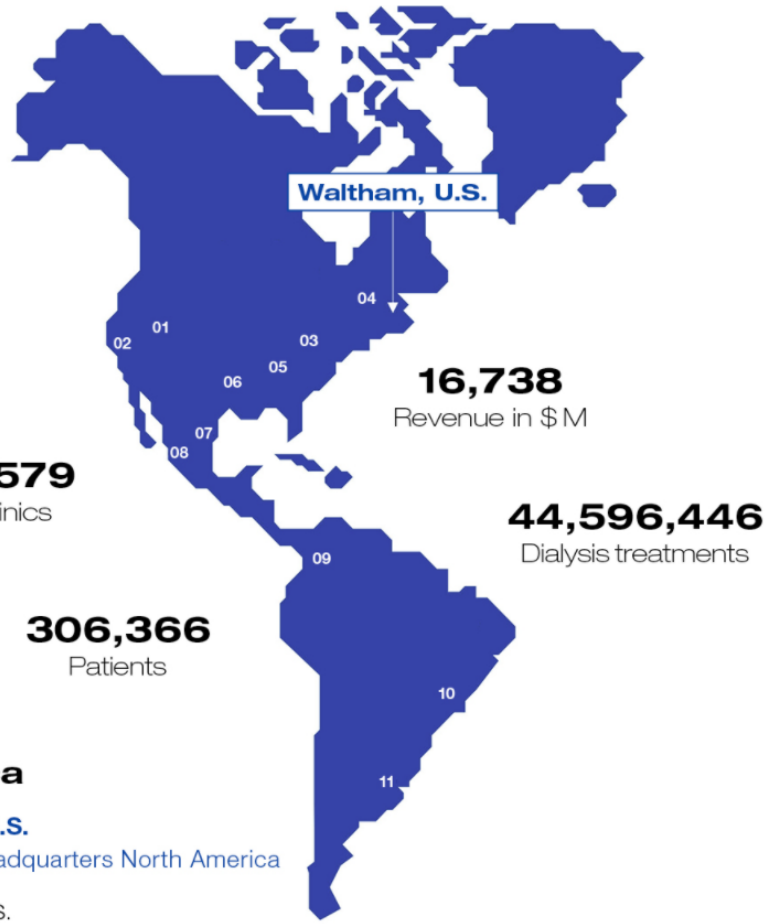
Enabling the healthcare enterprise

An agile story

Radu Craioveanu, CPHIMS
Director Software Development, Clinical Systems, IT Group
Fresenius Medical Care
Tuesday May 02, 2017

Fresenius Medical Care around the World



16,738
Revenue in $ M

3,579
Clinics

44,596,446
Dialysis treatments

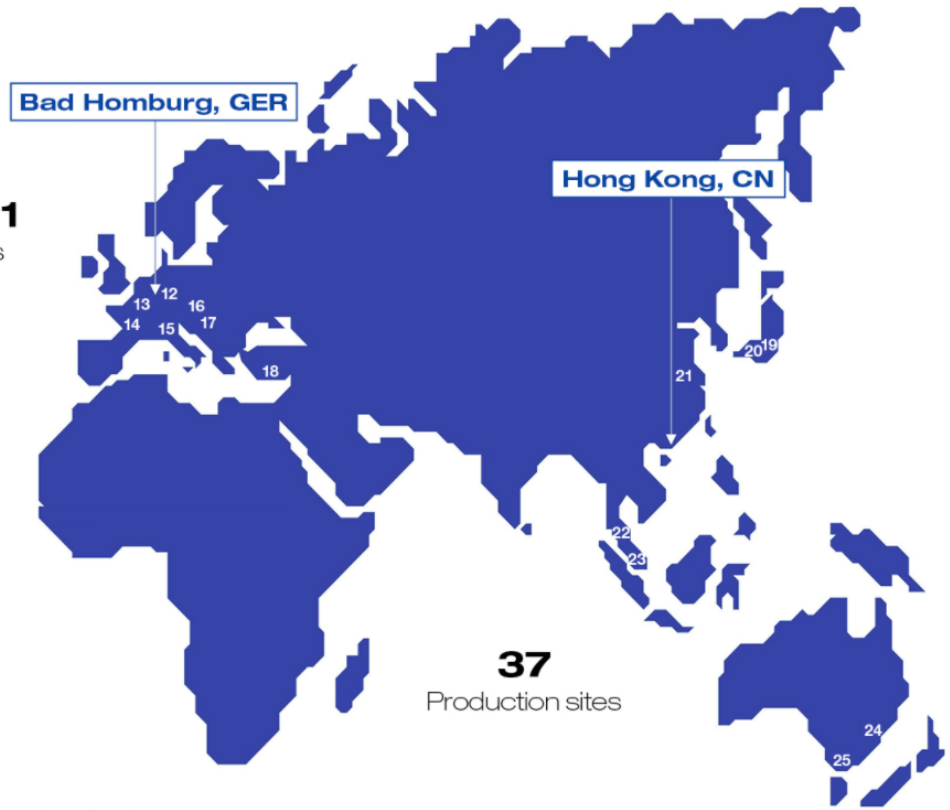
306,366
Patients

America

Waltham, U.S.
Regional headquarters North America

01 Ogden, U.S.
02 Concord, U.S.
03 Toledo, U.S.
04 Montreal, CA
05 Knoxville, U.S.
06 Irving, U.S.
07 Reynosa, MX
08 Guadalajara, MX
09 Santafé de Bogotá, CO
10 Jaguariúna, BR
11 Pilar, AR

108,851
Employees



37
Production sites

Europe

Bad Homburg, GER
Company headquarters and regional headquarters for Europe, Middle East, Africa and Latin America

12 Schweinfurt, GER
13 St. Wendel, GER
14 L'Arbresle, FR
15 Palazzo Pignano, IT
16 Krems, AT
17 Vršac, SRB
18 Antalya, TR

Asia-Pacific

Hong Kong, CN
Regional headquarters Asia-Pacific

19 Inukai, JP
20 Buzen, JP
21 Changshu, CN
22 Ipoh, MY
23 Enstek, MY
24 Smithfield, AU
25 Scoresby, AU

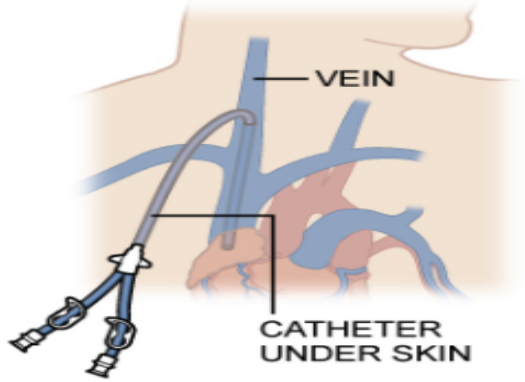
How Dialysis Works

In-center hemodialysis is the most common blood-cleansing therapy used by Americans with kidney failure. Patients typically are treated three times a week for three-to-four-hour sessions. Bloodlines can be attached to either a catheter or fistula.

