

FHIR TRAINING

FHIR ARCHITECTURE / COMPONENTS
APRIL-JUNE 2025

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SESSION
07-B



Methodology for this Session

- We will describe each architectural component category, and for each component we will explain
 - Brief description of the functionality
 - Related FHIR IG if there is any
 - Open-Source Implementations
 - Examples
 - Relationship with other components
- After that, we will play the FHIR Architecture Supermarket Game!
- You will be presented a project and find out which components are needed!

[Some of these concepts apply to any digital health project, regardless of the actual use of FHIR]

Fractal Disclaimer

We included in this session only 'generic' components and services that can be used in a (FHIR-based) Digital Health Project.

What is missing here is the actual software people use for patient care:

These are complete systems, sometimes based on some of the components we are representing in our session.

Reality is fractally shaped: these systems can also be components for bigger systems, and FHIR APIs can be the glue.

EHR System

HIS System

LIS System

CPOE System

Surgery Planning

PACS System

Immunization Registry

Logistics System

Finance System

Pharmacy Systems

Disease Registry

Care Planning



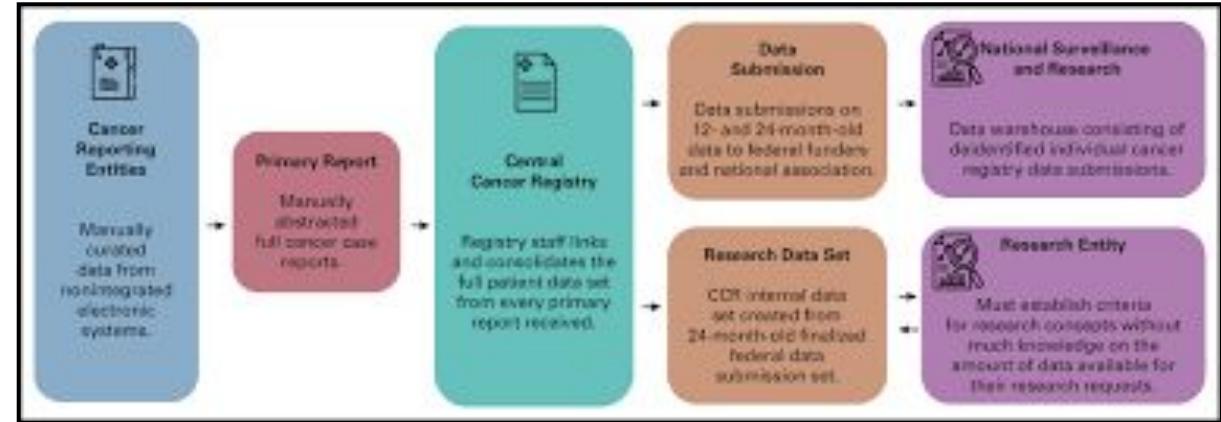
Component Categories ('the aisles' of our 'supermarket')

- Clinical Data Stores
- Infrastructure
- Registries
- Integration
- Secondary Use
- Validation
- Artificial Intelligence
- Notification Services

Clinical Data Stores

Components in this aisle

- Document Store
- Granular Data Store
- Imaging Repository



This category applies to services which allow exchange and store of clinical information.

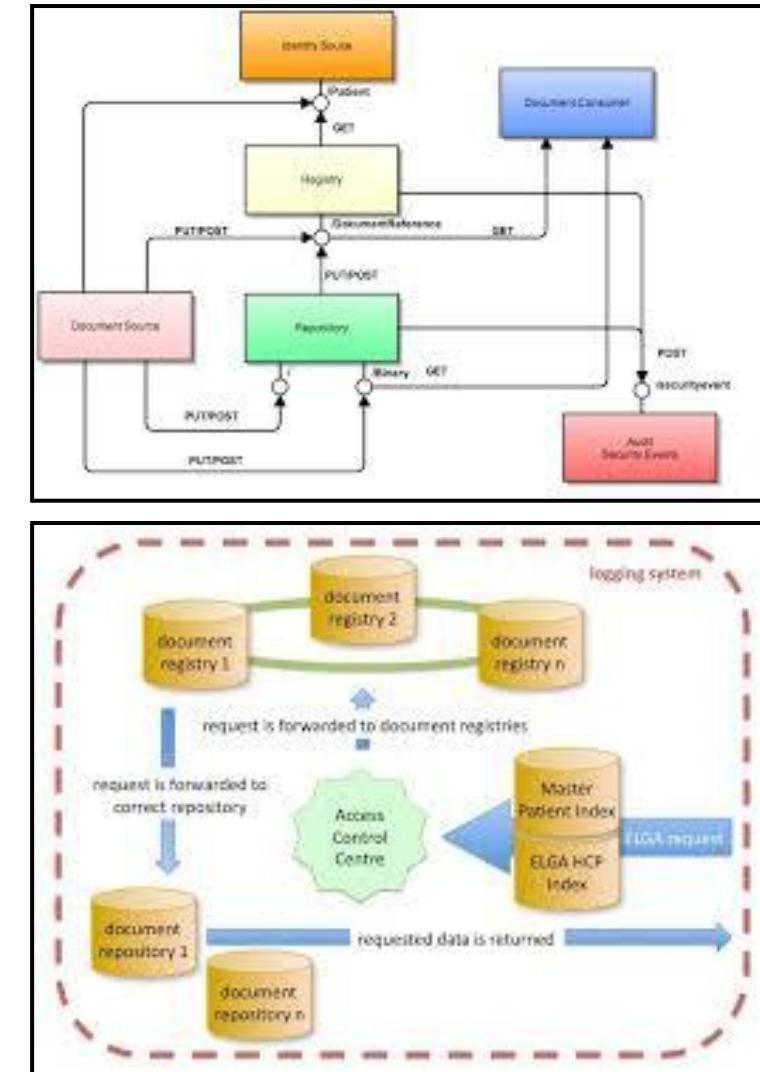
Not necessarily a FHIR Native Server (i.e.: storing the information internally as FHIR Resources). FHIR-enabled read and write access APIs can be enabled (this is called a 'façade')

Some of the issues: Scalability, Partitioning, Multi-Tenancy

* These are generic tools that can be utilized for several use cases –example: an immunization registry can involve just a specific Granular Data Store-

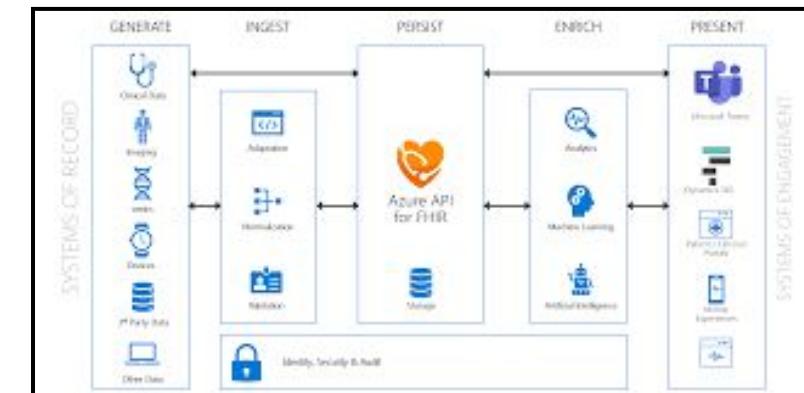
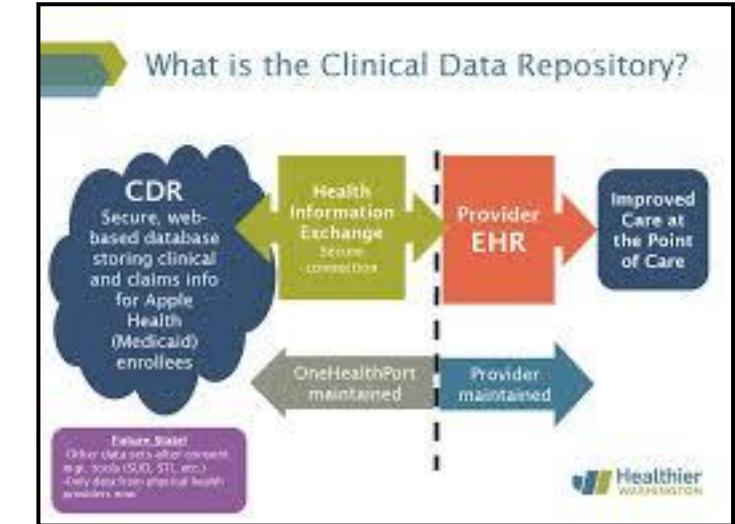
Document Store (DS)

- **Description:** A document store enables storage, searching and access to Clinical Documents.
- The search process is usually through something called 'a document registry'. **Registries usually store the metadata** for the documents (patient, author, document type/class, date, encounter, organizations involved, purposed audience – organization or individual providers, etc.). **The actual documents are stored in a 'document repository'**. A registry has also a pointer to each document in a repository. Documents can be CDA R2, PDFs, FHIR Documents, scanned documents of photos, etc.
- **Example:** One typical example of DS is any HIE in the USA



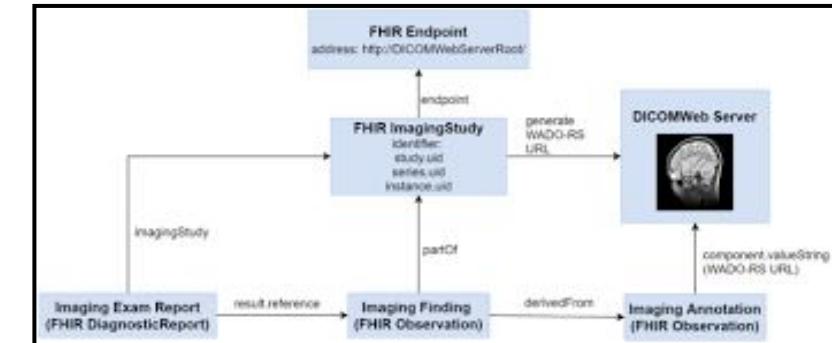
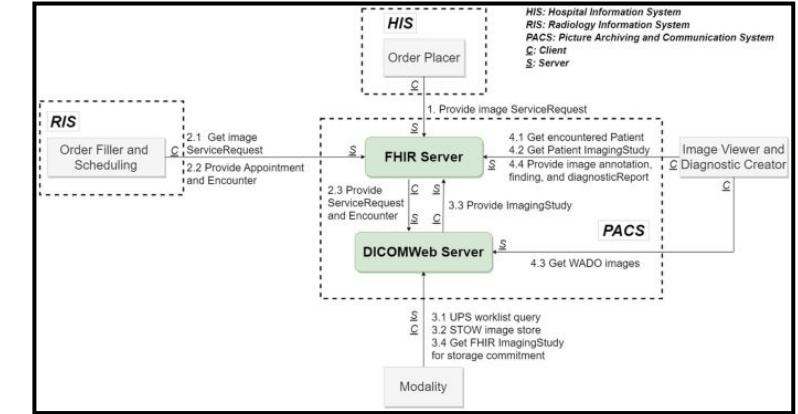
Granular Data Store (GDS)

- **Description:** A clinical data repository (CDR) that consolidates clinical data from various sources to provide a centralized, patient-centric view of healthcare information. It enables patients, healthcare providers and researchers to access and analyze patient data for improved care and research.
- **FHIR CDR** stores information in FHIR resource format (also called 'Native FHIR Servers'). The CDR vendor can also provide FHIR APIs to an existing non-FHIR clinical data store.
- **Example:** Several vendors provide FHIR GDS: Smile CDR / FHIR HAPI (open source), Google Healthcare API, Azure Health Data Services, Intersystem Iris, etc.
- **Granular as opposed to 'document' store:** A GDS stores each piece of information on its own: allergies, lab results, procedures, encounters, etc.



Imaging Repository (IR)

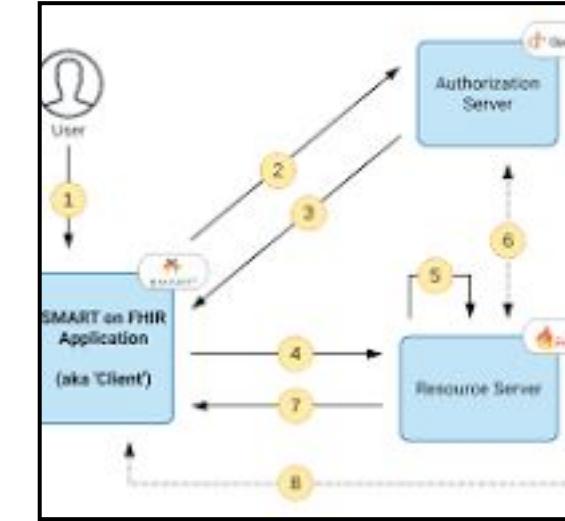
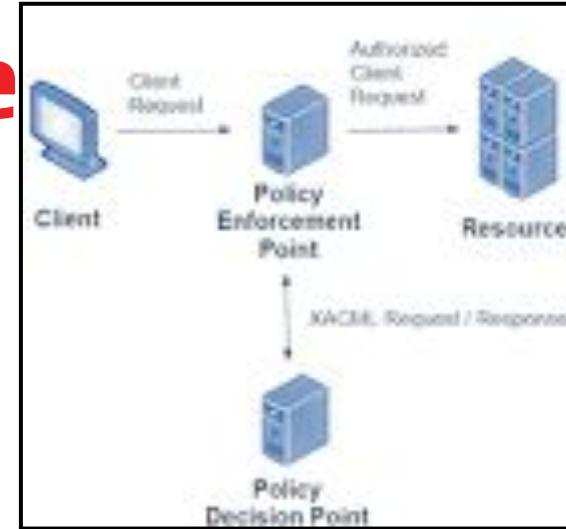
- Description:** A diagnostic imaging repository provides for the secure collection and storage of medical images and reports. This offers instant access to a patient's comprehensive imaging history for authorized clinicians. Healthcare providers can access a consolidated view of patient images from various systems. The required standards are DICOM Web and some specific FHIR resources (ImagingStudy)
- Example:** Several vendors provide Imaging Repositories as part of their overall Imaging Solutions: Phillips, GE, etc. There are a few open- source offerings.
- Why aren't the images in the same clinical data repository as the other discrete data (quantities, codes, text): because images are larger (several MB or TB) and complex to store, retrieve and distribute.**
- Plus...DICOM still rules here.**



Infrastructure

Components in this aisle

- Authentication
- Authorization
- Consent Management
- Audit Log
- API Gateway
- Digital Signature



This category applies to basic shared security and audit services.

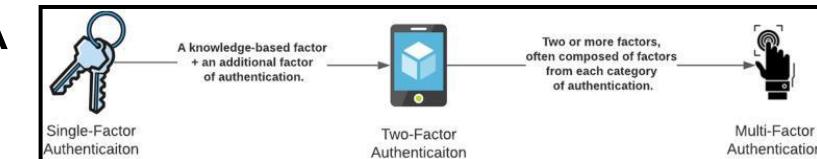
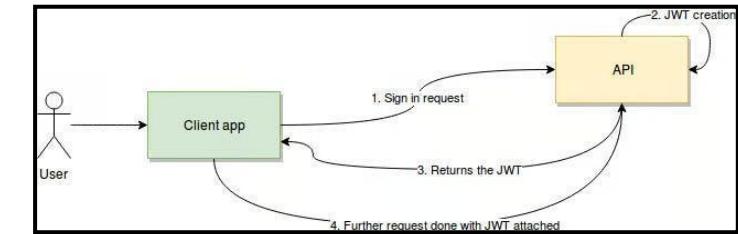
We need to make sure that the user is legitimate (**authentication**), can access only the information according to their roles (**authorization**), the patient approved the intended use of the information (**consent**), and there is record about when/from where/who accessed the information (**audit log**). We also need to provide separation of concerns and scalability or balancing (**API gateway**)

Some of these services are not 'healthcare' specific but HL7 defines some technologies where the underlying concept is adapted for healthcare.

Remember that for a user to gain (r/w) access to any information, you need to combine authorization, authentication and consent.

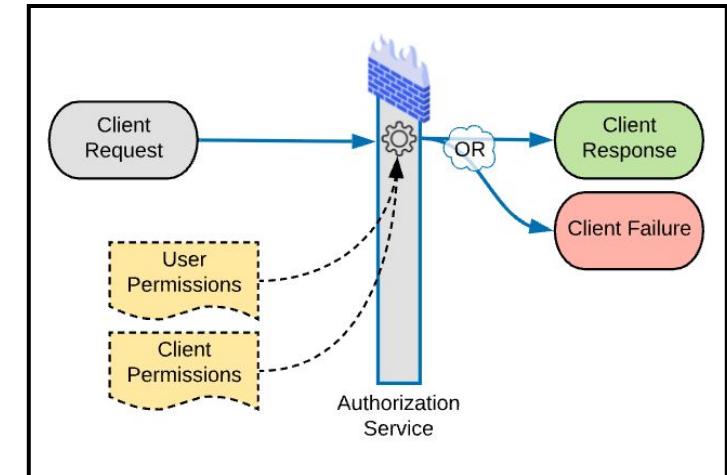
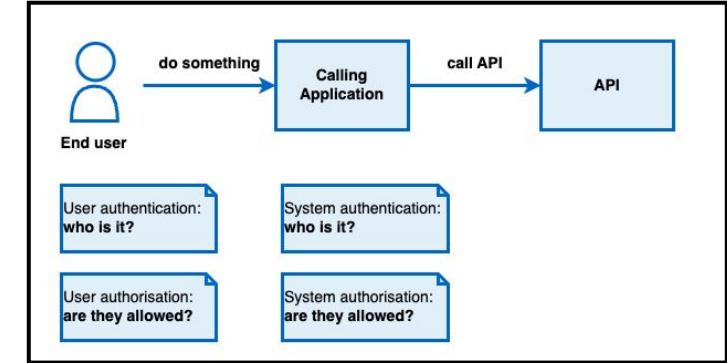
Authentication (AUTHE)

- **Description:** Any client sends the request to an authorization server, which first verifies the user's identity credentials through authentication mechanisms like OAuth 2.0 or OpenID Connect. This process ensures the user is who they claim to be. Usually, the authentication service will provide a TOKEN, which will be used by the client instead of the actual credentials.
- **Example:** Each cloud vendor provides its own authentication service. Most of them support oAuth2. A widely used open-source authentication service is KeyCloak (<https://www.keycloak.org/>)
- One of the discussions in the FHIR Community (FAST Accelerator) is about authentication without registration in every server (building trust at scale)



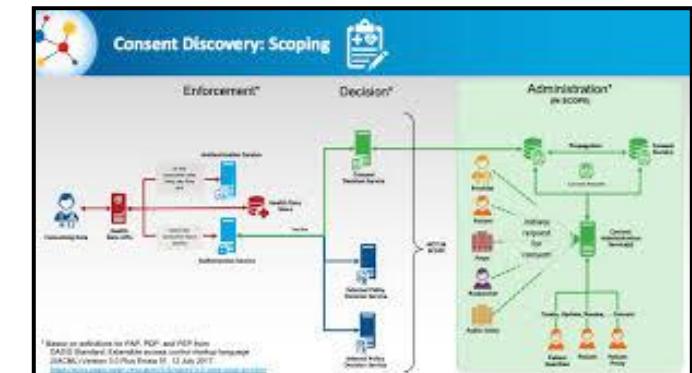
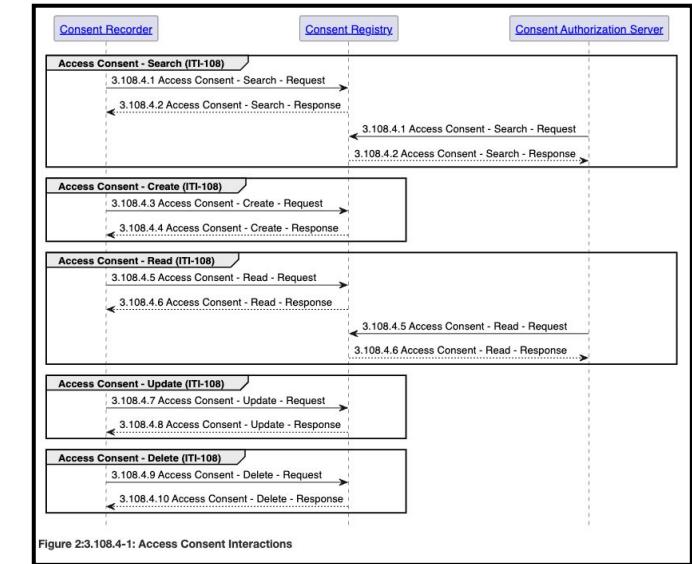
Authorization (AUTHO)

- **Description:** The authorization server checks if the user role allows access – read or write- to the requested data (these are called '**scopes**')
- **Example:** The most common scope definition for FHIR is in Smart-on-FHIR. In V2.2 Access can be defined for each FHIR Resource Type and Method (create, read, update, delete, search).
"patient/Condition.rs
patient/AllergyIntolerance.rs" means 'The user can search and read the conditions and allergies for the patient in context'
- Some cloud platforms define their own scopes and engines.



