# Overview

*Welcome! Thank you for taking an interest in the Open Client Registry. This is a community project and meant for others to adopt to their use cases as they wish.*

## What Does It Do?

A Client Registry holds patient identifers and may include patient demographic information. It is a necessary tool for public health use cases that require managing patients, monitoring outcomes, and conducting case-based surveillance.

This Client Registry is an open source and open standards-based implementation that offers the ability to:

- Assign and look-up unique identifiers,
- Allow connections from diverse point of service (POS) systems, such as electronic medical record (EMR) systems, that can submit messages in FHIR, and
- Configure decision rules around patient matching.

> **Caution**
>
> This implementation does not allow point-of-service systems to get patient demographic information stored in the Client Registry. This is also not a Shared Health Record, nor does it contain patient clinical data.

## Use Cases

The Client Registry is one component in a more complex HIS architecture needed to accomplish important use cases, such as:

- **Deduplicating patients**: Sometimes patients have multiple diagnostic results stored within a POS. The Client Registry will link patients based on

configurable decision rules so multiple test results for the same patient can be found.

- **Tracking patients lost to clinical care**: EMRs are often not interoperable with one another, resulting in difficulty tracking patients as they move between facilities to seek care. A Client Registry will help data managers to track patients, decreasing instances of duplicate and incomplete records, patients LTFU, and sub-optimal care.

> **Caution**
>
> The Client Registry is not deduplicating or even touching patient clinical and demographic records within point-of-service systems. Instead, it provides a way to enable use cases like deduplication - which must be an external process.

## Workflows

## Architecture

The Client Registry is not one application, instead it's a set of applications that work together in the Open Health Information Exchange (OpenHIE) architecture to serve point-of-service systems, like EMRs, insurance mechanisms, and labs.

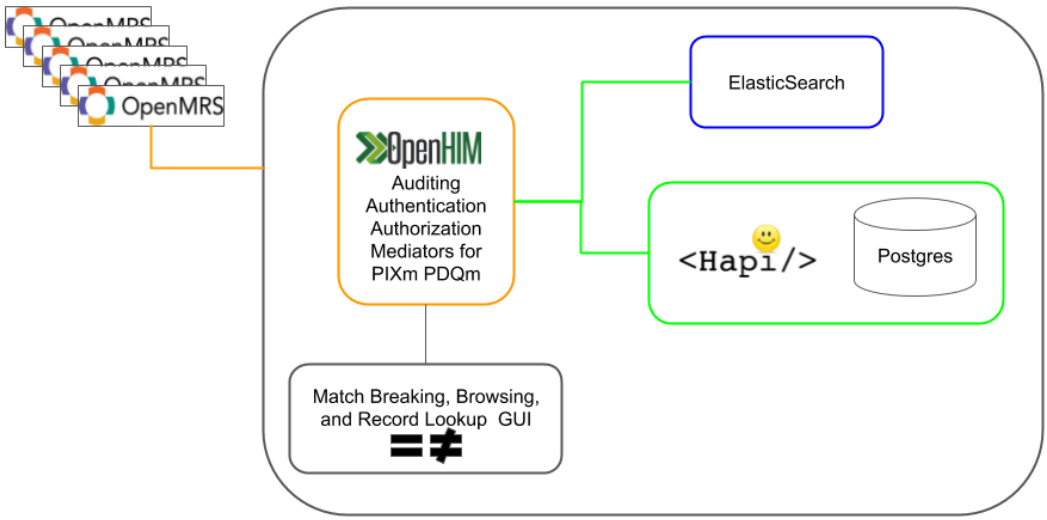
> **Caution**
>
> This is not an OpenHIE product. It is a prototypical client registry to facilitate discussion among a broad set of stakeholders.

The architecture is made up of:

- The **Open Health Information Mediator (OpenHIM)**: The OpenHIM is the entrypoint for POS systems, and includes authentication (are you who you say you are?), authorization (what roles do you have permission to fulfill?), and auditing of all transactions.
- The **HAPI FHIR Server**: HAPI is the reference FHIR server in Java and scalable into production environments.

- The **ElasticSearch**: Elasticsearch is a powerful search engine that is highly performant.
- An **optional UI** to view and break matches between records, and to select and chain together decision rules around matching algorithms.

## Simplified Architecture




Last update: February 3, 2020

# Getting Started

## How to Use this Site Effectively

Please read the User Manual first as it introduces the basics. Here are some suggestions about how to use this documentation depending on your role or interest.

