

FHIR IN THE CLOUDS

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Disclaimer

- Throughout this section we will mention FHIR related products and services provided by some cloud vendors.
- This is NOT endorsement, it's just "industry trend acknowledgment". Some of the screens are extracted from product blogs or documentation and are included only as illustration of the industry's capabilities.



Google Cloud

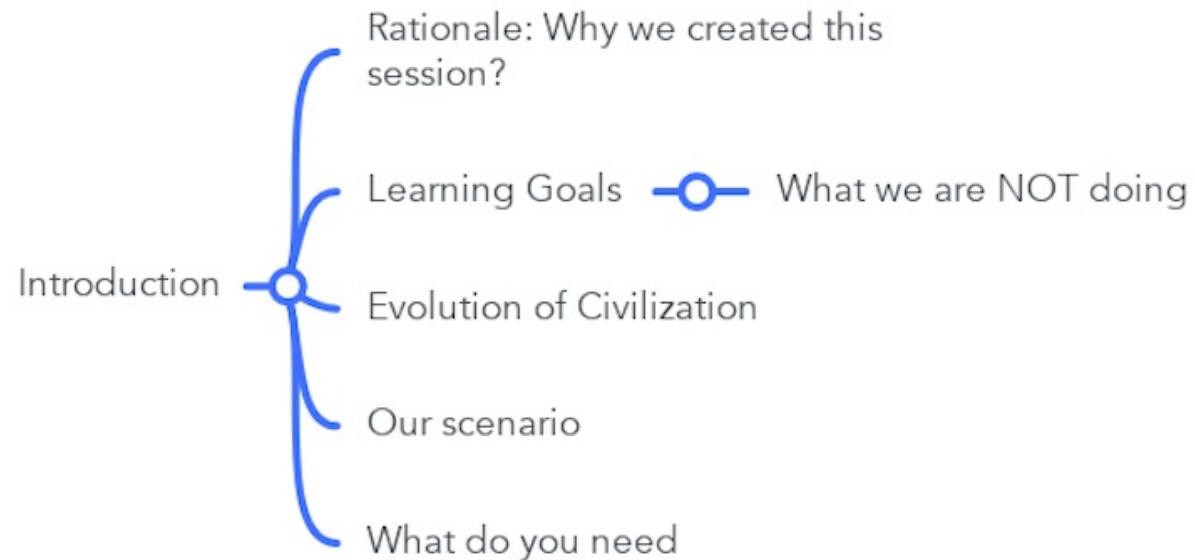


This is what we cover in
this edition. More to come!

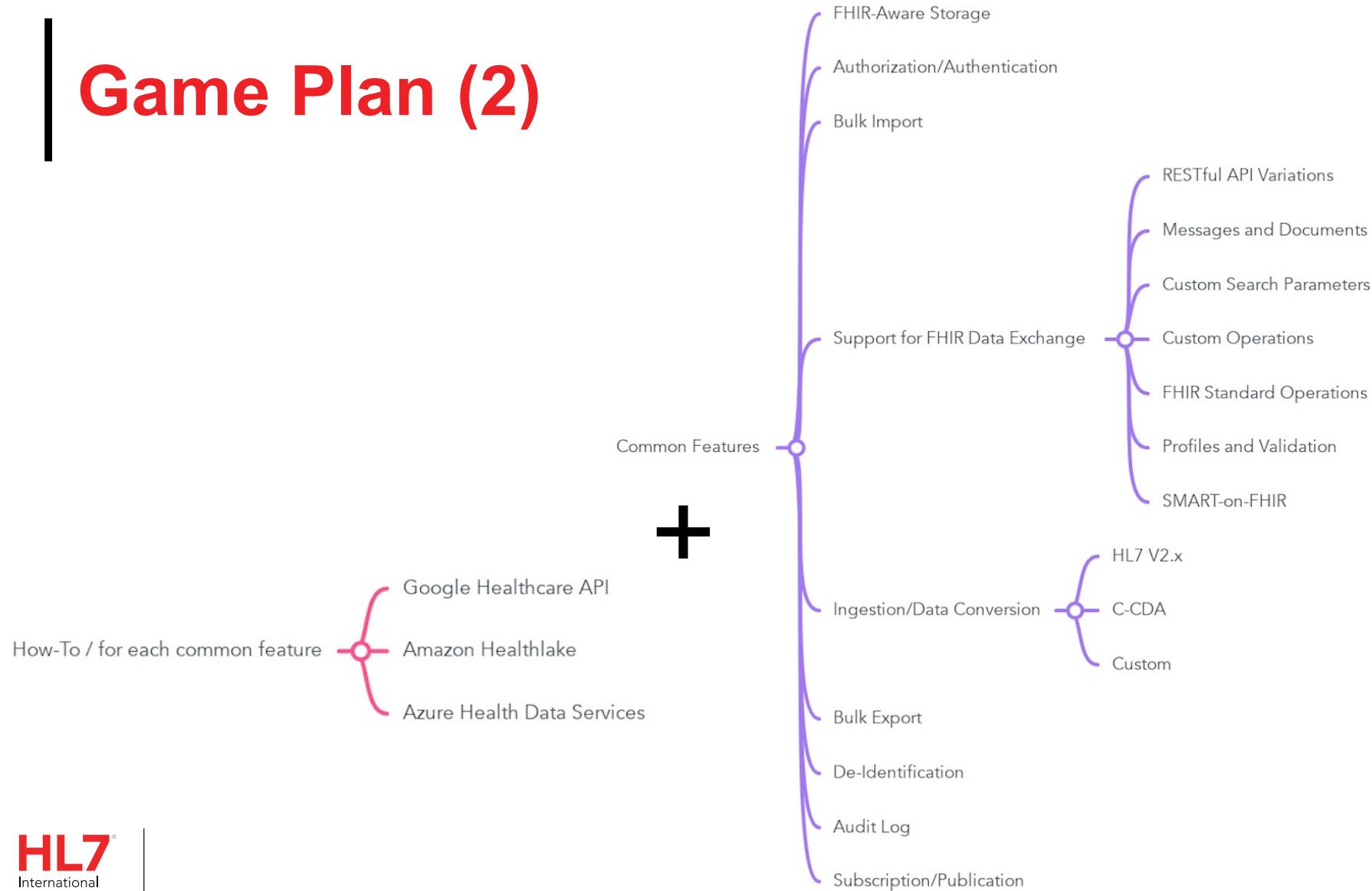
Materials

- This session includes:
 - **This slide deck** – mostly to guide the discussion
 - [**Postman Collection**](#) – with examples on how to call the FHIR APIs
 - [**Codelab #1 – General Description**](#) of the Cloud offerings and our use case – this slide deck, but expanded
 - [**Codelab #2 – Google Healthcare API**](#) how-to tour
 - [**Codelab #3 – Azure Healthcare Data Services API**](#) how-to tour
 - [**Codelab #4 – Amazon HealthLake**](#) how-to tour