CONNECTION TYPES

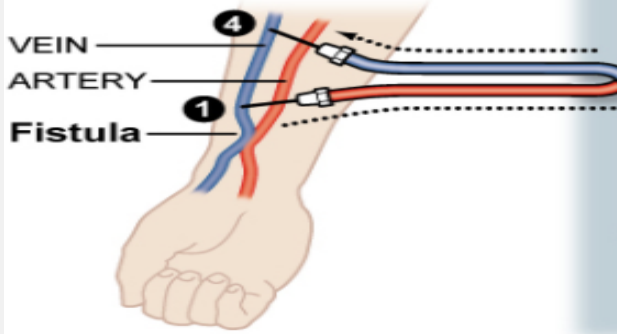
A Catheter

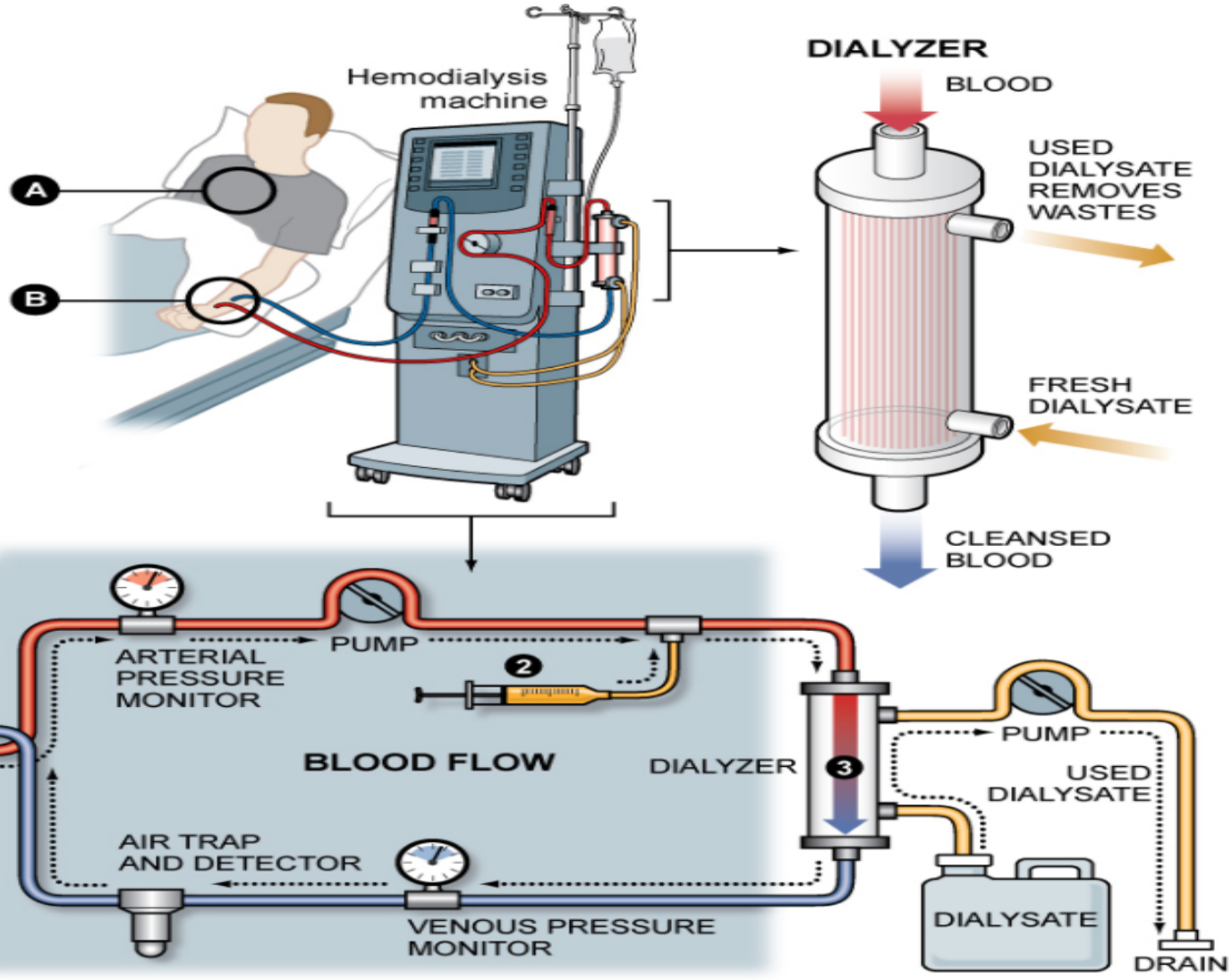
A tube inserted into a vein in the neck, chest or leg



B Fistula

A surgically created connection of an artery to a vein





1 Blood is pumped out of a patient's catheter or fistula into the blood line.

2 Heparin, a blood thinner, is added to prevent clotting.

3 Blood flows into the dialyzer, where impurities, salt, and excess fluid are drawn into the dialysis solution.

4 Cleansed blood is returned.

Graphic by Al Granberg

Factors driving change at Fresenius

Advances in medicine and technology

All the research in the world is meaningless unless it turns into meaningful results for patients, which is why our research and development efforts are designed to quickly turn new findings into market-ready products. This quick time to market enables us to offer safer and more effective individualized treatment to each and every patient. We focus on technologies to reduce product size and simplify their use, while integrating various treatment elements to create holistic therapy systems.

Sustained growth in patient numbers

It is estimated that by 2020, there will be 3.8 million kidney patients worldwide, fueled by an increase in the number of people who suffer from diseases such as high blood pressure and diabetes. As the number of kidney patients rises, health care systems across the globe will be challenged to find the resources to care for them. Meeting the resulting demand for safe, effective and efficient therapies and associated technologies and products is central to our research and development activities.

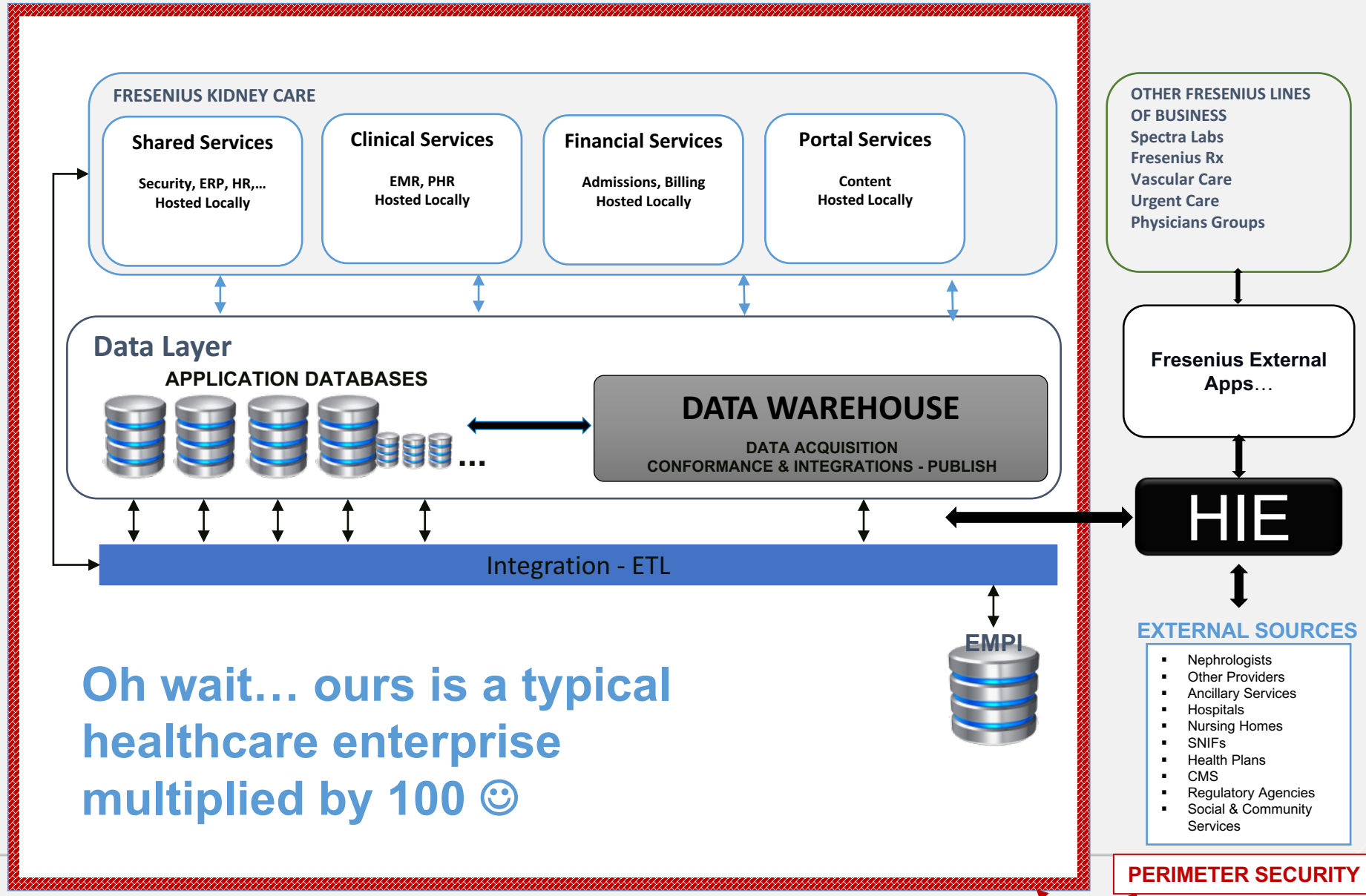
Increase in concomitant diseases

Our society is aging overall and the risk of developing end-stage renal disease increases with age. As patients age they also experience a greater likelihood of developing concomitant diseases such as cardiac and vascular conditions. Treating these patients' comorbidities is increasingly a focal point of our research and development efforts.

Rising cost pressure in health care

An aging population, growth in chronic illnesses, and the desire to offer new and improved technologies in patient care all present major long-term financial challenges to health care systems across the globe. For this reason, we believe successful product innovations must not be not only high quality, but also affordable. Based on our experience operating dialysis clinics, we consider these two priorities to be entirely compatible.

Ours is a typical healthcare enterprise



Oh wait… ours is a typical healthcare enterprise multiplied by 100 ☺

Challenge

Challenge: Disjointed User Experience

To perform their tasks, clinic staff use not only core clinical systems but also a large number of disparate information systems, each one with a different UI.

Challenge: Clinical Interoperability

Where we have multiple systems, the user is often responsible for managing the coordination of workflows across those systems, often with the help of additional reports.

Goal: Seamless User-Centric Workflow

Improve the clinic staff workflow by integrating the various touchpoints into a more seamless User-Centric workflow to eliminate redundant data entry and navigation.

Manage user/patient/location context across systems for a seamless workflow.