- **Implementer**: The workflow and decision rules pages explain the record linkage process and have links to resources to help teach others how to understand it and run it in an organization.
- **Data manager or analyst** The decision rules page is an overview of how matching is configured and discusses how algorithms are selected and chained together.
- **Developer** or **systems administrator**: The installation and configuration pages go into more detail about setup and configuration.

> **Tip**
>
> Regardless if you're just curious, an implementer, or a developer, please read the introduction page first and then the User Manual. We've kept them short.

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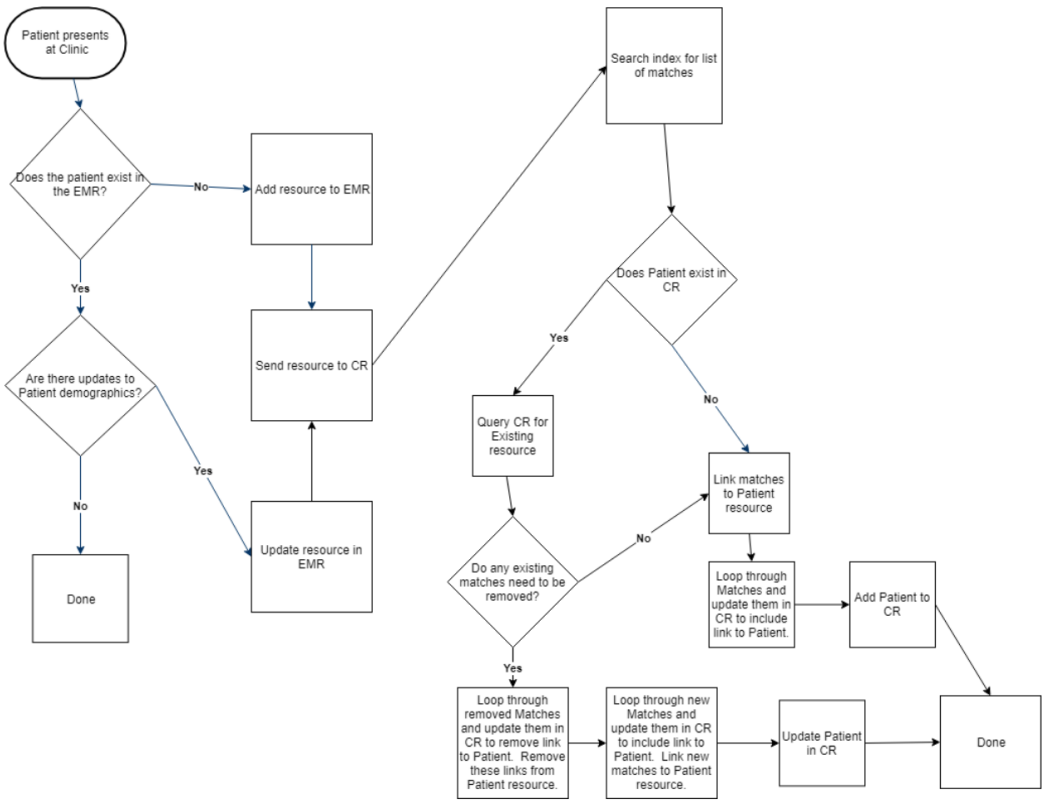
# Workflows

This page is under construction and will be revised.

## Big picture

The process for a point-of-service system like an EMR to get a unique ID from the Client Registry is straightforward though it looks complicated at first.




Let's break this down.

1. A POS provides some demographic information to the Client Registry.
2. The Client Registry looks for an existing record matching that patient.
3. If there is an existing record, the Client Registry provides the unique ID back to the POS.

4. If there is not an existing record, the Client Registry makes a new one and provides a unique ID back to the POS.

## In Greater Detail

When requests are submitted with demographic data in a FHIR message, the Client Registry reads an submitting system's ID of that patient. The Client Registry searches for that submitting system's ID in its records. This happens regardless if it is a new patient or update of existing patient.

When the submitting system's ID matches an existing record, the Client Registry updates the patient demographic information of that record with changes submitted. Once the update is complete, the existing record linkages may affected. This is because algorithms may not continue to link records as before because details have changed. Therefore, the Client Registry will pool all patients that were previously matched and break all the matches. The Client Registry will rerun matching algorithms again to see what matches are currently true matches of the patient. Then the Client Registry will be updated with the true matches given the changes in demographic data.