Consent Management (CONS)

- Description:** Patient Consent management is the central component in a consent ecosystem and at the core of a scalable consent architecture. This project is about answering the question "is it possible to determine if payer/provider X have authority to view healthcare data Y about patient Z?".
- Consent involves defining which roles can access which specific information for which intended use, and the granularity and opportunity (opt-in vs opt-out) is defined at the project level, because it depends on local laws and regulations.
- Consent Management will usually have several components, covering how to define it, store it, and implement it.
- Example:** <https://cloud.google.com/healthcare-api/docs/concepts/consent-model> (based on the Consent FHIR resource)

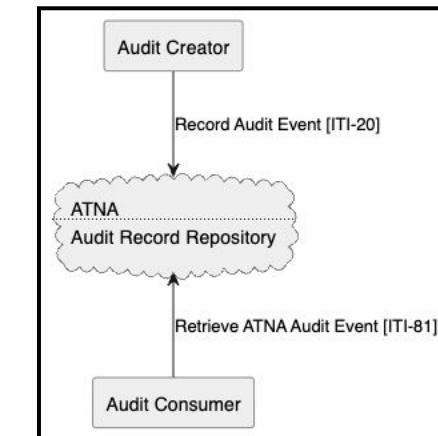
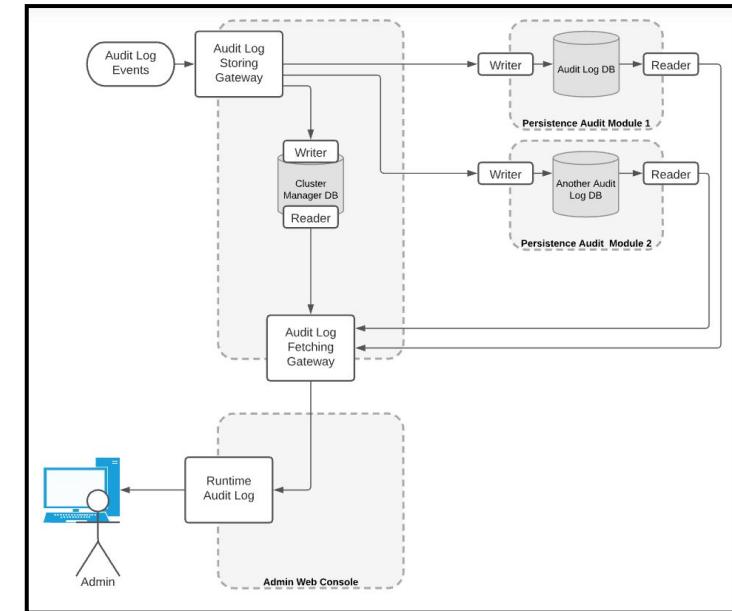


Bibliography: <https://profiles.ihe.net/ITI/PCF/index.html>

FHIR Implementation Guides: <https://build.fhir.org/ig/HL7/fhir-consent-management/>

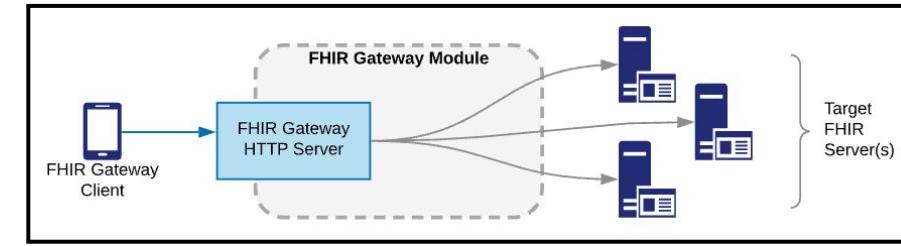
Audit Log (AL)

- **Description:** All systems must ensure that **audit logs are created and maintained**, with an adequate level of auditing.
- Audit logs should be **held for a period** in compliance with local regulations.
- The Audit Log service also needs to provide **access to the audit logs** to administrators, and sometimes even to patients ("Who has accessed my records?")
- Almost no offer provide support for the AuditEvent report, and some cloud vendors provide their specific audit scheme.
- **Example:** Basic Audit Log Patterns (IHE)

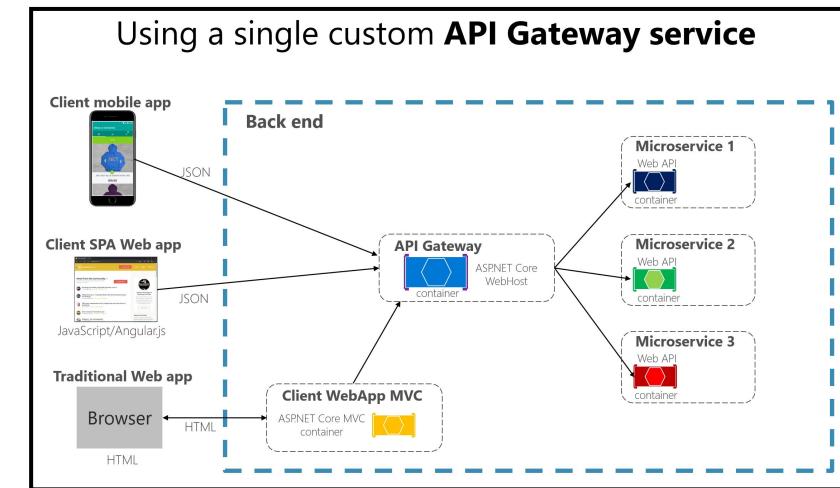


API Gateway (AG)

- Description:** A centralized entry point for managing interactions between clients and backend services in a microservices architecture or other systems. It acts as a reverse proxy, routing client requests to the appropriate service and often performs cross-cutting tasks like authentication, load balancing, service discovery, transforming, monitoring, logging, caching and throttling
- Different cloud vendors provide their own tool that works seamlessly in their own environment (Google Apigee, Azure API Management, Amazon API Gateway, etc.)
- Think of an API Gateway as a modern, light-weight version of an ESB (Enterprise Service Bus)
- Example - Open-Source Offerings:** NGINX, APIsix, Kong Community Edition, etc.
- Example - FHIR Gateway:**
<https://google.github.io/fhir-gateway/>

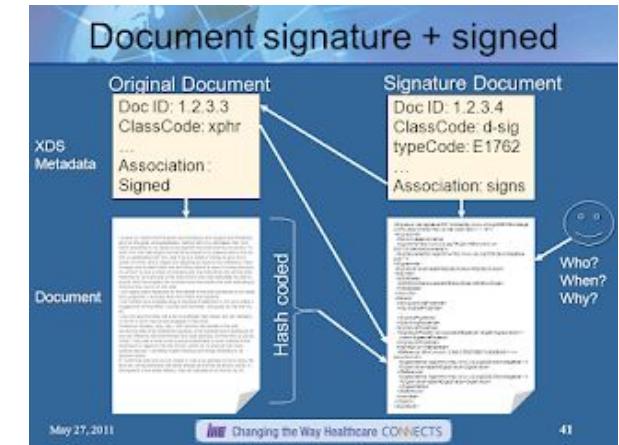
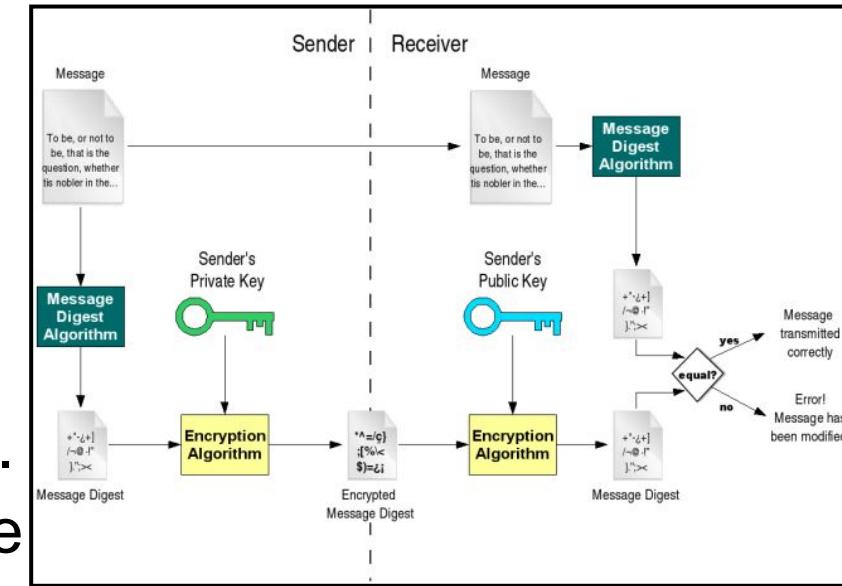


Feature	Enterprise Service Bus (ESB)	API Gateway
Primary Goal	Integration. To connect, mediate, and control communication between diverse internal applications.	Management. To securely expose, manage, and monitor APIs for external or internal consumers.
Architecture	Central component of a Service-Oriented Architecture (SOA).	Key component of a Microservices Architecture.
Scope	Enterprise-wide, internal focus. A central, shared bus for many applications.	Typically external-facing, but also used internally. Acts as a facade or proxy for a collection of services.
Communication	"Smart Pipes." Performs complex routing, orchestration, and heavy data transformation (e.g., SOAP to REST, XML to JSON, protocol bridging).	"Dumb Pipes, Smart Endpoints." Focuses on simple routing, request/response, and proxying. Heavier logic lives in the microservices themselves.
Core Features	- Complex routing & orchestration, Message transformation, Protocol conversion (FTP, JMS, SOAP, etc.), Service composition	- API security (Authentication/Authorization), Rate limiting & throttling, Caching, Monitoring, logging & analytics, Request/response transformation (lighter)
Deployment	Often a large, centralized, monolithic product.	Lightweight, decentralized, and often deployed as a container alongside applications.



Digital Signature (DS)

- **Description:** Provides the infrastructure for Digital Signature, also called PKI: certificate generation and retrieval and revoking, time stamping, signature validation, etc.
- Ensures authenticity, integrity and non-repudiation.
- FHIR enables the use of the **Provenance** resource to store the actual signature for a resource or document. Some DS implementations create a detached document with the signature.
- **Example: NHS Digital Signature Service :**
<https://digital.nhs.uk/developer/api-catalogue/digital-signature-service>



Registries

Components in this aisle

- Patient Identity
- Provider Directory
- Endpoint Directory
- Device Directory



This category applies to shared services identifying the entities that participate in healthcare delivery.

No system in digital health is possible without proper identification (at least) of the patient, provider, practitioner and location.

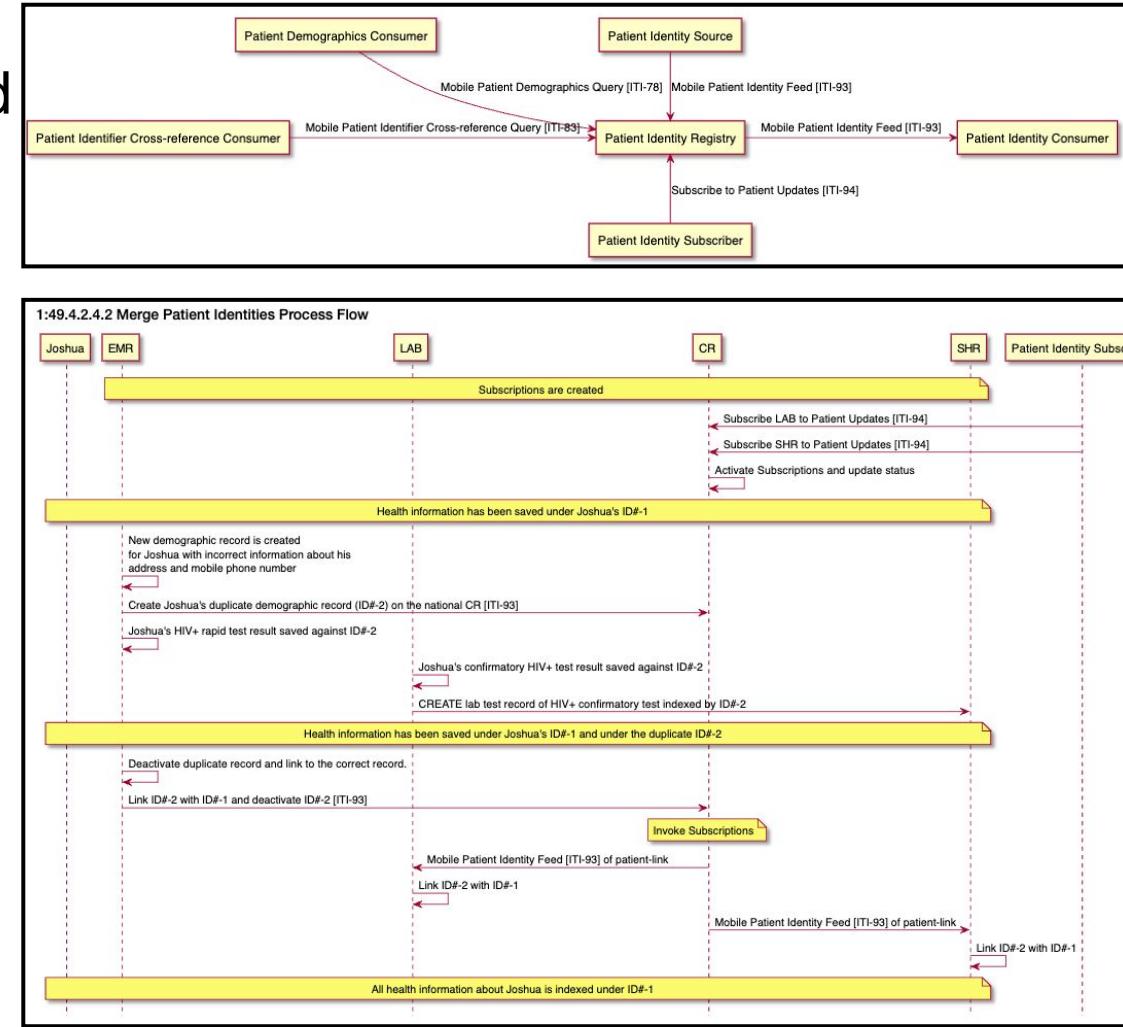
That's why we call them 'Master Files'

Sometimes access to Practitioner/Provider/Location/Endpoint entities is through a single and linked "Provider Directory" which federates identity of all the participants in healthcare and their physical and virtual locations.

In countries with multiple commercial payers, the directory may also involve (and use as filter) the payers' plans and networks associations (which provider works for which payer under which plan)

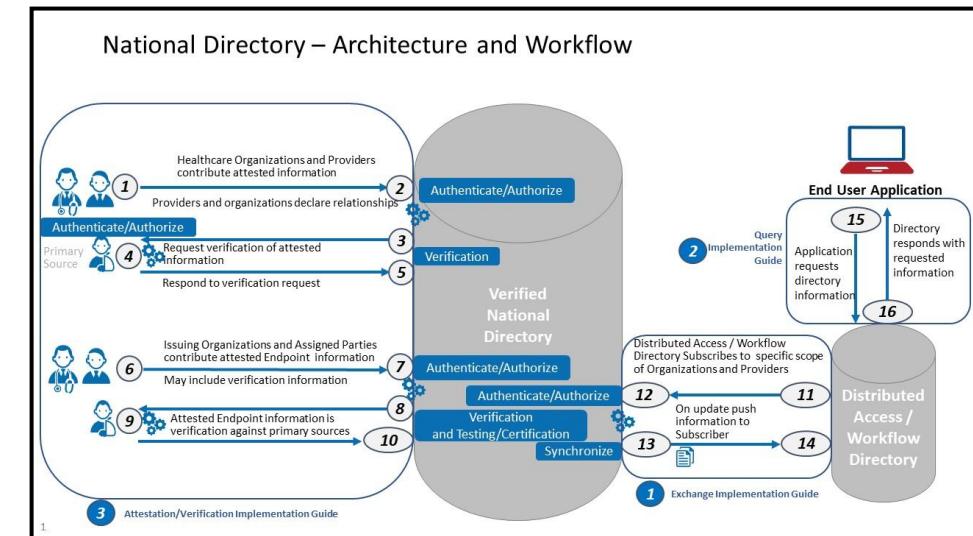
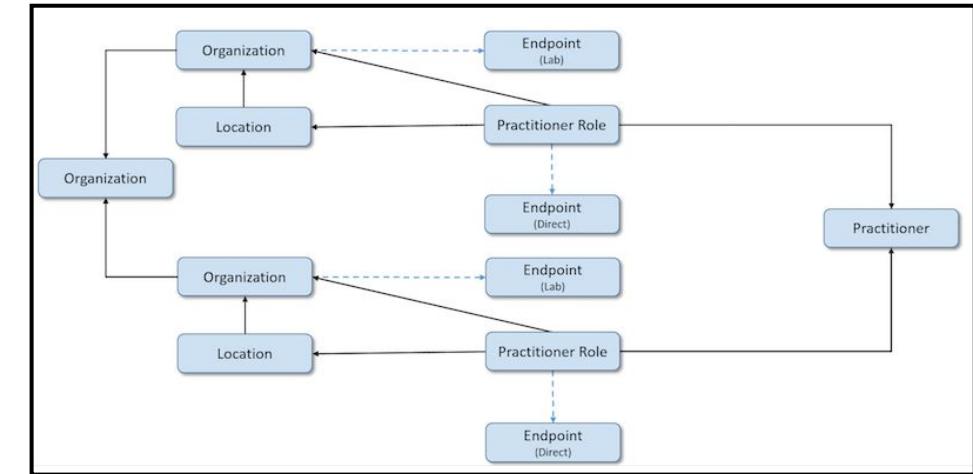
Patient Identity (MPI)

- Description:** Also called MPI (Master Patient Index). It can be a centralized and/or federated database within a healthcare organization (region, country) that maintains unique identifiers and demographic information for all patients, linking their records across different systems and facilities.
- Single source of truth for patient identification
- Ensures unique patient identification, prevents duplicate records
- Key to interoperability and care continuity
- Example Open-Source Offerings:** FHIR HAPI (MDM option) – See https://hapifhir.io/hapi-fhir/docs/server_ipa_md/m/mdm.html



Provider Directory (PRI)

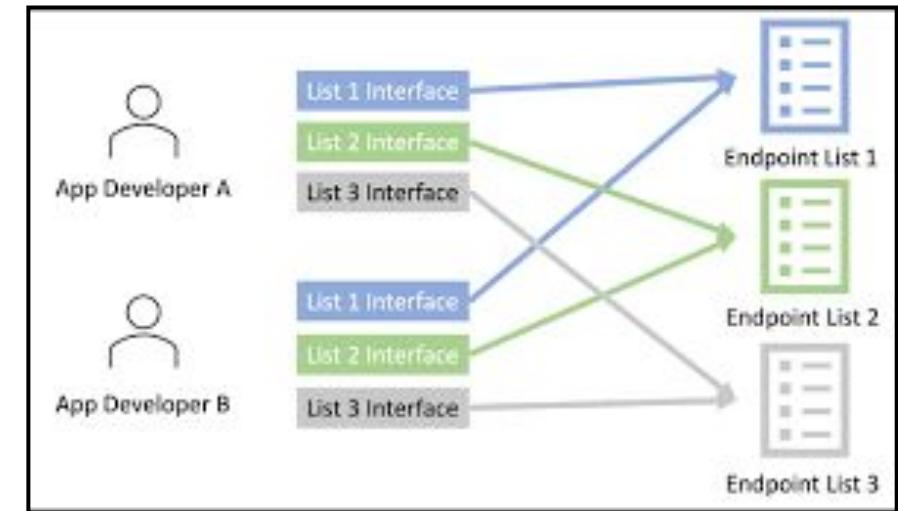
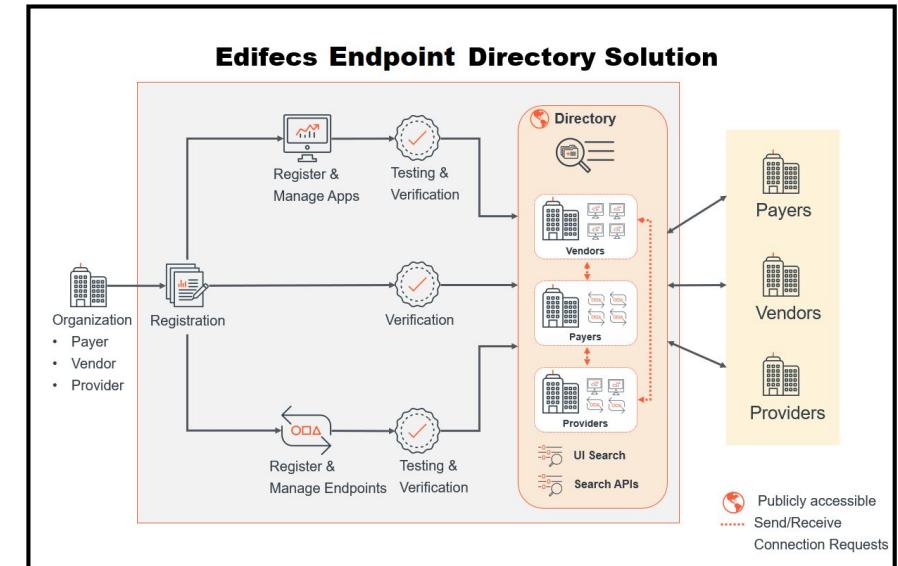
- Description:** A provider directory involves identification for organizations, professionals working for them, and facilities or locations where care is delivered.
- Practitioners are usually identified in their roles for each organization (remember that the same person can perform different jobs for different organizations).
- These directories can be **federated** (querying multiple services) or **synchronized** (single source of truth)
- Example Open-Source Offerings:** FHIR HAPI (MDM option)



