



careevolution
HEALTHCARE TECHNOLOGY

Architecture and Scalability

An Introduction to the CareEvolution RHIO Technology Platform and issues of platform scaling.

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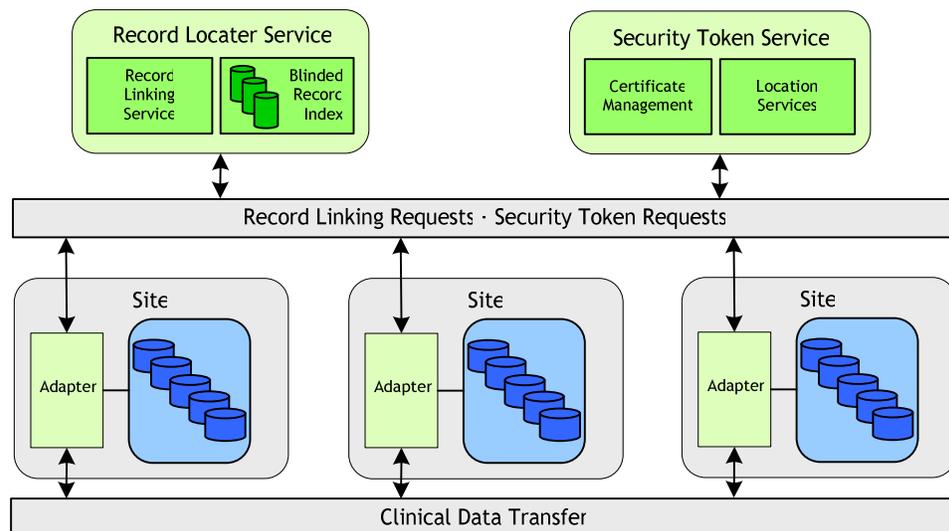
Background

Predicting the evolutionary growth of any given RHIO - let alone the RHIO landscape as a whole - is difficult and uncertain. Given the incremental uptake of RHIOs by members, a critical feature of any RHIO technology platform must include the ability to enable just-in-time evolution and incremental growth of the system. While scalability is typically discussed in terms of how large a workload (data and simultaneous users) a given architecture is able to support, we assert that an effective RHIO technology platform must simultaneously be able to be deployed easily and efficiently on a small scale at RHIO launch and then grow as needed.

There is little controversy that a RHIO “lifecycle” typically begins with a pilot phase with limited scope and size, spending much of its adolescence gradually growing to a larger implementation encompassing several participating institutions, and hopefully eventually hitting a growth spurt where broad, nearly universal participation and use occurs in a metropolitan area or region. As such, an ideal technology platform would flex with the RHIO’s developmental needs - enabling small scale initial deployment that is leveraged with as the system grows. What is critical is that the technology platform offer the same superior functional capabilities in areas of security, privacy, reliability, audit, and integration capabilities at startup that any national network would demand. This is what the CareEvolution RHIO Technology Platform offers - complete functional capability across the performance and sizing continuum from initial pilot to full scale regional deployment.

The CareEvolution RHIO Technology Platform

The CareEvolution RHIO Technology Platform is a Federated, Service Oriented Architecture (FSOA).

