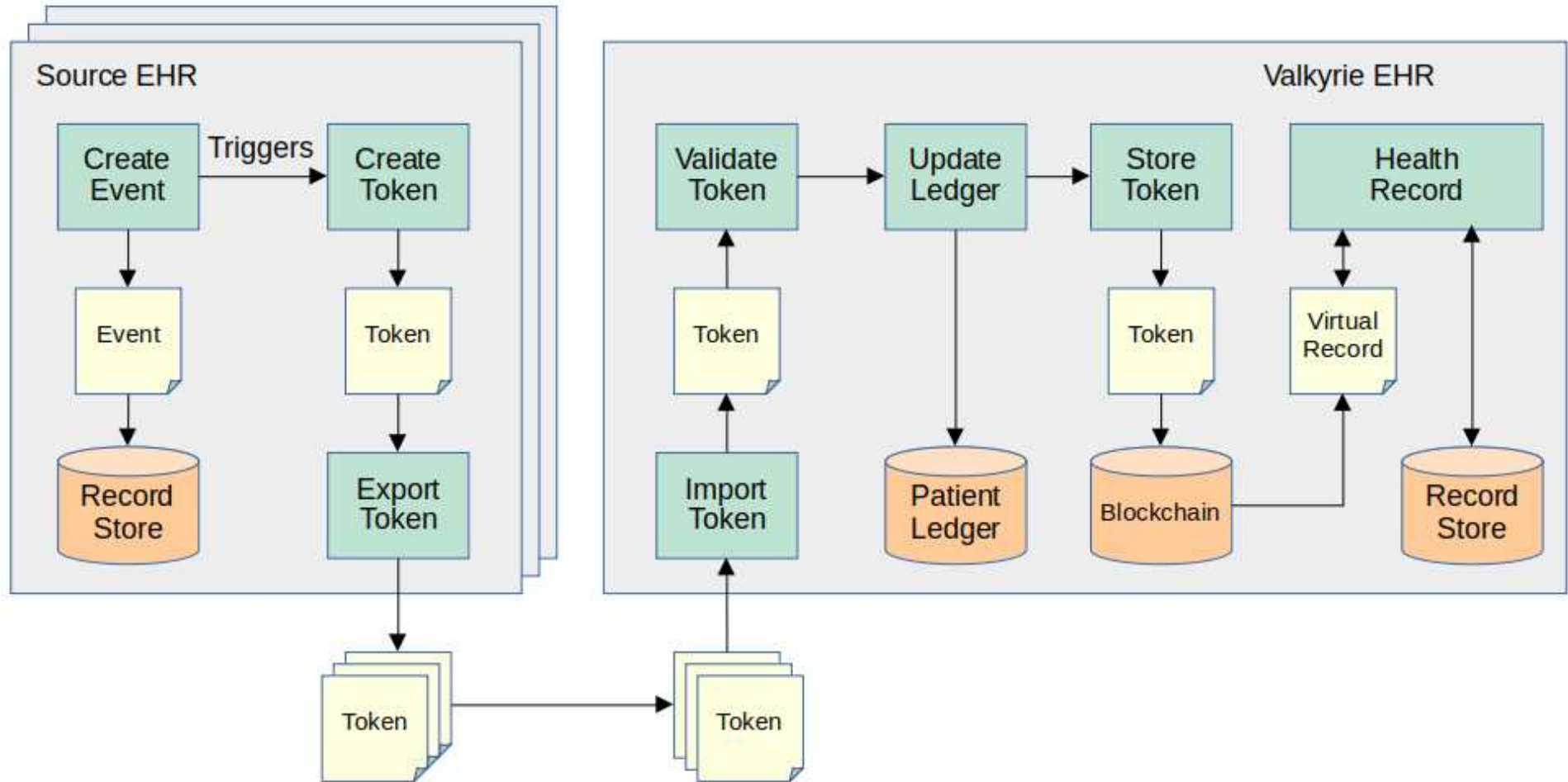
Token Gateway Domain

Patient Domain
Blockchain Domain

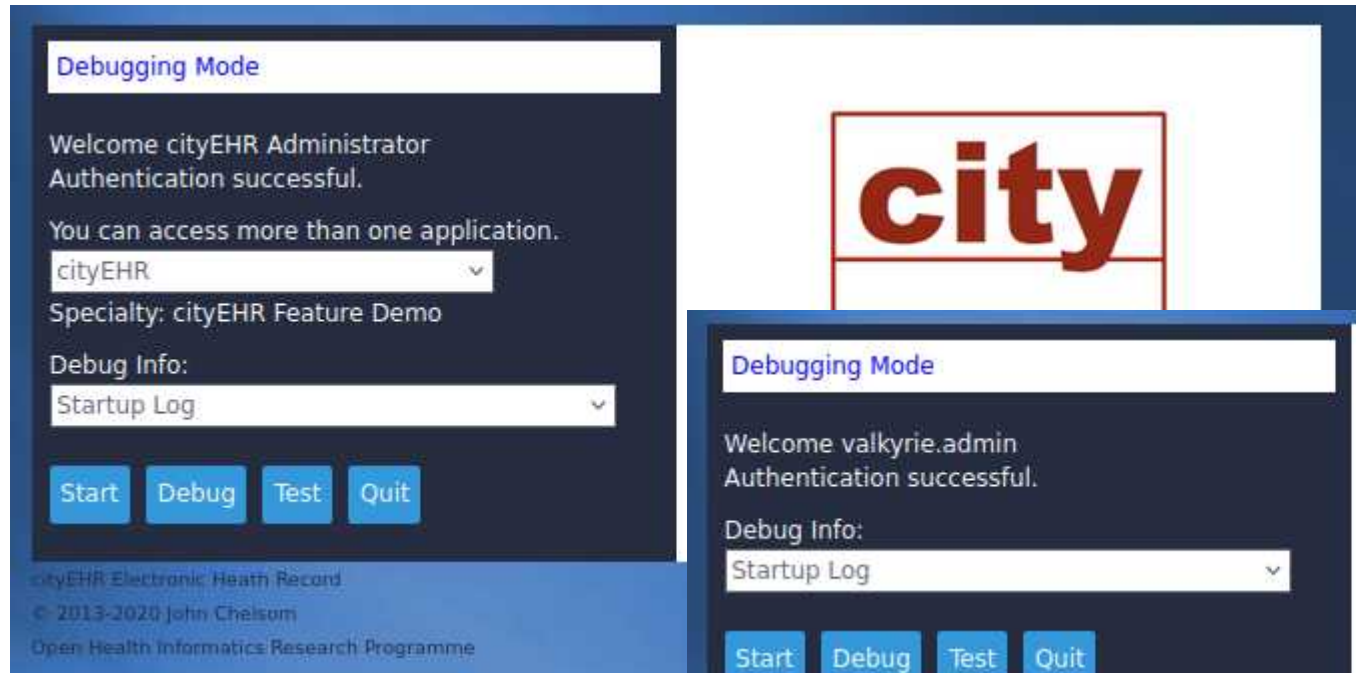
Content Domain
Virtual Record Domain

EHR Gateway Domain

Prototype Using XForms (cityEHR)



cityEHR – Framework For Multiple EHR Applications



Set Up The Role of the Application

Quit Administration

Dashboard Patient Search Patient Cohorts In-Tray Clinics Orders Registration

Hide

valkyrie - Administration - Manage Application Parameters

Show

▼ System

Specialties: Valkyrie Base (Common) Model Debug Info: Startup Log

Manage Application Parameters Base language: en-gb - English / en-gb - English Parameter Set: Valkyrie Federated Health Record Edit

Manage System Parameters

Manage System Icons

Manage Stylesheets

Import Language Pack

Apply All Language Packs

View Audit Log

Valkyrie Federated Health Record (valkyrie)