Endpoint Directory (END)

- Description:** An endpoint directory addresses the problem of **FINDING** a FHIR server (or any other server)
- Endpoint can be related to organizations / providers and payers, but sometimes...
 - several organizations rely on a single endpoint, or
 - there are different endpoints for different functionalities for the same organization.
- The Endpoint reported attributes may include the payload type, status, protocol (fhir REST, msg?), type of environment (test, staging, dev, prod), use cases and profiles

(yes, there is an *Endpoint* resource in FHIR)

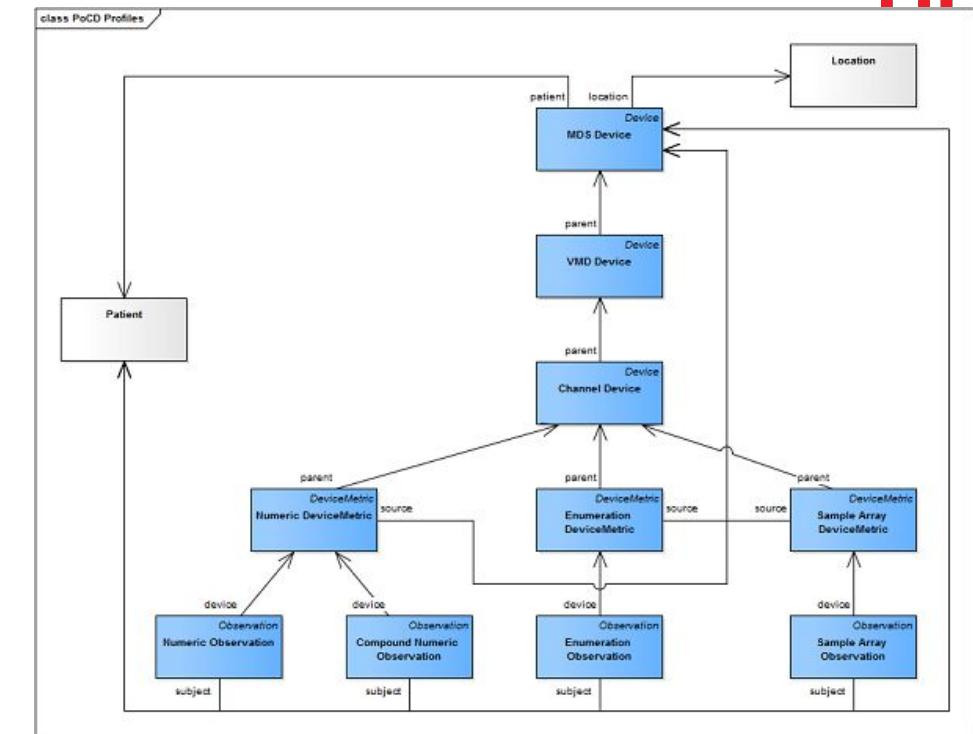


Bibliography:

<https://confluence.hl7.org/spaces/FHIR/pages/113672758/Endpoint+directory+implementations+and+frameworks>

Device Directory (DEV)

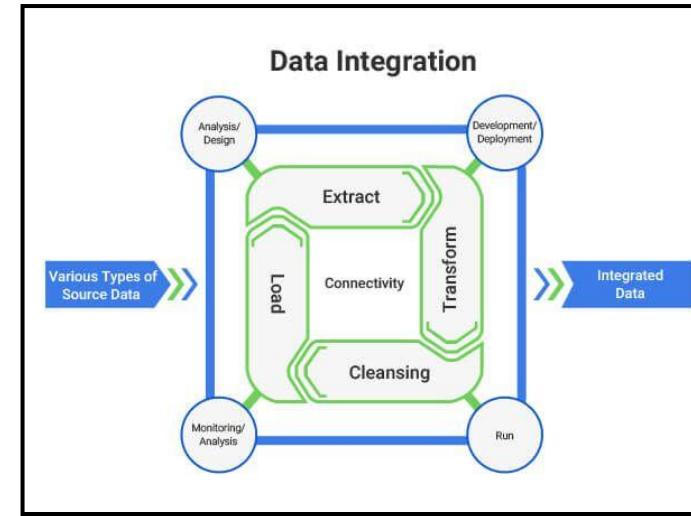
- Description:** A database with unique identification and attributes for all devices used in an organization:
 - imaging devices,
 - laboratory analyzers,
 - ICU monitors (pocd),
 - implantable devices (phd),
 - wearables provided to patients (phd)(etc.)
- Example:**
 - [US Core Implantable Device](#)



Integration

Components in this aisle

- Artifact Transformation Engine
- CDS Hooks Service
- CQL Engine
- FHIR Bulk Import
- FHIR Restful API
- IPS Generator
- Messaging Queue
- SMART-on-FHIR Apps
- Pub/Sub Service



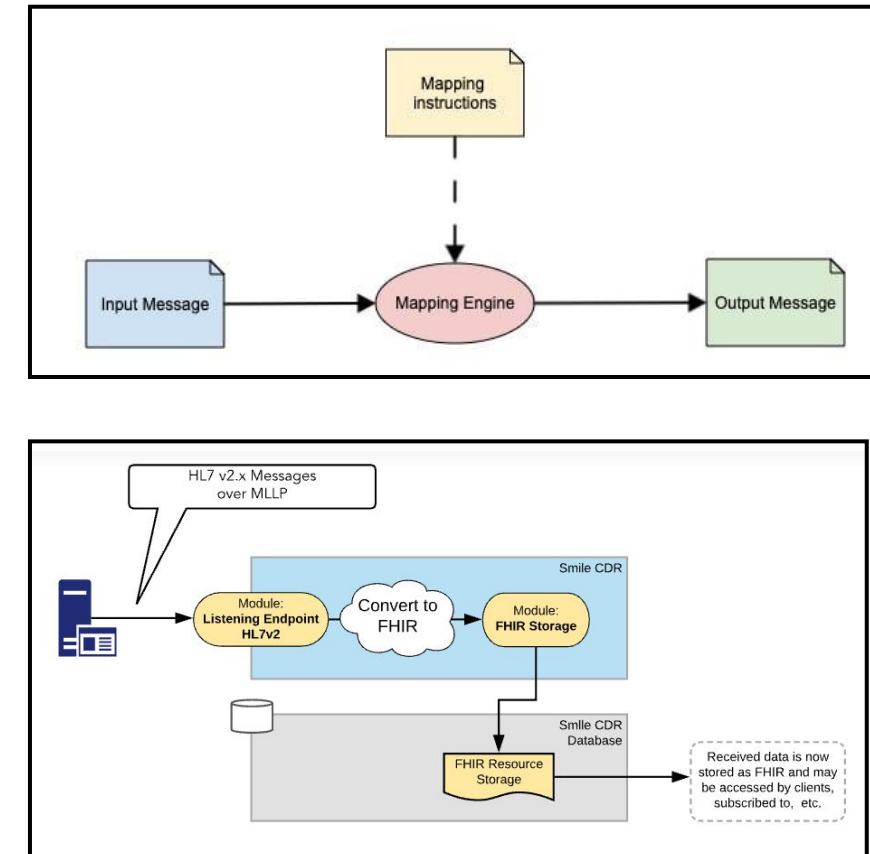
This category applies to services which allow plain data exchange, applying knowledge through standard methods, or dynamic transformation between data formats.

We will encounter this kind of need almost on every project.

Some information will always be in a format that we do not support, or we will need to integrate a new app to our ecosystem.

Artifact Transformation Engine (ENG)

- **Description:** Perform transformation from a syntax to others.
- **Source Syntax** can be an HL7 Standard (V2.x, CDA R2), arbitrary JSON or XML, openEHR instances, CSV or XLS file format, etc.
- **Target Syntax** usually is FHIR (this is called INGESTION), but this can be reversed too.
- Very often transformation includes terminology mappings and completing elements with fixed values or values from other sources.
- HL7 provides suggested mappings from HL7 V2.x and CDA/CCDA but not an open-source engine.
- **Example:** There are several commercial offerings: Mirth, Intersystems, Infor, etc.
- Azure and Google provide a mapping language and transformation engine in their FHIR Cloud environments Same for FHIR Server vendors: Aidbox, Smile CDR, Vonk, etc.

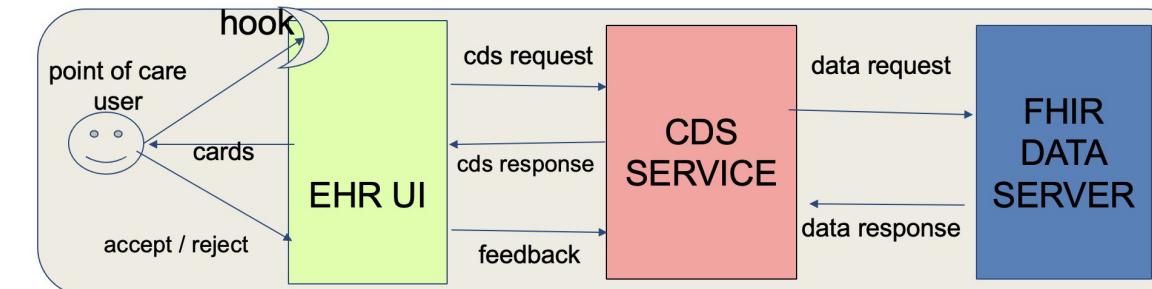


Bibliography:

FHIR Implementation Guides: <https://hl7.org/fhir/us/ccda/> <https://hl7.org/fhir/uv/v2mappings/2024Jan/>

CDS HOOKS SERVICE (CDS)

- **Description:** A clinical decision support (CDS) uses the context and patient clinical information to provide guidelines around next steps for patient care.
- The CDS Hooks Standard allow CDS to work through a standard API (now 2.0)
- It defines how to describe, register, discover, secure, invoke and get the results for each service. Uses FHIR Resources to represent clinical information and cards to represent the output of the service



hook

What is the user doing in the EHR

cds request

Which user, which patient

Which service

Additional clinical or demographic data

FHIR data server and authentication parameters

cds response : Set of cards

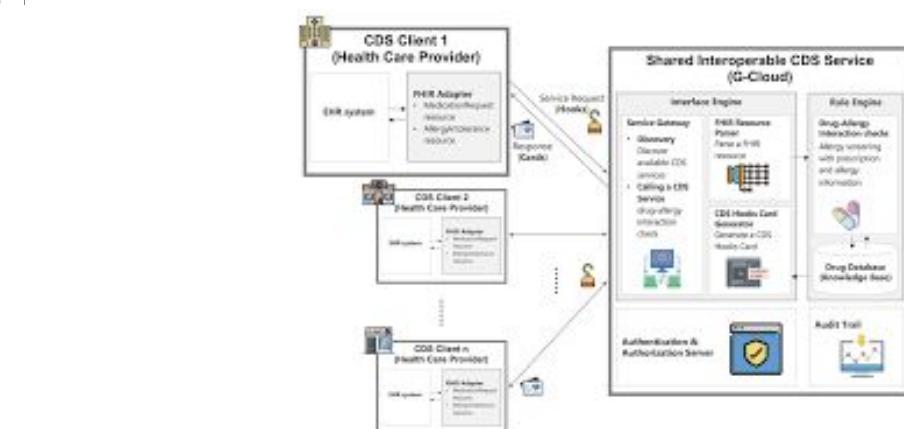
cards: source, information, recommendation (actions), smart app link

data request / response

FHIR resources required for service

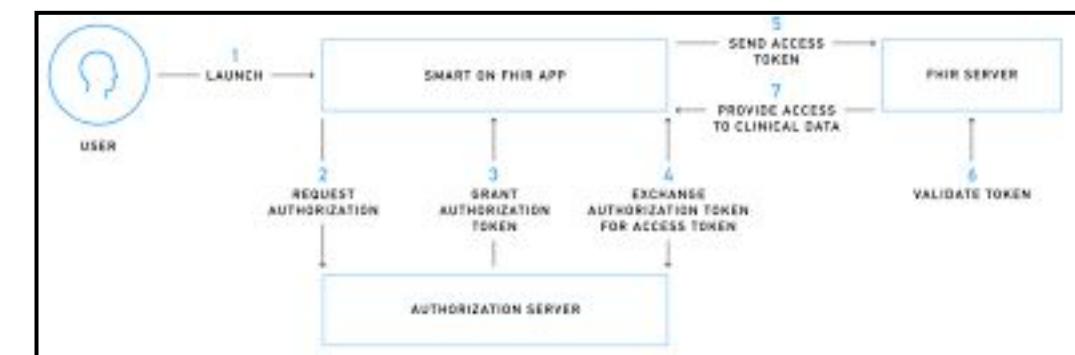
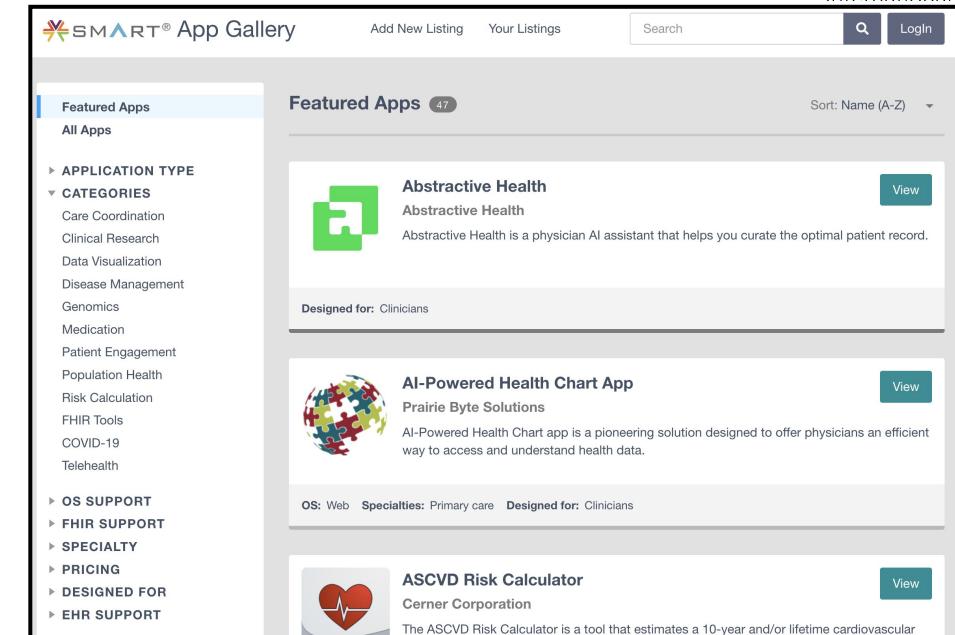
feedback

whether actions were accepted by user
reasons for override



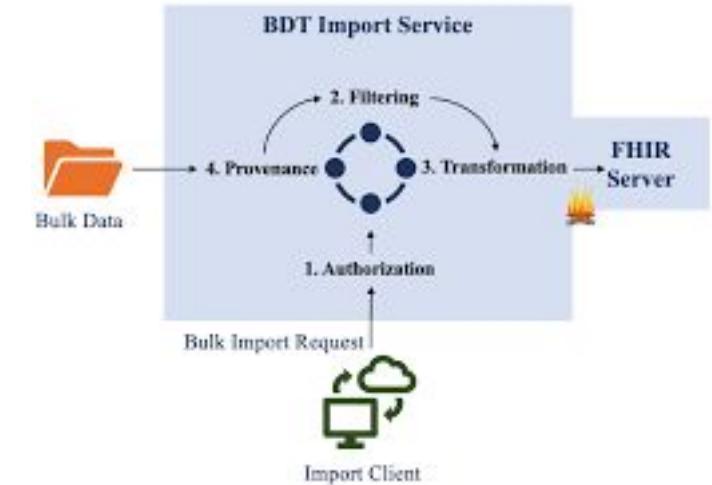
SMART-on-FHIR Apps (SMART)

- **Description:** A way to integrate an app or web site to an existing EHR.
- It defines how to launch the app from the EHR allowing also data access through FHIR Resources.
- It also helps to specify authorization through something called 'scopes': which kind of resources can be read/written, and for which set (only a specific patient in context, all her patients' records for the clinician, etc.)
- The underlying EHR or software needs to support this specification, but your project can also include a gallery of SoF Apps.



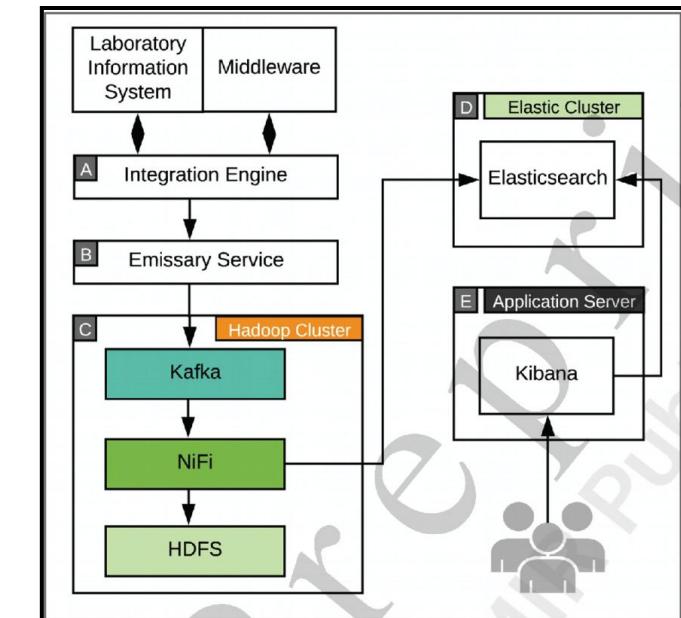
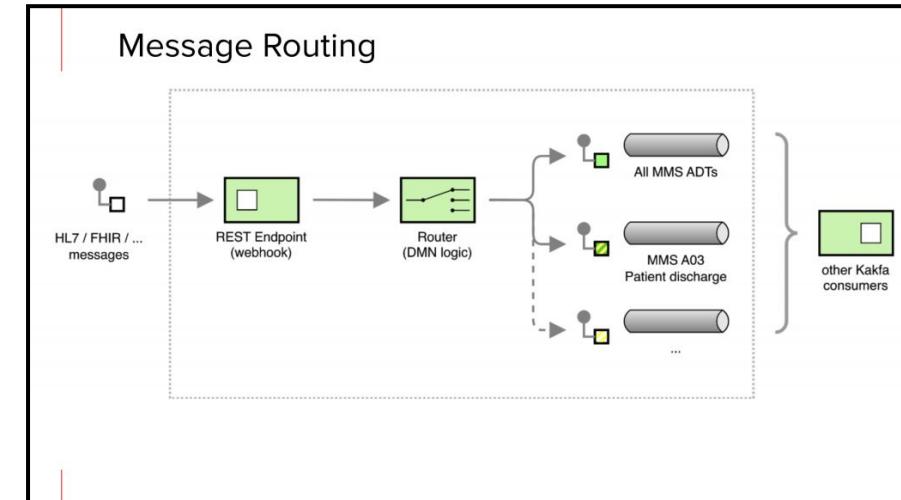
FHIR Bulk Import Service (FHIR-IMP)

- **Description:** This service provides a way to incorporate several thousands of records into an existing FHIR Store. (use case: registries initial load, migrations, etc.)
- There is no standardized way yet to invoke it –there is discussion – see bibliography below
- Each FHIR CDR vendor creates its own mechanism, rules and parameters.
- Performance is very important so some integrity controls can be turned off during bulk-import operations.
- **Example:**
<https://cloud.google.com/healthcare-api/docs/concepts/fhir-import>



Messaging Queue (MQ)

- Description:** This service allow asynchronous communication between other components by acting as a temporary storage for messages. Usually they will define a producer, a queue, and a consumer.
- There are different levels of complexity and features (priority, topic definition, distributed processing, replay of messages, etc).
- Examples:** Amazon SQS, RabbitMQ, Apache Kafka, Azure Service Bus
- MQs can be used as transport for FHIR Messages or as the basis for FHIR Subscriptions, but that's not the only place for this kind of component in your architecture: message queues enable the implementation of event driven architectures.

