



Building a SQL Persistence Provider for a FHIR Server

<https://github.com/Microsoft/fhir-server>

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Docto**r**FHIR**cat**

THIS SESSION

FHIR Server For Azure in 30 seconds

Why are we doing this?

Quick Overview of FHIR Search

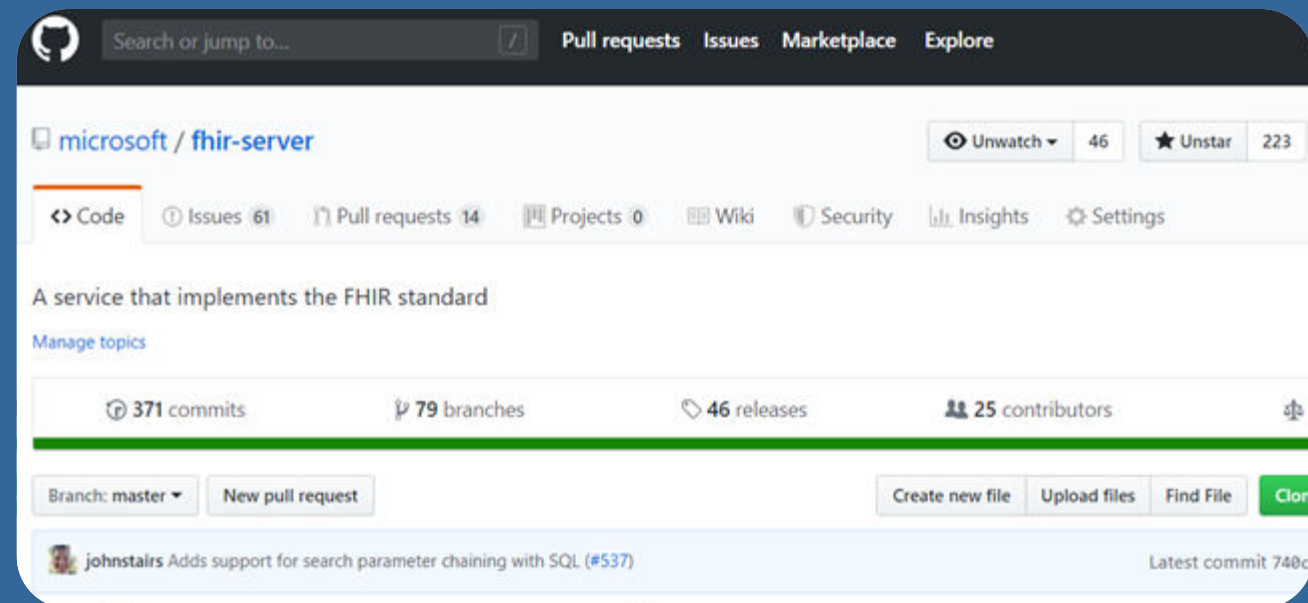
Table and Index Design

Queries

Implementation

Roadmap

FHIR Server for Azure



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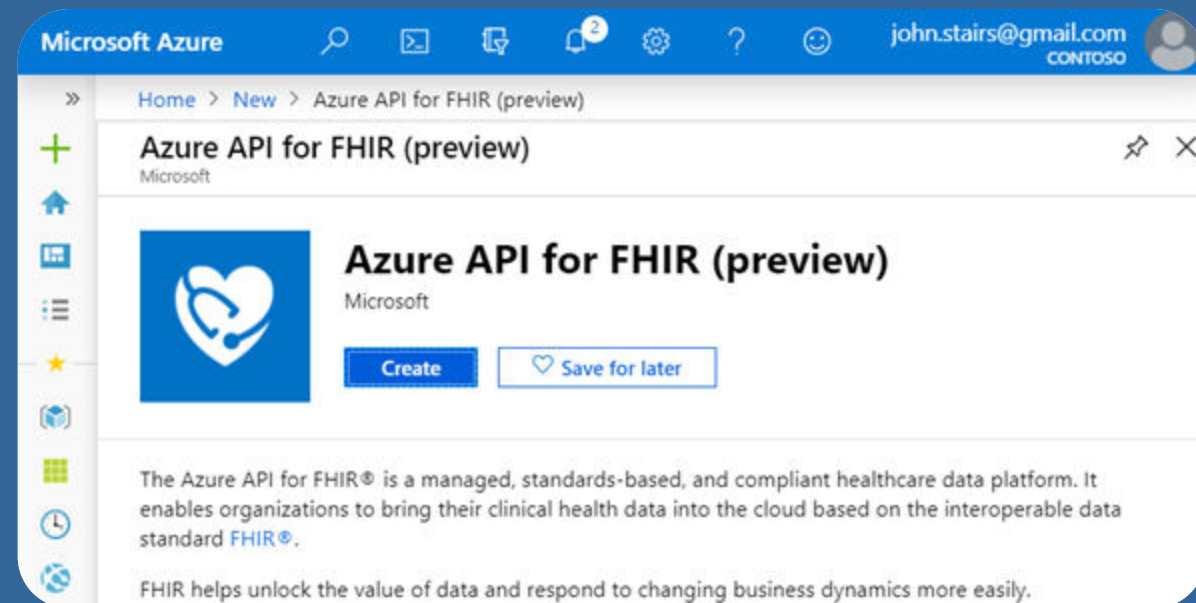
A service that implements the FHIR standard