Valkyrie Federated Health Record

Valkyrie Source System

Hash key seed

h32y24765jr

Quit Administration

Dashboard Patient Search Patient Cohorts In-Tray Clinics Orders Registration

Hide

cityEHR - Administration - Manage Application Parameters

Show

▼ System

Specialties: cityEHR Base (Common) Model Debug Info: Startup Log

Manage Application Parameters Base language: en-gb - English / en-gb - English Parameter Set: Valkyrie Federated Health Record Edit

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Manage Stylesheets

Import Language Pack

Apply All Language Packs

View Audit Log

Valkyrie Federated Health Record (valkyrie)

Valkyrie Federated Health Record

Valkyrie Source System

Hash key seed

h32y24765jreje

Encrypted Tokens

Encrypted Token

Patient Identifier

Session Parameters

Event Locator

Event Domain

Event Address

Event Metadata

Clinical Coding

```
<?xml version="1.0" encoding="UTF-8"?>
<encryptedToken id="" linkId="" securityDomain="patientDomain">
  <patientId>1234567890</patientId>
  <sessionParameters userId="" sessionId=""/>
  <eventLocator securityDomain="ehrGatewayDomain">
    <eventDomain>198.192.56.18</eventDomain>
    <eventAddress securityDomain="sourceEHR">
      ehr/access/38388383
    </eventAddress>
  </eventLocator>
  <eventMetadata securityDomain="virtualRecordDomain">
    <effectiveTime>2021-09-24</effectiveTime>
    <eventType id="note123" displayName="Clinic Note"/>
    <provenance organisation="" assignedPerson=""/>
  </eventMetadata>
  <clinicalCoding securityDomain="contentDomain">
    <code codeSystem="SNOMED" code="3113331"/>
    <code codeSystem="SNOMED" code="7575859"/>
    <code codeSystem="SNOMED" code="9484847"/>
  </clinicalCoding>
</encryptedToken>
```

Tokens are generated and exchanged in XML or JSON format.

Sections of the token are encrypted using the public key of the Valkyrie Domain in which they are used.

Each Domain that uses the token decrypts the relevant section(s) using its private key