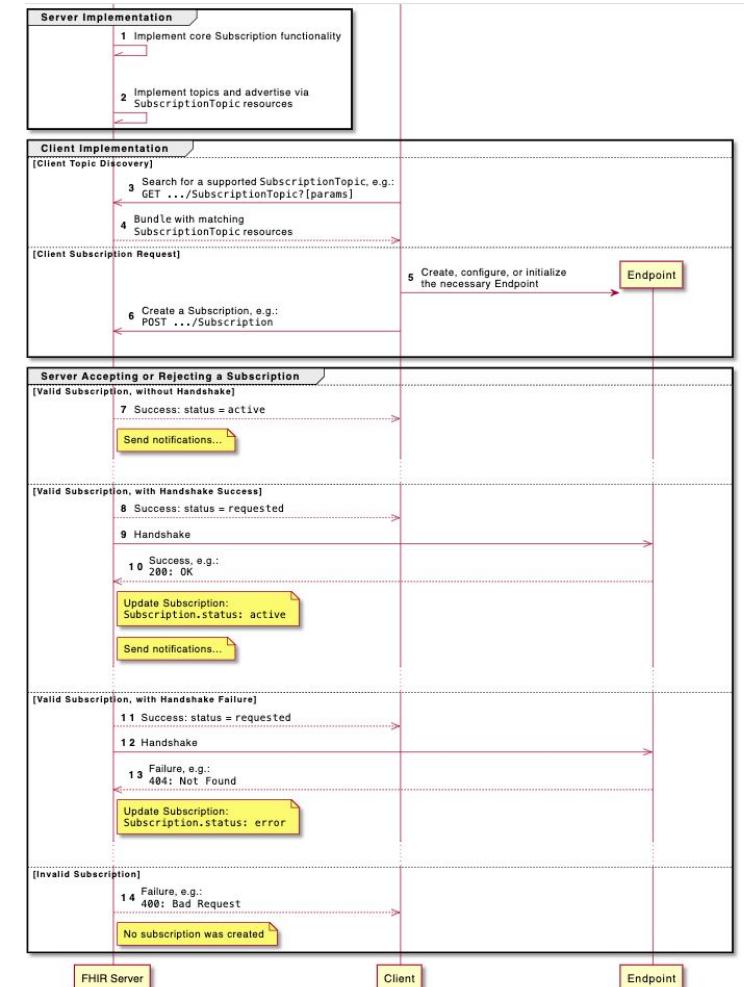


Subscription Services (SUB)

- **Description:** Subscription Services are like message queues. We describe this component separately because there is a FHIR Specification for this:
- Using a FHIR-based subscription service you can choose a "Subscription Topic" from the server menu, this usually define
 - - resource class (example: Patient)
 - - filter (which resources, like search criteria)
 - - how to notify your system: protocol (webhook, RESTful, etc.) and type (just an alert, id of the resources, full resource)

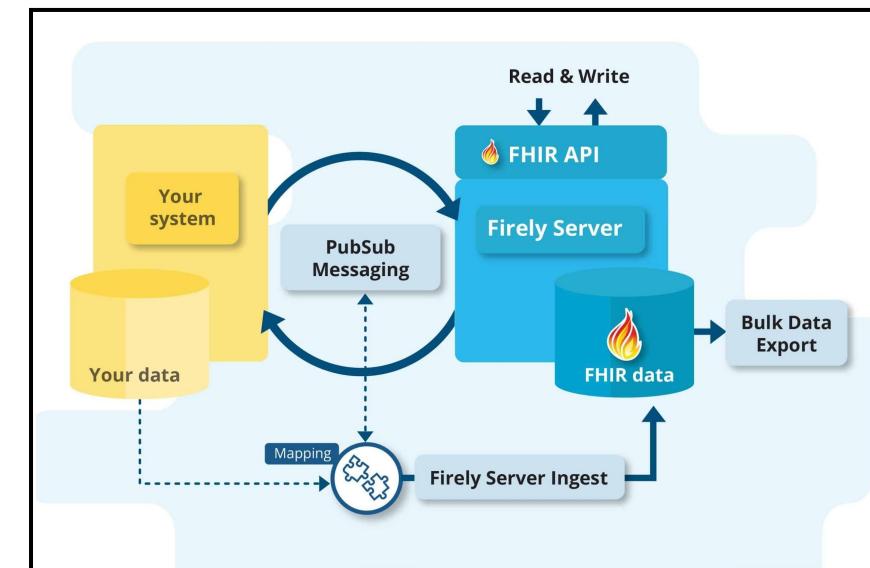
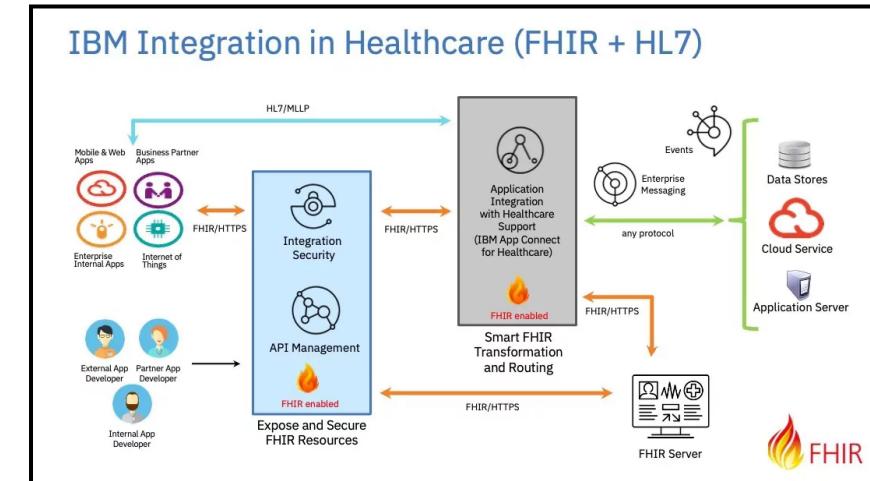
Microsoft Azure and HAPI FHIR implement FHIR Subscriptions. Google Healthcare has its own pub/sub definition.

- **Example:**
<https://smilecdr.com/docs/subscription/introduction.html>



FHIR RESTful API (FHIR)

- Description:** This is the only component or service we thought that we would need! Something that will have access to our data and can answer to a GET/PUT/POST/DELETE.
- Variants:**
 - In front (or as part) of native FHIR server (see GDS): just return/update the resources requested by the clients.
 - In front of a non-FHIR data server or API: this is called FHIR Façade: translate from/to FHIR format the data the server has behind
- Which API for what?:** The /metadata method will return the CapabilityStatement



Bibliography: <https://medinform.jmir.org/2022/7/e35724/>

FHIR Implementation Guides: <https://hl7.org/fhir/us/core/> (most famous API: US Core Patient Access)

IPS Generator (IPS) / Smart Health Links

- Description:** This component will create an International Patient Summary document based on the data about a patient.
 - The data may be stored in a FHIR Server or accessible thru a façade or proprietary API.
 - The URL for the IPS can be embedded in a Smart Health Links QR Code
 - Example:** FHIR HAPI Servers support out of the box the \$summary operation. Applied to a patient, it will return a valid IPS document with all mandatory sections populated
- Try it with the reference server:
- [https://hl7-ips-server.hl7.org/fhir/Patient/63/\\$summary](https://hl7-ips-server.hl7.org/fhir/Patient/63/$summary)



<https://smart-health-links-ips.cirg.washington.edu/>

International Patient Summary (IPS) Viewer for Connectathon

Links to published Implementation Guide, the latest CI build and Connectathon-2 branch

Submit Data

This is for test data only. **Please do not submit PHI.**

Paste your IPS here:

Repository of IPS Samples

View IPS

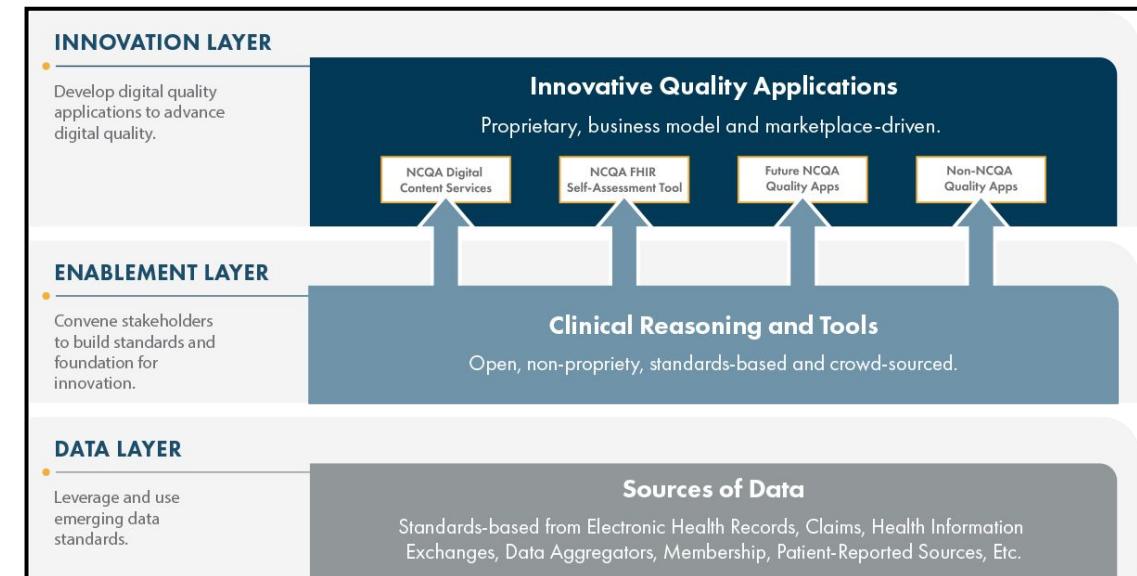
A list of sample files is shown on the right, with a red arrow pointing to the 'Repository of IPS Samples' button:

- XML_Samples
- AK_Repository_Example_01.json
- AT_EGA_Graph_01.json
- CA_IPS_Bundle_01.json
- CA_FhirVersion_01-mixed.json
- CA_FhirVersion_01.json
- CIL_IHC_Loemper_01.json
- IC_Lev_Vidarson_01.json
- EU_Genotype_Cancer_01.json
- EU_Genotype_Cancer_02.json
- EU_George_Cancer_01.json
- HQ_IPS_Sample2.json
- HQ_IPS_Sample3.json

File	Last Commit	View
shardindexbook Create CA_Bundle_fullyconnected.json	7 months ago	
XML_Samples	sh1031 sample of European patient summary (not IPS-ready transform)	7 months ago
AK_Repository_Example_01.json	Moving samples to connectathon folder	7 months ago
AT_EGA_Graph_01.json	Moving samples to connectathon folder	7 months ago
CA_IPS_Bundle_01.json	Adding new AT-IPD sample (selected). Fixing country name	7 months ago
CA_FhirVersion_01-mixed.json	Minimum CA PS Bundle	7 months ago
CA_FhirVersion_01.json	Fixing name: Juniper not Juniper	7 months ago
CIL_IHC_Loemper_01.json	and H1N1 now sample	7 months ago
IC_Lev_Vidarson_01.json	Moving samples to connectathon folder	7 months ago
EU_Genotype_Cancer_01.json	Moving samples to connectathon folder	7 months ago
EU_Genotype_Cancer_02.json	Moving samples to connectathon folder	7 months ago
EU_George_Cancer_01.json	Moving samples to connectathon folder	7 months ago
HQ_IPS_Sample2.json	Uploading samples from Hong Kong - Jan 2022 Connectathon	7 months ago
HQ_IPS_Sample3.json	Uploading samples from Hong Kong - Jan 2022 Connectathon	7 months ago

CQL Engine (CQL)

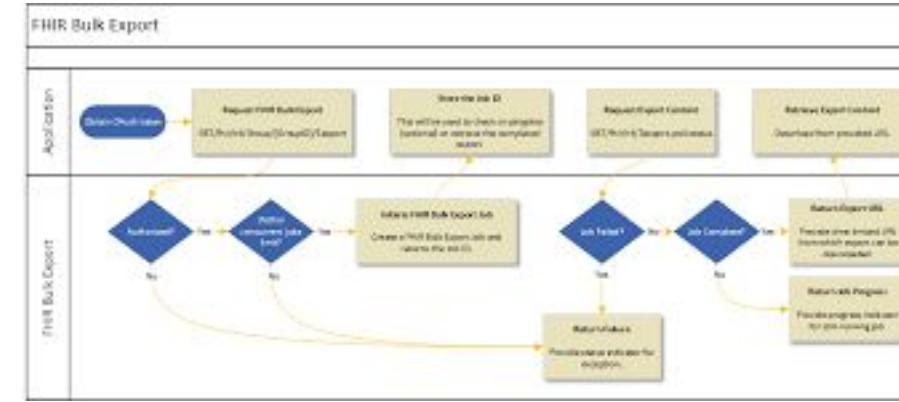
- Description:** This service will interpret and process CQL expressions, used to calculate quality measures and detect gaps in care.
- To process them, it needs access to the required FHIR resources through a FHIR store.
- Example:** Several providers have their own CQL engine:
 - HAPI FHIR has its own CQL execution engine
 - https://hapifhir.io/hapi-fhir/docs/clinical_reasoning/cql.html
 - FIRE.LY also has a .net based CQL engine
 - <https://github.com/FirelyTeam/firely-cql-sdk>
 - Google provides an (experimental) CQL engine
 - <https://github.com/google/cql>



Secondary Use

Components in this aisle

- FHIR Bulk Export
- De-Identification
- FHIR-to-OMOP
- SQL-on-FHIR
- FHIR-to-Parquet



This category applies to services which allow (asynchronous) extraction of massive clinical and financial healthcare data from FHIR format to other formats or from source or FHIR data to FHIR Bulk Format.

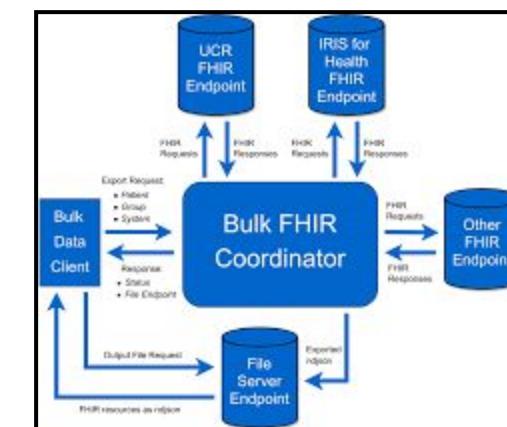
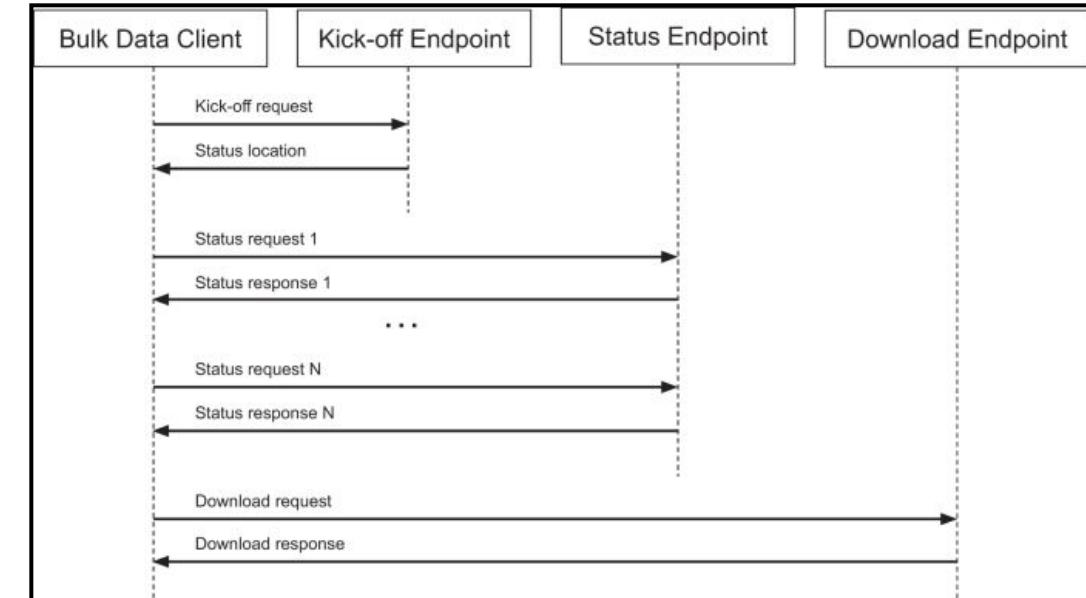
They are a "prelude" to secondary use.

FHIR Bulk Export defines a standard operation to request data extraction from an EHR or other system. The result of the extraction will be a set of NDJSON files (at least one per each resource type).

We will encounter this kind of need almost on every project, specially if some form of population health analysis, measures, or KPIs are needed (if no measure/analysis is needed, why are we even doing this project?)

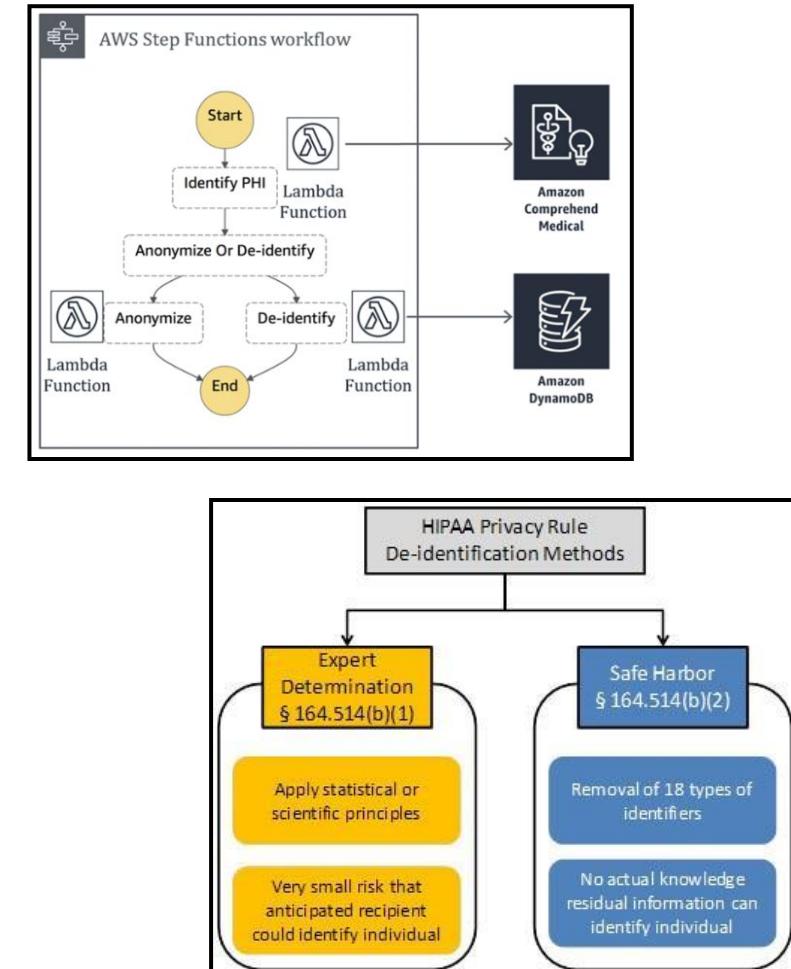
FHIR Bulk Export (FHIR-EXP)

- Description:** This service will accept a \$export operation, and process it:
 - The operation parameters include which resources to extract, criteria for inclusion, specific patient group to target, date last changed, file storage target, etc.
 - After the operation is accepted, the service will provide a status endpoint for operation monitoring. Then it will gather the required data and create one or more files (one per resource type) with the requested resources for the client to download.
- Example:** Since it is required by US regulations, most FHIR Native servers and EHR vendors support \$export. The only problem is...**performance**.
 Make sure it meets your expectations.