Game Plan (1)



Game Plan (2)



Objectives: FHIR IN THE CLOUDS

- Participants will gain an understanding of:
 - basic capabilities of FHIR-as-a-service offerings
 - Set up a basic FHIR service using the different cloud vendors approaches
 - Share information for clinical clients
 - Transfer information to "big data" provider

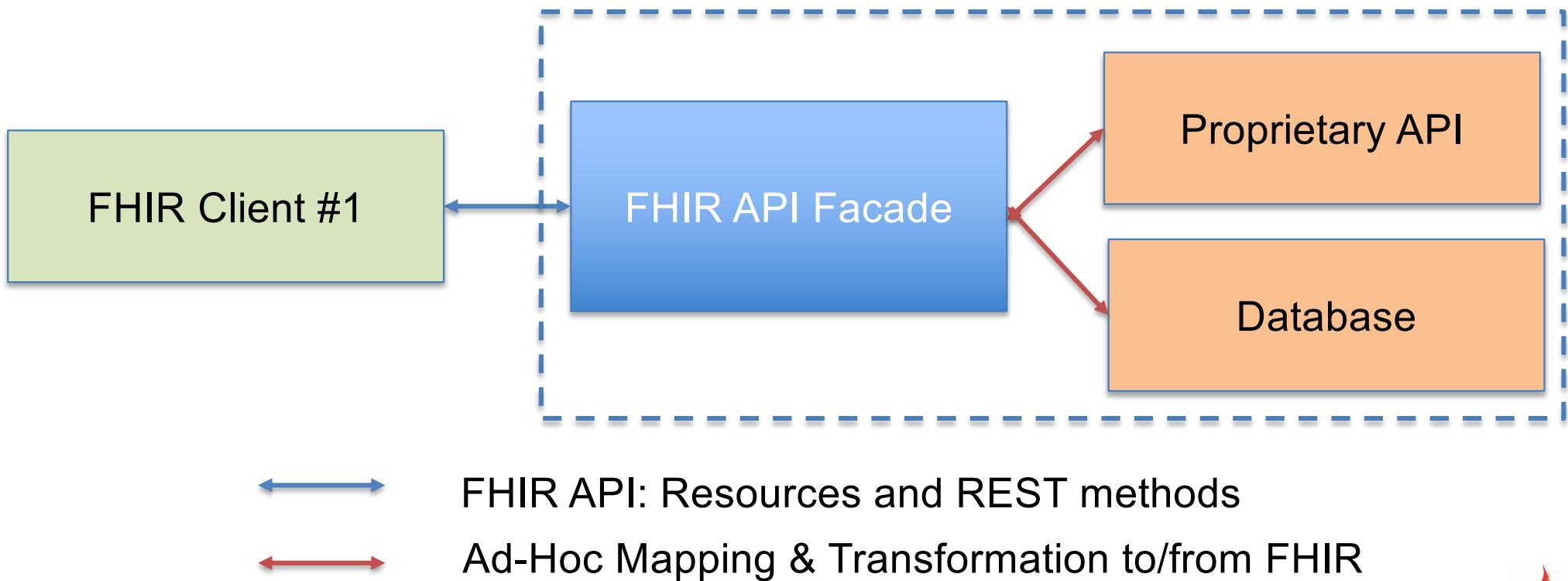
What we are NOT doing

- We will **NEITHER discuss performance** (“how many resources can you create per minute?”) **NOR scalability** (“how many resources can you store?”). If you are interested in these topics, there are several articles online. Example: [here](#) and [here](#)
- We will **NOT discuss security (encryption, authorization, authentication) in depth**: this may require a whole new session, and sometimes it’s related to your choice of Cloud vendor.
- We will **NOT provide credits** for you to test our approaches. Most of the cloud services provide some credits or months free if you want to test them. We tested basic functionality of ALL these services for under \$100 in total.