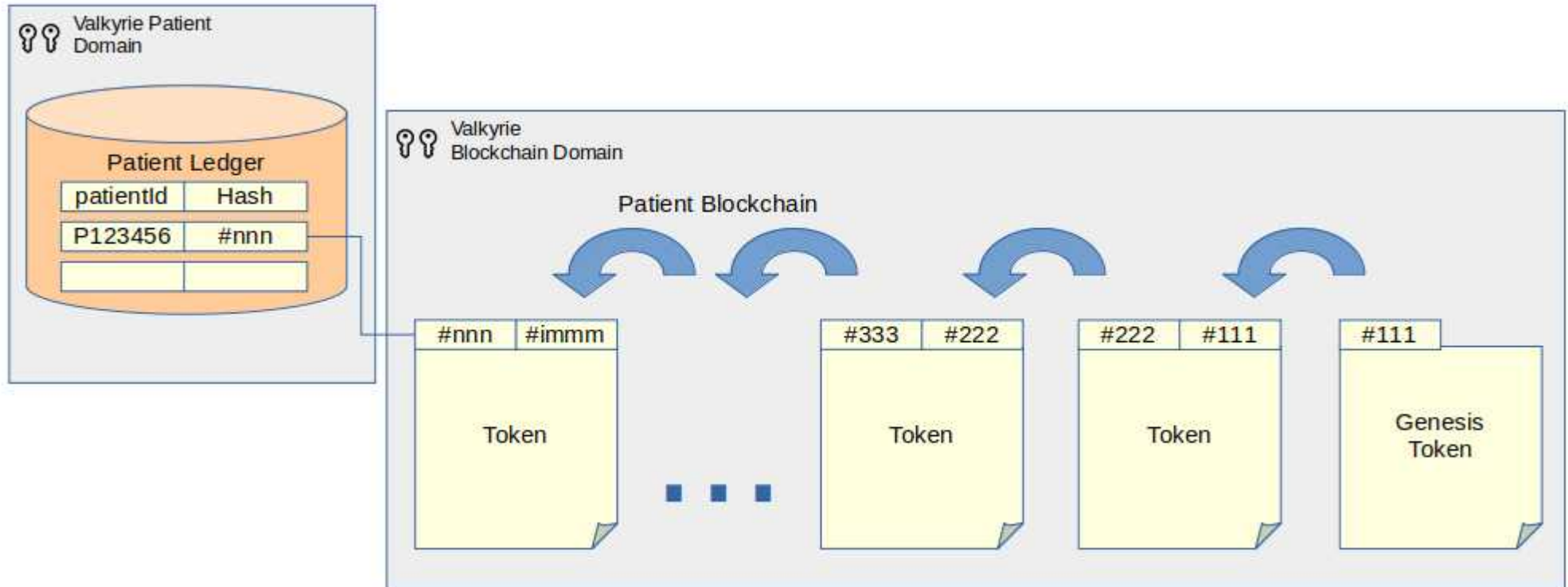
Tokens Exported When Events are Stored

```
<!-- Export Valkyrie token, if configured -->
<xxf:variable name="valkyrieParameters" select="xxf:instance('application-parameters-instance')/valkyrie"/>
<xf:action
  if="$valkyrieParameters/valkyrieSystem/@value='true' or $valkyrieParameters/valkyrieSource/@value='true'">
  <xf:dispatch name="export-valkyrieToken" target="valkyrie-model">
    <xxf:context name="applicationIRI" select="xxf:instance('session-parameters-instance')/applicationIRI"/>
    <xxf:context name="composition" select="xxf:instance('form-instance')"/>
  </xf:dispatch>
</xf:action>
```

If the cityEHR application is designated as a Valkyrie source then encrypted token is exported when a new event is committed to the patient record.

Blockchain of Encrypted Tokens

The patient registration event generates the genesis token (block) in the blockchain for a patient. Subsequent tokens are appended to the chain and the Patient Ledger is updated to reference the current end of the blockchain.



Storage of Encrypted Tokens

Tokens are stored as individual documents in the XML data store.

Quit Administration

Dashboard Patient Search Patient Cohorts In-Tray Clinics Orders Registration

Hide valkyrie - Administration - Browse Physical Databases Show

System: EHR Application Database: Built-in Database Node: builtin-basicEHR Version: 1.4.1dev

/db/ehr/xmlstore/applications/ISO-13606-EHR_Extract-valkyrie/valkyrie/tokenStore

Show BTUs ☐ Sort by: Type Filter:

Name	Type	Size	Last Modified
d1c2110bc7a224f849470b937fd6ed65	resource	4096	2026-02-25T13:35:28.012Z
91aa26219651c50cabd4b5a5a340c443	resource	4096	2026-02-25T13:36:09.983Z
879c8c8d5528d9b6fc91e5685fbb795b	resource	4096	2026-02-26T13:59:34.353Z
f39da7e7fcbc69634978879111d36373	resource	8192	2026-02-26T14:01:49.409Z
3138fb5cda08044808d57e85babf4582	resource	4096	2026-02-25T13:20:36.225Z
c4f625488cdd6e134dda16dabf1a8829	resource	4096	2026-02-25T13:33:14.818Z