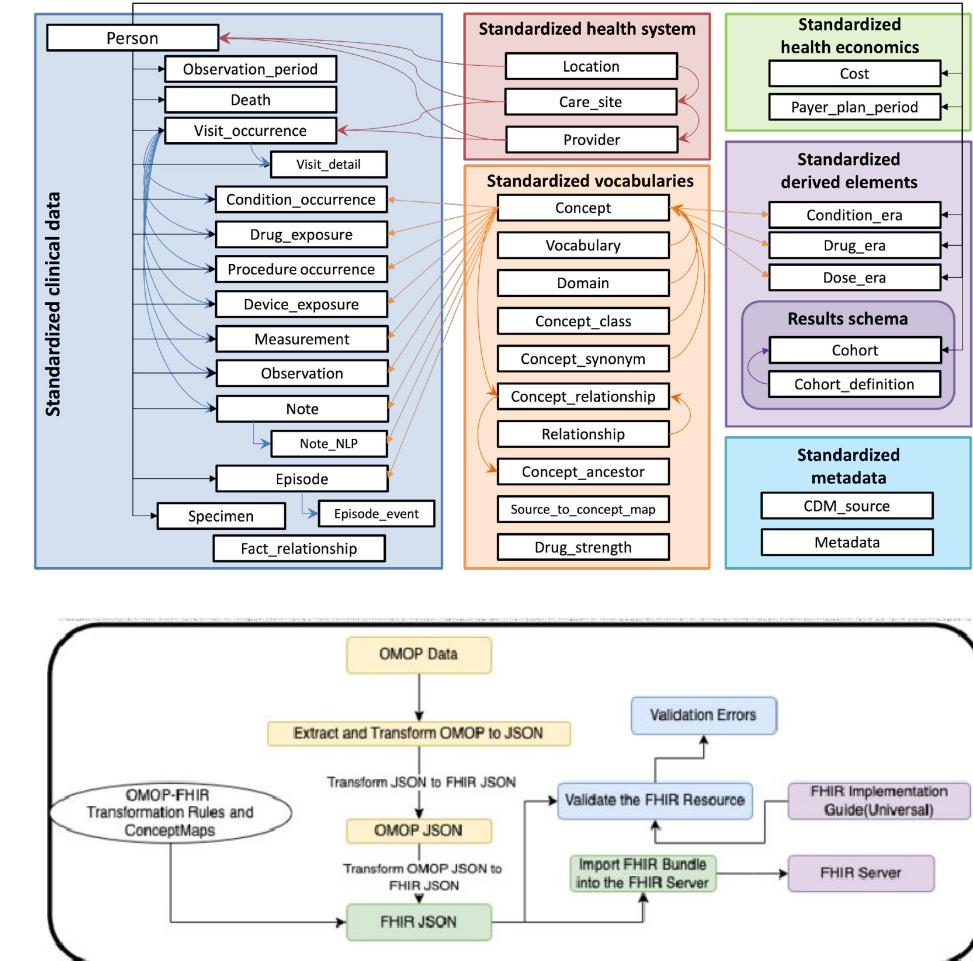
De-Identification Services (DID)

- **Description:** This service needs to apply de-identification algorithm to the exported resources. It involves removal or masking of relevant patient demographics (identifiers, locations, names, etc.) to ensure healthcare information confidentiality.
- **Example:** FHIR Cloud Vendors provide strategies to de-identify patients while creating exports (Microsoft) or the option to create a new "de-identified" store before exporting (Google).
- Regulations for De-Identification may be different in each country and project: vendors usually provide also a scripting language to customize the de-identification strategy (removal of fields, use fixed values, use random values in a specified range, change slightly the values, etc.)



FHIR-to-OMOP Transformer (FHIR-OMOP)

- Description:** This service will transform FHIR resources into the OMOP SQL format.
 - We are including this service in this category because you will not usually create ONE patient for OMOP, it's for population health analysis and measures.
 - OMOP is widely used globally for data analysis. It's a combination of a SQL Schema with a robust terminology system.
 - There is no official mapping yet, but several active projects. There are also some projects working on OMOP-FHIR conversion**
- Example Conversor:**
<https://github.com/OHDSI/FhirToCdm>

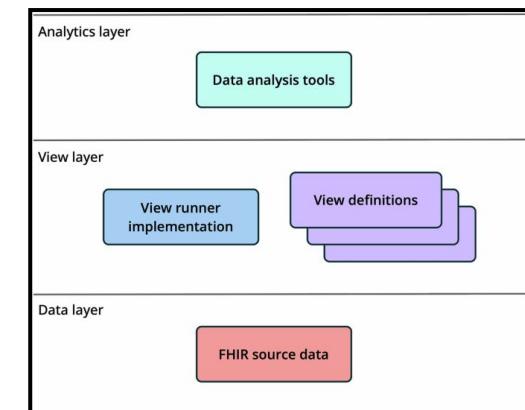


SQL-on-FHIR Engine (FHIR-SQL)

- **Description:** This service will provide a standardized data layer to access any FHIR Store using plain SQL, through processing standard views to simplify nesting, choices, extensions, etc.
- Not all vendors support the specification which is not an official HL7 IG yet.
- **Example: SQL-on-FHIR is supported by**
 - FHIR Aidbox (Health Samurai)
 - Google Healthcare (Google)
 - Pathling (CSIRO)

```
{  
  "resourceType": "ViewDefinition",  
  "resource": "Patient",  
  "name": "patient_demographics",  
  "select": [  
    {  
      "column": [  
        {"name": "patient_id", "path": "getResourceKey()"},  
        {"name": "gender", "path": "gender"},  
        {"name": "dob", "path": "birthDate"}  
      ],  
      "foreach": "name.where(use = 'official').first()",  
      "column": [  
        {"path": "given.join(' ')", "name": "given_name"},  
        {"path": "family", "name": "family_name"}  
      ]  
    }  
  ]  
}
```

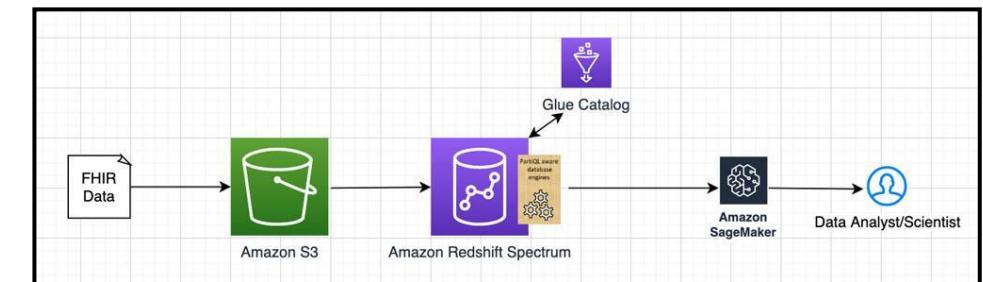
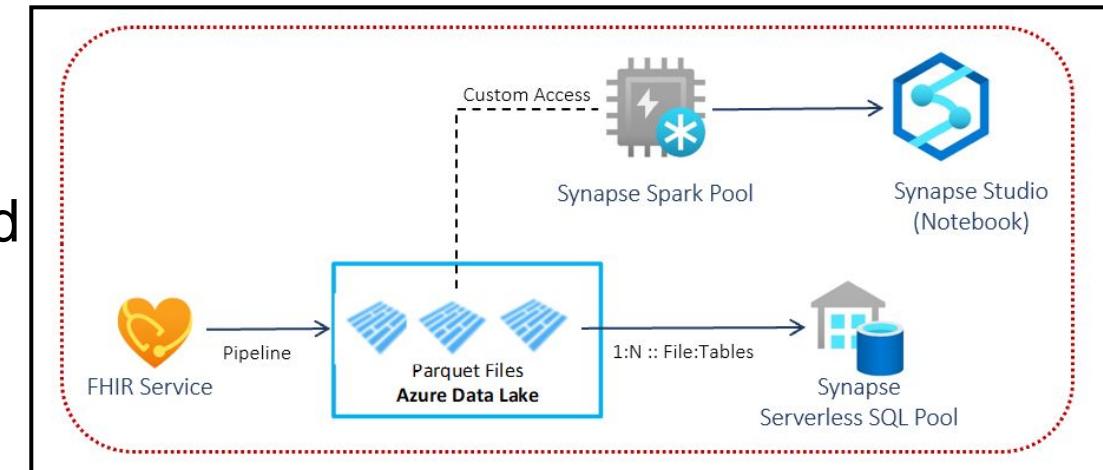
id	gender	dob	given_name	family_name
5e23837b-....	female	1952-03-08	Malvina Gerda	Vicario
93f09189-....	male	1981-08-08	Yolotzin Adel	Bristow
44d86263-....	other	2015-01-28	Jin Gomer	Aarens



FHIR-to-Parquet (PARQ)

- **Description:** This service will convert FHIR resources into Parquet format. Parquet is widely used for ingesting data for analytics and ML.
- There is no standard specification for the conversion.
- One file for each resource type will be generated.

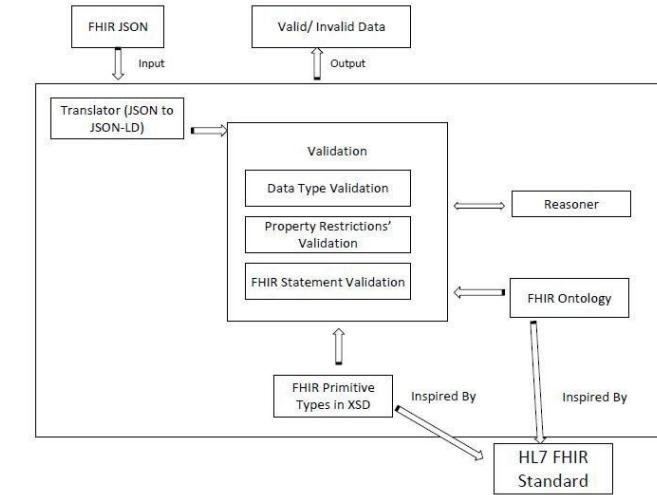
- **Example:**
- Google created a new open-source component called FHIR Data Pipes ETL for FHIR to Parquet automatic conversion.
- Microsoft uses a Synapse pipeline to get information from the FHIR Store to an Azure Data Lake.



Validation

Components in this aisle

- Resource Validation
- Medication Definitions
- Terminology Access
- Terminology Authoring and Distribution
- Business Rules, Workflow and Validation
- Questionnaire and Measure Definitions



Some of the validation can be performed with the profiling infrastructure provided by FHIR, but some other validation needs custom programming (i.e. : Business Rule Validation)

Validation often involves also terminology checking, and for that we need to have access to updated terminology.

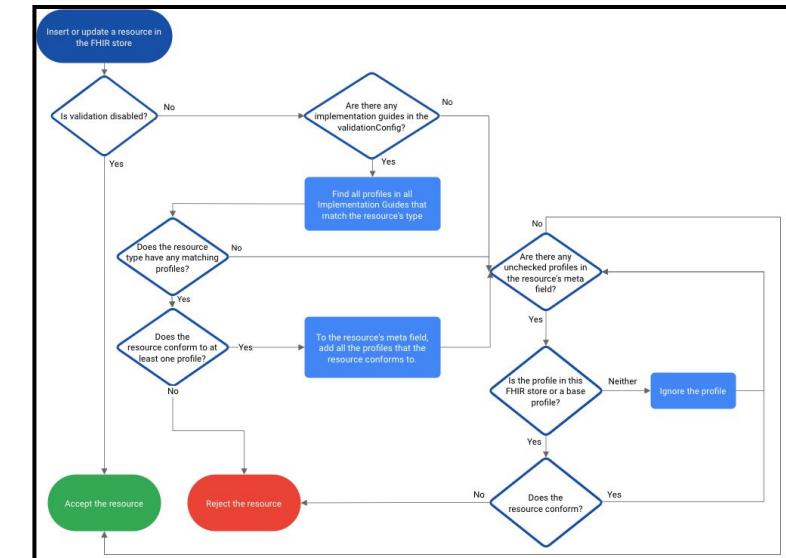
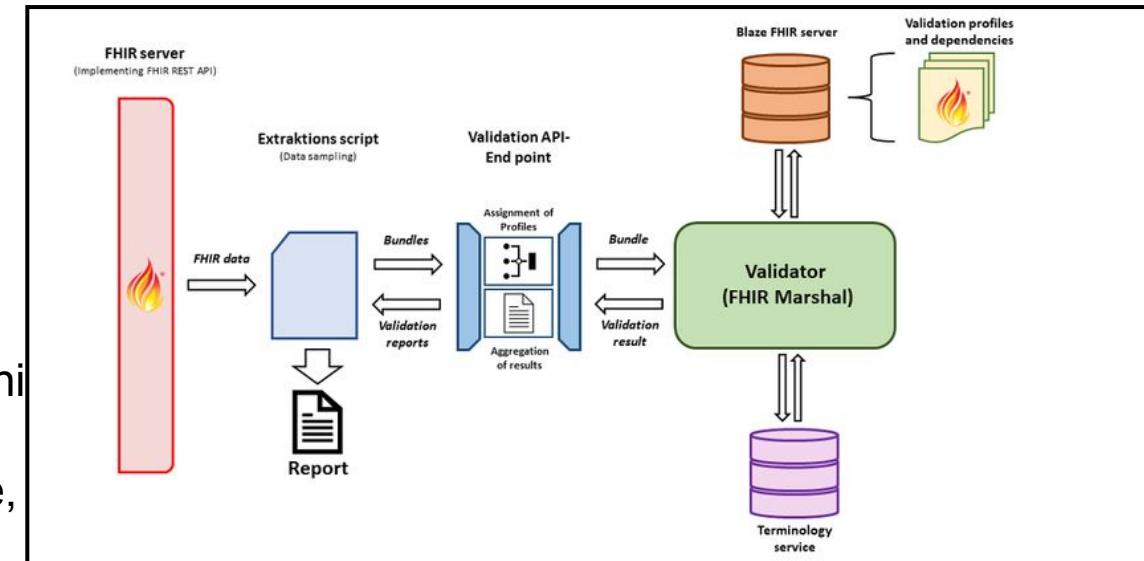
Medication, Questionnaire and Measures definitions go beyond simple "concept" definition, so they deserve their own infrastructure.

Resource Validation (VAL)

- Description:** This service can do validation of resources at 3 levels:
 - 'schema' -> Valid FHIR JSON ,
 - 'schematron' -> Valid FHIR JSON, including relationships between elements,
 - 'structure definition' -> Valid FHIR & Profile Structure, including (or not) terminology.

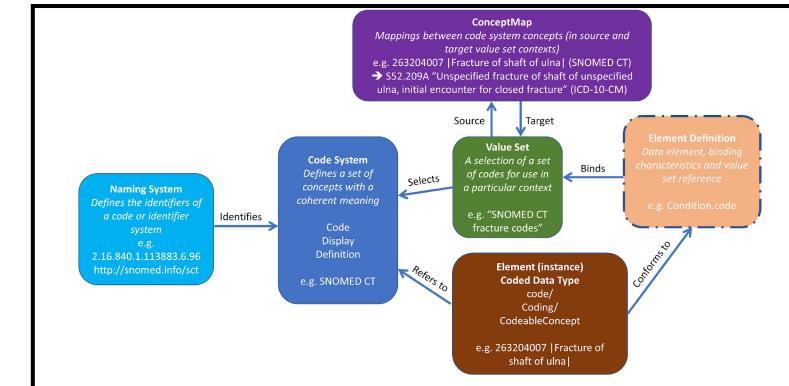
Sometimes the resources are ingested with basic schema validation and later on they are analyzed against the profile and terminology.

- Example:** FHIR Validator (<https://validator.fhir.org/>) is the classic tool, but most FHIR Servers (FHIR HAPI, Google, Microsoft, AWS, FireLy, Aidbox) can validate a resource if provided by the Implementation Guide Package by executing the **\$validate** method.
- Some engines can automatically validate profiles and terminology RFFORF ingestion



Terminology Access (TERM)

- Description:** This service provides standardized access to terminology, through support for the Terminology Services FHIR Specification.
- This allows any application or other servers to validate codes against defined value sets, populate combo boxes, map a code from one code system to another, etc.
- Sometimes the terminology endpoint is "the door" to a federation or ecosystem terminology server (some terminology servers are specialized in specific code systems or value sets or require paid or assigned licenses).
- Examples:**
 - FHIR HAPI** provides an open-source Terminology Server out of the box.
 - CSIRO** provides Ontoserver, a terminology server with authoring and distribution capabilities.
 - Regenstrief (LOINC), VSAC and SNOMED** provide their own FHIR-enabled services for their terminologies.

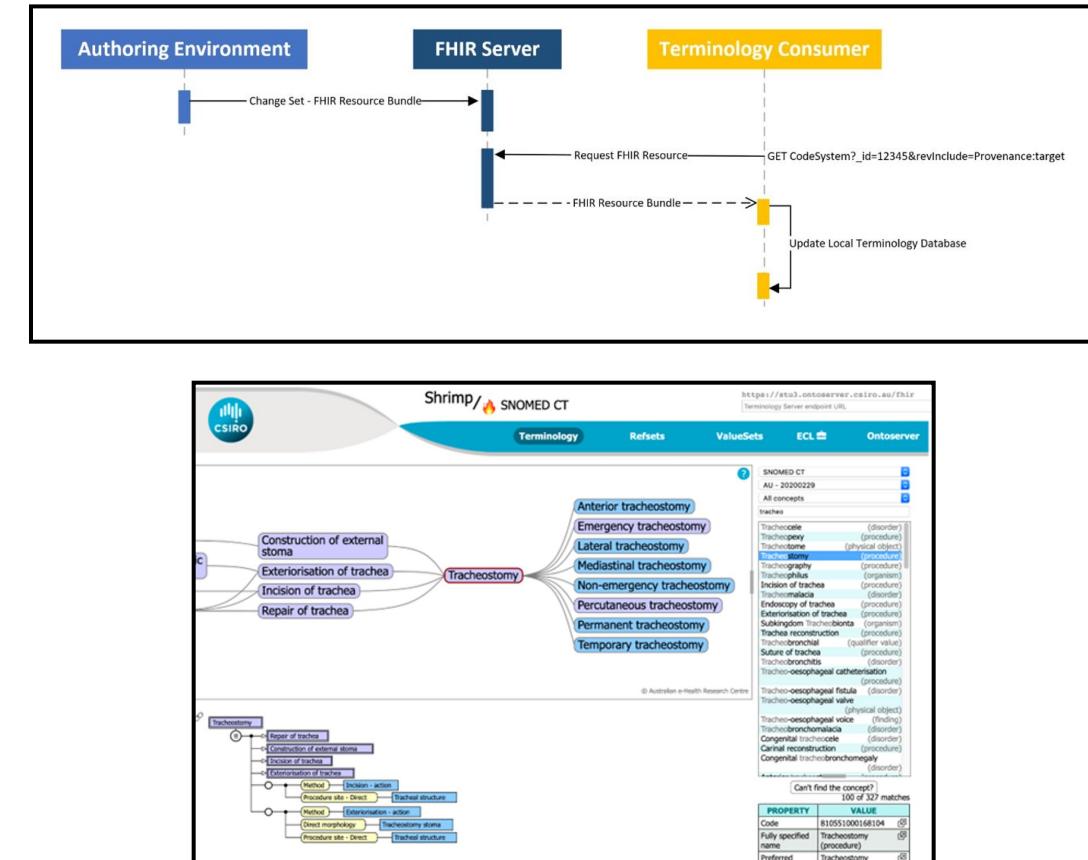


Bibliography: <https://confluence.hl7.org/spaces/FHIR/pages/81023947/Terminology+Services>