Minimize the number of UIs that users must master to perform their tasks

Enable clinic staff to manage data in the most appropriate system based on their task workflow

Challenge response

Fresenius FABRIC

a SMART Healthcare Application Platform for Patients, Clinicians, Physicians

Adheres to SMART concepts : Substitutable Medical Applications & Reusable Technologies (SMART)

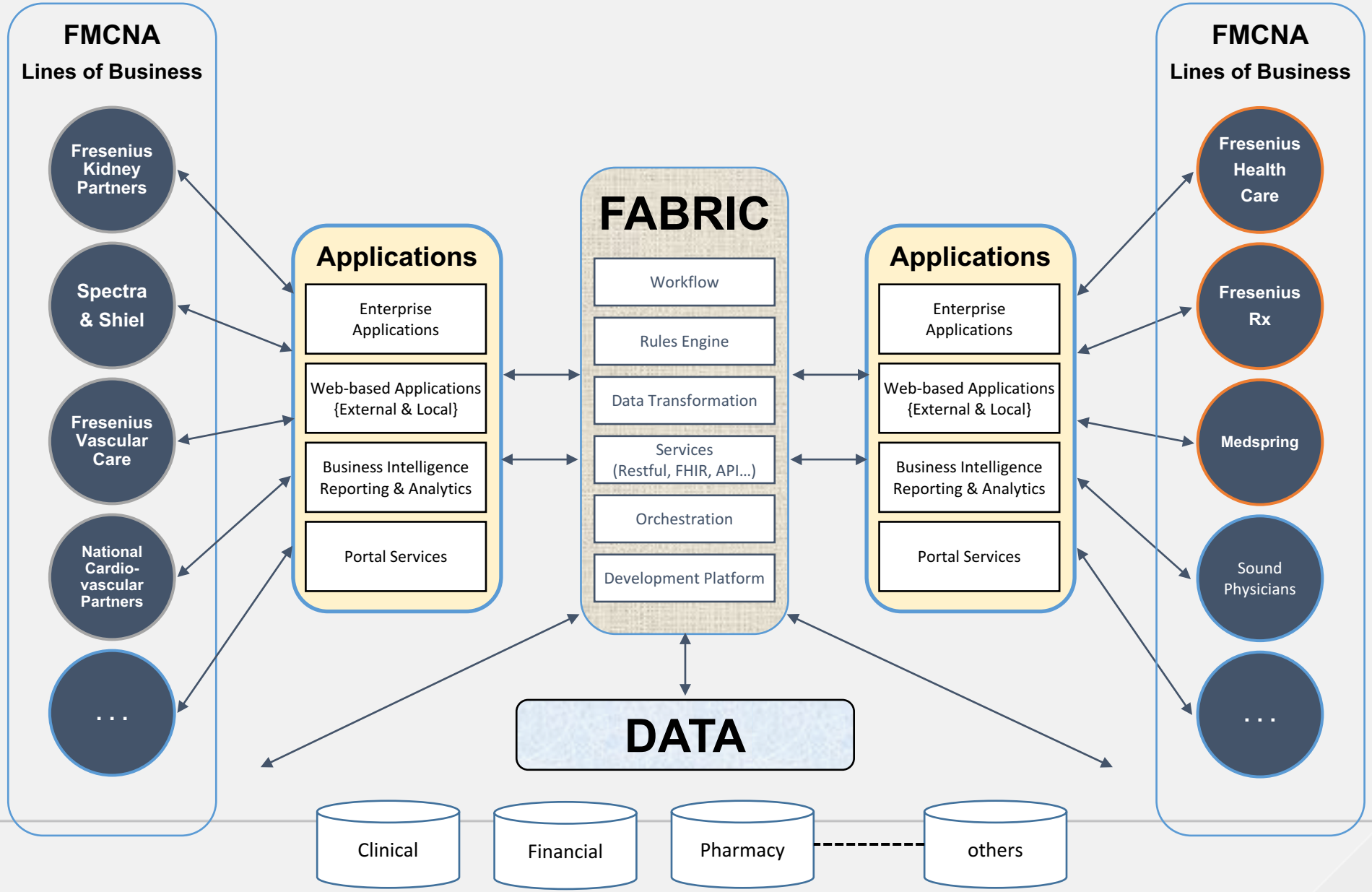
Fresenius FABRIC is

- Collaborative app development
- Secure User and backend integration
- Transformative power of technology
- High performance and availability in all data centers

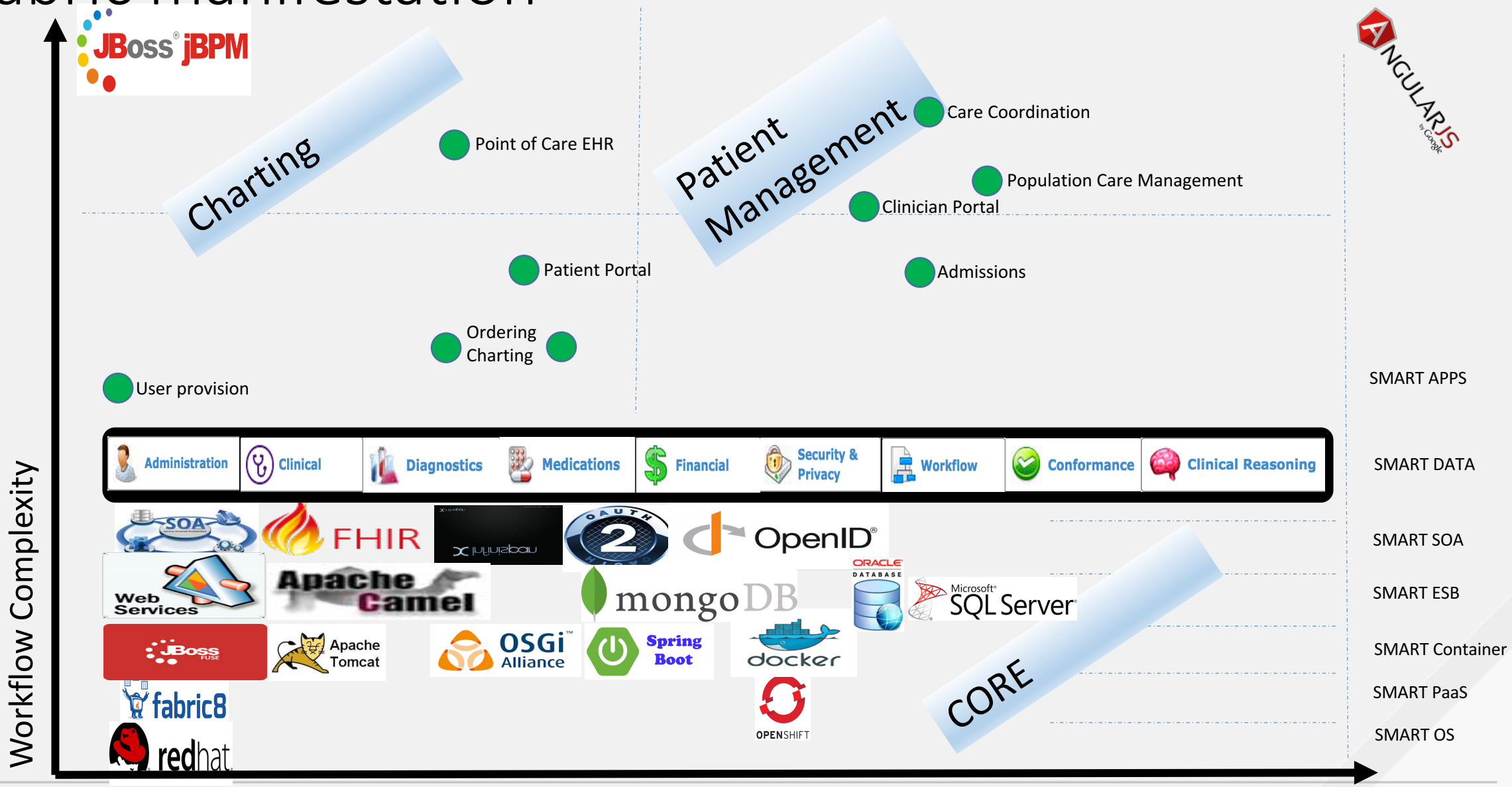
Fresenius FABRIC enables to

- Harness the Encourage user engagement
- Transform a system of record into a system of engagement
- Unleash back-end data
- Reduce development time and effort

Fabric concept



Fabric manifestation



Fabric layers under the hood

Open Source with
Commercial License Support

Current Layers

SMART OS – *RedHat 6.x*

SMART PaaS - *Platform as a Service (container manager) – FABRIC8*

SMART Containers – *OSGI, SPRING BOOT (JVM stacks – Oracle WebLogic, JBoss EAP, Tomcat, Node.js)*

SMART ESB – *Web Services Apache CXF, Apache Camel Routes, Persistence (Mongo DB), back ends MS SQL, Oracle DB..*

SMART SOA – *FHIR Healthcare API, User Authorization, Caching, Workflow*

SMART DATA – *FHIR Resources*

SMART APPS – *Angular Apps*

Evolving Layers

SMART Paas – *OpenShift 3.0*

SMART Containers – *Docker*

SMART SOA – *Data Virtualization*

Fabric components under the hood

Open Source with
Commercial License Support

Current Functions

JBoss Keycloak - *OpenID Connect, OAuth2.0 to AD & LDAP(OID, OAM)*
JBoss Grid – *HA DR distributed WS cache*
JBoss Fuse - *Lightweight ESB and SOA, HA DR*
Apache Camel - *Routing and mediation rules, Orchestration HA DR*
Apache CXF - *Services (HL7 FHIR, SOAP, XML/HTTP, RESTful HTTP)*
Apache Active MQ - *Transport Protocols (HTTP, JMS, JBI) HA DR*
MONGO - *Audit, Transaction storage and replay, HA DR*
Fabric8 - *CI/CD, Service registration and Discovery, HA, DR*
OSGI - *Managed containers, service versioning, hot deployments*
Jboss EAP – *JVM ontainers, service versioning, hot deployments*
SpringBoot - *containers, service versioning, hot deployments*
Monitoring - *Riverbed Opnet, BMC Coradient, Solarwinds*