Retrieving the Blockchain of Encrypted Tokens

```
<xf:action ev:event="get-patientBlockchain">
  <xxf:variable name="applicationIRI" select="event('applicationIRI')"/>
  <xxf:variable name="patientId" select="event('patientId')"/>
  <xxf:variable name="patientBlockchain" select="event('patientBlockchain')"/>

  <!-- Check patient ledger - status is returned blank if the patient is already in the ledger -->
  <xf:dispatch name="get-patientLedgerEntry" target="valkyrie-model"> [6 lines]

  <!-- Get the hashId for the current token -->
  <xxf:variable name="currentBlockHashId"
    select="xxf:instance('patientLedgerEntry-instance')/@currentBlockHashId"/>

  <!-- Clear the blockchain -->
  <xf:delete nodeset="xxf:instance('patientBlockchain-instance')/*"/>

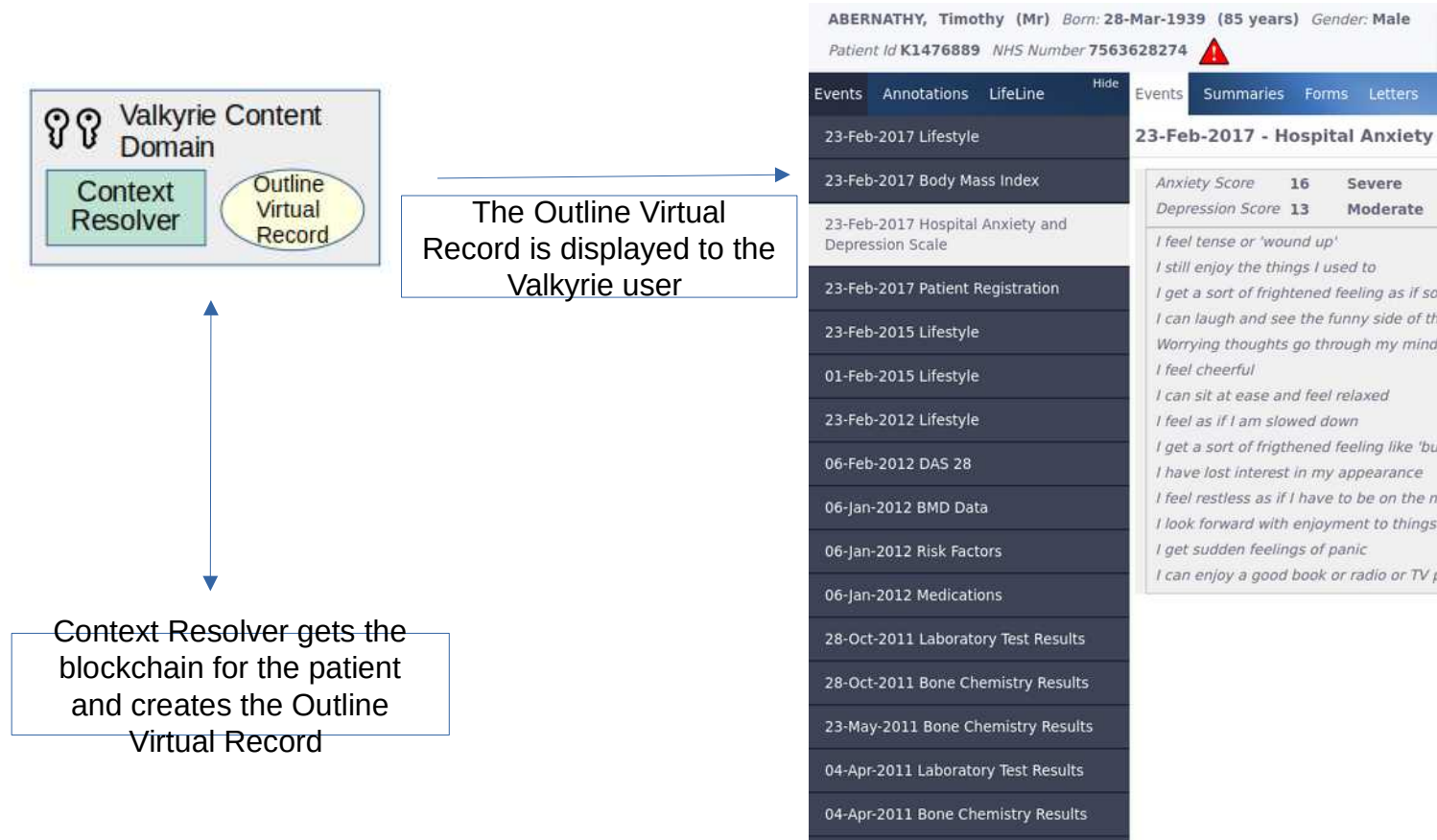
  <!-- Only if patient is found in the ledger
    Build blockchain in patientBlockchain-instance-->
  <xf:action
    if="xxf:instance('valkyrieControl-instance')/status='' and $currentBlockHashId!=''">

    <xf:dispatch name="build-blockChain" target="valkyrie-model">
      <xxf:context name="applicationIRI" select="$applicationIRI"/>
      <xxf:context name="hashId" select="$currentBlockHashId"/>
      <xxf:context name="blockchain" select="xxf:instance('patientBlockchain-instance')"/>
    </xf:dispatch>

    <!-- Set return parameter $patientBlockchain -->
    <xf:insert nodeset="$patientBlockchain"
      origin="xxf:instance('patientBlockchain-instance')"/>
  </xf:action>

</xf:action>
```