Another scenario is when the Client Registry searches and doesn't find anyone already with same submitting system's ID. If there is not existing match, the Client Registry runs the matching algorithms for existing patients who matches that patient and will provide record linkages with other records.

## Requirements

In order for this process to work as expected, there are some requirements:

- Requests sent to the Client Registry must be made of FHIR messages. FHIR is a popular specification for accessing an API for providing data in health systems. Messages must support FHIR R4.

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# Decision Rules

## Overview

Demographic data from submitting systems is stored in HAPI FHIR. It is also recommended that the demographic data that is primarily stored in HAPI FHIR be indexed into Elasticsearch.

For match processing, there are two options. One is run in mediator-only mode, which is highly flexible and supports a handful of algorithms that can be chained together. Additional algorithms can be added as needed.

The second is to use ES. ES is very fast and supports compound queries but currently only supports Levenshtein distance. When using ES, every request to the FHIR Server is cached in ES.

(One additional caveat for Levenshtein distance is that the mediator-only matching can support edit distances exceeding two, while ES edit distance cannot exceed two.)

Every client wishing to use the Client Registry must be authenticated and authorized. See the configuration page for more information.

## How to Set Decision Rules

Decision rules determine how matches are made among records, for example, by using a certain algorithm on one field and a different algorithm on another.

Let's use the below example:

`rules.givenName` is used as one rule on the field givenName.

`rules.givenName.algorithm` defines an algorithm, in this instance Jaro-Winkler, and an threshold for that algorithm unique to it.

`rules.givenName.path` is a required FHIRpath for the fields, a standard way to define how to traverse a FHIR resource. In future, a GUI may be used for defining the FHIRpath.

By default, all of the rules are chained together in a logical AND statement. In ES the search queries are assembled into compound queries.

### Link to file

Contents of `server/config/decision_rules.json`

```
{
  "__comments": {
    "path": "Its a fhir path, for syntax refer to https://
www.hl7.org/fhir/fhirpath.html",
    "type": "String, Date, Number or Boolean",
    "threshold": {
      "levenshtein": "Lower the number, the closer the match, 0
being exact match",
      "jaro-winkler": "number between 0 and 1, where 0 for no match
and 1 for exact match"
    }
  },
  "rules": {
    "givenName": {
      "algorithm": "jaro-winkler",
      "threshold": 0.89,
      "path": "name.where(use='official').last().given",
      "type": "string",
      "systems": ["system1", "system2", "system3"]
    },
    "familyName": {
      "algorithm": "damerau-levenshtein",
      "threshold": 3,
      "path": "name.where(use='official').last().family",
      "type": "String"
    },
    "gender": {
      "algorithm": "exact",
      "path": "gender",
      "type": "String"
    }
  }
}
```

Last update: January 28, 2020

# Matching Benchmarks

Last update: February 3, 2020

# Admin Interface

Last update: February 3, 2020

# Dashboard

## Kibana Dashboard

Under construction.

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Last update: February 3, 2020

# Additional Resources

Last update: February 3, 2020

# Security

It is difficult (and irresponsible) to try to explain all of the best practices in computer security. This page focuses on how security is addressed in the Open Client Registry. For links to information on server and network hardening and production best practices see the production page.

Several areas are addressed, user authentication, node authentication, ATNA auditing, and non-production (demos, tests) configuration.

Secure Node Any IHE actor which is capable of authenticating itself to other nodes and transmitting data securely. Audit Repository Responsible for the storage of audit events

IHE ITI

The IHE IT Infrastructure (ITI) domain addresses the implementation of standards-based interoperability solutions to improve information sharing, workflow and patient care.

## User Authentication

## Node Authentication

Authenticate Node [ITI-19]

## ATNA Logging

Audit Trail and Node Authentication (ATNA) Integration Profile is

## Non-Production

```
# create a private key with pem extension
openssl req -newkey rsa:4096 -keyout dhis2_key.pem -out
dhis2_csr.pem -nodes -days 365 -subj "/CN=dhis2"
# generate a
openssl x509 -req -in dhis2_csr.pem -CA ../certificates/
server_cert.pem -CAkey ../certificates/server_key.pem -out
dhis2_cert.pem -set_serial 01 -days 36500
#
openssl pkcs12 -export -in dhis2_cert.pem -inkey dhis2_key.pem -out
dhis2.p12
```

The `.p12` filename extension is for PKCS #12 file archives. PKCS #12 is for storing several cryptographic objects together including user-defined values. In the provided example .p12 files in the Client Registry repository, they include an X.509 (public key) certificate and a private key, and some information about the owner, including, for the Client Registry, the `subject`, meaning the name of the system (such as a specfic EMR POS system) that it was issued for.