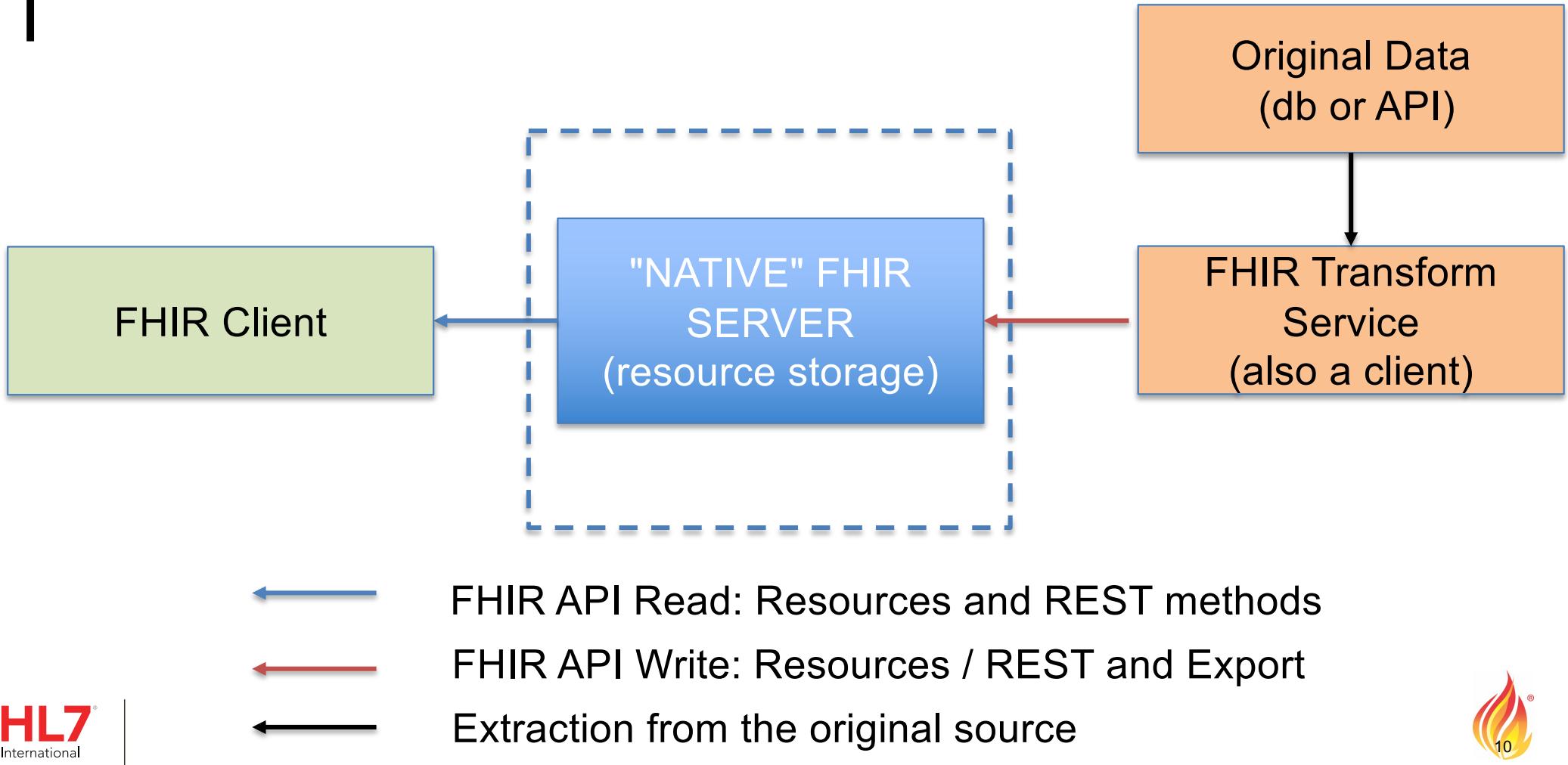
What we are NOT doing

- We will **NOT discuss costs.** Costs can be extremely variable depending on your country, region, and specific contract. You need to refer to your cloud provider or local distributor. Some cloud vendors provide a cost calculator.
- We are **NOT endorsing** any specific vendor or approach, we are just exploring the landscape and sharing our general findings with you.
- We are **NOT using “secret sauces” or “special tuning”**. This session is based on publicly available documentation from the cloud vendors (and others), reachable through the management consoles.

WHY? FHIR FACADE



WHY? FHIR REVERSE FACADE



The advance of civilization

"Civilization advances by extending the number of important operations which we can perform without thinking of them"

Alfred North Whitehead



The advance of civilization

Some years ago...

**THE NEW COMPAQ PROLIANT
MISSION-CRITICAL SERVERS**

intel inside

ProLiant 1000 ProLiant 2000 ProLiant 4000

HIGH PERFORMANCE NETWORK SERVERS

Processor	DX2/66 or Pentium 60MHz	DX2/66 or Pentium 66MHz	DX2/66 or Pentium 66MHz
Architecture	TriFlex/PC One Processor	TriFlex with up to two symmetric processors	TriFlex with up to four symmetric processors
Network Interface	Up to 12 High-Speed Channels; NetFlex 2 with Packet Blaster Technology Standard		
Standard Disk Controller	Integrated Fast SCSI-2 and Smart SCSI Array Controller (selected models)		
Storage Capacity	550MB-112GB Internal/External	1050MB-140GB Internal/External	1050MB-140GB Internal/External
Typical Usage	Departmental network services, primarily NetWare	Departmental network application services: NetWare, NT and Unix	Application services for preemptive downgrading—NT and Unix
Transaction Rating	50-150 TPS	200-300 TPS	300-400 TPS
Estimated Starting Street Price ¹	\$6,000	\$8,900	\$13,900

SERVER DEPENDABILITY AND AVAILABILITY

Management	Second-generation Compaq Insight Manager (standard) combines with innovative hardware design to constantly monitor, assess and report server health and performance
Fault Prevention	Insight Manager alerts you to server status changes in over 800 component parameters, allowing proactive server management backed by 3-Year Pre-Failure Warranty
Fault Tolerance	Standard support for RAID levels 1,4,5; hot pluggable drives; on-line spare drive; off-line backup processor ¹ ; advanced ECC RAM ³
Fault Recovery	Standard rapid recovery services automatically return server to full operational status even in the event of a critical subsystem failure

SIMPLICITY, EASE OF OWNERSHIP AND SUPPORT

SmartStart	Standard CD-based intelligent hardware configuration and system software installation, providing simplified server configuration for NetWare, NT or Unix. (CD-ROM drive standard)
System Warranty	Free Three-Year, On-Site Limited Warranty
Pre-Failure Warranty	Three-Year, On-Site Warranty replacement of designated components that fall below preestablished thresholds
4-Hour Warranty Response Upgrade	Optional Three-Year On-Site Warranty upgrade to 4-hour response
Technical Support	Toll-free, 7 x 24 technical phone support from Compaq engineers
CompaqCare System Partners	Highly trained, dedicated, third-party professionals who provide systems maintenance and comprehensive technical support
QuickFind/PaqFax	Proactive notification and delivery of new technical information/7 x 24 fax response for updated specification, configuration and settings data

This is called IAAS
"Infrastructure as a Service"

Now

Name Add additional tags

Application and OS Images (Amazon Machine Image) Info
An AMI is a template that contains the software configuration (operating system, application server, and applications) required to launch your instance. Search or Browse for AMIs if you don't see what you are looking for below

Search our full catalog including 1000s of application and OS images

Quick Start

Amazon Linux Ubuntu Windows Red Hat SUSE Linux

Browse more AMIs
Including AMIs from AWS, Marketplace

Amazon Machine Image (AMI)

Amazon Linux 2 AMI (HVM) - Kernel 5.10, SSD Volume Type Free tier eligible

ami-0fa49cc9dc8d62c84 (64-bit (x86)) / ami-02cb75f995890cd96 (64-...)
Virtualization: hvm ENA enabled: true Root device type: ebs

Cancel **Launch instance**



Cloud Services Models

SAAS - Software as a Service:

Focus on end user. Example: gmail, Office 360

IAAS - Infrastructure as a Service:

Example: Server Instances, Storage, DB

You may be in charge of updating, patching, security, but NO hardware.