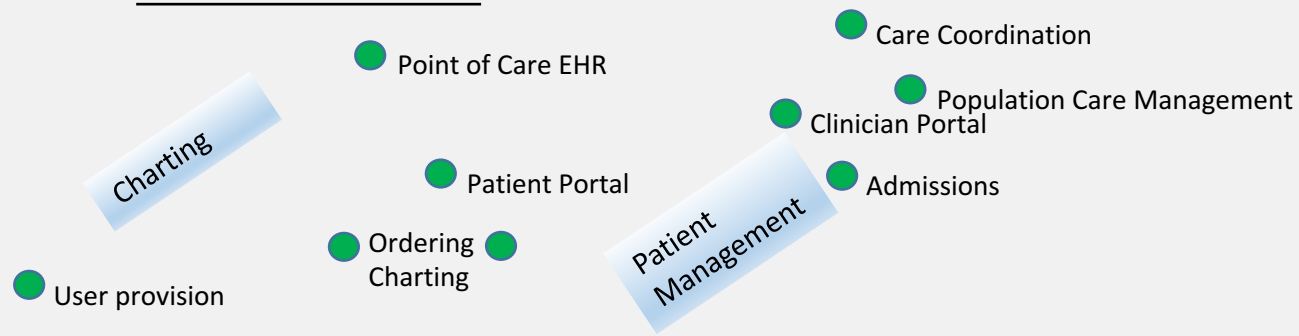
Evolving Functions

Jboss Data Virtualization – *HA DR distributed federated data*
Apache Kafka – *Messaging System for containers/topics, HA DR*
Apache Artemis MQ - *Transport Protocols (HTTP, JMS, JBI), HA DR*
JBoss BPM - *Service and Business Rules develop and deploy, HA DR*
OpenShift - *CI/CD, Service registration and Discovery, HA, DR*
Docker - *Managed containers, service versioning, hot deployments*
Monitoring - *OpenShift*, Riverbed Opnet, BMC Coradient, Solarwinds

Apps under the hood

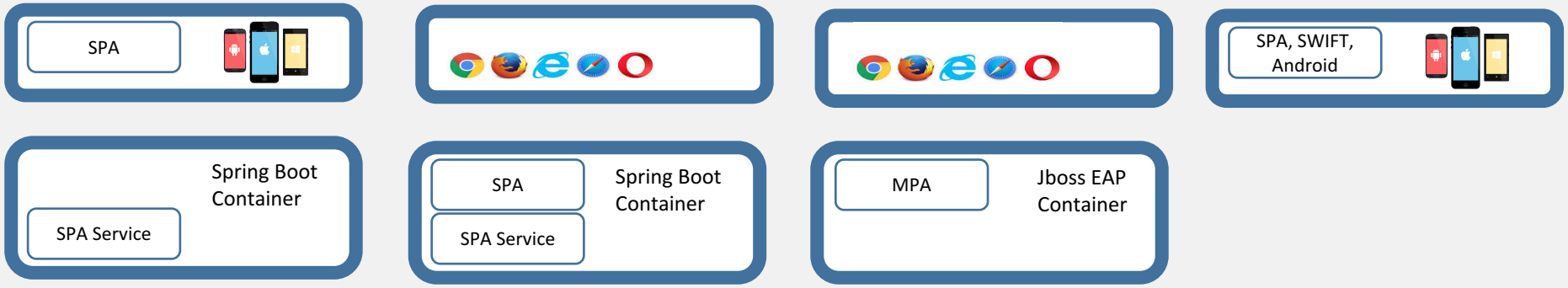
SMART APPS

Light **Angular, React, Mobile First, Mobile Ready**
Flexible **Swift, Android, Web, SMART on FHIR**
Dual Data Center **HA Active-Active**



SPA advantages over MPA:
Faster page loading times
Improved user experience because the data is loading in the background form server
No need to write the code to render pages on the server
Decoupling of front-end and back-end development
Simplified mobile development; you can reuse the same backend for web application and native mobile application

SPA disadvantages to MPA:
Heavy client frameworks which are required to be loaded to the client
UI code is not compiled, so it's harder to debug and it's exposed to potential malicious user
SEO (search engine optimization) implications; since your pages are built in the browser, the search engine crawler will see a different version of the page than that of your users



FHIR under the hood

SMART DATA FHIR

Dual Data Center **HA Active-Active**
FHIR **Medical Ontology, REST API, Open Source HAPI FHIR JPA Server**
Integrated **BPM and CDS built in**

FHIR

Open Source from HL7 and FHIR Community Org

•HL7 FHIR supports a range of clinical and administrative healthcare interoperability scenarios ranging from simple RESTful mobile solutions to clinical documents to complex messaging-based EHR infrastructures.

•Ease of implementation
•Leverages established IT standards
•Leverages Web 2.0+ standards
•Optimized for Cloud-based applications
•Interoperable support for document, message, REST and SOA architectures

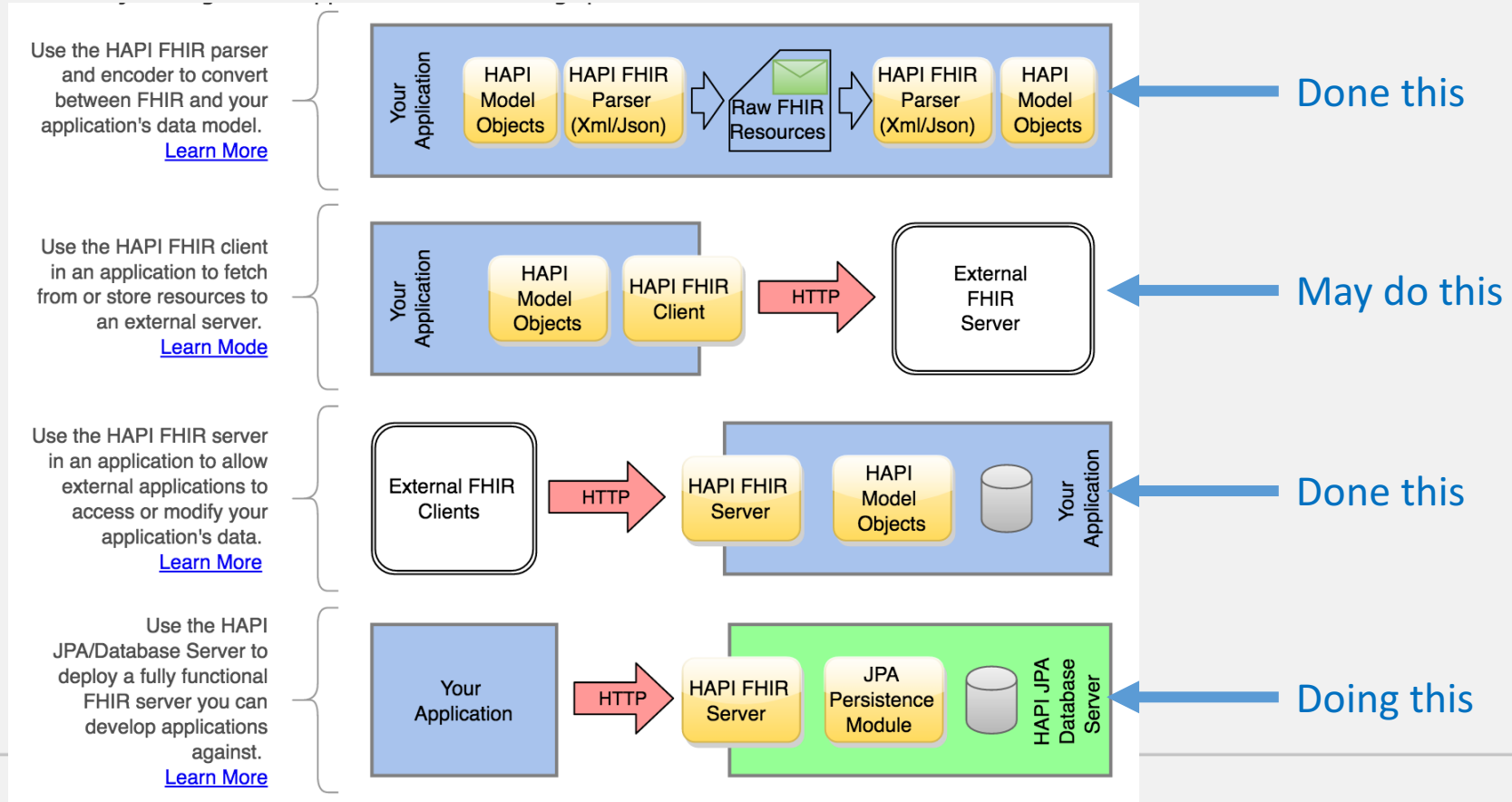
FHIR stacks under the hood

SMART DATA FHIR

Dual Data Center **HA Active-Active**

FHIR **Medical Ontology, REST API, Open Source HAPI FHIR JPA Server**

Integrated **BPM and CDS built in**



BPM under the hood

SMART DATA BPM

FHIR **Workflow, Business Process**
Dual Data Center **HA Active-Active**

JBPM Suite, KIE Knowledge Is Everything
(Drools, jBPM, OptaPlanner)
BPMN 2.0, BEPL
User, Role and Credential Based
Authoring, Simulation
Data Modeler tied to FHIR Object Model
Deployment Management, Analytics

SOA FHIR JBoss jBPM

SOA FHIR JBoss jBPM

BPM and FHIR under the hood

SMART DATA BPM

FHIR **Workflow, Business Process**

Dual Data Center **HA Active-Active**

Infrastructure	• Resource: Task • Patterns: Definition, Request, Event • Documentation: Overview, Overview, Communication Patterns, Ad-Hoc PatternsManagement Patterns & Examples
Scheduling	• Appointments: Appointment / AppointmentResponse • Availability: Schedule / Slot
Clinical Process	• Referrals: ReferralRequest, ProcedureRequest • Orders: NutritionOrder, VisionPrescription • Definitions: ActivityDefinition, PlanDefinition • Miscellaineous: ProcessRequest & ProcessResponse, DeviceRequest & DeviceUseStatement, SupplyRequest & SupplyDelivery