A useful way to understand this better is to open one of the .p12 files using no password (hit enter) for the Import Password, and the subject name for the PEM pass phrase (in this example 'openmrs' without quotes and in lowercase).

When certificate is self-signed, then issuer and subject field contains the same value

```
# from client-registry/server/sampleclientcertificates
$ openssl pkcs12 -info -in openmrs.p12
Enter Import Password:
MAC Iteration 2048
MAC verified OK
PKCS7 Encrypted data: pbeWithSHA1And40BitRC2-CBC, Iteration 2048
Certificate bag
Bag Attributes
    localKeyID: 36 7A 50 BC 1C 0E 69 93 22 7F CC FB 4D 07 C2 BE B2
37 02 C6
subject=/CN=openmrs
issuer=/CN=localhost/O=Client Registry
-----BEGIN CERTIFICATE-----
...
-----END CERTIFICATE-----
PKCS7 Data
```

```
Shrouded Keybag: pbeWithSHA1And3-KeyTripleDES-CBC, Iteration 2048
Bag Attributes
    localKeyID: 36 7A 50 BC 1C 0E 69 93 22 7F CC FB 4D 07 C2 BE B2
37 02 C6
Key Attributes: <No Attributes>
Enter PEM pass phrase:
Verifying - Enter PEM pass phrase:
-----BEGIN ENCRYPTED PRIVATE KEY-----
...
-----END ENCRYPTED PRIVATE KEY-----
```

the p12 is normally protected with a password and is not shared. It is imported in an application (e.g. a browser or a password manager) When a authentication must take place, the browser sends the identification information and its public key. The server then offers a challenge only the owner of the private key can solve. The browsers then sends back the solution of the challenge and the user is both identified and authenticated. Anyone getting access to the p12 will be able to impersonate the real owner.

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Last update: February 3, 2020

# OpenMRS MPI Client

Under construction.

Last update: January 28, 2020

# Docker

> **Warning**
>
> The latest tag is not supported by ES.

Under construction.

Last update: January 28, 2020

# Installation (Lite)

> **Warning**
>
> This guide is for demonstrations or tests only, not for production environments.

> **Note**
>
> This installation method requires familiarity with the command line.

## HAPI FHIR Server CLI

For non-production environments, the HAPI maintainers provide a simple CLI-based tool to run it.

The only required dependency is Java >= 8 (1.8).

See HAPI FHIR CLI for instructions for the OS of choice.

The Client Registry requires FHIR version R4 and HAPI must be started for this version. To run HAPI:

```
hapi-fhir-cli run-server -v r4
```

The HAPI Web Testing UI is available at http://localhost:8080/ The Web Testing UI should be disabled for production. It allows the viewing of any resource on the server.

The FHIR Base URL is at http://localhost:8080/baseR4/

Visit http://localhost:8080/ to ensure HAPI is up and running or

```
curl -X GET "localhost:8080/baseR4/Patient?"
```

## ElasticSearch (Optional)

By default, the configuration does not require ES but including it will enable ES-based matching.

Install and start ES for the intended OS. See the ES install instructions

The required version is >=7.5.

Once installed and started, ensure that ES is up and running:

```
curl -X GET "localhost:9200/_cat/health?v&pretty"
```

Status should be yellow for a single-node cluster.

## Client Registry Service (Standalone)

Clone the repository into a directory of choice.

```
git clone https://github.com/intrahealth/client-registry.git
```

Enter the server directory, install node packages.

```
cd client-registry/server
npm install
```

Copy and edit the configuration file to your liking.

```
cp config/config_development_template.json config/
config_development.json
# edit the servers...
```

The minimum changes to start a running standalone system are:

- Change `fhirServer.baseURL` to "http://localhost:8080/baseR4/"

Run the server from inside client-registry/server:

```
node lib/app.js
```

Congratulations! Now it's time to run a query.

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Last update: February 3, 2020

# Installation (Production)

> **Warning**
>
> Installing and maintaining a production installation is not trivial. This installation method requires strong familiarity with the command line and expertise administering Linux environments.