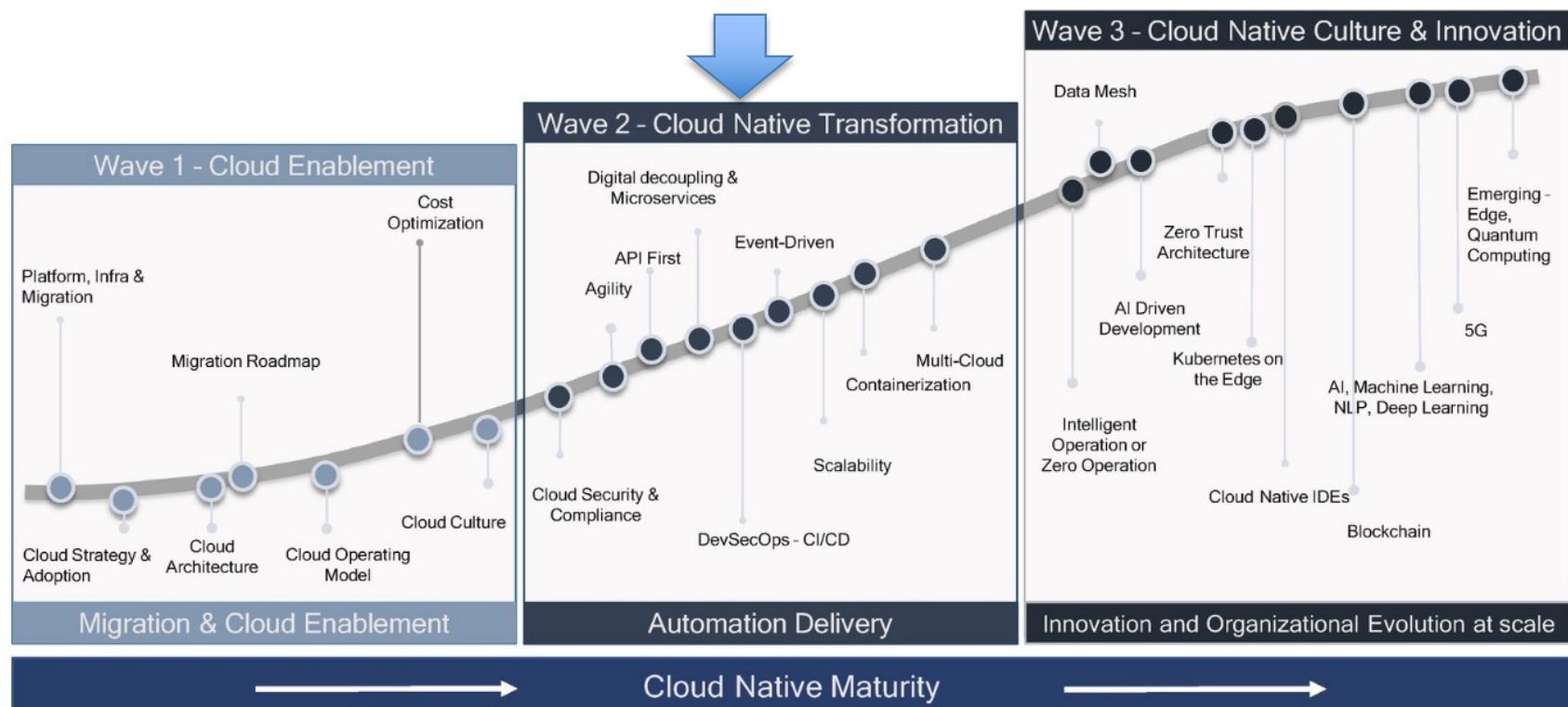
PAAS - Platform as a Service:

You focus on developing your app. Anything else is included and managed elsewhere: OS, network, security. **Automatic scalability is feasible.**

Cloud Native Maturity Continuum

We are "here"

Beware of some hype here



From Cloud Native Architecture & Design <https://amzn.to/3wQMbe6>

The advance of the FHIR civilization (1)

Some years ago...

The following example shows a very simple interceptor example.

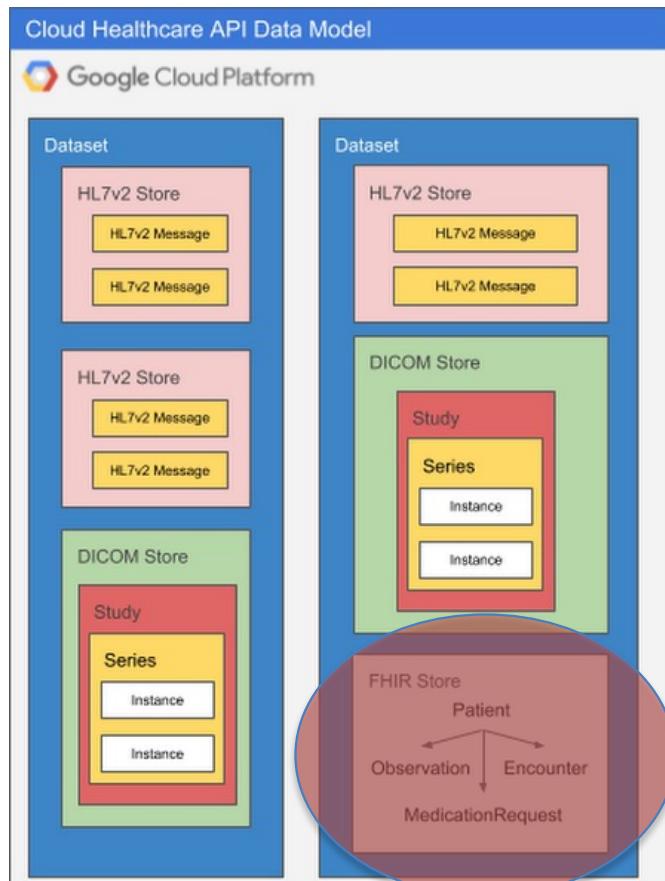
```
@Interceptor
public class SimpleServerLoggingInterceptor {

    private final Logger ourLog = LoggerFactory.getLogger(SimpleServerLoggingInterceptor.class);

    @Hook(Pointcut.SERVER_INCOMING_REQUEST_PRE_HANDLED)
    public void logRequests(RequestDetails theRequest) {
        ourLog.info("Request of type {} with request ID: {}", theRequest.getOperation(), theRequest.getRequestId());
    }
}
```

We were programming in Java to enable logging in a FHIR server

The advance of the FHIR civilization - Now



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International

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Cloud Healthcare API > Documentation > Guides Was this helpful? Send feedback

Viewing error logs in Cloud Logging

This page explains how to view logs in Google Cloud's operations suite for supported request types.

Logging

Errors triggered in each of the following requests are logged to [Cloud Logging](#).

- Dataset de-identification
- DICOM export
- DICOM import
- DICOM de-identification
- FHIR export
- FHIR import
- FHIR de-identification

Errors are also logged if a Pub/Sub message can't be published to Pub/Sub. See [Troubleshooting Pub/Sub notifications](#) for more information.

