

Federated Electronic Health Records Using a Blockchain

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The Valkyrie Project



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

2021 – 2027
NOK 16m (\$1.5m)

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 / Fornytelse
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>

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.



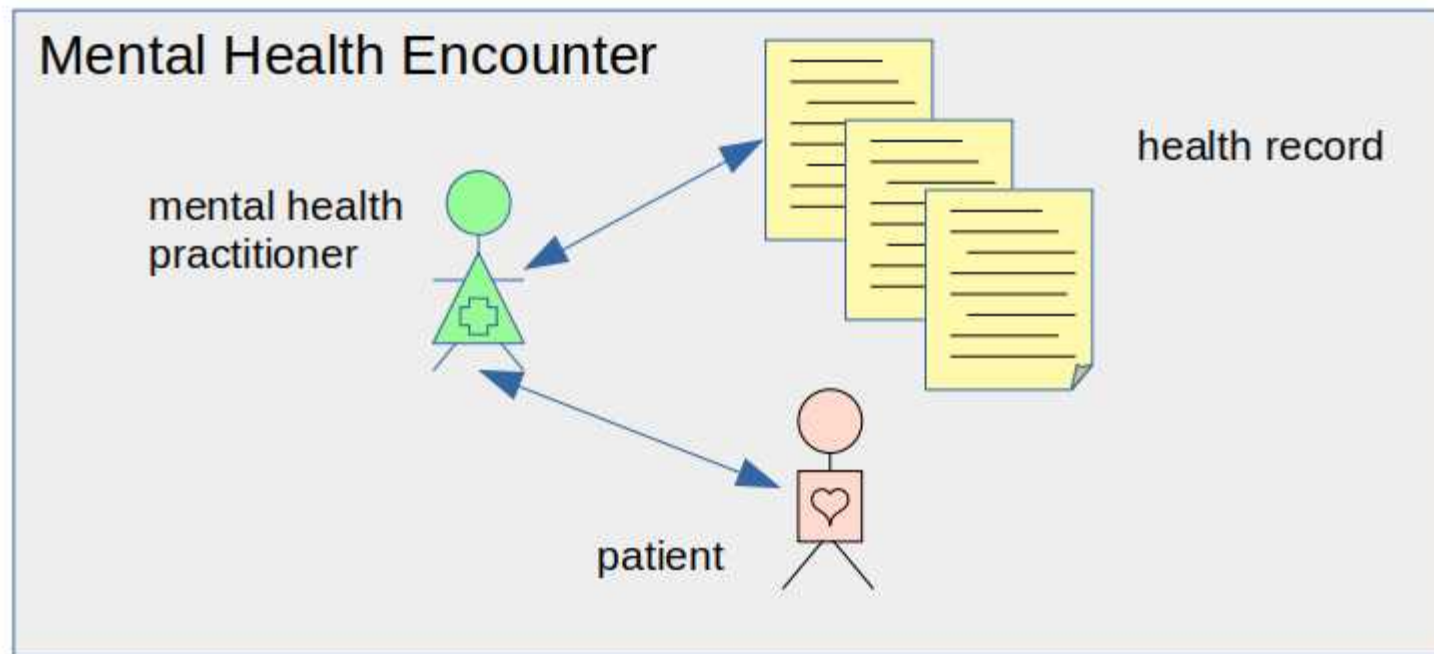
<https://ehealthresearch.no/en/projects/valkyrie-distributed-service-oriented-architecture-for-coordinated-healthcare-services>

Athens, Greece, August 25–29, 2024

Federated Electronic Health Records Using a Blockchain

FORDHAM UNIVERSITY

Federated Health Record 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.