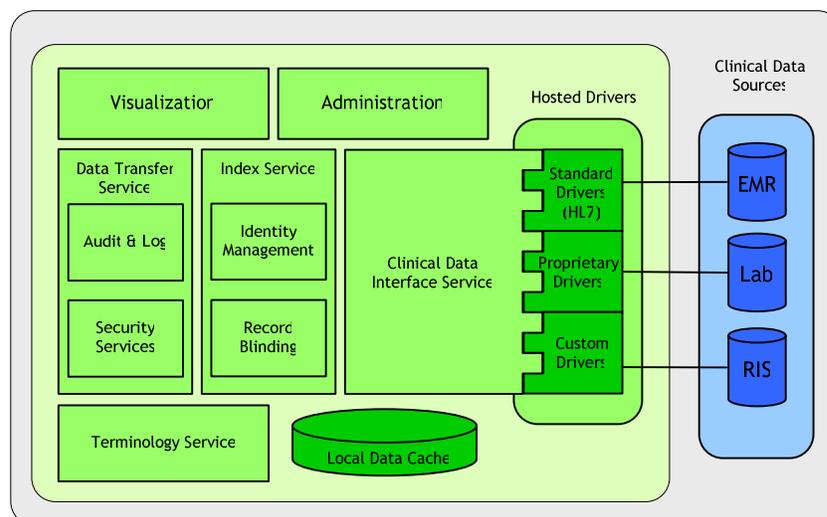


The key components of the architecture are briefly described below and greater detail regarding each follows.

- **Adapter** -- Each participating institution runs the CareEvolution Adapter Service that provides the interface between the Record Locator Service, peer institutions, and the institution's local clinical data sources.
- **Record Locator Service (RLS)** -- The Record Locator Service (RLS) maintains an index of the locations of patient records for each person in the system. Clinical information is never sent to the RLS. Furthermore, the RLS only stores secured, **blinded** demographic information necessary for record linking. When a patient is registered with an institution, a query is submitted to the RLS. The RLS returns the location of any matching records. A location consists of a site identifier and a record identifier specific to the remote site.
- **Security Token Service (STS)** - The STS serves as an intermediary amongst participating members authenticating inter-member data exchange requests and insuring that no member is directly aware specifically of any other member. Adapters use the site identifier to query the STS to find the location and public key for the institution holding the desired record. Only then can peer institutions then use their local record identifier to locate the linked record.
- **Peer to Peer Data Exchange (PtPE)** - Finally, the located data interchange is managed purely between the adapters at the two institutions using encrypted web services.

The CareEvolution Adapter

The CareEvolution adapter is composed of an Index Service, a Data Transfer Service, a Clinical Data Interface Service, a Terminology Service, and a Local Data Cache.

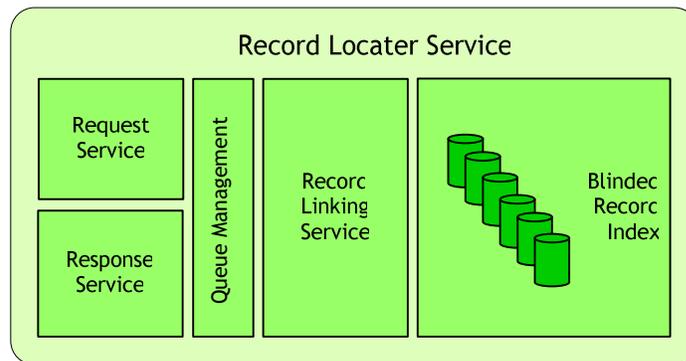


- **Record Index Service** - The Record Index Service provides the interface between the host systems and the Record Locator Service. It standardizes and blinds demographic information before sending requests to the Record Locator Service.
- **Data Transfer Service** - The Data Transfer Service manages adapter to adapter communication of clinical information. This is managed in pure peer to peer fashion.
- **Clinical Data Interface Service (CDIS)** - The CDIS hosts a set of pluggable drivers for communication with an institution's local clinical data sources such as EMR, lab, or pharmacy systems. The CDIS allows for easy customization to support the disparate clinical data sources of each institution. Each driver may run in one or more threads or processes dependent on the available hardware and required workload.
- **Terminology Service** - The Terminology Service is used by the Data Transfer Service and CDIS to provide translation between local and UMLS standard terms.
- **Local Data Cache** - The Local Data Cache provides a data store in which both record location index information and clinical information is cached. The Local Data Cache may be a single physical DBMS or can be federated across multiple physical databases.

The CareEvolution Record Locator Service

The Record Locator Service (RLS) provides the functions necessary for record linking and indexing. The Request Service, Response Service, and Queue Management Services manage the communications infrastructure between the RLS and client adapters.