Predictive, Descriptive Analytics under the hood

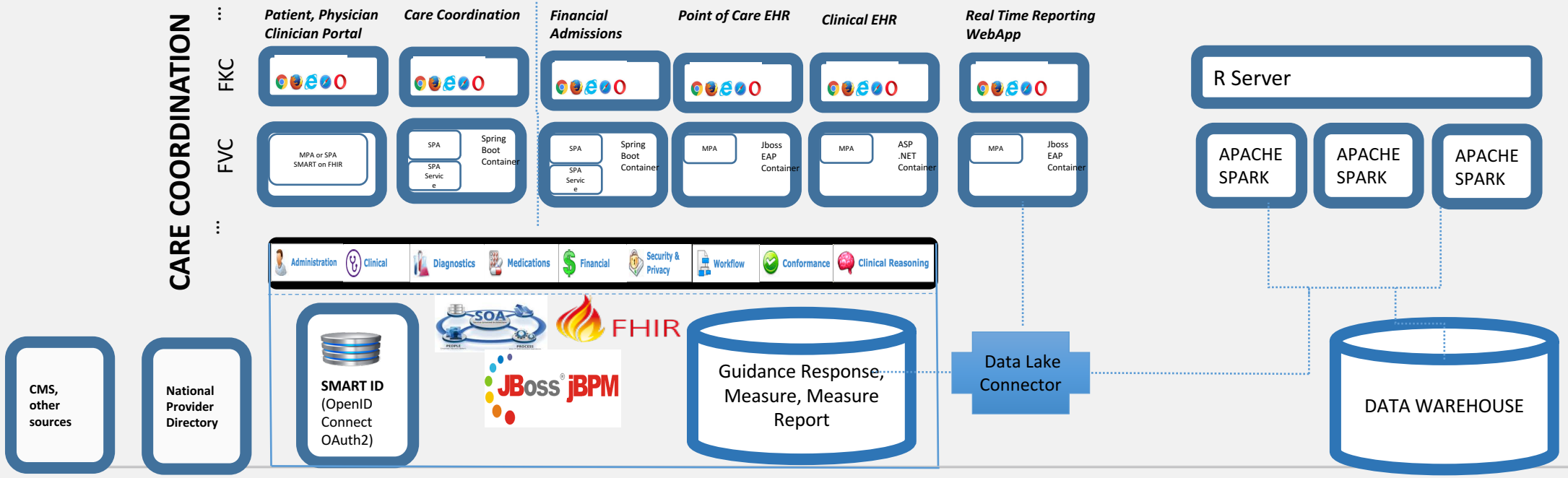
SMART DATA CLINICAL PRECISION

Dual Data Center **HA Active-Active on FABRIC**

Outputs **FHIR based Decision Support and Clinical Quality Measures**

Inputs **FKC Data and Rules, CMS Data and Rules**

Intelligent Compute Engine **R Server executing on top of Apache Spark**



Spark and mongoDB data lake under the hood

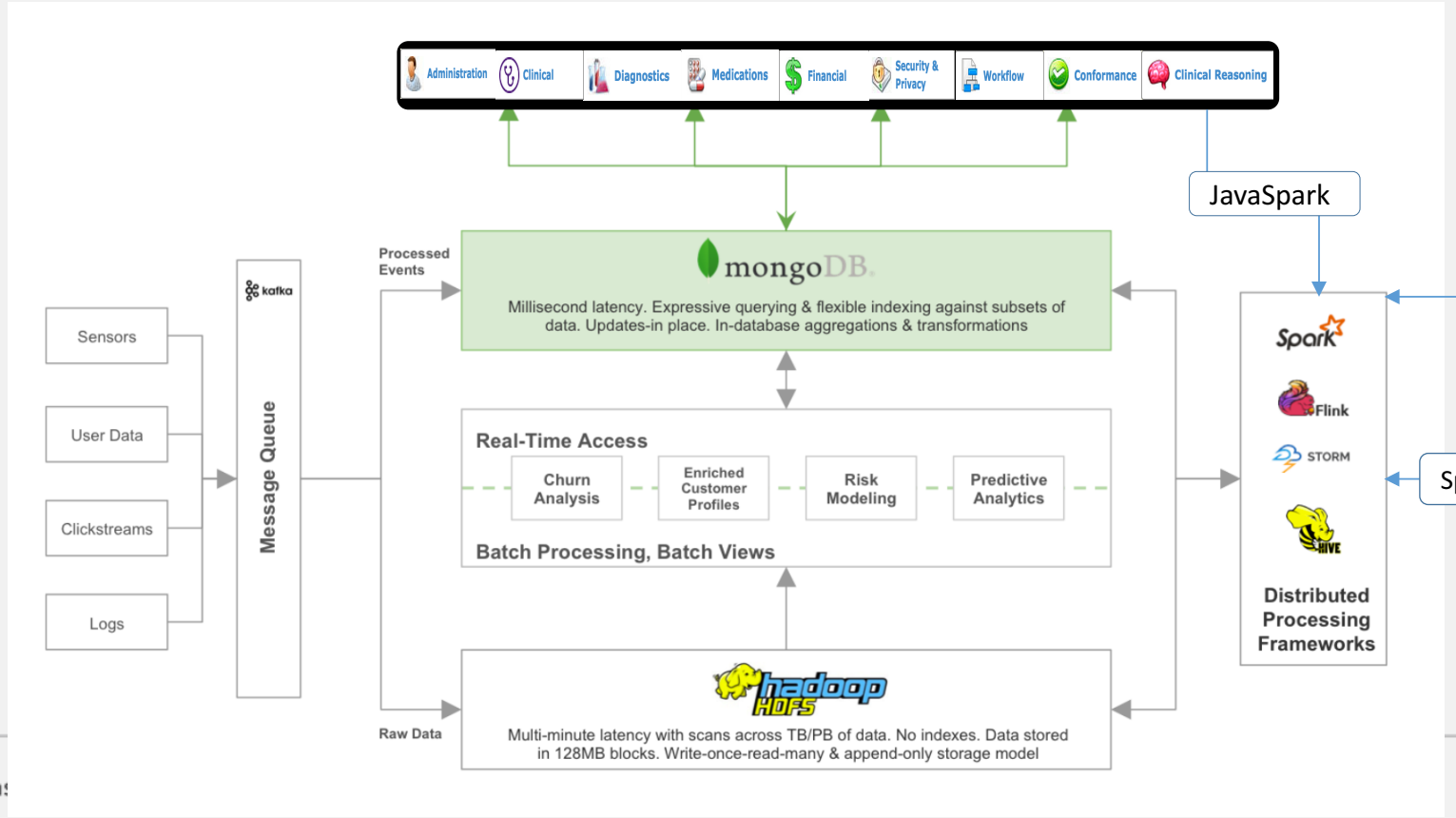
SMART DATA CLINICAL PRECISION

Dual Data Center **HA Active-Active on FABRIC**

Outputs **FHIR based Decision Support and Clinical Quality Measures**

Inputs **FKC Data and Rules, CMS Data and Rules**

Intelligent Compute Engine **R Server executing on top of Apache Spark**



EMPI and FHIR under the hood

SMART SOA FHIR EMPI

Integrated **Contextual, Organizational**

Dual Data Center **HA Active-Active**

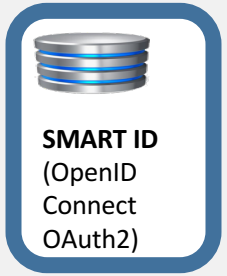
User, Role and Credential Based

System to System Access based on EMPI

Multi System Patient Search

System to System ID translation

```
{
  "use" : "official", // usual | official | temp | secondary (If known)
  "type" : "MRN", // Description of identifier
  "system" : "www.fmcna.com", // The namespace for the identifier
  "value" : "500012345", // The value that is unique
  "period" : {01-01-2015, 12-25-2016}, // Time period when id is/was valid for use
  "assigner" : "Fresenius Kidney Care" // Organization that issued id (may be just text)
}
{
  "use" : "official", // usual | official | temp | secondary (If known)
  "type" : "MRN", // Description of identifier
  "system" : "www.freseniusRxTn.com", // The namespace for the identifier
  "value" : "10002222", // The value that is unique
  "period" : {01-01-2015}, // Time period when id is/was valid for use
  "assigner" : "Fresenius Rx Tennessee" // Organization that issued id (may be just text)
}
```