The production stack consists of 10 components:

- OpenHIM core and OpenHIM admin console. Requires MongoDB and Nginx or another reverse proxy.
- Client Registry Service as an OpenHIM mediator.
- HAPI FHIR Server with a database backend.
- ElasticSearch (>=7.5)
- Client Registry UI
- Kibana Dashboard

The expected operating system is Linux for production. Only Ubuntu versions have been tested.

It is critical that systems administrators note the version compatibilities outlined below. This guide does not cover most aspects of enterprise systems administration, rather it attempts to cover this Client Registry platform. If there are key areas missing, please open an issue on GitHub.

## Prerequisites

- If entities outside of your LAN are connecting to the Client Registry, you will need a public-facing domain name. This is necessary for a certificate which is required for any interactions.
- See production considerations

## OpenHIM

OpenHIM supports the last 2 versions of NodeJS LTS and requires MongoDB.

- Follow the instructions to install OpenHIM core and admin console. The maintainers use the NPM PPA installation method.
- Note the important step to obtain a certificate immediately after installation. The configuration should be that any client must have a certificate and the server has a certificate (mutual TLS).
- Follow the instructions including console configuration.
- Note the important step to change the console password. It is also recommended that the console only be accessible on a local subnet and not to the WAN.

## HAPI FHIR Server

HAPI FHIR should use a database backend in production. HAPI FHIR stores the patient demographic data from queries. If the data is lost, then the Client Registry is unrecoverable.

- Follow the JPA Server information and instructions for how to customize the hapi.properties file and build the server using maven.
- The ES integration is separate from HAPI FHIR Server, so there is not need to use it as an indexer. ES only works with an old version of ES.
- Install and configure the preferred database. Postgres has been tested by the maintainers but any database should work that HAPI supports. Change default passwords on the database.
- Confirm that HAPI accepts requests.
- The web interface for HAPI should be disabled for privacy reasons.

!! In production, Postgres should run on multiple nodes, with one as the leader and others as followers. This is to ensure high availability and backups of the data.

## ElasticSearch

- Follow the instructions for installation
- Systemd is the preferred system and service manager. There are commands to initiate systemd and journalctl.

!! warning ES is not production-ready when run one a single node. It is recommended to run ES on several nodes. Those nodes can also run followers of Postgres.

## Client Registry UI

Under construction.

## Kibana Dashboard

Under construction.

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# Example API Query (cURL)

## Certificates (Mandatory)

A system querying the Client Registry needs a server-issued certificate or it will not be authorized to use the service.

The way that this works is that a server creates a certificate for a client. The certificate is signed by the server issuing it. The querying system then uses that certificate that has been issued to them in their requests. The server's public key is used by the querying system to verify that the certificate being sent is how the server verifies that the certificate was created by them.

There is a set of generated certificates for testing and demonstrations. They are not appropriate for production.

## A Simple CLI Query

Inside /client-registry/server directory, a cURL query using the provided example JSON file would be:

```
curl --cert sampleclientcertificates/openmrs.p12 --cert-type p12 --
cacert certificates/server_cert.pem -d @/Users/richard/src/
github.com/openhie/client-registry/DemoData/patient1_openmrs.json -
H "Content-Type: application/json" -XPOST https://localhost:3000/
addPatient
```

Should result in a successful result in stdout:

```
info: Received a request to add new patient
{"timestamp":"2020-01-28 14:29:20"}
info: Searching to check if the patient exists
{"timestamp":"2020-01-28 14:29:20"}
info: Getting http://localhost:8080/baseR4/Patient?identifier=431287
from server {"timestamp":"2020-01-28 14:29:20"}
info: Patient [{"system":"http://clientregistry.org/
openmrs","value":"431287"},{"system":"http://
system1.org","value":"12349","period":
```

{"start":"2001-05-06"},"assigner":{"display":"test Org"}}] doesnt exist, adding to the database {"timestamp":"2020-01-28 14:29:20"}

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# Example API Query (Python)

> **Note**
>
> This example is available in the Jupyter notebook at: github.com/intrahealth/client-registry/examples/simple_query.ipynb

This is a simple query in Python exactly like the cURL query:

```
curl --cert sampleclientcertificates/openmrs.p12 --cert-type p12 --
cacert certificates/server_cert.pem -d @/Users/richard/src/
github.com/openhie/client-registry/DemoData/patient1_openmrs.json -
H "Content-Type: application/json" -XPOST https://localhost:3000/
addPatient
```