Presenting the Virtual (Federated) Record



Context Resolver gets the blockchain for the patient and creates the Outline Virtual Record

The Outline Virtual Record is displayed to the Valkyrie user

Here the outline is shown in cityEHR, with the list of events in the virtual record.

The user clicks on an event to retrieve a PDF view of that event from the original source EHR system.

Accessing Events in the Federated Record

The screenshot shows a patient record for Timothy ABERNATHY, born 28-Mar-1939 (85 years), Male. The interface includes a top navigation bar with 'Dashboard', 'Patient Search', 'Patient Cohorts', 'In-Tray', 'Clinics', 'Orders', and 'Registration'. A left sidebar lists various events, including '23-Feb-2017 Lifestyle', '23-Feb-2017 Body Mass Index', and '23-Feb-2017 Hospital Anxiety and Depression Scale'. The main content area displays the '23-Feb-2017 - Hospital Anxiety and Depression Scale' with a 'Page load time' indicator. The scale results are as follows:

Item	Score	Severity
Anxiety Score	16	Severe
Depression Score	13	Moderate

The scale items and their corresponding responses are:

- I feel tense or 'wound up' - Most of the time
- I still enjoy the things I used to - Definitely as much
- I get a sort of frightened feeling as if something awful is about to happen - Very definitely and quite badly
- I can laugh and see the funny side of things - As much as I always could
- Worrying thoughts go through my mind - A great deal of the time
- I feel cheerful - Not at all
- I can sit at ease and feel relaxed - Not often
- I feel as if I am slowed down - Nearly all the time
- I get a sort of frightened feeling like 'butterflies' in the stomach - Quite often
- I have lost interest in my appearance - Definitely
- I feel restless as if I have to be on the move - Not very much
- I look forward with enjoyment to things - Definitely less than I used to
- I get sudden feelings of panic - Quite often
- I can enjoy a good book or radio or TV program - Not often

A blue arrow points from the '23-Feb-2017 Hospital Anxiety and Depression Scale' event in the sidebar to the diagram below.

```
graph LR; VVRD[Valkyrie Virtual Record Domain] <--> VEGD[Valkyrie EHR Gateway Domain]; VVRD --> IE[Integration Engine]; subgraph VVRD; SVR((Session Virtual Record)); RR[Record Resolver]; end; subgraph VEGD; IE; end;
```

The diagram illustrates the interaction between the Valkyrie Virtual Record Domain and the Valkyrie EHR Gateway Domain. The Virtual Record Domain contains a Session Virtual Record and a Record Resolver. The EHR Gateway Domain contains an Integration Engine. Arrows indicate data flow between these components.

The Record Resolver passes the domain and locator for the Event to the EHR Gateway.

The EHR Gateway requests the Event view from the Source EHR.

The view returned to the EHR Gateway is sent back to the Record Resolver and is displayed to the Valkyrie user.

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13th - 18th September
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