FKC

FVC

Fresenius Rx

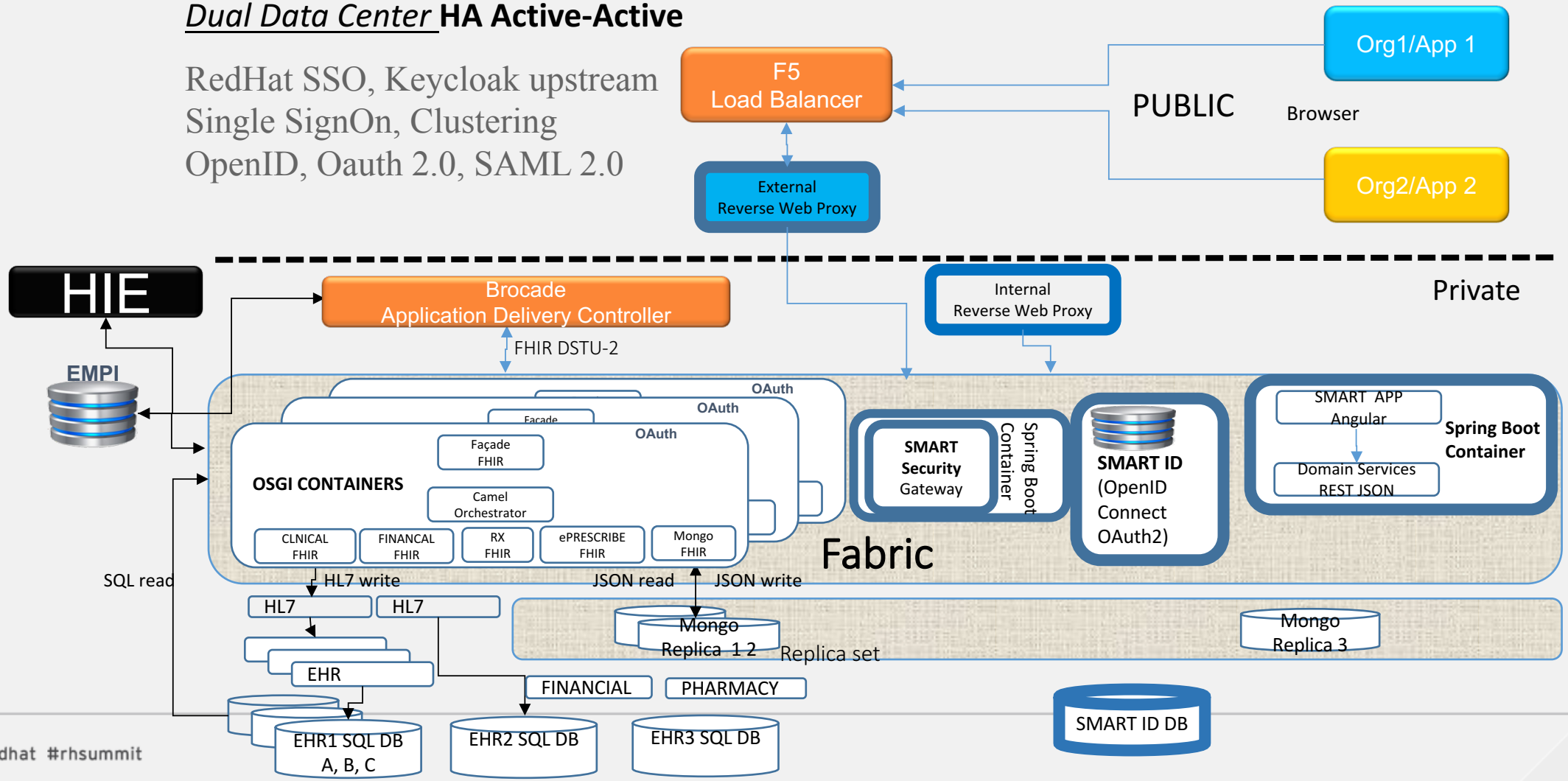
SSO and OAuth under the hood

SMART SOA SMART ID

Integrated **Contextual, Organizational, External**

Dual Data Center **HA Active-Active**

RedHat SSO, Keycloak upstream
Single SignOn, Clustering
OpenID, Oauth 2.0, SAML 2.0



FHIR security under the hood

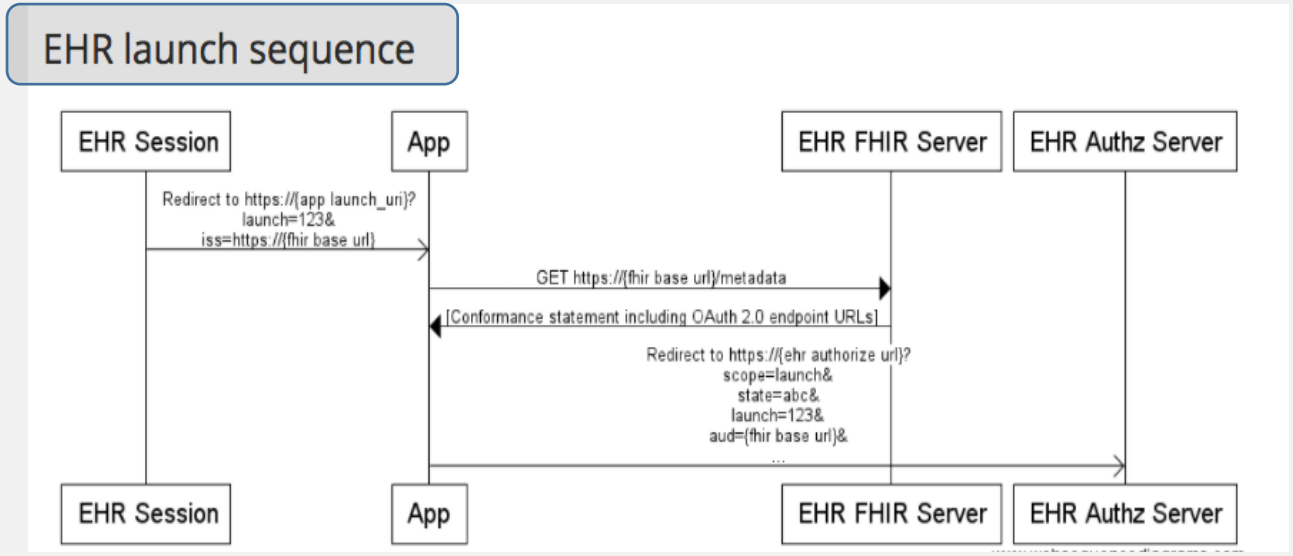
SMART SOA SMART ID

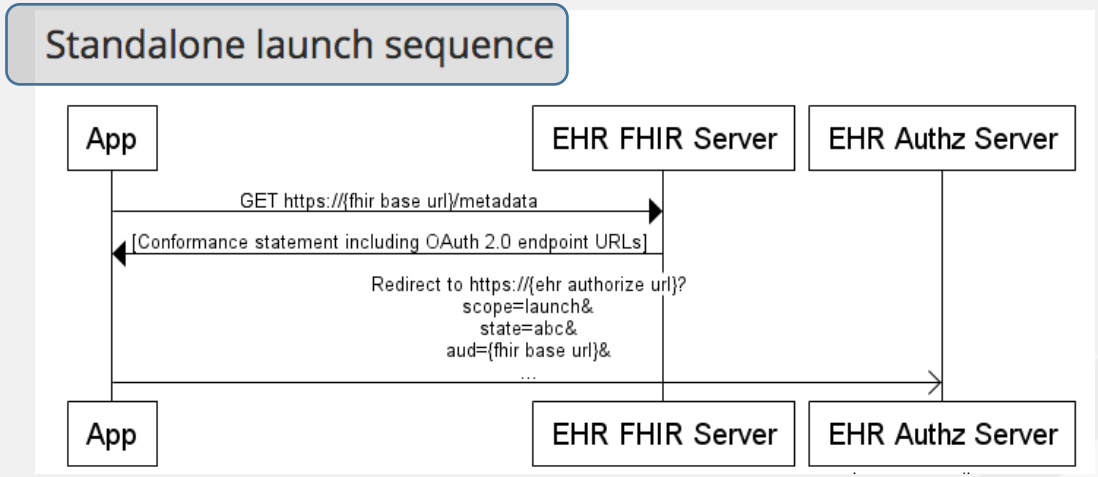
Integrated **Contextual, Organizational, External**

Dual Data Center **HA Active-Active**

FHIR, SMART on FHIR, Argonaut Security Use Cases

1. Patient uses provider-approved web application to access health data
2. Patient uses provider-approved mobile app to access health data
3. Clinician uses provider-approved web application to access health data
4. Clinician uses provider-approved mobile app to access health data
5. Clinician in organization A uses EHR A to access patient data in EHR B, operated by organization B





Cache under the hood

SMART SOA FHIR CACHE

Dual Data Center **HA Active-Active**

JBoss GRID, Infinispan
In-memory local and clustered cache
Clustering
Expiration
Eviction

Built into the FHIR Service Resources
Listeners
Transactions
Persistence
Management and monitoring