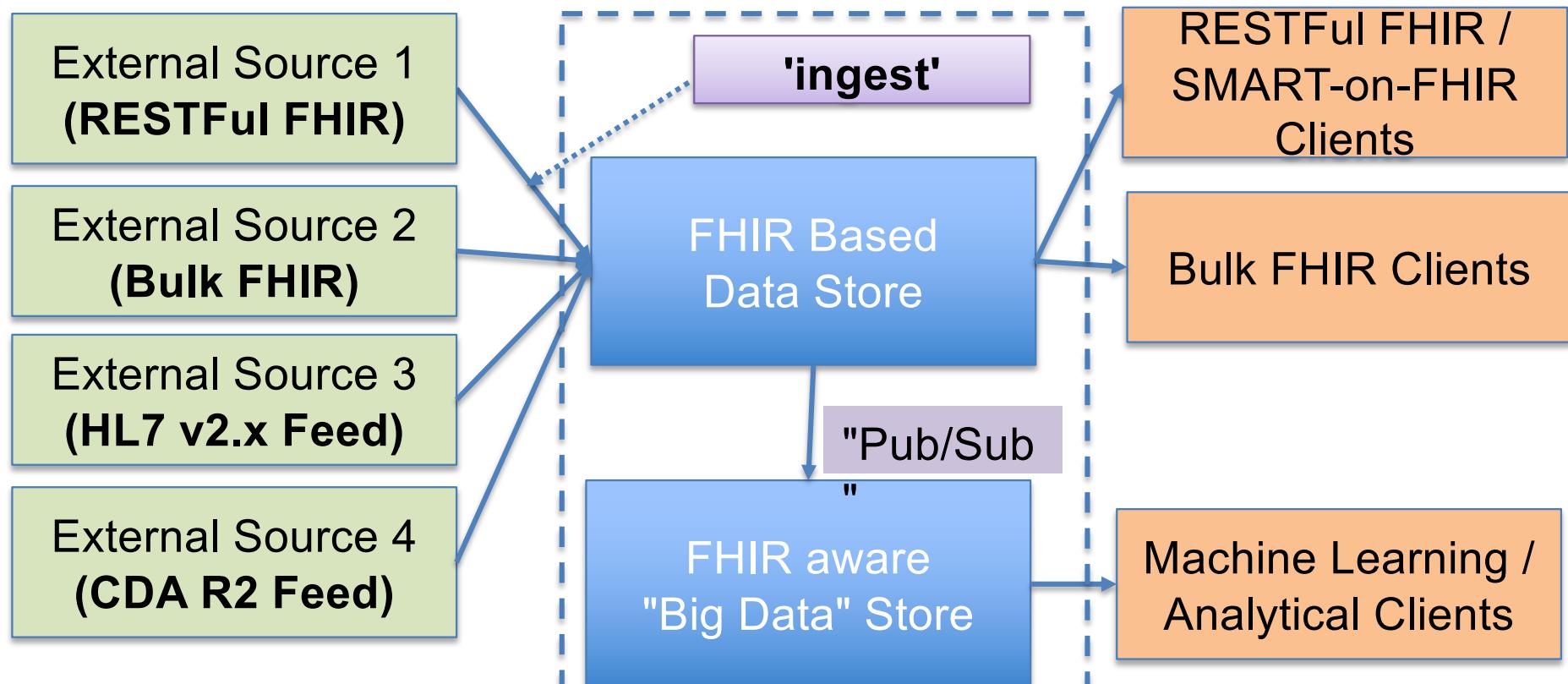
Logging is automatic and doesn't need to be enabled. To disable Cloud Logging for one or all monitored resources, see [Logs exclusions](#).

Viewing logs

To view all logs, go to the [Logs Explorer](#). To view logs for operations with an error status, click the more information icon for the operation on the **OPERATIONS** tab in the healthcare browser and then click [View details in Stackdriver](#).



It's not just "the cloud". It's FHIR-as-a-service



FHIR-as-a-Service ("FAAS") ?

- Overall Strategy
- FHIR-Aware Storage
- Authorization / Authentication
- Bulk Import
- FHIR Data Exchange
- Data Conversion
- Bulk Export
- Synchronization
- Automatic De-Identification
- Audit Log
- Subscriptions

For each one of these issues, we'll go through a general description, and then explore the how-to for each cloud vendor

Overall Strategy

It's not just "Here is your FHIR storage"

It's more "Here is your Healthcare Repository"

Some vendors also include imaging (DICOM), V2 message stores, NLP processing, etc.

FHIR-aware Storage

"Native" FHIR Storage

Information is stored as FHIR resources.

Creates a Clinical Data Repository, enabling exchange with any REST / Bulk FHIR client or pipeline

The screenshot shows the Google Cloud Platform interface for managing a FHIR store. The left sidebar has 'Healthcare' selected under 'Browser'. The main content area is titled 'Datastore details' for 'generic-fs' in the 'Datasets / generic-fhir-store (southamerica-east1) / generic-fs' project. It displays the following information:

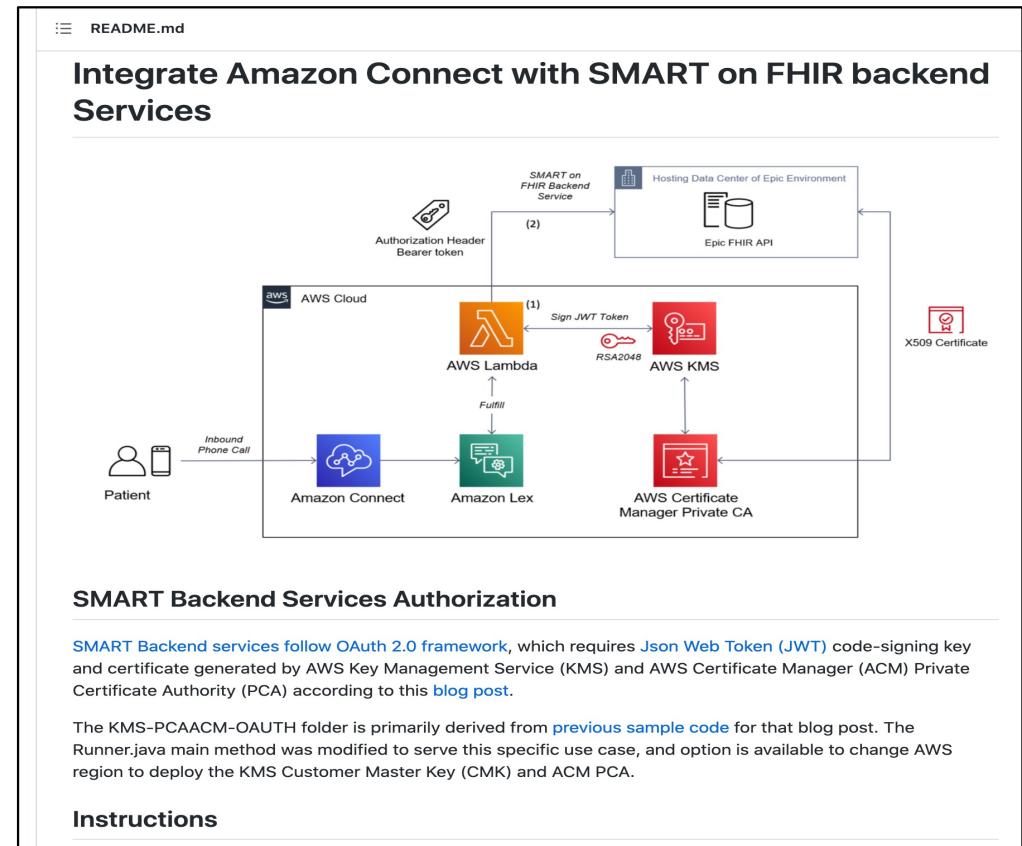
ID	generic-fs
Type	FHIR
Path	projects/braided-grammar-166423/locations/southamerica-east1/datasets/generic-fhir-store/fhirStores/generic-fs
FHIR Store Configuration	
FHIR Version	R4
Allow update create	Disabled
Referential integrity checks	Enabled
Resource versioning	Enabled

Below this, there's a section for 'BigQuery Streaming' with a note about exporting resource changes to BigQuery. There's also a 'Streaming Configs' section with a 'ADD NEW STREAMING CONFIG' button. At the bottom, there's a 'Cloud Pub/Sub Notifications' section where users can specify a Cloud Pub/Sub topic to receive notifications upon changes to the data store.

Authorization/Authentication

Including Smart-On-FHIR

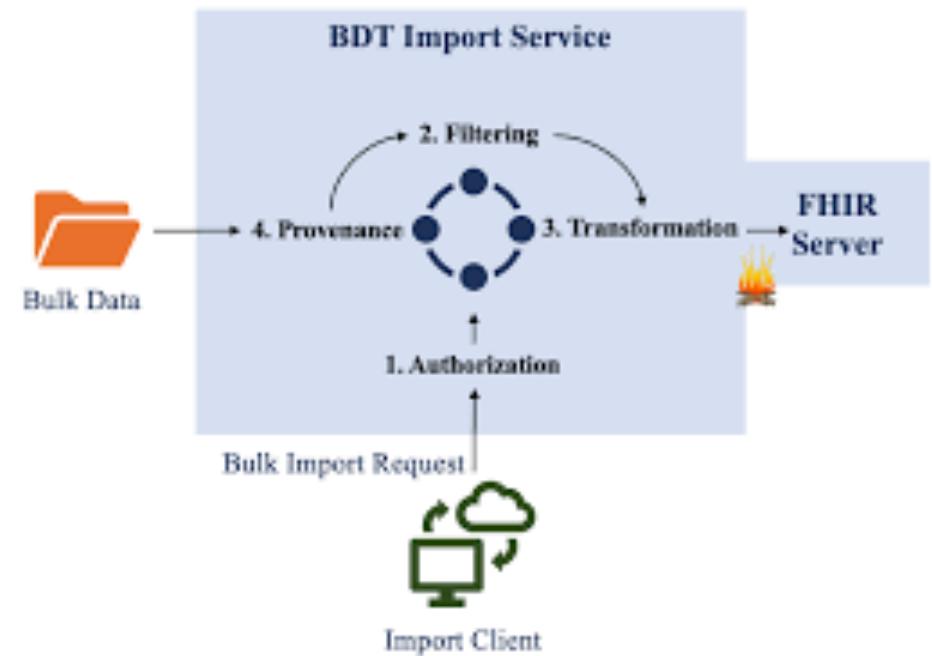
- oAuth2 Variants
- SMART-on-FHIR
- Authentication and Role based Authorization
- Consent support



Bulk Import

How to initialize my FHIR store: patients, providers, organizations, concepts

Maybe 100000s of records...



Support for FHIR Data Exchange

- ❑ Regular RESTful API
- ❑ Limitations for transactions
- ❑ Other Exchange Methods (documents, messages)
- ❑ Custom Search parameters
- ❑ Standard Operations (example \$everything)
- ❑ Terminology Service operations (example \$expand, \$lookup)
- ❑ Custom operation definition
- ❑ Profiles and Validation (example \$validate)

Data Conversion

As part of the 'ingestion' process

Automatically transform from

- HL7 v2.x to FHIR
- C-CDA to FHIR
- Custom to FHIR

Converting your data to FHIR

Article • 04/25/2022 • 6 minutes to read • 5 contributors



The `$convert-data` custom endpoint in the FHIR service is meant for data conversion from different data types to FHIR. It uses the Liquid template engine and the templates from the [FHIR Converter](#) project as the default templates. You can customize these conversion templates as needed. Currently it supports three types of data conversion: C-CDA to FHIR, HL7v2 to FHIR, JSON to FHIR.

Note

`$convert-data` endpoint can be used as a component within an ETL pipeline for the conversion of raw healthcare data from legacy formats into FHIR format. However, it is not an ETL pipeline in itself. We recommend you to use an ETL engine such as Logic Apps or Azure Data Factory for a complete workflow in preparing your FHIR data to be persisted into the FHIR server. The workflow might include: data reading and ingestion, data validation, making `$convert-data` API calls, data pre/post-processing, data enrichment, and data de-duplication.