FHIR Implementation Guides: <https://hl7.org/fhir/terminology-service.html>

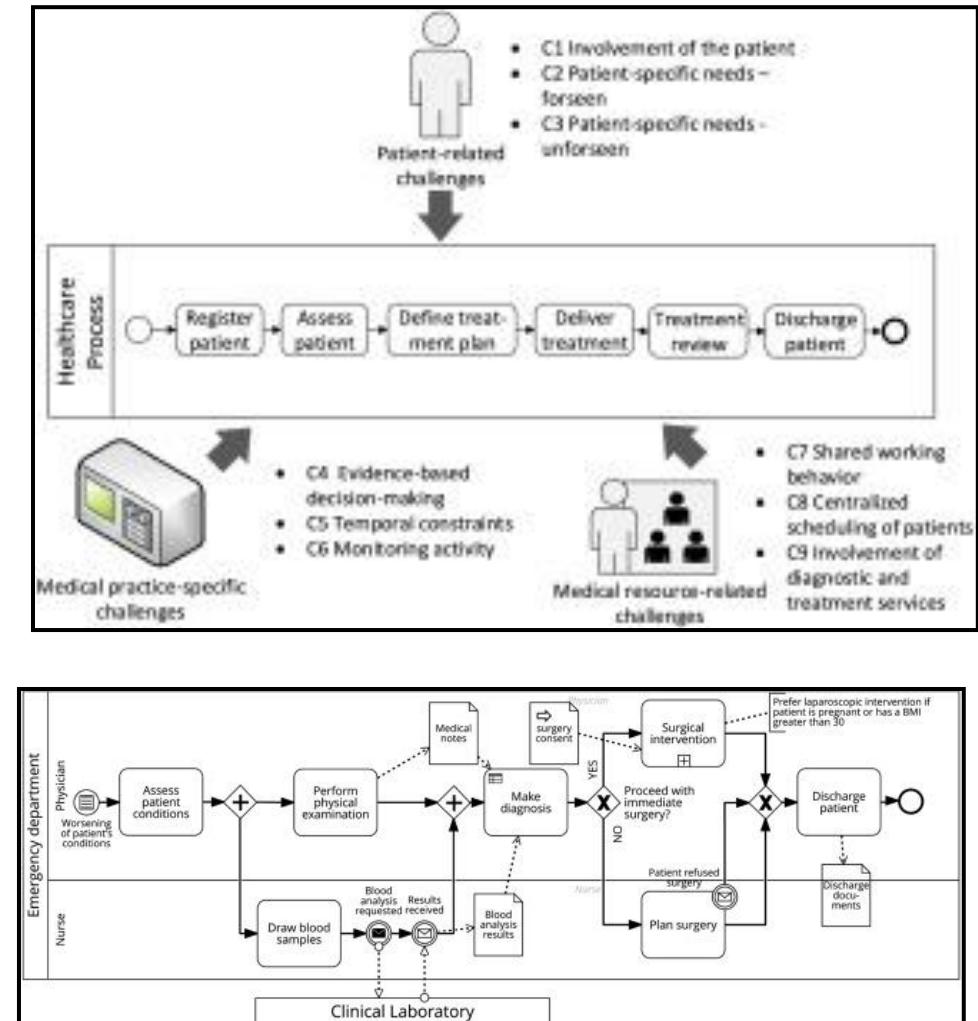
Terminology Authoring and Distribution (TERM-AD)

- Description:** This service allows creation and maintenance of ValueSets, Code Systems, and Concept Maps.
- It also provides a mechanism for terminology import/export.
- Finally, it can facilitate distribution of terminology between different sites, usually through a hierarchy or syndication scheme
- Example: CSIRO (AU) offers a syndicated terminology server: Ontomed**



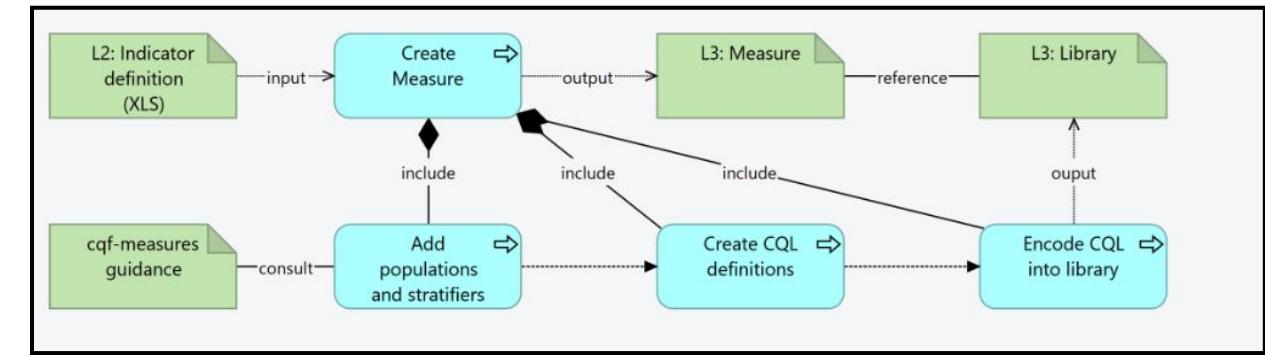
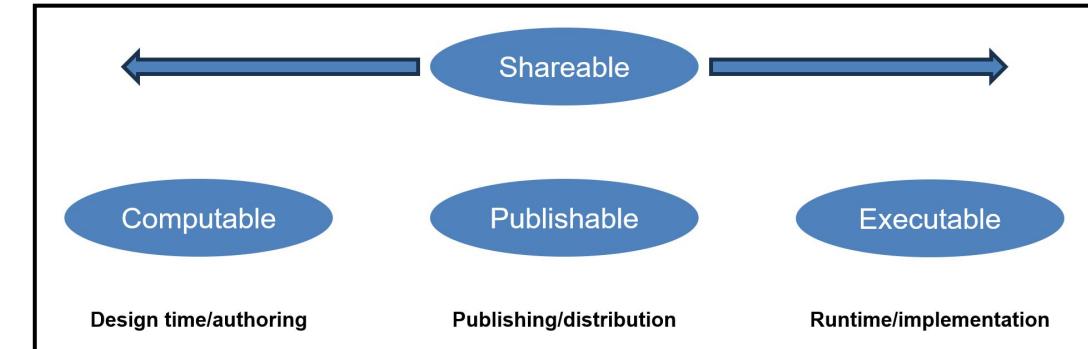
Business Rules, Workflow and Validation (BRW)

- **Description:** This component allows to define and implement local business rules for processing, workflow or validation.
- Rules and workflow can be implemented through scripts, compiled language, rules engines, CQL scripts, Workflow engines, BPMN+ diagrams, etc.
- Rules are frequently combined with 'definitional' or 'canonical' resources to convey knowledge.
- **Example:** A list of BPMN capable workflow engines is here:
https://en.wikipedia.org/wiki/List_of_BPMN_2.0_engines



Questionnaire, Medication and Measure Definitions (CRM)

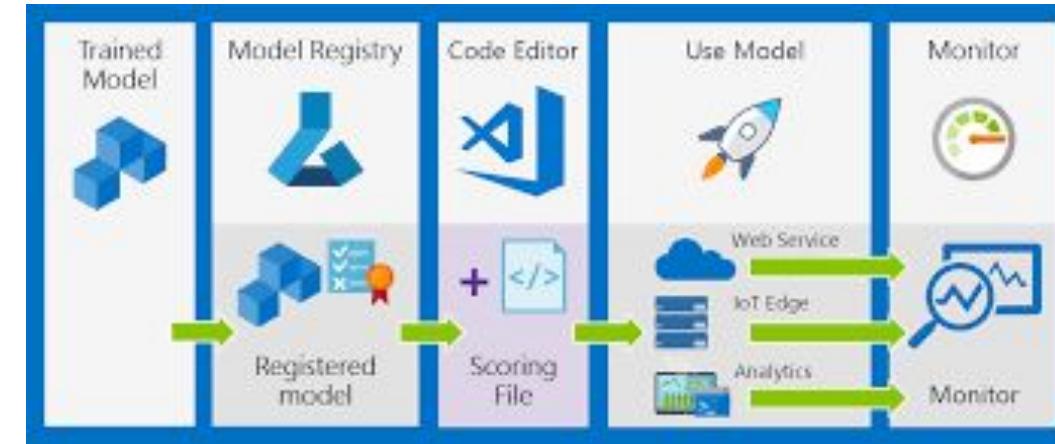
- **Description:** This service allows the authoring and access to what is called "Knowledge Representation Resources" or "Canonical Resources".
- With these kind of FHIR resources you can semantically represent and exchange library, medication, activity, procedure, guideline, questionnaire and measure definitions.
- **Examples:**
<https://hcforms.nlm.nih.gov/>
 - Has several tools for defining



Artificial Intelligence

Components in this aisle

- Machine Learning
- Image Recognition
- Language Translation
- Natural Language Processor
- Chatbot
- Generative AI
- A2A Service
- MCP Server



This kind of service provides access to machine learning tools, services, and infrastructure (can be in house or –most likely- cloud based).

Machine Learning Training (MLT)

- **Description:** Allows ingesting and processing datasets –also from FHIR NDJSON or Parquet) to create, develop, and train models
- **Examples:**
 - Amazon SageMaker
 - Azure Machine Learning
 - Google Vertex-AI

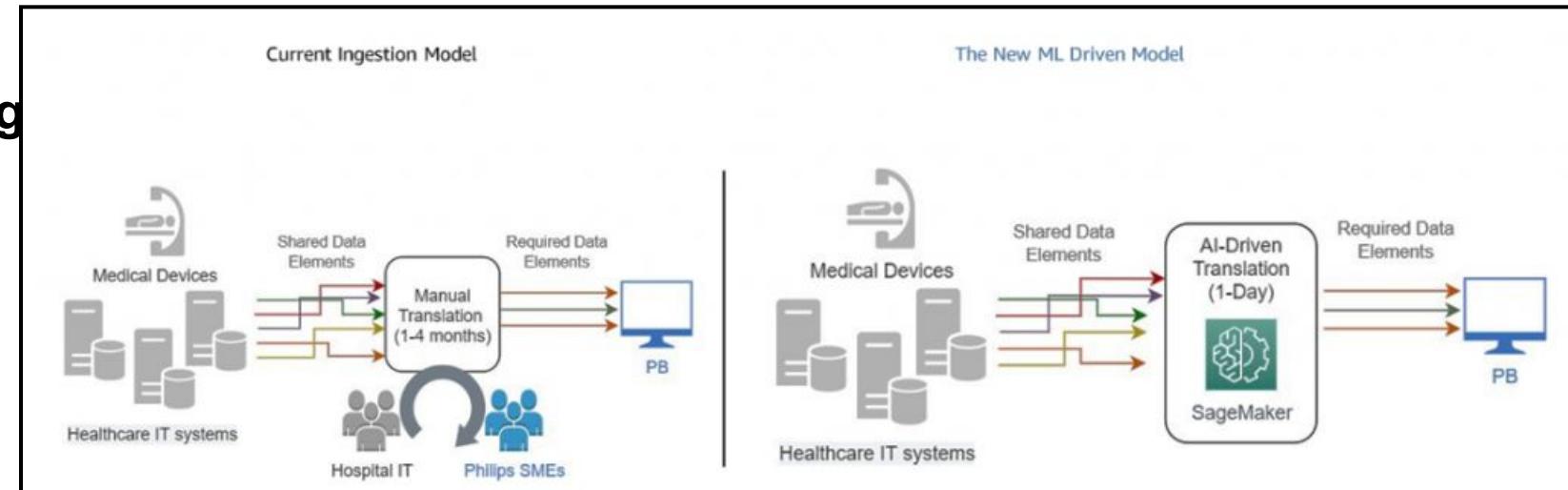
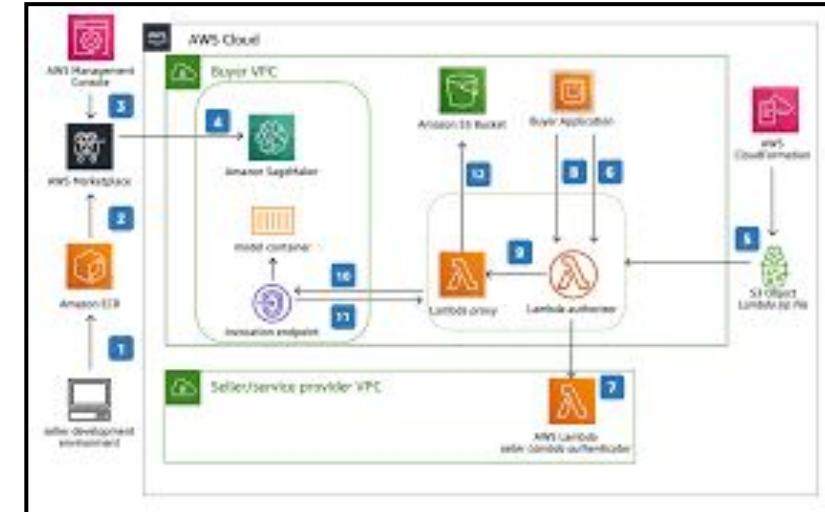
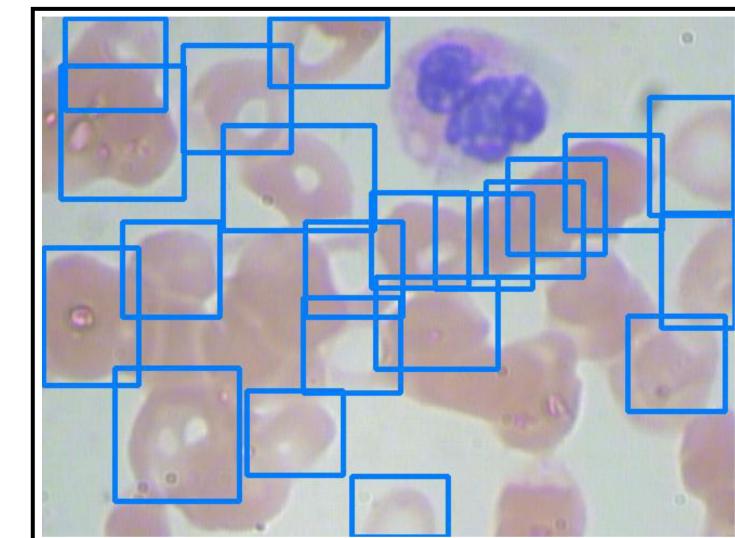
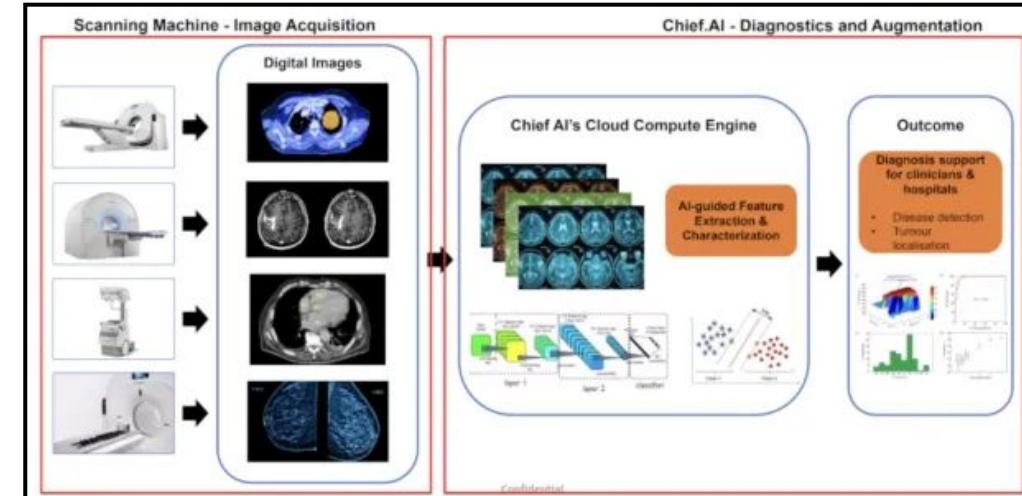


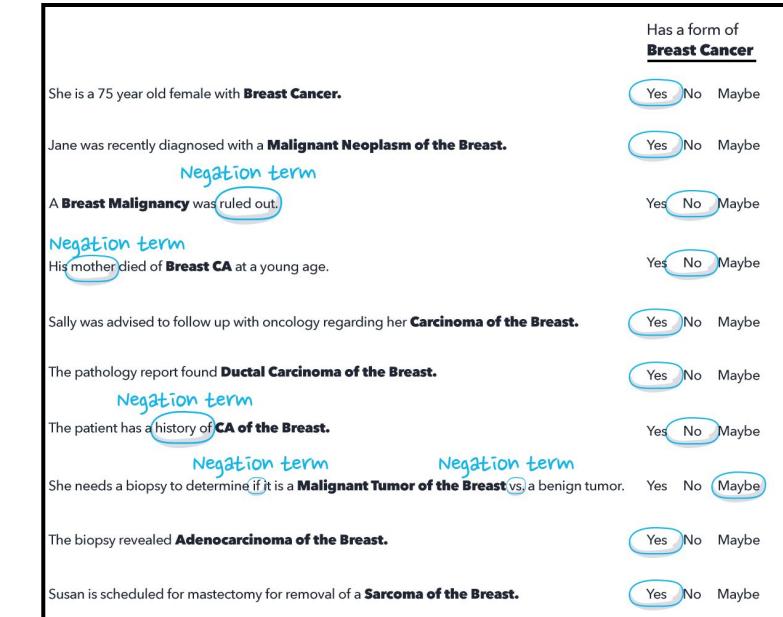
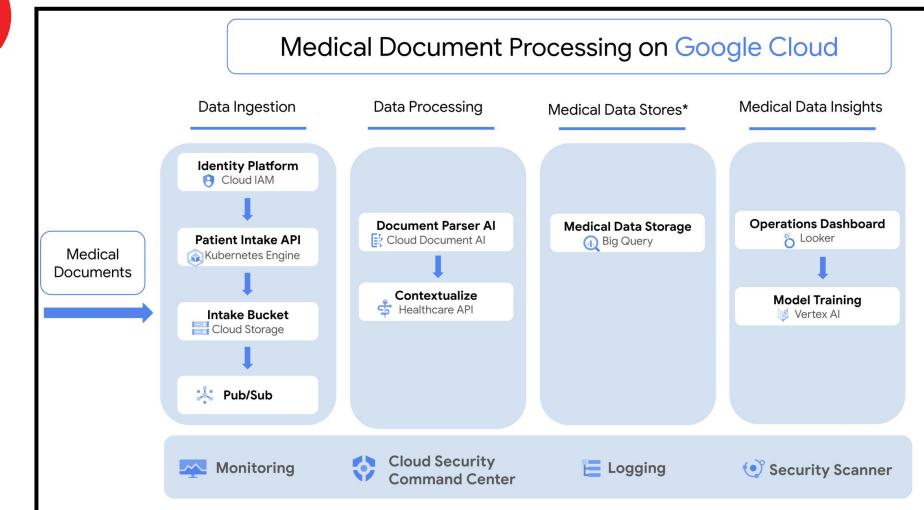
Image Recognition (CV)

- **Description:** This service can interpret and analyze visual data and derive meaningful information from digital images or videos.
- Some typical real-world applications in healthcare include Medical Image Analysis, Surgical Guidance, Disease Detection, Automated Cell Counting and Patient Monitoring. It can also be used process manually created or scanned documents and transform them into processable entities.
- **Example:** Amazon Rekognition, Google Vision AI, Azure AI Vision. **Open Source:** OpenCV (<https://opencv.org/>)



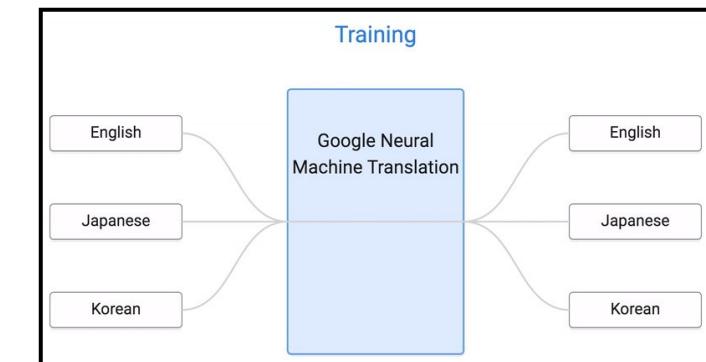
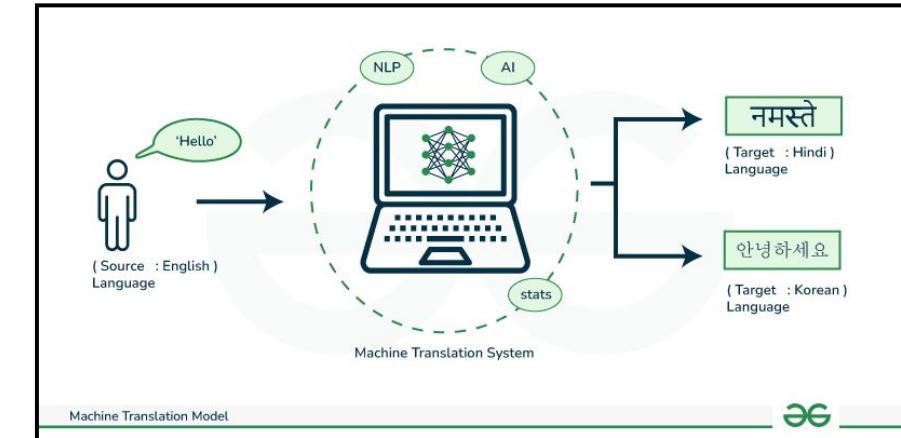
Natural Language Processor (NLP)