The only requirement is a version of the requests package that has been modified to take p12 certs.

```
pip3 install requests_pkcs12
```

Import the required modules.

```
from pathlib import Path
# import requests modded dor pkcs12
from requests_pkcs12 import get, post
```

This example assumes running from `github.com/intrahealth/client-registry/examples` . Change paths as required. Using the Path module ensures that the path resolution works in Mac, Linux, Windows.

```
clientcert_folder = Path("../server/sampleclientcertificates")
clientcert = clientcert_folder / "openmrs.p12"

servercert_folder = Path("../server/certificates")
servercert = servercert_folder / "server_cert.pem"

payload_folder = Path("../DemoData/")
```

```
payload_bytes = payload_folder / "patient1_openmrs.json"
payload = open(payload_bytes)
```

Define headers and initiated the POST request.

```
headers = {'Content-Type': 'application/json'}
response = post("https://localhost:3000/addPatient",
headers=headers, data=payload,
                pkcs12_filename=clientcert,
                pkcs12_password='',
                verify=servercert)
print(response)
```

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# Server Configuration

Often there are many records of the same person but in many people in different systems. The purpose of the Client Registry is to link patients in different systems, but not to transfer any data, neither clinical records nor demographic data.

> **Caution**
>
> The Client Registry does not store clinical information. Having the Client Registry enables the ability to create a Shared Health Record in the future.

The Client Registry stores the patient demographic data submitted to it in queries. The Client Registry stores demographic data at least in the HAPI FHIR Server, which can have any database backend an implementer chooses to use.

ElasticSearch (ES) is an optional search engine, and requires configuration. ES can also store patient data fields selectably.

JSON files are used to configure the system. Later iterations will support environment variables and a graphical interface. See https://github.com/openhie/client-registry/tree/master/server/config for example configuration files discussed here.

## Deciding Between a Standalone or Mediator Configuration

A central application is the Client Registry Service, as distinct from the larger Client Registry platform. There are two options for running the application, as an OpenHIM mediator or as standalone application.

Choose running the app standalone when:

- For testing, demonstration, or development environments.

- There are few clients that will connect to managing client authentication and roles will not be a burden.
- There is no need for an additional layer of auditing.

Choose running the app as a mediator when:

- For production. The central application should be run as a mediator registered in OpenHIM.
- There are many clients that will need to connect.
- There is a need to audit transactions.
- There is an existing health information exchange layer or OpenHIM.
- One advantage of using the OpenHIM interface is the ability to change settings like the FHIR server.

## Security and Privacy

Many configuration options relate to privacy and security. These steps are critical to address.

Whether in standalone or as a mediator, the Client Registry must interact only with known, trusted clients with TLS certificates. Clients must be registered and certificates assigned to them.

In standalone mode, the server runs TLS by default, and requires signed certificates. Client certificate needs can be turned off in OpenHIM when running as a mediator and this feature must be regularly audited to ensure security.

## Connecting Services

The default ports are as follows:

- **3000**: Client Registry Service
- **9200**: ElasticSearch
- **8080**: HAPI FHIR Server

In `server/config/config_development_template.json` there is a template for configuration.

Link to file

Contents of `server/config/config_development_template.json`

```
{
  "app": {
    "port": 3000,
    "installed": false
  },
  "mediator": {
    "api": {
      "username": "root@openhim.org",
      "password": "openhim-password",
      "apiURL": "https://localhost:8080",
      "trustSelfSigned": true,
      "urn": ""
    },
    "register": false
  },
  "fhirServer": {
    "baseURL": "http://localhost:8080/clientregistry/fhir",
    "username": "hapi",
    "password": "hapi"
  },
  "elastic": {
    "server": "http://localhost:9200",
    "username": "",
    "password": "",
    "max_compilations_rate": "10000/1m",
    "index": "patients"
  },
  "structureDefinition": {
    "reportRelationship": "patientreport"
  },
  "matching": {
    "tool": "mediator"
  },
  "systems": {
    "openmrs": {
      "uri": "http://clientregistry.org/openmrs"
    },
    "dhis2": {
      "uri": "http://clientregistry.org/dhis2"
    },
```

```
    "lims": {
      "uri": "http://clientregistry.org/lims"
    },
    "brokenMatch": {
      "uri": "http://ihris.org/CR/brokenMatch"
    }
  },
  "sync": {
    "lastFHIR2ESSync": "1970-01-01T00:00:06"
  },
  "__comments": {
    "matching.tool": "this tells if the app should use mediator
algorithms or elasticsearch algorithms for matching, two options
mediator and elasticsearch"
  }
}
```

## General App Configuration

`app.port` is the port the application will run on.