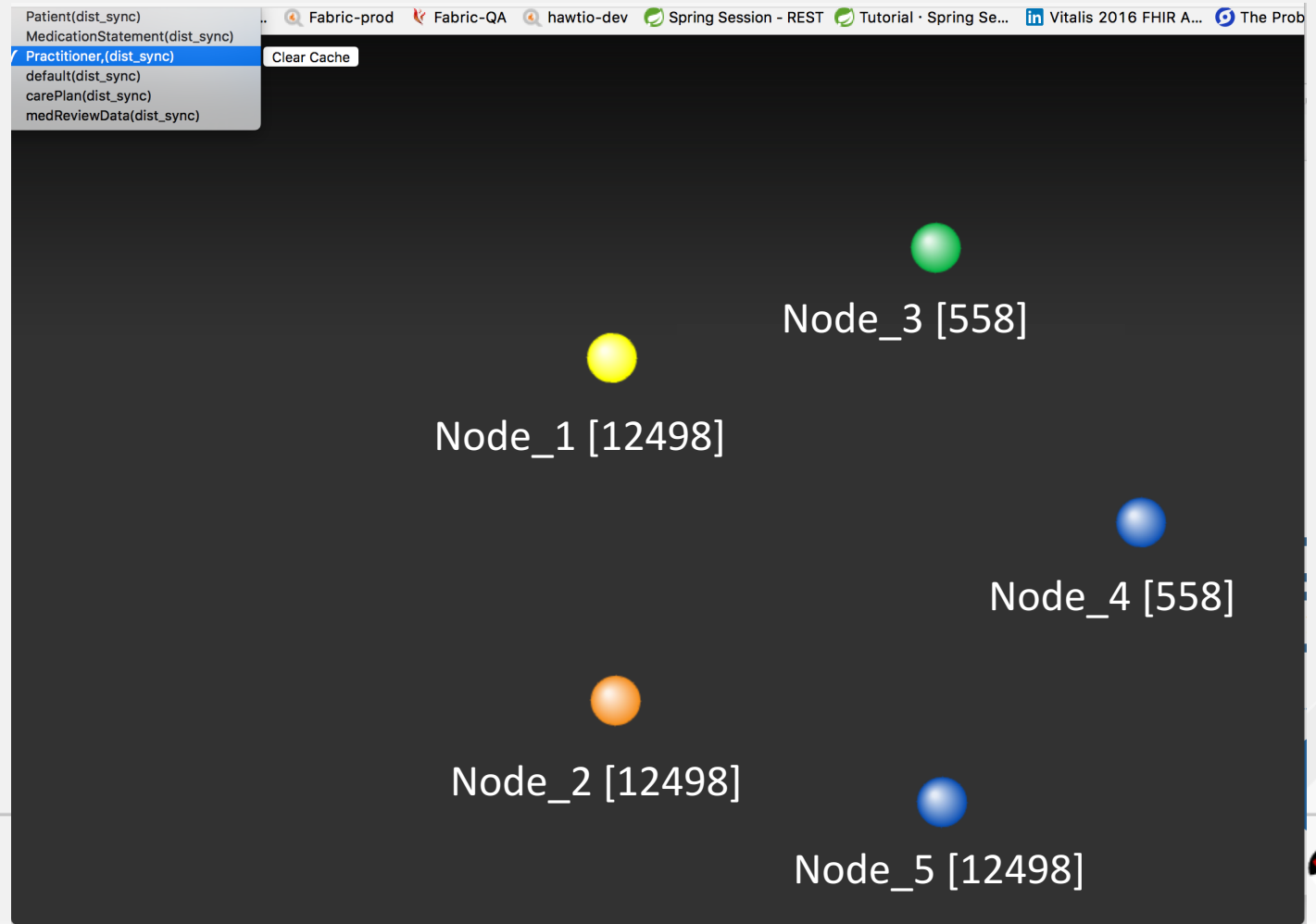
Data Center 1 **Data Center 2**

Cache under the hood

SMART SOA FHIR CACHE

Dual Data Center **HA Active-Active**

FHIR Resources cache
Multiple nodes
Shard and Cluster



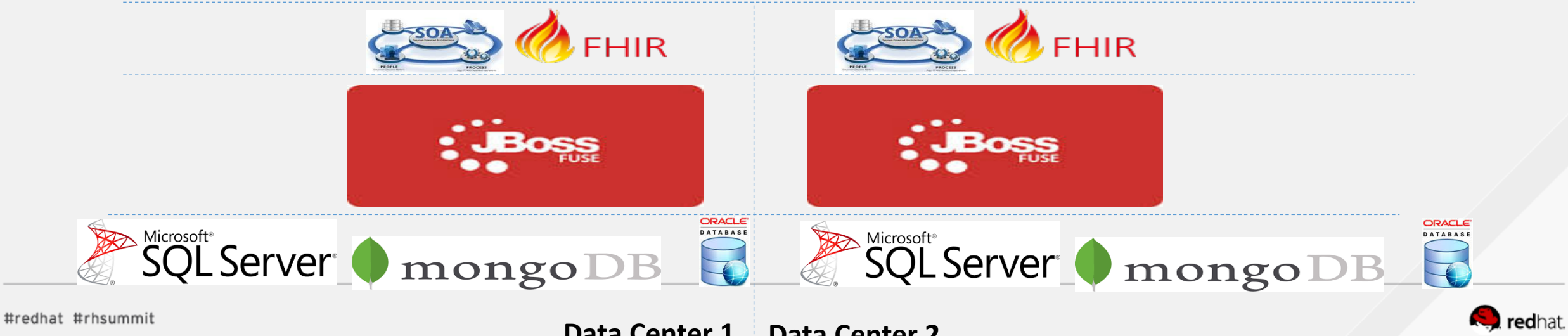
ESB under the hood

SMART ESB FUSE

Dual Data Center **HA Active-Active**

JBoss FUSE
Web Services Apache CXF, Apache Camel Routes, Persistence (Mongo DB), back ends MS SQL, Oracle DB

Integration pattern between FHIR servers and other data and systems



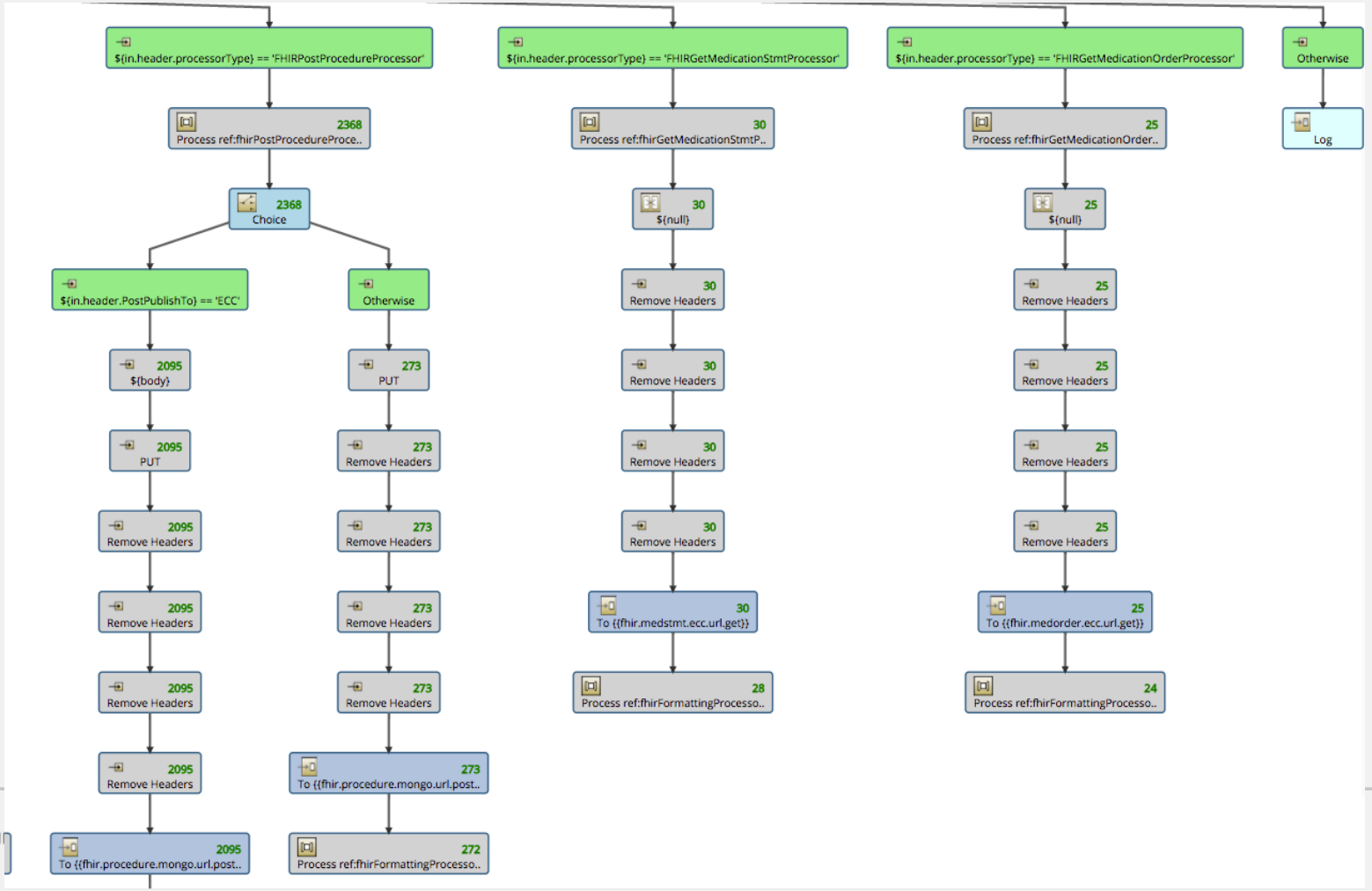
ESB Camel under the hood

SMART ESB FUSE

Dual Data Center **HA Active-Active**

FUSE Camel Routes

FHIR calls based on resource
(e.g. Medication, Medication Statement and Medication Order…)



ESB Endpoints under the hood

SMART ESB FUSE

Dual Data Center **HA Active-Active**

FUSE Camel Endpoints
(e.g. Procedure, MedicationOrder, Observation, Patient, Medication Statement…)