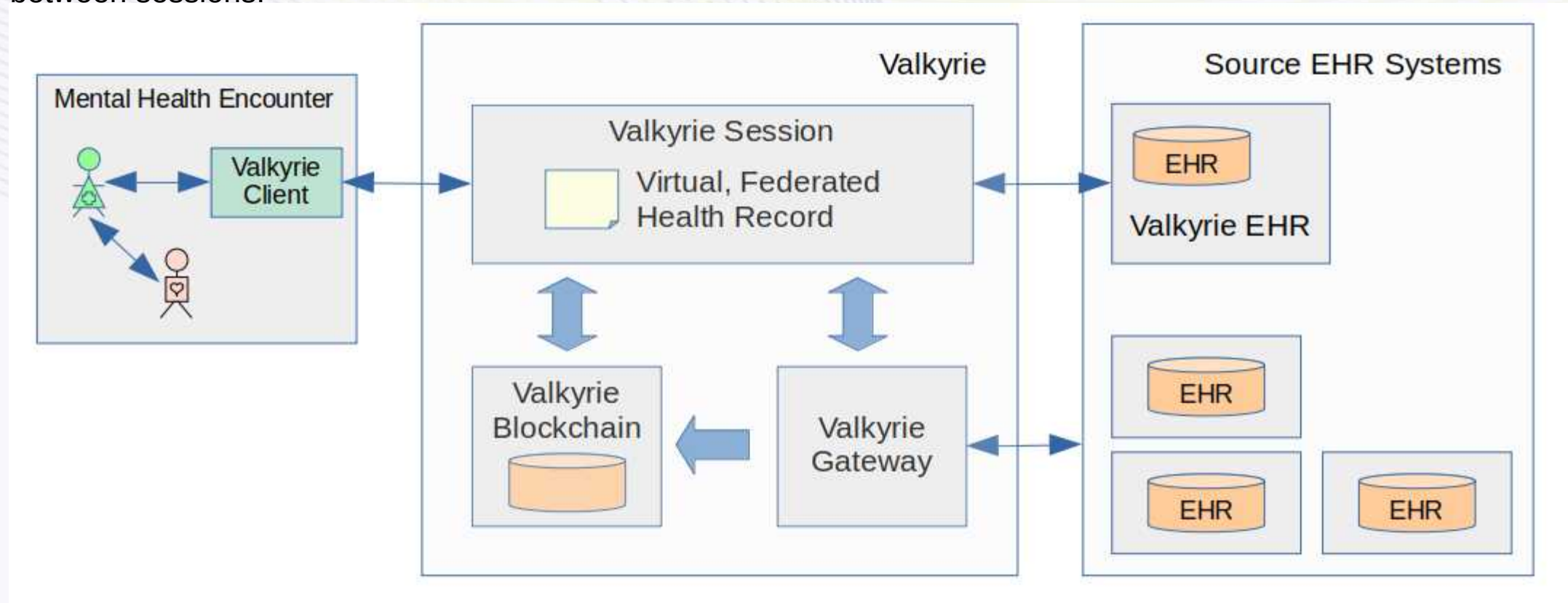
Although Norway has an advanced eHealth infrastructure, there is no integrated view across these information silos.

This is the usual scenario in any country.