Use the `$convert-data` endpoint

The `$convert-data` operation is integrated into the FHIR service to run as part of the service. After enabling `$convert-data` in your server, you can make API calls to the server to convert your data into FHIR:

`https://<>FHIR service base URL>/>/>/$convert-data`

Parameter Resource

`$convert-data` takes a [Parameter](#) resource in the request body as described in the table below. In the API call request body, you would include the following parameters:

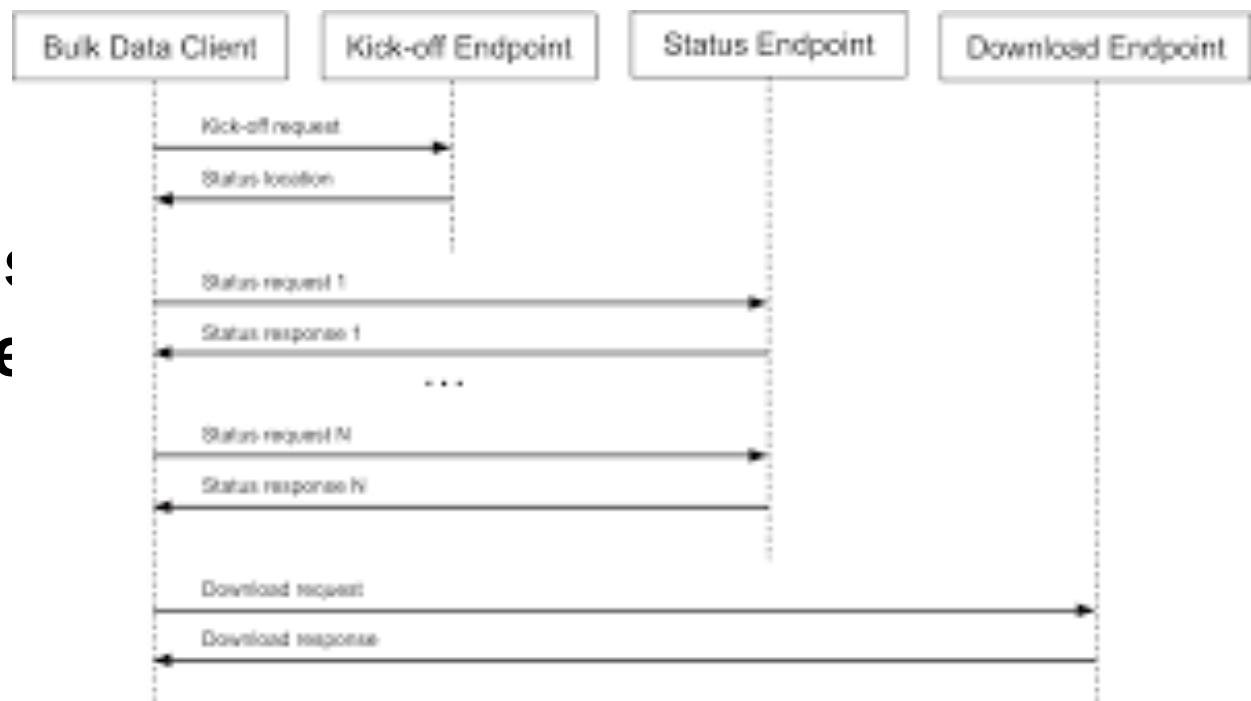
Parameter Name	Description	Accepted values
inputData	Data to be converted.	For <code>HL7v2</code> : string For <code>Ccda</code> : XML For <code>Json</code> : JSON
inputDataType	Data type of input.	<code>HL7v2</code> , <code>Ccda</code> , <code>Json</code>



Bulk Export

How to get clinical information out for population health analytics, payer claims transfer between stores

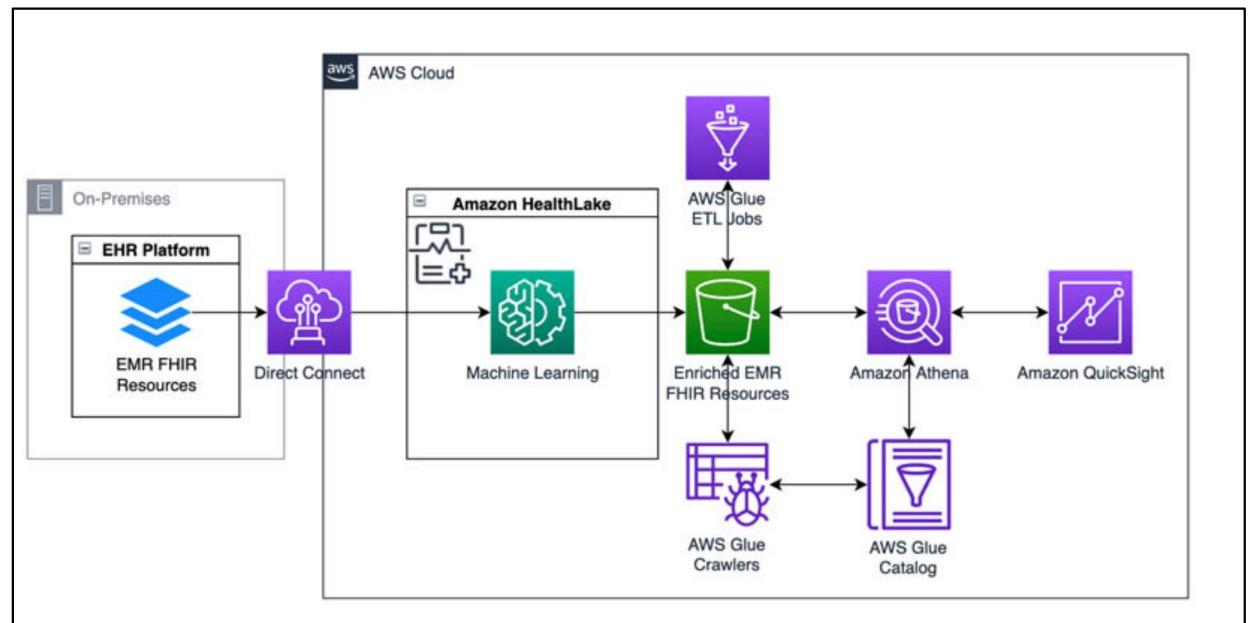
Maybe 100000s of records...