- **Request Service** - The Request Service exposes the web service interface to receive asynchronous record add and update requests. The requests are queued for record linking.
- **Response and Queue Services** - The Response Service manages the communication of the results of record linking operations to the originating adapters for the linked records. Like all CareEvolution components the Request Service, the Response Service, and the Queue Management Service can be hosted with one instance of each on a single machine, multiple threads for each process on a single machine, or multiple processes on multiple machines. The required configuration is dependent on the traffic serviced by the RLS.



- **Blinded Record Linking Service** - The core work of the RLS, the actual record linking, is performed by the Blinded Record Linking Service. The Blinded Record Linking Service implements an incremental probabilistic matching algorithm to link each record added to the Blinded Record Index with the existing records in the index. Multiple instances of the Blinded Record Index Service can be used.

The Blinded Record Index data store is implemented as a federation of databases with each node of the index storing a subset of the records. This allows record linking to be done in parallel across disjoint subsets of the records in the index. As the size of the record index grows additional nodes can be added to the federation allowing the index to expand.

Scaling with CareEvolution : UP, OUT, & DOWN

Systems attempt to handle growth by **either** “scaling up” or “scaling out.” A system is said to “scale up” if performance increases proportionally as the hardware capabilities (e.g. disks, memory, CPUs) of existing machines in the system increase. A system is said to “scale out” if performance increases proportionally as the number of machines participating in a system increases. Systems must be architected from the ground up to effectively scale both up and out. To effectively scale up on a single multiprocessor machine or scale out on multiple machines, a system must be able to divide the work it undertakes into quantized, parallelizable units that maintain a consistent view of shared state while executing in multiple processes and threads. Minimizing shared state is critical. Tightly coupled processes with shared state are difficult or impossible to run efficiently in parallel.

Components in the CareEvolution RHIO Technology Platform have been designed and built to both scale up **and** out. These components utilize a tasking and queuing architecture that effectively quantizes the work done by the system. Components operate with a configurable number of threads to allow for scaling up on a single multiprocessor machine. Additionally, multiple

instances of these components can operate on multiple machines enabling the system to scale out. This architecture allows independent tasks to be processed in parallel.

Finally, the CareEvolution RHIO Technology Platform is also designed to “scale down”. It can be fully deployed with a minimal hardware footprint. Because components do not have conflicting resource requirements, all components can successfully be deployed together on a single machine.

The CareEvolution RHIO Technology Platform can run in a number of different configurations to adjust to the scaling needs of customers. Supported scenarios include running the entire system on a single machine, running each component on a separate machine, and running multiple copies of specific components on separate machines.

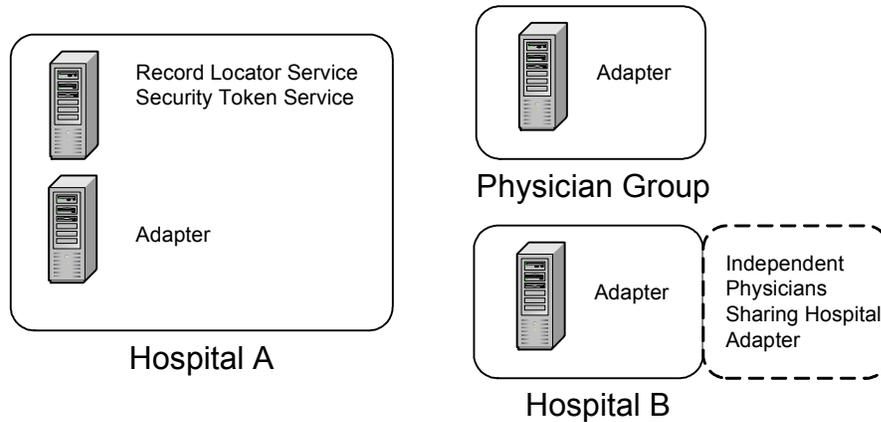
Scaling DOWN – Starting RHIO Pilots



A small pilot program could be implemented by having the RHIO infrastructure, the Record Locator and Security Token Service hosted at one of the participating institutions on the same machine as that institution’s adapter. Any additional institutions would only be required to host a single machine running their adapter. We have successfully deployed pilot health information exchanges (HIE) between 2-5 institutions using very economical startup hardware.