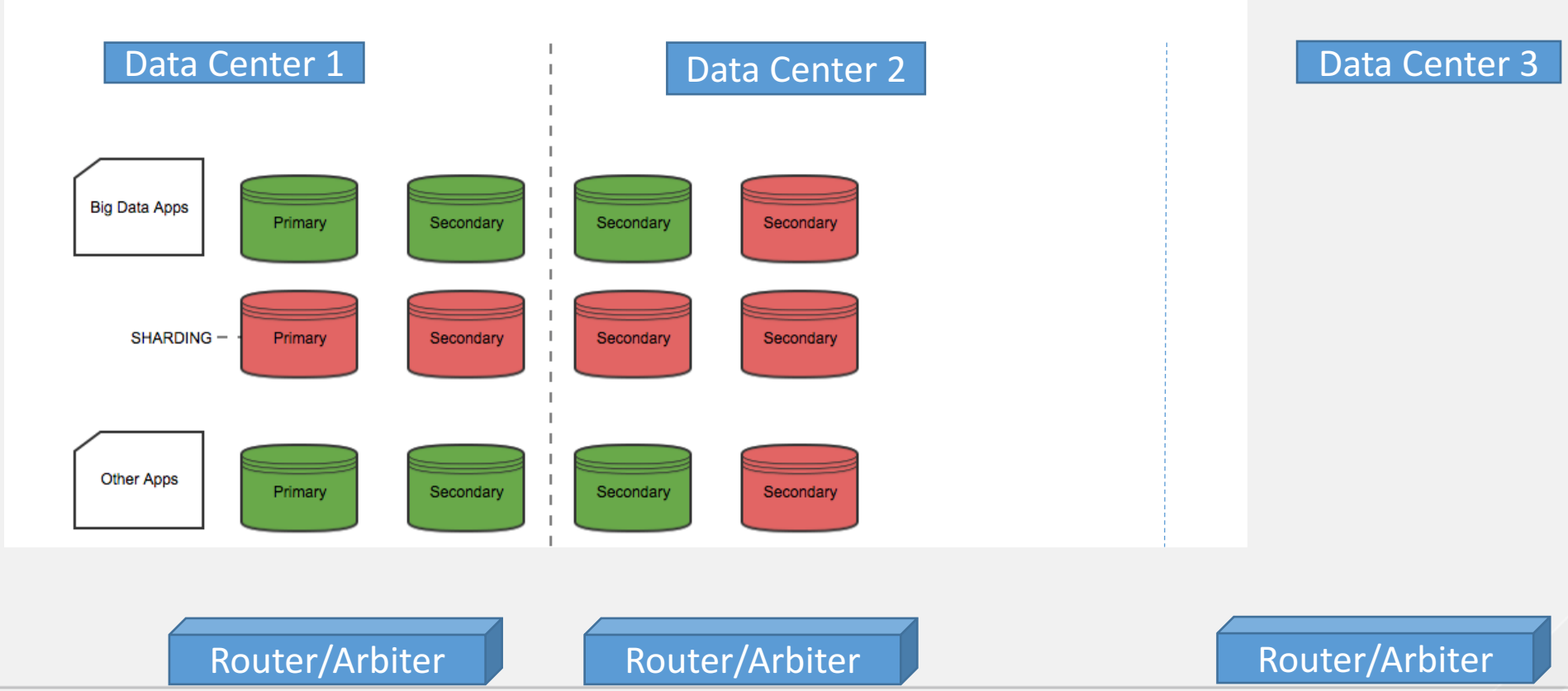
State	Context	Endpoint URI
▶	fhirDomainCamelContext	http4://bol-faba-p04.dsd.fmcna.com:8190/ecc-fhir-service/fhir/ProcedureRequest/_search?throwExceptionOnFailure=true
▶	fhirDomainCamelContext	http4://bol-faba-p04.dsd.fmcna.com:8190/ecc-fhir-service/fhir/MedicationOrder/_search?throwExceptionOnFailure=true
▶	fhirDomainCamelContext	http4://bol-faba-p04.dsd.fmcna.com:8190/ecc-fhir-service/fhir/metadata?throwExceptionOnFailure=true
▶	fhirDomainCamelContext	http4://bol-faba-p04.dsd.fmcna.com:8190/ecc-fhir-service/fhir/Observation/_search?throwExceptionOnFailure=true
▶	fhirDomainCamelContext	http4://bol-faba-p04.dsd.fmcna.com:8190/ecc-fhir-service/fhir/Patient/_search?throwExceptionOnFailure=true
▶	fhirDomainCamelContext	http4://bol-faba-p04.dsd.fmcna.com:8190/ecc-fhir-service/fhir/Procedure/_search?throwExceptionOnFailure=true
▶	fhirDomainCamelContext	http4://bol-faba-p04.dsd.fmcna.com:8190/ecc-fhir-service/fhir/MedicationStatement/_search?throwExceptionOnFailure=true
▶	fhirDomainCamelContext	http4://bol-faba-p04.dsd.fmcna.com:8190/fhir-mongo-service/fhir/Observation?throwExceptionOnFailure=true
▶	fhirDomainCamelContext	http4://bol-faba-p04.dsd.fmcna.com:8190/fhir-mongo-service/fhir/Procedure?amp%3BthrowExceptionOnFailure=true&bridgeEndpoint=true
▶	fhirDomainCamelContext	http4://bol-faba-p04.dsd.fmcna.com:8190/fhir-mongo-service/fhir/Procedure/_search?throwExceptionOnFailure=true
▶	fhirDomainCamelContext	seda://encountermongo
▶	fhirDomainCamelContext	seda://procedurerequestmongo
▶	fhirDomainCamelContext	seda://validateMongo

mongoDB under the hood

HA PERSISTENCE SMART ESB

Operational Persistence – **Mongo DB**

Dual Data Center **Master-Slave** to *Triple Data Center* **Active-Active**



Why all this tech?

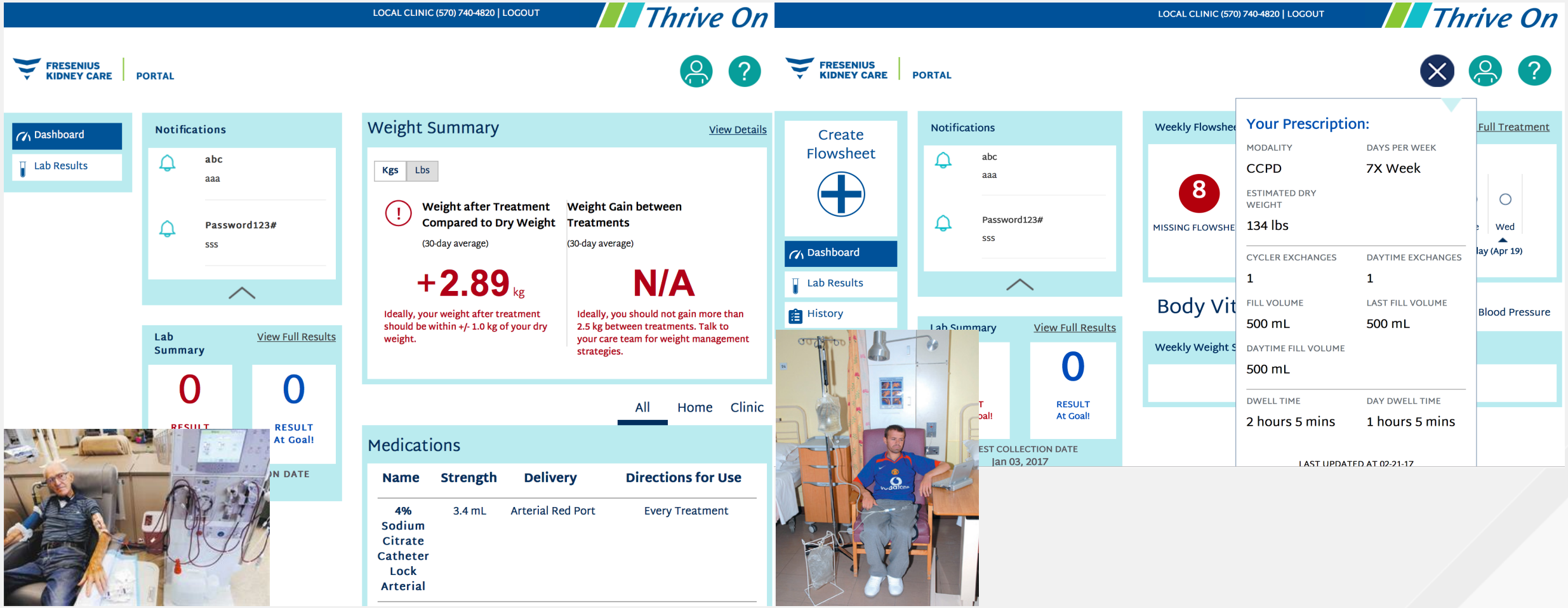
Consumer Directed Exchange, Interop, ONC, CARIN, SMART on FHIR

- SMART App Gallery
  - https://apps.smarthealthit.org/
- Argonaut Interoperability Project
  - http://argonautwiki.hl7.org/index.php?title=Main_Page
  - http://argonautwiki.hl7.org/index.php?title=Argo-sponsors

Argonaut Project Sponsors

- Accenture
- athenahealth
- Beth Israel Deaconess Medical Center
- Cerner
- Epic
- Intermountain Healthcare
- Mayo Clinic
- MEDITECH
- McKesson
- Partners HealthCare System
- SMART at the Boston Children's Hospital Computational Health Informatics Program
- The Advisory Board Company
- Surescripts

Why all this tech?



THANK YOU


plus.google.com/+RedHat


facebook.com/redhatinc


linkedin.com/company/red-hat


twitter.com/RedHatNews

youtube.com/user/RedHatVideos