`app.installed` can be left to True. This tells the Client Registry Service to load structure definitions into HAPI FHIR Server, otherwise it will not.

## Mediator App Configuration

`mediator.register` to true if the application will run as a mediator. Or, to false if the app will run as standalone.

`mediator.api.xx` settings are only if running as a mediator.

`mediator.api.username | password` must be different. The existing settings are defaults and must be changed when configuring the OpenHIM.

`mediator.api.trustSelfSigned` should be set to false in production or any sensitive environment. True is only for demonstrations.

## FHIR Server

The currently supported FHIR version is R4.

`fhirServer.baseURL` is the default. Note that it may change depending on the way HAPI is installed. It may, for example, default to a baseURL of http://localhost:8080/baseR4/.

`fhirServer.username | password` must be changed from defaults in HAPI.

## ElasticSearch Configuration

For ES, the relationship between patient resources in FHIR and what fields are synchronized in ES must be explicitly defined. This is termed the Report Relationship mapping. One must define what resource to be used (patient) and what fields need to be available in ES. After this, the Client Registry reads these fields, and populates ES with the information.

## OpenHIM Mediator JSON Configuration

If using OpenHIM, it must be configured for proper clients and roles to accept and forward requests from the Client Registry. An example export of a working JSON configuration that can be imported for development purposes is available.

Link to file

Contents of `server/config/mediator.json`

```
{
  "urn": "urn:uuid:4bc42b2f-b5a8-473d-8207-5dd5c61f0c4a",
  "version": "0.0.1",
  "name": "Client Registry",
  "description": "Uganda Client Registry",
  "config": {
    "fhirServer": {
      "username": "hapi",
      "password": "hapi",
      "baseURL": "http://localhost:8080/hapi/fhir"
    },
    "elastic": {
      "server": "http://localhost:9200",
      "username": "",
      "password": "",
      "max_compilations_rate": "10000/1m",
      "index": "patients"
    },
```

```
        "matching": {
          "tool": "elasticsearch"
        }
      },
      "configDefs": [{
        "param": "fhirServer",
        "displayName": "FHIR Server",
        "description": "FHIR Server Configuration Details",
        "type": "struct",
        "template": [{
            "type": "string",
            "description": "The base URL (e.g. http://localhost:
8080/hapi/fhir)",
            "displayName": "Base URL",
            "param": "baseURL"
          },
          {
            "type": "string",
            "description": "Username required to access FHIR
server",
            "displayName": "Username",
            "param": "username"
          },
          {
            "type": "password",
            "description": "Password required to access FHIR
server",
            "displayName": "Password",
            "param": "password"
          }
        ],
        "values": []
      }, {
        "param": "elastic",
        "displayName": "Elasticsearch Server",
        "description": "Elasticsearch Server Configuration Details",
        "type": "struct",
        "template": [{
            "type": "string",
            "description": "The base URL (e.g. http://localhost:
9200)",
            "displayName": "Base URL",
            "param": "server"
          },
          {
            "type": "string",
            "description": "Username required to access
elasticsearch server",
            "displayName": "Username",
```

```
            "param": "username"
          },
          {
            "type": "password",
            "description": "Password required to access
elasticsearch server",
            "displayName": "Password",
            "param": "password"
          }, {
            "type": "string",
            "description": "Number of requests to compile per
minute",
            "displayName": "Maximum Compilations Rate",
            "param": "max_compilations_rate"
          }, {
            "type": "string",
            "description": "index to use for data storage",
            "displayName": "Index Name",
            "param": "index"
          }
        ],
        "values": []
      }, {
        "param": "matching",
        "displayName": "FHIR Server",
        "description": "FHIR Server Configuration Details",
        "type": "struct",
        "template": [{
          "type": "option",
          "values": ["mediator", "elasticsearch"],
          "description": "Tool to Use for Matching",
          "displayName": "Tool to Use for Matching",
          "param": "tool"
        }],
        "values": []
      }],
      "defaultChannelConfig": [{
        "requestBody": true,
        "responseBody": true,
        "name": "Add Patients",
        "description": "Post a new patient into the client
registry",
        "urlPattern": "/addPatient",
        "matchContentRegex": null,
        "matchContentXpath": null,
        "matchContentValue": null,
        "matchContentJson": null,
        "pollingSchedule": null,
        "tcpHost": null,
```

```
        "tcpPort": null,
        "autoRetryPeriodMinutes": 60,
        "autoRetryEnabled": false,
        "rewriteUrlsConfig": [],
        "addAutoRewriteRules": true,
        "rewriteUrls": false,
        "status": "enabled",
        "alerts": [],
        "txRerunAcl": [],
        "txViewFullAcl": [],
        "txViewAcl": [],
        "properties": [],
        "matchContentTypes": [],
        "routes": [{
          "name": "Add Patient",
          "secured": false,
          "host": "localhost",
          "port": 3000,
          "path": "/addPatient",
          "pathTransform": "",
          "primary": true,
          "username": "",
          "password": "",
          "forwardAuthHeader": false,
          "status": "enabled",
          "type": "http"
        }],
        "authType": "public",
        "whitelist": [],
        "allow": [],
        "type": "http",
        "methods": [
          "POST"
        ]
      }],
      "endpoints": [{
        "name": "Activate Client Registry",
        "host": "localhost",
        "path": "/addPatient",
        "port": 3000,
        "primary": true,
        "forwardAuthHeader": false,
        "status": "enabled",
        "type": "http"
      }],
      "_uptime": 2201.945,
      "_lastHeartbeat": "2017-12-15T03:47:03.365Z",
      "_configModifiedTS": "2017-12-15T02:52:49.054Z"
    }
```