- **Description:** A service that understands, interpret, and generate human language. Remember that this can be in written or spoken format (so an "ambient" system is also an NLP service)
- **Some applications:** extract information from structured text, chat bots, sentiment analysis, medical coding, "ambient" systems : hear the conversation between care givers and patients and create the draft documentation
- **Example:** Amazon (Comprehend, Transcribe, Lex, HealthScribe) Azure (LUIS, Speech Services, Nuance DAX), Google (Cloud Natural Language API, Healthcare NLP, Speech-to-Text/Text to Speech)
- **Open-Source:** Apache cTAKES, Whisper+MedSpacCY



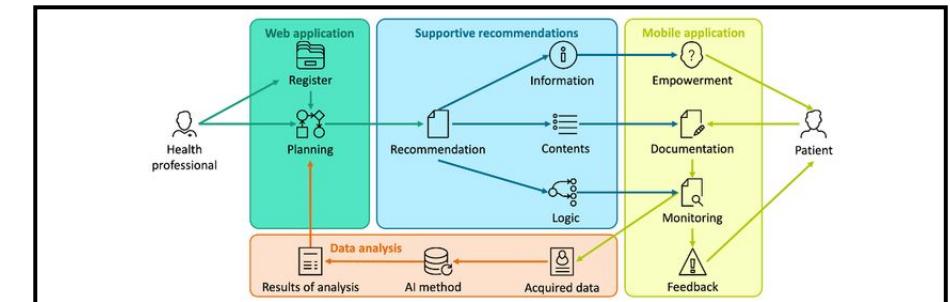
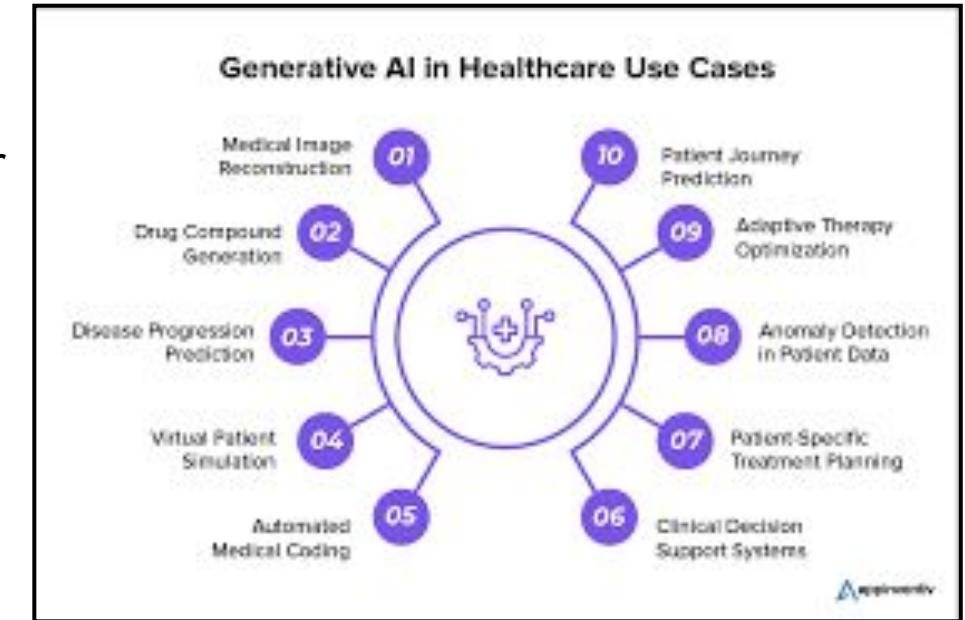
Language Translator (LT)

- Description:** This service is a "special case" of a natural language processor. It starts by recognizing the meaning of a natural language fragment, but the output is the same fragment in a different natural language.
- Useful in healthcare if you have to deal with cross borders patient summaries, or patients not able to speak the local language.**
- Example:** Amazon Translate, Azure Translator, Google Cloud Translation



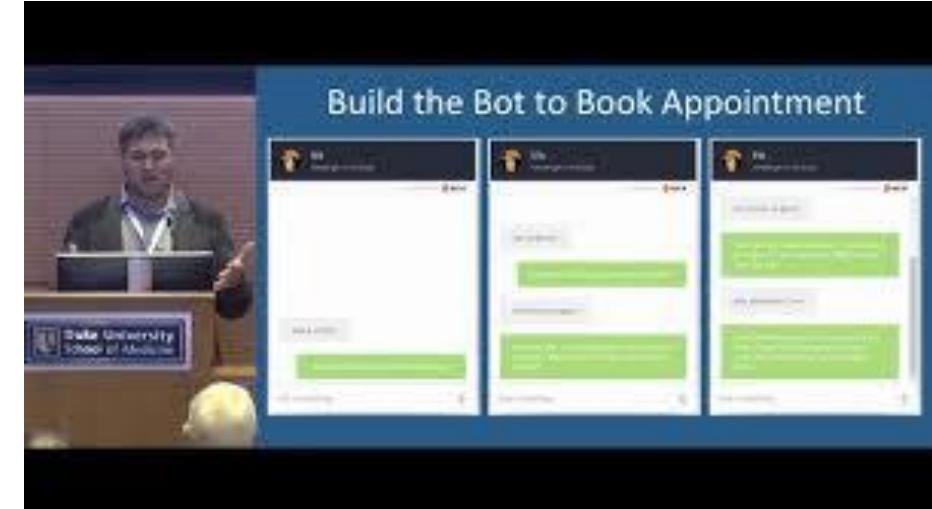
Generative AI (GenAI)

- **Description:** This service can create text, images, or videos based on its training on large datasets of information (LLM or large language models). Remember that there are two parts to this: the model (open source or proprietary), and the platform where the model is running (cloud or in-house, both are expensive for different reasons).
- **RAG (Retrieval-Augmented Generation):** Usually, LLMs need to be supplemented with more specific information to provide context to the model and avoid 'hallucinations'.
- Some applications: patient summaries from different documents or one encounter ("ambient" = NLP+ GenAI), personalized recommendations or pamphlets for medications, chatbot responses, synthetic data for system or data exchange testing, etc.
- **Examples** (Usually platforms support more than one model): OpenAI GPT, Google's Vertex AI, Anthropic Claude, Amazon Bedrock
- **Open Source:** Llama3, Mistral, DeepSeek



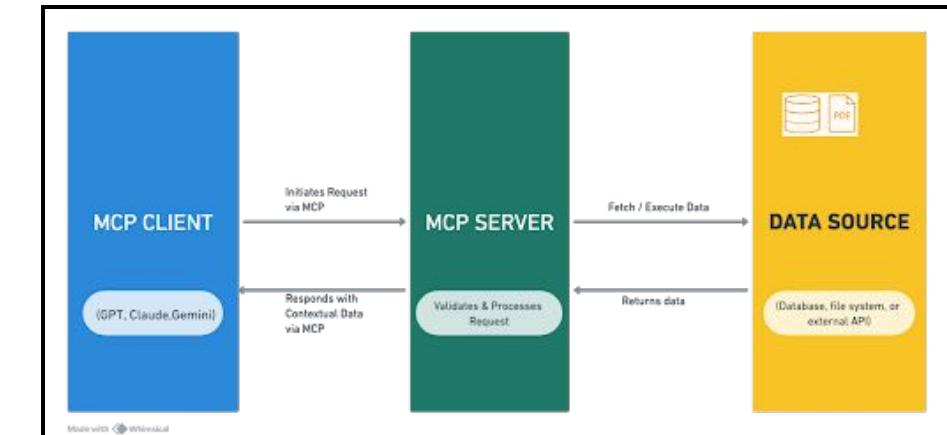
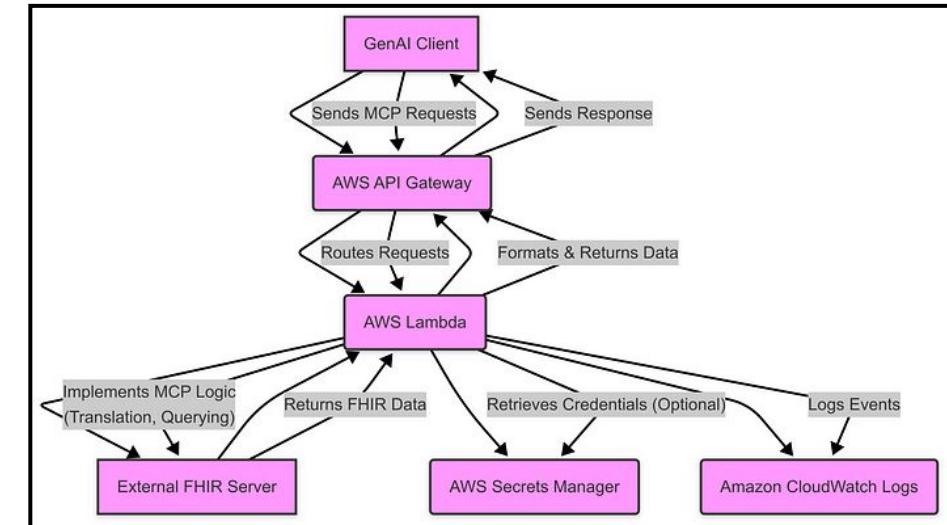
Chatbot and Agents (CHAT)

- **Description:** A component to enable smoother interaction with providers and patients (they can write a few words or just talk instead of learn/ use complicated UI schemes).
- A chatbot can answer questions, schedule appointments, monitor health, and even offer mental health support. If the user delegate a more complex task to a chatbot, it is 'an agent'. And we can also delegate tasks to an agent, without the chatbot.
- **What was first, the chatbot or the agent?**
- Chatbots and agents need : NLP, Generative AI, context and some way to interact with the underlying systems, and with other agents.
- We will see this in the next few slides



MCP Server (MCPS)

- **Description:** A service to provide just-in-time context to an AI chatbot, agent or any GenAI client. This new option emerged in November 2024. It uses a standard called MCP – Model Context Protocol (created by Anthropic)
- It is called "The USB-C cable of AI applications."
- Based on complementing the original model by calling a service in a standardized way that will provide the required information AT THE MOMENT.
- In the laboratory, this could be, for example:
 - The last five blood glucose values, and the glycosylated hemoglobin for the last six months (from laboratory systems or EHRs).
 - The current clinical guidelines for the treatment of diabetes (from the hospital management system). The medications the patient is taking (from the EHR).

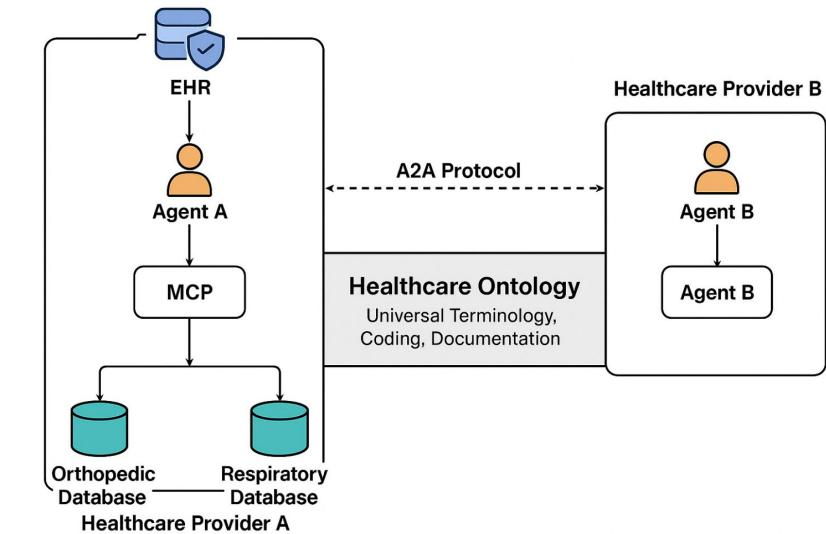


Bibliography: <https://modelcontextprotocol.io/examples>

FHIR Implementation Guides: Not yet. Several independent projects: <https://github.com/flexpa/mcp-fhir>

A2A Service (A2AS)

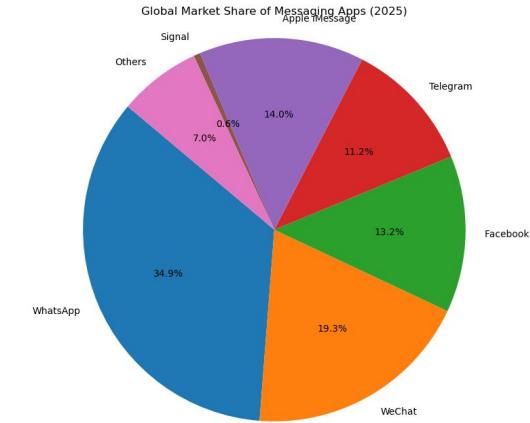
- Description:** Enable standard communication and collaboration between agents. Allows agents to discover each other's capabilities, negotiate interaction modes (text, FHIR, etc) and secure interactions. This protocol was created by Google. Applications: adaptive scheduling, predictive resource management, intelligent triage.



Notification Services

Components in this aisle

- E-Mail Notification
- EHR Push Notifications
- Messaging Integration



The main goal of these services is to reach the provider, payer or patient as soon as possible for alerts or just routine notifications or reports. Much has changed from the 'beeper' times, but the idea is the same, reach a person through the most common ways they use to communicate. An important thing to remember when notifying is whether/how a follow up action detected and recorded. "Notification is half of the problem"

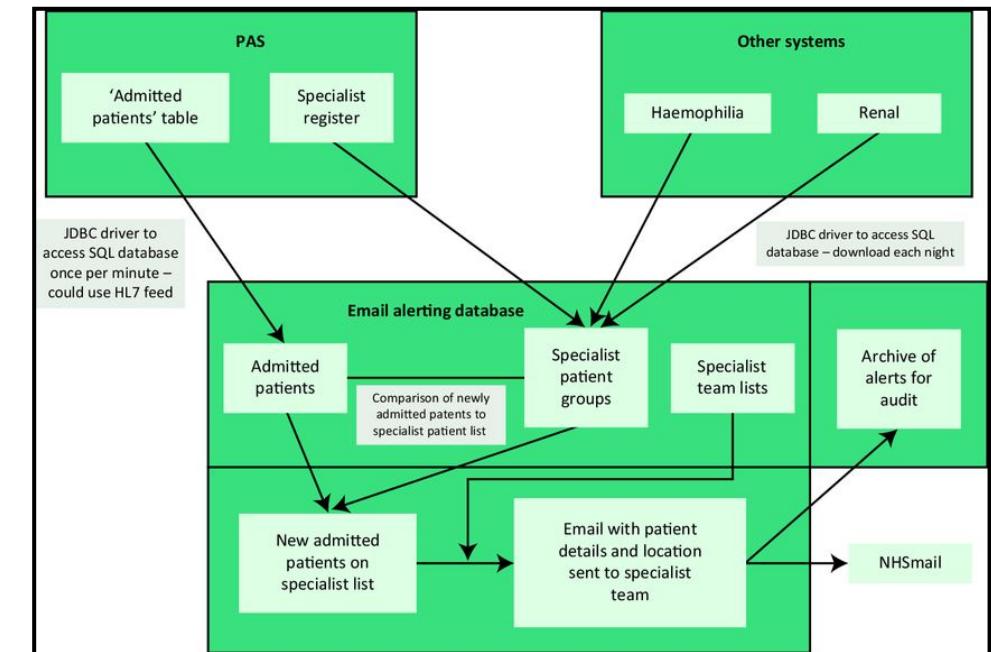
Some services and libraries in this area: Amazon SNS, Azure Communication Services, Google Cloud Pub/Sub+Firebase

Open-Source: Restcomm, Postal

Most used: Twilio, Whatsapp API

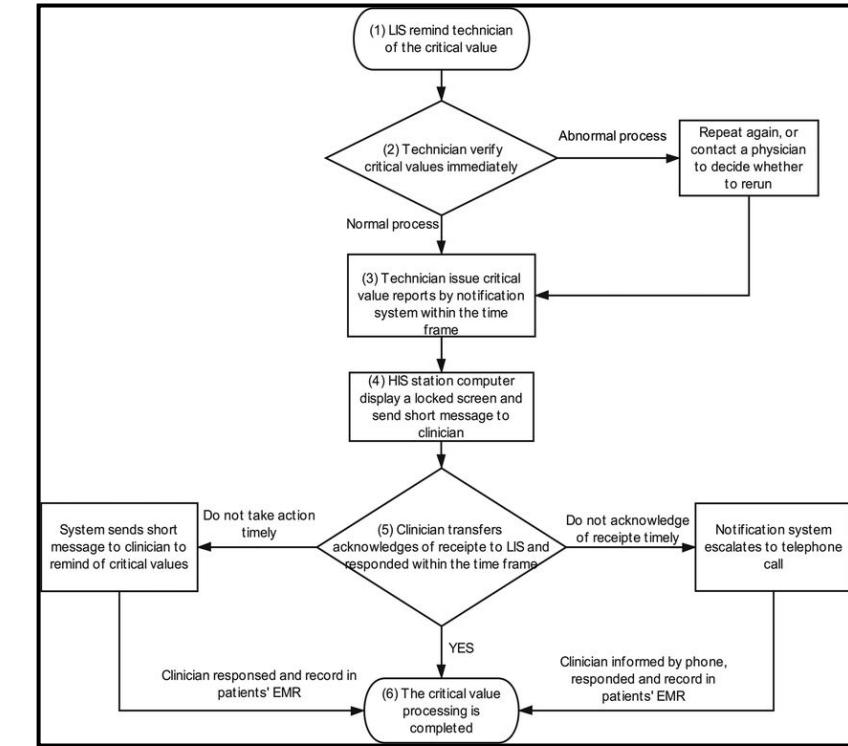
E-Mail Notification

- **Description:** This service will send the alert or notification via email.
- Some of the problems to solve:
 - Which email address to use for the sender and receiver (multi tenancy or hidden multitenancy)
 - Volume (emails/hour) blocking the sender
 - How to record consent
 - People answering to the notification
 - How to handle monitoring, errors and resending
 - How to make sure of the clinician or patient receiving the notification
 - How to handle privacy and confidentiality regulation or restrictions



EHR Push Notification

- **Description:** This component will just send the alert or notification directly to the EHR or patient portal.
- This kind of solutions has a main advantage: the security/encryption/privacy issues are already solved by the EHR or portal.
- The only problems are:
 - we need another notification for the clinician or patient actually enter the EHR or portal!
 - Additional burden for the clinician, nurse or technician



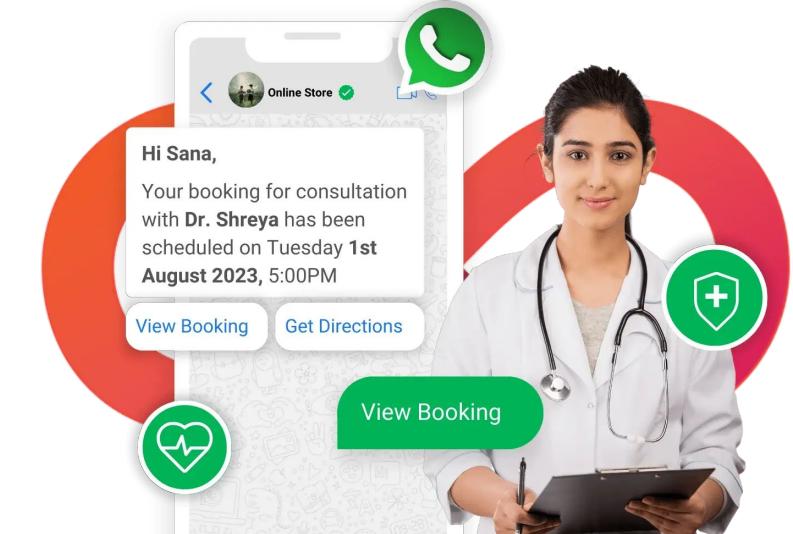
Bibliography: <https://pmc.ncbi.nlm.nih.gov/articles/PMC9279013/>