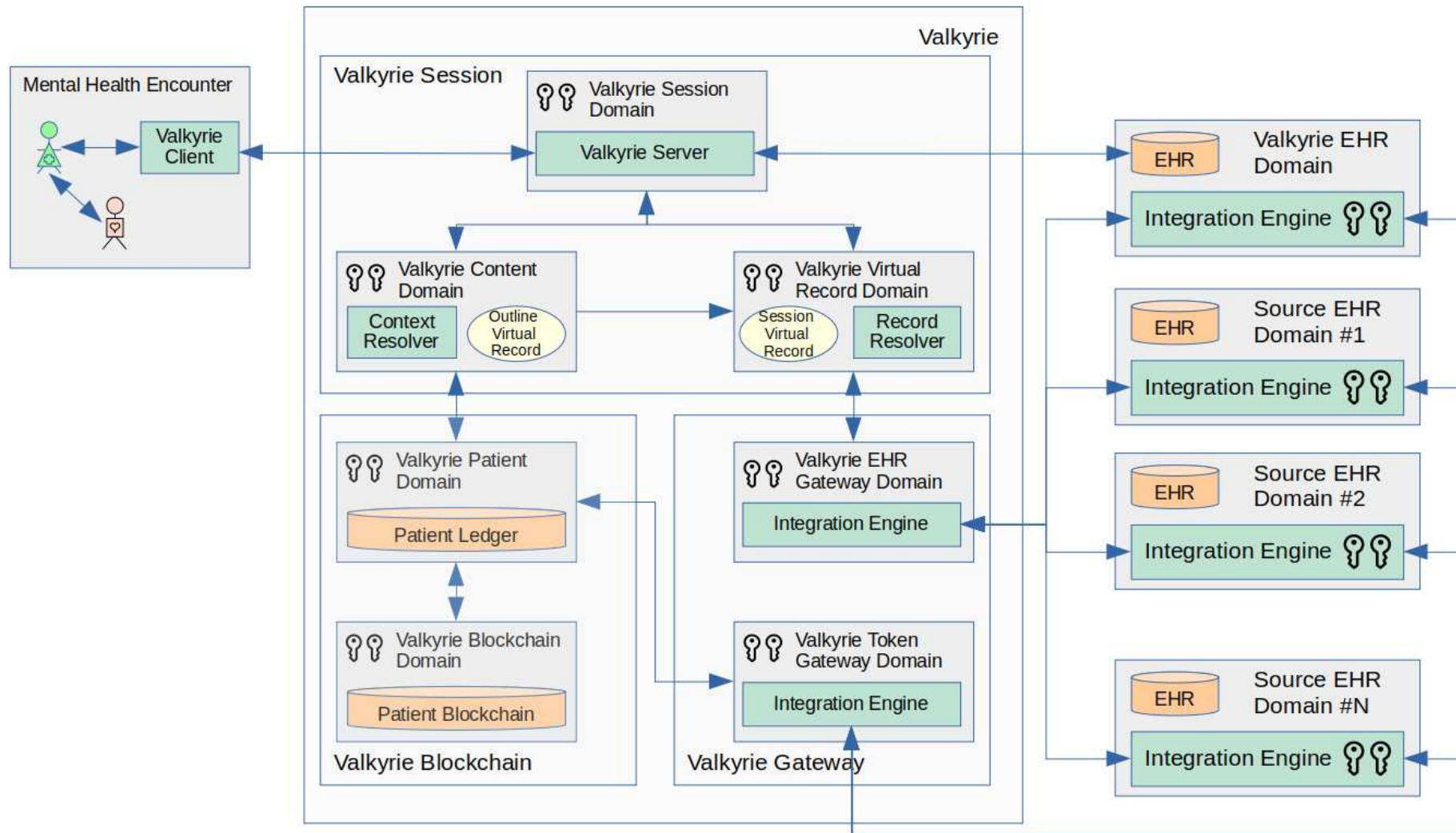
The Valkyrie Architecture

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

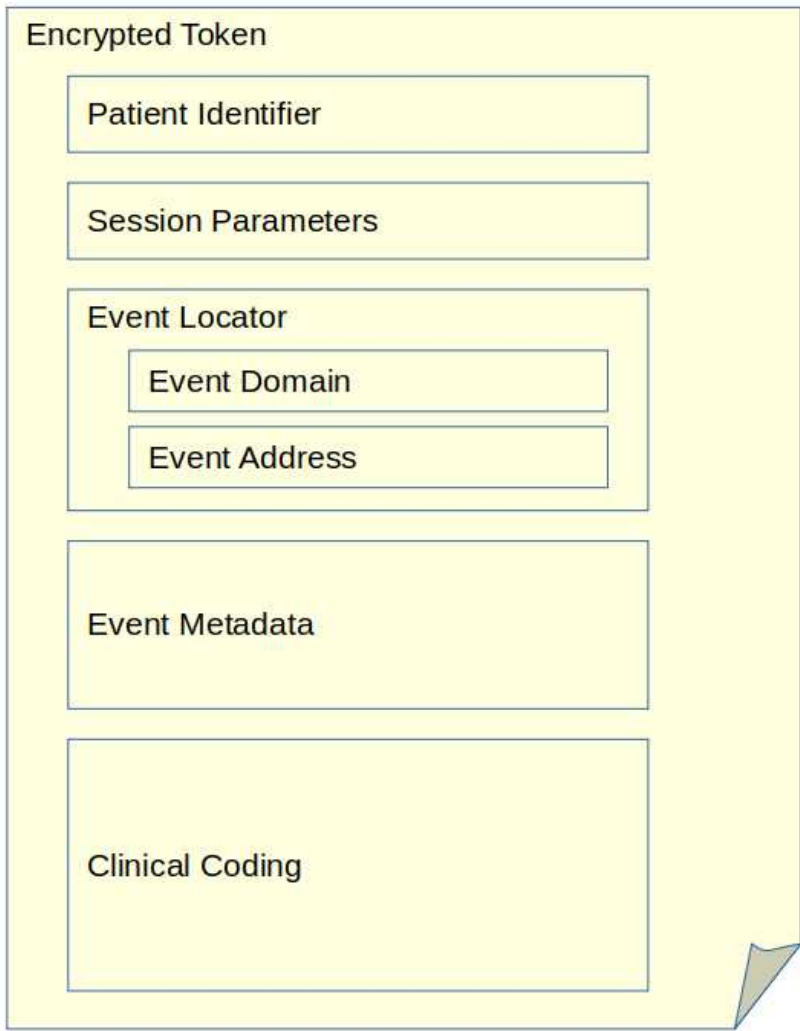
Token Gateway Domain

Patient Domain
Blockchain Domain

Content Domain
Virtual Record Domain

EHR Gateway Domain

Encrypted Tokens



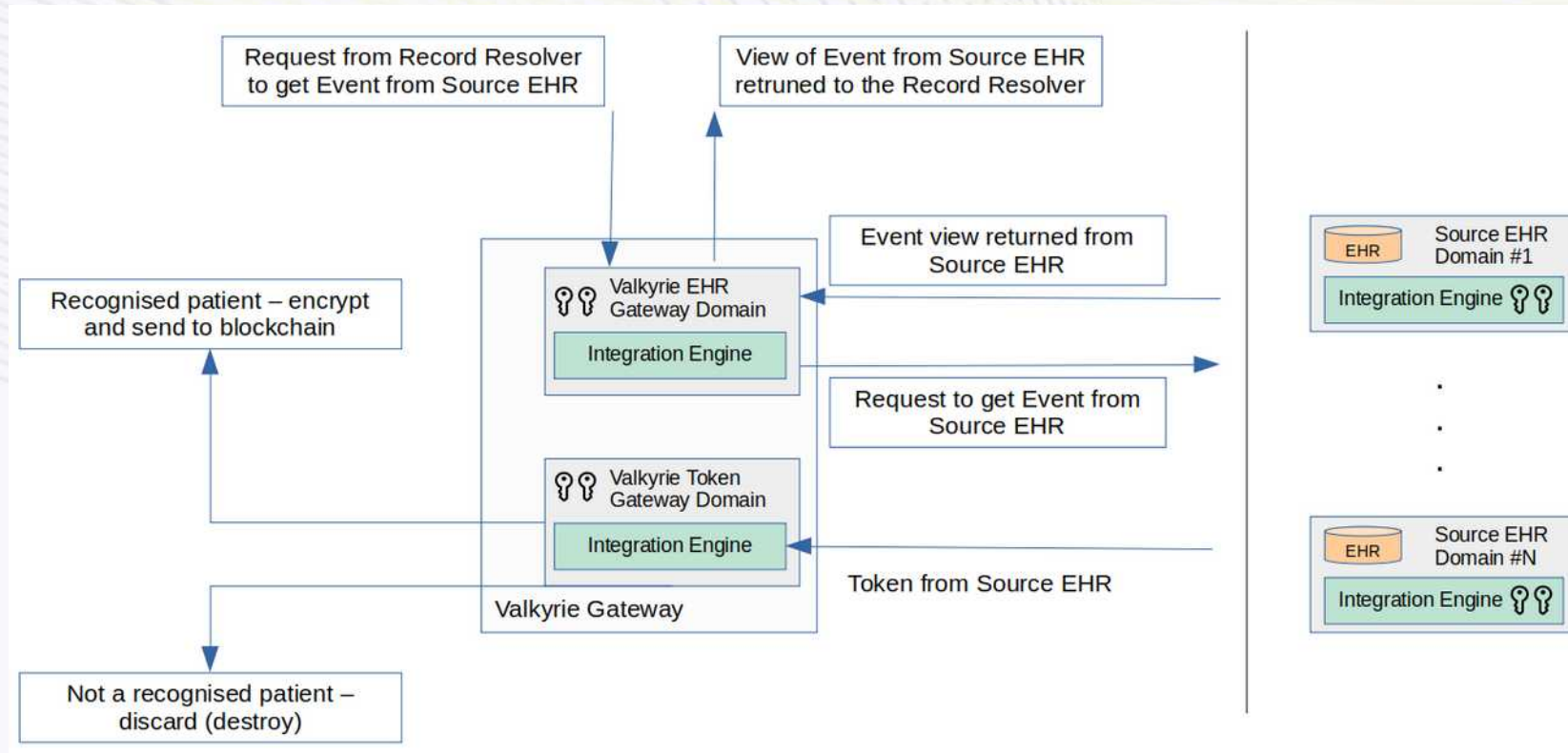
```
<?xml version="1.0" encoding="UTF-8"?>
<encryptedToken id="" securityDomain="patientDomain">
  <patientId>1234567890</patientId>
  <sessionParameters userId="" sessionId=""/>
  <eventLocator securityDomain="ehrGatewayDomain">
    <eventDomain>198.192.56.18</eventDomain>
    <eventAddress securityDomain="sourceEHR">
      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

The Valkyrie Gateway



The Valkyrie Gateway receives tokens generated from the Source EHR systems.