Last update: February 3, 2020

# Configure Benchmarks

Last update: February 3, 2020

# Production Considerations

This page is under construction.

> **Warning**
>
> Server and network hardening and production best practices are out of scope. This document only attempts to capture aspects relevant to the Client Registry.

Hardening and production best practices include:

- Removing unnecessary services, software, network protocols
- Backup and recovery
- Patches
- Vulnerability scanning
- Limiting remote administration
- Managing open internal and external ports
- Auditing, logging software

See, for example, the Guide to General Server Security: Recommendations of the National Institute of Standards and Technology by Karen Scarfone, Wayne Jansen, Miles Tracy, July 2008, (NIST Special Publication 800-123).

## IT Resource Planning

Benchmarking will be completed in future phases to make recommendations for medium to heavy workloads. The below resource suggestions should be revised based on benchmarking for the particular context into which the Client Registry is being deployed.

## Servers

For an MVP in a production environment where potential data loss is acceptable, a single large server can be used. ES has high memory requirements.

## CPU

- Local development: PC with multiple cores
- Production: Use 2-8 cores.

## Memory

Memory usage depends on the number of records and the performance required.

Local development on a PC: 8GB of RAM should be available

Production, at minimum: 32GB with 24GB free for the Client Registry is recommended for light loads if using one VM.

- 16GB minimum for ElasticSearch with 32GB preferred or 64GB for high volume: Follow the guidelines provided by the maintainers here.
- 8GB for OpenHIM, mediator, Postgres, and HAPI FHIR Server.

## Disk Space

This depends heavily on the workload. Expect 200GB at minimum per node.

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# Backup and Recovery

# Backup

The primary datastore is the database configured for HAPI FHIR Server. This means that while an ES cluster should be backed-up, the ES index can be rebuilt from HAPI.

# Recovery

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Last update: February 3, 2020

# Troubleshooting

Last update: February 3, 2020

# Building Documentation

This documentation is built using MkDocs and the Material for MkDocs theme.

PDF export is done using mkdocs-pdf-export-plugin. All configuration information is in mkdocs.yaml in the repository. Note that at some future time the docs may be migrated into the main client registry repository.

Edits to docs are made in the master branch of the client registry repository docs repo.

After docs are edited, they are pushed to origin master, and then the `mkdocs gh-deploy` is run on the command line. This pushes into the gh-pages branch on GitHub. Only master is ever edited. The gh-pages is only modified by the CLI.

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Last update: February 3, 2020

# Contributing

There may be many areas of potential contribution as the Client Registry is not one application, it's several and can be more than that in your use case.

It's recommended that you identify the specific feature or use case that needs support and

For a quick question, reach out on the iHRIS Slack team. Sign up here

For a bug or feature, reach out to the relevant repository to share the information. See the developer page for links to the different applications.

For a broader discussion with others interested and with a background in Client Registry implementation science, please join the OpenHIE Client Registry Community calls and get involved.

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Last update: January 22, 2020

# About

Last update: February 3, 2020