Synchronization

From

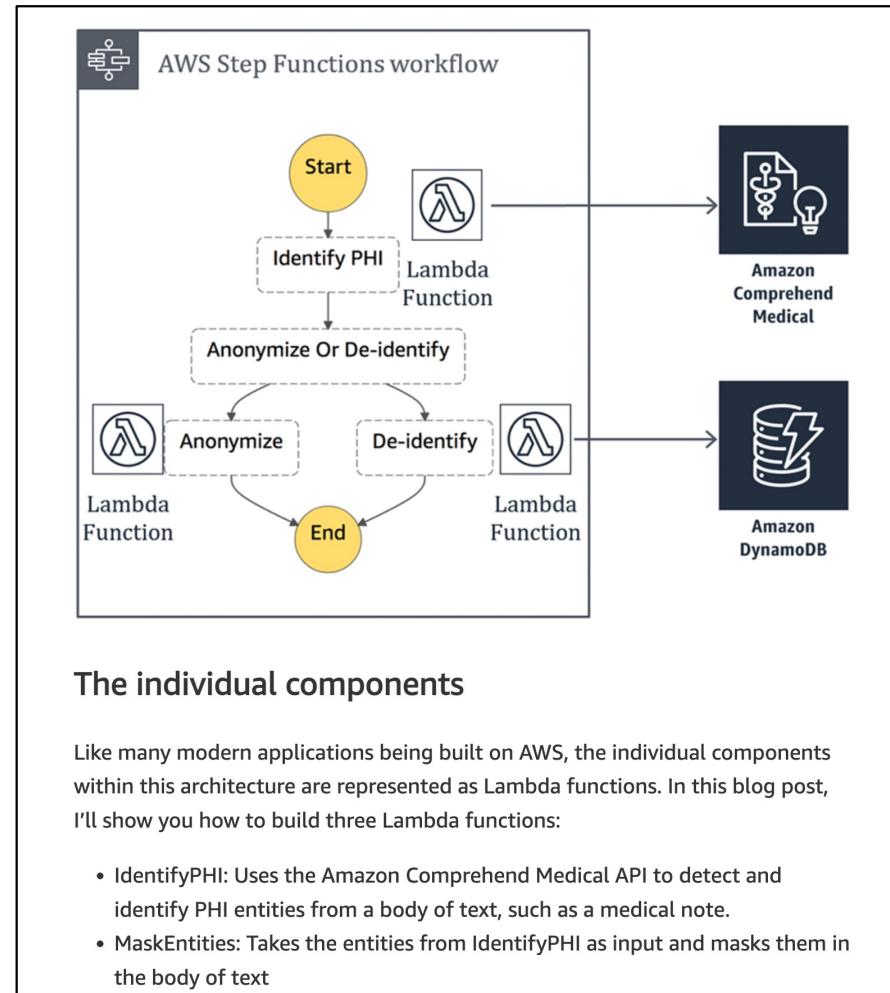
'raw' => FHIR-data =>
'big data store',
automatically:
every time you
add/modify a
resource, it's reflected
in your big data store



De-Identification

As required by regulations

Remove relevant patient demographics (ids, location, names, etc.) to ensure healthcare information confidentiality



Audit Log

Full Audit Log

- Using each platform's own log strategy
- HIPAA Compliance

IBM Cloud Docs /
Managing your account, resources, and access /

EN

Enabling HIPAA support for your account

If you're the account owner, you can enable your IBM Cloud® account to be HIPAA supported. HIPAA support can be useful if you plan to include Protected Health Information (PHI) in HIPAA-enabled services.

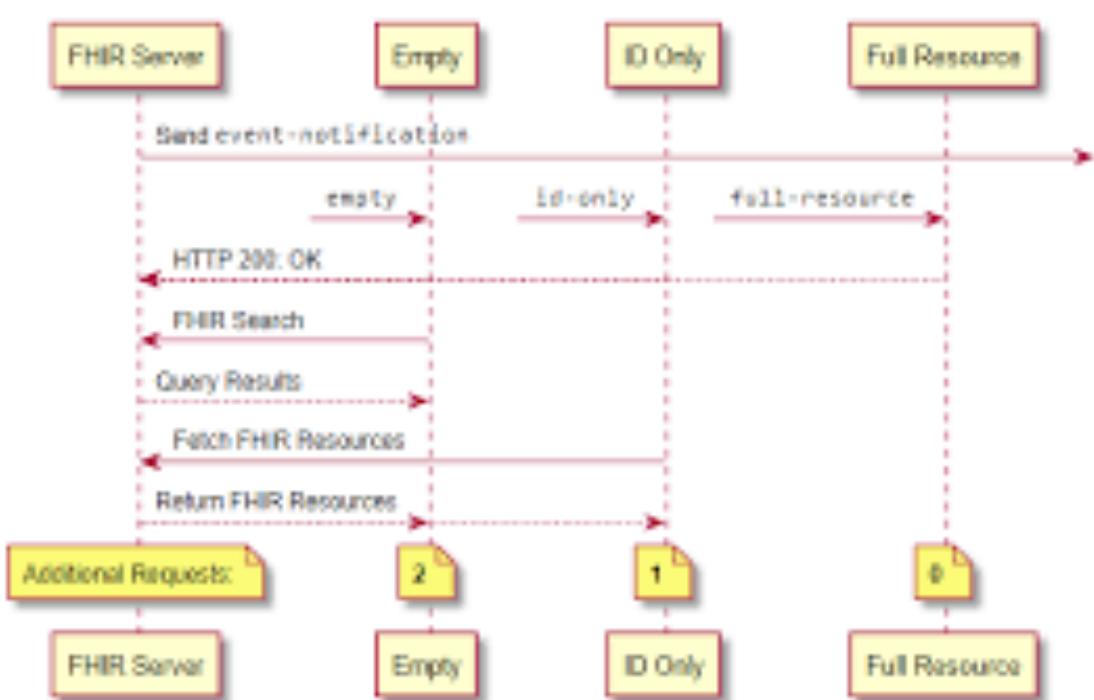
The US Health Insurance Portability and Accountability Act (HIPAA) and the Health Information Technology for Economic and Clinical Health (HITECH) Act define standards for handling electronic healthcare transactions and information. If you or your company is a covered entity as defined by HIPAA, you must enable the HIPAA Supported setting if you run sensitive workloads that are regulated under HIPAA and the HITECH Act. Learn more about IBM Cloud compliance in [Compliance on the IBM Cloud](#).

Enabling this setting has the following effects:

- Enables you to filter on HIPAA Enabled services in the catalog
- Indicates to IBM that your account stores protected health information (PHI)
- Digitally accepts the IBM Business Associate Addendum (BAA) for covered entities

Subscriptions

"Let me know if a FHIR resource of "this" class was created/updated/deleted"



References (1)



Google Cloud

<https://cloud.google.com/healthcare>



<https://aws.amazon.com/health>



Microsoft
Azure

<https://azure.microsoft.com/en-us/services/health-data-services>

We couldn't cover this time (1)



<https://www.ibm.com/products/fhir-server>



<https://docs.oracle.com/health-sciences/health-hdr-81/HDRFG/fhirserverarch.htm>

We couldn't cover this time (2)

- There are other cloud offerings from *non 'big-5'* vendors.
- Worth mentioning: **AidBox, Firely, and CDR Smile**
- They also offer most of these services.
- There are also open source alternatives for most of the services, so you can go on-premise or contract IAAS cloud services and roll-out your own services/pipelines.

Questions and Conclusions

- Questions?