Passed over https but also encrypted with the private key of the source domain.

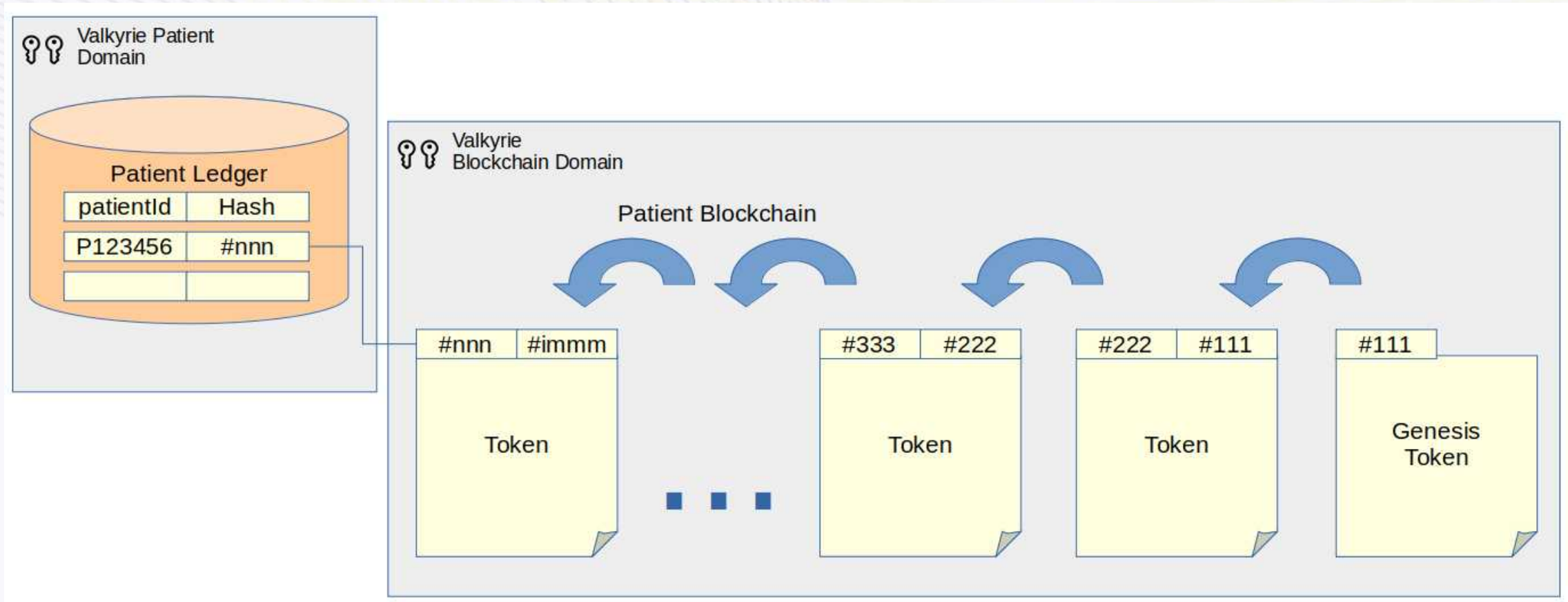
Gateway decrypts the token, checks the patient Id and throws away any tokens for patients not registered with Valkyrie.

For registered patients, sections of the token are encrypted using the public key of the relevant Valkyrie domain.

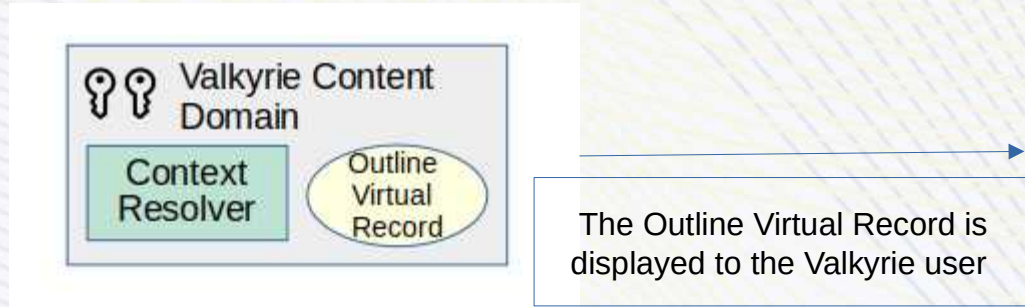
The token is then passed to the Blockchain

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.



Presenting the Virtual (Federated) Record



The Outline Virtual Record is displayed to the Valkyrie user

ABERNATHY, Timothy (Mr) Born: 28-Mar-1939 (85 years) Gender: Male
 Patient Id K1476889 NHS Number 7563628274

Events	Annotations	LifeLine	Hide
23-Feb-2017	Lifestyle		
23-Feb-2017	Body Mass Index		
23-Feb-2017	Hospital Anxiety and Depression Scale		