FHIR Implementation Guides (early development)

<https://confluence.hl7.org/download/attachments/216242256/HL7%20WGM%20Jan%202024%20Virtual-%20Device%20Alerting%20Update%20-%202024-01-30A.pdf>. --- also CommunicationRequest/Communication resource

Messaging Integration

- **Description:** This component can integrate with a messaging service (Whatsapp, Signal, Telegram, iMessage, Teams or an internal messaging service)
- This solution is faster than email, but it shares the same concerns on privacy and security.
- **HOWEVER**, we've seen more and more push on Whatsapp integration because...it's what the users want and can be integrated easily with a bot for follow up actions— especially outside of the US (34% of the global market use whatsapp for messaging)



Bibliography: <https://PMC.ncbi.nlm.nih.gov/articles/PMC6393161/>

FHIR Implementation Guides: CommunicationRequest/Communication resources

Diagram 1

This is OpenHIE
Architecture Diagram
Developed by <https://ohie.org/>
and recommended by PATH

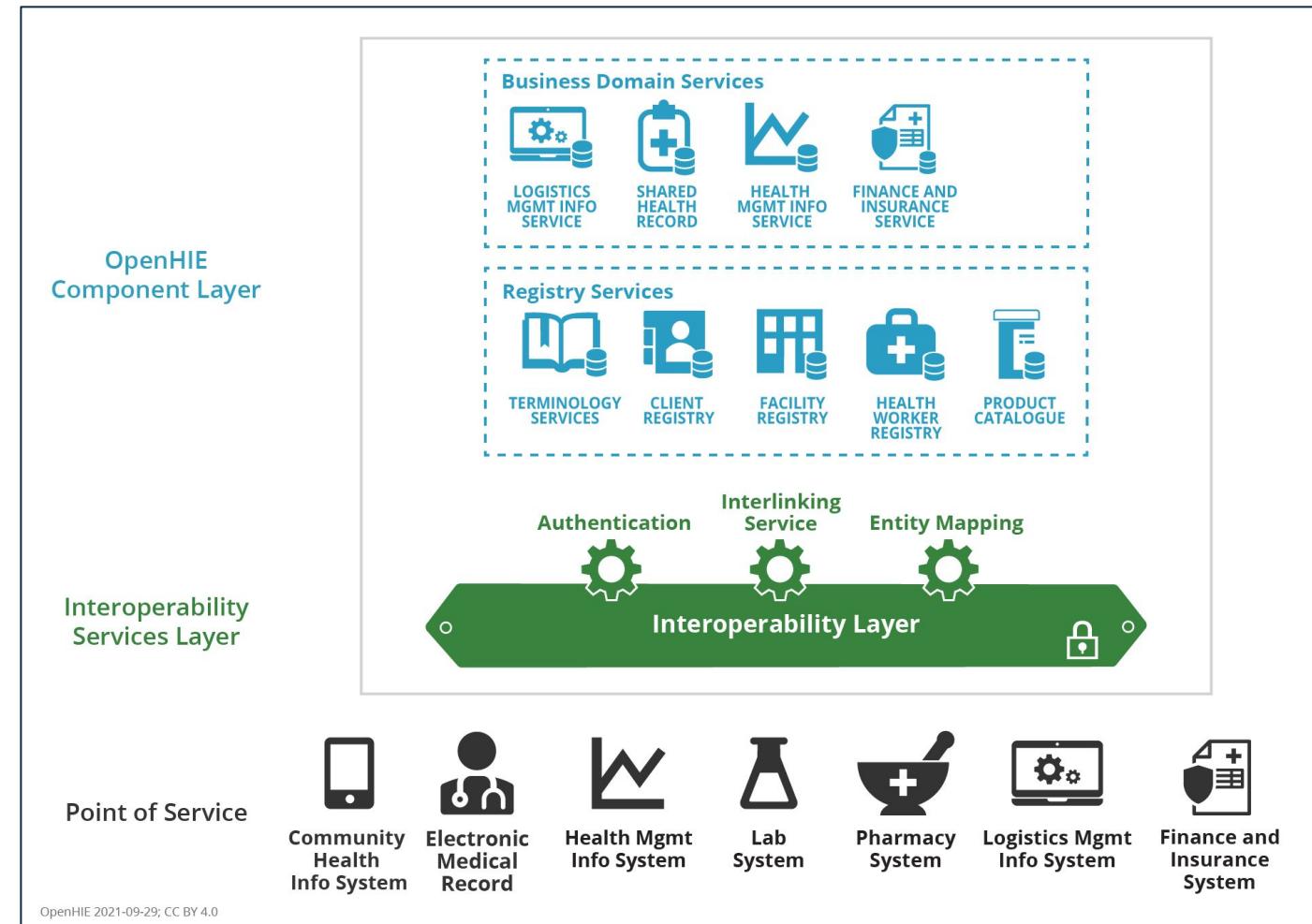


Diagram 2

This is Azure pipeline for FHIR based BI/Data Sharing using FHIR

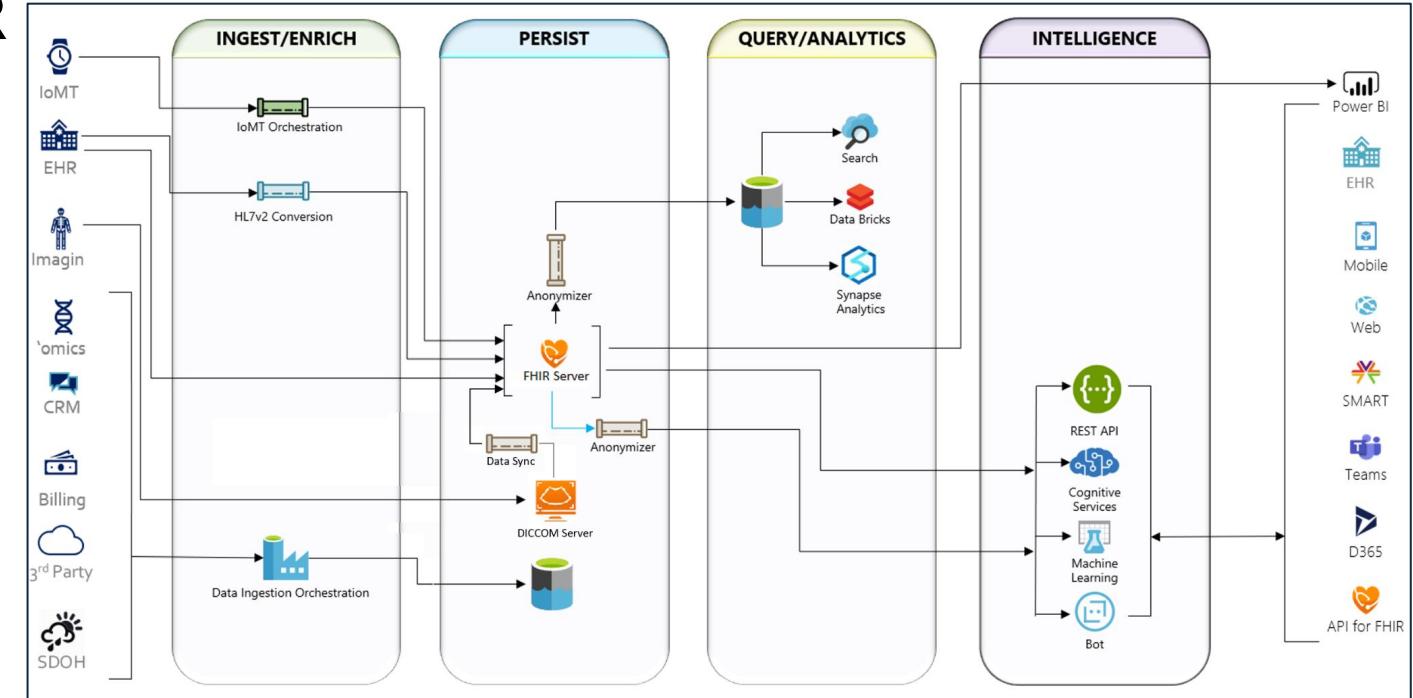


Diagram 3

This is a national digital health architecture based on openHIE

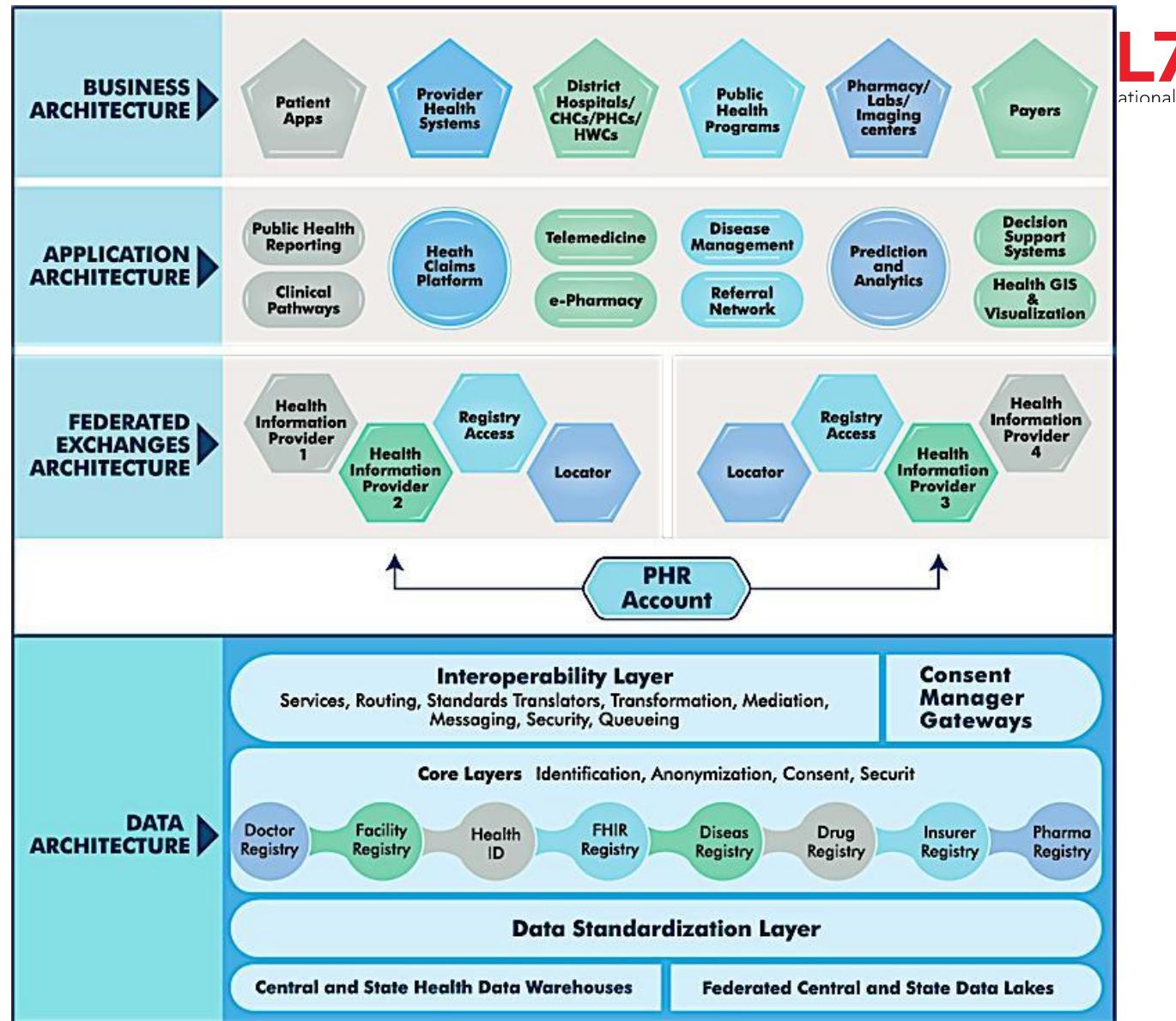


Diagram 4

A regional digital health architecture based on FHIR

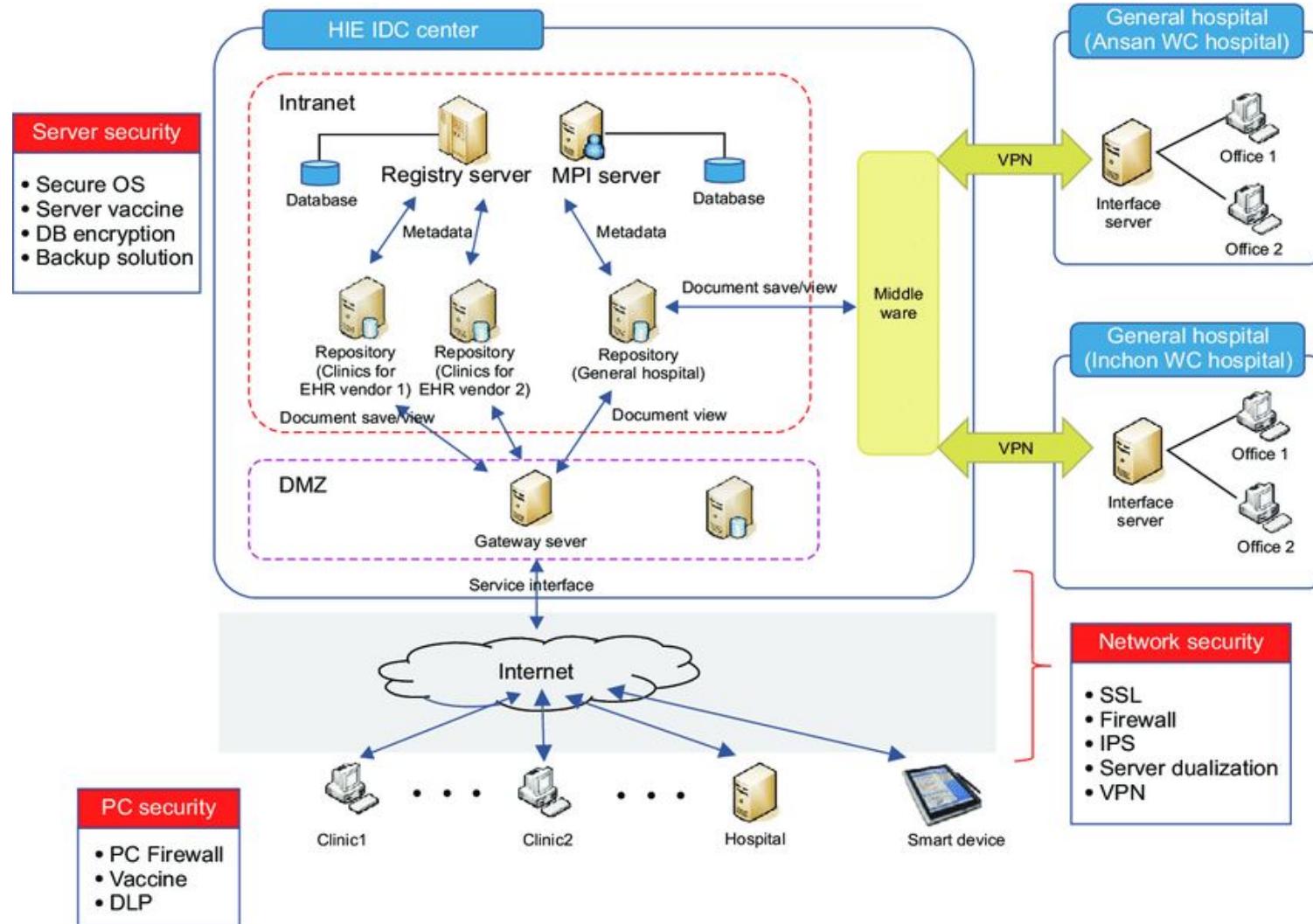
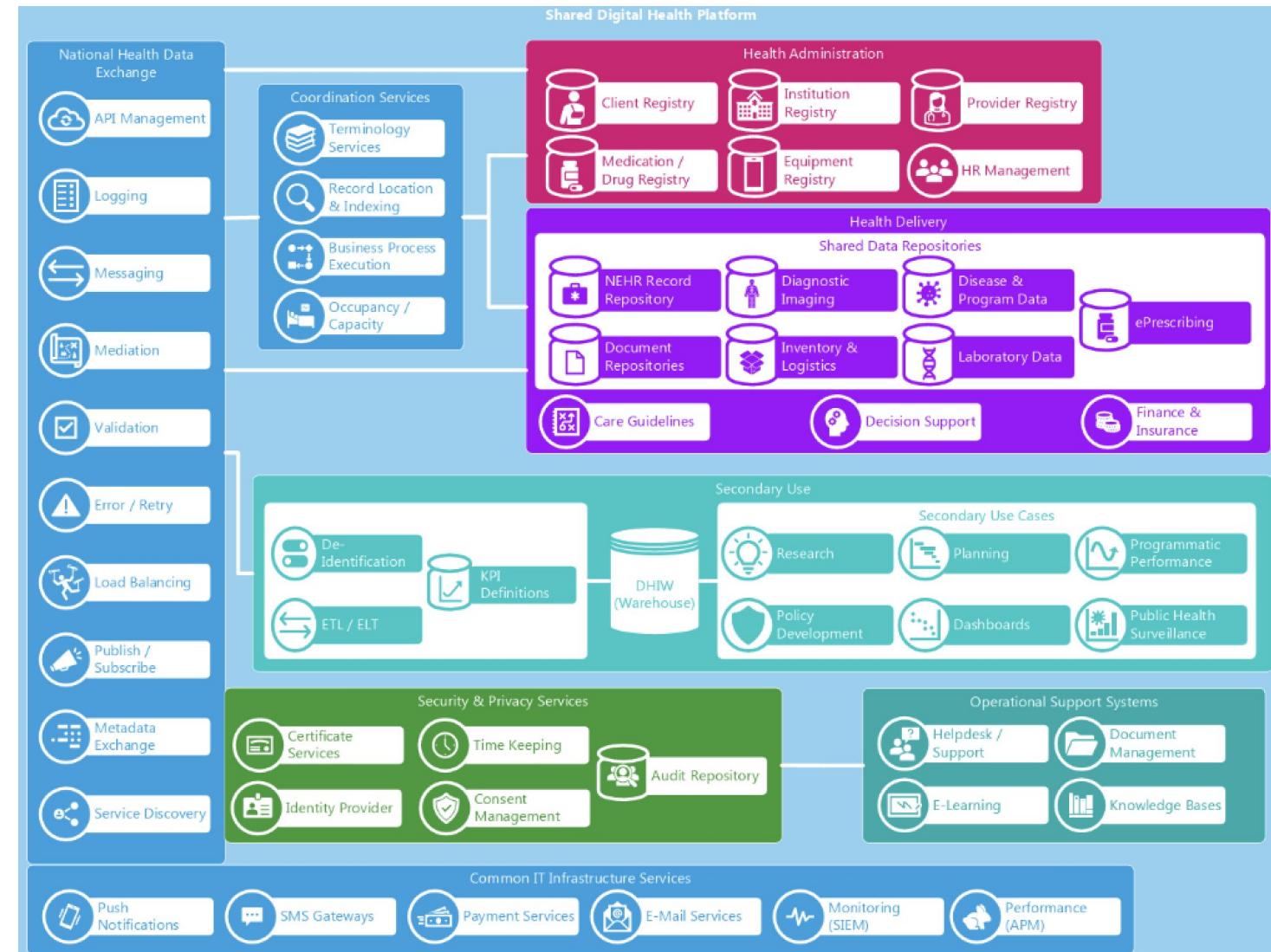


Diagram 5

Sri Lanka Architecture, based on OpenHIE



Questions?

- Let's play!

<https://tinyurl.com/fhirarch>



FHIR Architecture Supermarket Game

Double-click only on the components you think are needed for each project to add them to the shopping cart

Created by Diego Kaminker (diego@hl7.org) and Benji Graham (bgraham@belleso.io) for HL7 International, 2025

[4] Using Gen-AI, the International Patient Summary and Electronic Product Information to personalize Medication Leaflets
Effective medication management poses significant challenges, particularly when navigating multiple medications with intricate dosages and schedules. This paper presents a prototype mobile application to streamline information retrieval from dense medication leaflets. By utilizing automated information extraction based on large language models, the application seamlessly retrieves pertinent details from the Austrian medicinal product index upon scanning the medication package.

Bibliography/Example New Game Show Solution

The Aisles

Clinical Data Stores

Case Report

Infrastructure

API Gateway
Manages

Registries

Device Directory
Directory of

Integration

Artifact Transformation Engine

Shopping Cart

Thank you!