During the pilot phase all functional and integration evaluations regarding privacy, security, integration, audit & log, and visualization are available without investing hundreds of thousands of dollars. As the budding RHIO organizations are learning, the key is to move the RHIO out of the conference room to the pilot stage where end-users can begin to experience the “promise”. Our Startup Package is designed to make this an inconsequential capital expenditure hurdle. If organizational, legal, and governance issues are resolved, we can get started - funding will not slow down pilot progress. Pilot success begets participation, which is essential to continued funding.

Scaling UP – GROWTH STAGE

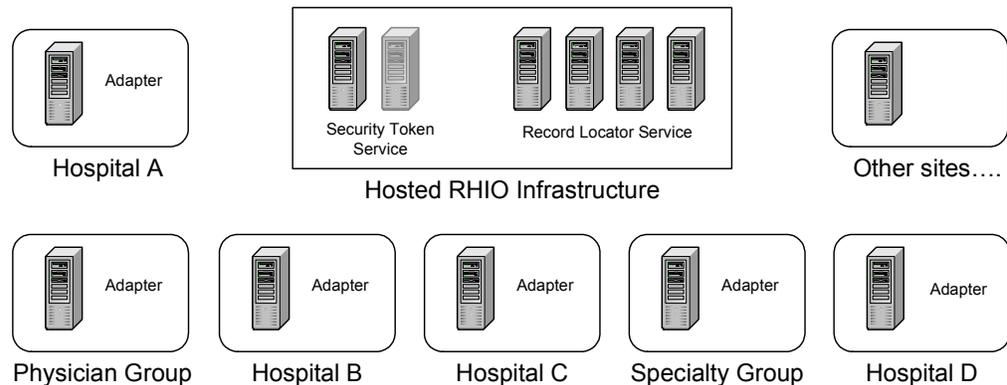


As participants are added to the RHIO it will be necessary to run the Record Locator Service and Security Token Service on distinct hardware scaled to the projected growth. In a migration from a pilot implementation, the adapter can be hosted on the original hardware with a new machine allocated to the RLS and STS. Each additional institution will need to deploy dedicated Adapter infrastructure. The CareEvolution Implementation Services team uses specific data and concurrent user models to size the infrastructure at this stage.

Support for Independent Physicians

Not every physician with the desire to participate in an RHIO will have the capability or desire to host their own adapter. Using the CareEvolution RHIO Technology Platform, those physicians can share an adapter with another participating institution - the HOSTED adapter model.

Scaling OUT - Full Scale Regional Deployment



An RHIO with a significant number of participating institutions will need a dedicated “set” of infrastructure to host both the STS and RLS. The RHIO infrastructure can be deployed at a participating institution or hosted at a dedicated data center. The RLS can be implemented with the Blinded Record

Index deployed as a federated database across a collection of machines. CareEvolution has validated the platform using a multi-state regional model with over 20 million distinct consumers in the blinded record index. We have developed and volume tested a detailed multi-entity scale-out infrastructure to serve such large scale RHIO implementations.

We actively seek partners in validating the performance and scaling characteristics of the CareEvolution RHIO Technology Platform for national or regional rollouts.

Summary

The health information exchange environment is evolving. It is critical to select an RHIO platform that can efficiently service the current and future needs of your RHIO. The CareEvolution RHIO Technology Platform has been designed to grow and evolve from small pilot systems to large scale RHIOs. The CareEvolution RHIO Technology Platform can serve your needs both today and into the future.

About CareEvolution, Inc.

CareEvolution is a leading provider of secure interoperability solutions. Our RHIO platform offering is a robust Service Oriented Architecture (SOA) to enable RHIOs' heterogeneous underlying EMRs to "share" clinical information in a secure, reliable, and incremental manner. Distinct component such as Identity Management, Record Location, Clinical Data Integration, Audit & Log, Data Persistence, Visualization, Terminology, and Data Mining may be adopted piecemeal or as a comprehensive technology platform.

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