23-Feb-2017	Patient Registration		
23-Feb-2015	Lifestyle		
01-Feb-2015	Lifestyle		
23-Feb-2012	Lifestyle		
06-Feb-2012	DAS 28		
06-Jan-2012	BMD Data		
06-Jan-2012	Risk Factors		
06-Jan-2012	Medications		
28-Oct-2011	Laboratory Test Results		
28-Oct-2011	Bone Chemistry Results		
23-May-2011	Bone Chemistry Results		
04-Apr-2011	Laboratory Test Results		
04-Apr-2011	Bone Chemistry Results		

23-Feb-2017 - Hospital Anxiety and Depression Scale

Anxiety Score	16	Severe
Depression Score	13	Moderate

I feel tense or 'wound up'
I still enjoy the things I used to
I get a sort of frightened feeling as if so
I can laugh and see the funny side of th
Worrying thoughts go through my mind
I feel cheerful
I can sit at ease and feel relaxed
I feel as if I am slowed down
I get a sort of frighened feeling like 'but
I have lost interest in my appearance
I feel restless as if I have to be on the m
I look forward with enjoyment to things
I get sudden feelings of panic
I can enjoy a good book or radio or TV p

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.

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

Accessing Events in the Federated Record



ABERNATHY, Timothy (Mr) Born: 28-Mar-1939 (85 years) Gender: Male
 Patient Id K1476889 NHS Number 7563628274

Dashboard Patient Search Patient Cohorts In-Tray Clinics Orders Registration

Events Annotations LifeLine Hide

23-Feb-2017 Lifestyle
 23-Feb-2017 Body Mass Index
 23-Feb-2017 Hospital Anxiety and Depression Scale
 23-Feb-2017 Patient Registration
 23-Feb-2015 Lifestyle
 01-Feb-2015 Lifestyle
 23-Feb-2012 Lifestyle
 06-Feb-2012 DAS 28
 06-Jan-2012 BMD Data
 06-Jan-2012 Risk Factors
 06-Jan-2012 Medications
 28-Oct-2011 Laboratory Test Results
 28-Oct-2011 Bone Chemistry Results
 23-May-2011 Bone Chemistry Results
 04-Apr-2011 Laboratory Test Results

23-Feb-2017 - Hospital Anxiety and Depression Scale Page load time: [Export Format: HL7 CDA]

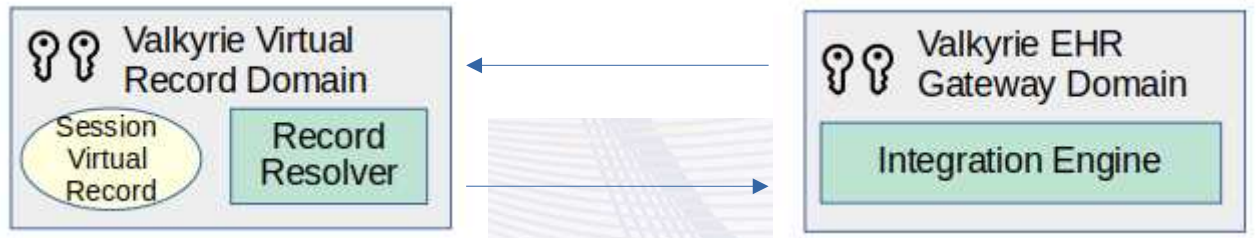
Anxiety Score	16	Severe
Depression Score	13	Moderate

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 frighened 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

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.



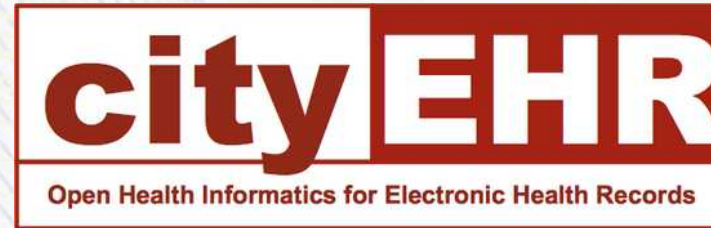
Prototype Implementation



The prototype implementation is made with open source software

CityEHR

cityehr.org



EHRbase

ehrbase.org



Mirth Connect

github.com/nextgenhealthcare

Hyperledger Fabric

hyperledger.org/projects/fabric



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