Manage topics

371 commits 79 branches 46 releases 25 contributors

Branch: master New pull request Create new file Upload files Find File Clone


johnstairs Adds support for search parameter chaining with SQL (#537) Latest commit 740c



Microsoft Azure john.stairs@gmail.com CONTOSO

Home > New > Azure API for FHIR (preview)

Azure API for FHIR (preview) Microsoft

 **Azure API for FHIR (preview)** Microsoft

Create Save for later

The Azure API for FHIR® is a managed, standards-based, and compliant healthcare data platform. It enables organizations to bring their clinical health data into the cloud based on the interoperable data standard FHIR®.

FHIR helps unlock the value of data and respond to changing business dynamics more easily.

Why Another Provider?

GOALS

Enable FHIR transactions

Search parameter chaining

`/Encounter?participant:Practitioner.name=Jane`

`_include/_revinclude`

`/MedicationRequest?_include=MedicationRequest:patient`

GOALS

Transactional CRUD operations

Not SQL on FHIR

Good scalability

Efficient, predictable search performance

Minimal chattiness

Efficient bulk ingestion

It's All About Search

SAMPLE RESOURCE

```
{
  "resourceType": "Patient",
  "id": "2f56f39f-edcd-43a2-968d-b37b1c1e4673",
  "identifier": [
    {
      "system": "https://github.com/synthetichealth/synthea",
      "value": "ca68b514-fdb2-4118-a2de-e79fb02a2081"
    },
    {
      "system": "http://hl7.org/fhir/sid/us-ssn",
      "value": "999-86-4854"
    }
  ],
  "name": [
    {
      "use": "official",
      "family": "Jacobs",
      "given": [
        "Aaron"
      ]
    }
  ],
  "gender": "male",
  "birthDate": "1998-12-02"
}
```


EXAMPLE EXTRACTED PARAMETERS

| Dates | Search Parameter | Start | End |
|-------|------------------|-----------------------------------|-----------------------------------|
| | _lastUpdated | 2019-06-10T22:23:17.1590000+00:00 | 2019-06-10T22:23:17.1590000+00:00 |
| | birthdate | 1998-12-02T00:00:00.0000000+00:00 | 1998-12-02T23:59:59.9999999+00:00 |

| Tokens | Search Parameter | System | Code |
|------------|---|---|--------------------------------------|
| | deceased | http://hl7.org/fhir/special-values | false |
| | gender | http://hl7.org/fhir/administrative-gender | male |
| | identifier | https://github.com/synthetichealth/synthea | ca68b514-fdb2-4118-a2de-e79fb02a2081 |
| identifier | http://hl7.org/fhir/sid/us-ssn | 999-86-4854 | |

| Strings | Search Parameter | Value |
|---------|------------------|--------|
| | family | Jacobs |
| | given | Aaron |
| | name | Jacobs |
| name | Aaron | |

EXAMPLE SEARCHES

/Patient?birthdate=1998

/Patient?identifier=http://hl7.org/fhir/sid/us-ssn|999-86-4854

/Patient?family=Jacobs

/Patient?gender=male

Database Tables

RESOURCE + SEARCH PARAMETER TABLES

Resource

| Type | Id | Version | Deleted | Raw |
|---------|-------------|---------|---------|------------|
| Patient | 2f56f39f... | 1 | 0 | 0x95D8C... |
| Patient | 2f56f39f... | 2 | 0 | 0x95CFA... |

Token Search Param

| Type | Id | Version | Parameter | System | Code |
|---------|-------------|---------|------------|---|-------------|
| Patient | 2f56f39f... | 1 | identifier | http://hl7.org/fhir/sid/us-ssn | 999-86-4854 |
| Patient | 2f56f39f... | 1 | identifier | http://hl7.org/fhir/sid/us-ssn | 999-86-4854 |
| Patient | 2f56f39f... | 2 | identifier | https://github.com/synthetichealth/synthea | ca68b514... |
| Patient | 2f56f39f... | 2 | identifier | https://github.com/synthetichealth/synthea | ca68b514... |

...and similar tables for Date, Quantity, String, Number, Reference, Uri, etc.

SLIMMING THINGS DOWN

Resource

| ResourceTypeId | Id | Version | IsHistory | ResourceSurrogateId | Deleted | Raw |
|----------------|-------------|---------|-----------|---------------------|---------|------------|
| 82 | 2f56f39f... | 1 | 1 | 685567 | 0 | 0x95D8C... |
| 82 | 2f56f39f... | 2 | 0 | 685568 | 0 | 0x95D8C... |

Token Search Param

| ResourceSurrogateId | ParameterId | ResourceTypeId | IsHistory | SystemId | Code |
|---------------------|-------------|----------------|-----------|----------|-------------|
| 685567 | 325 | 82 | 1 | 6 | 999-86-4854 |
| 685567 | 325 | 82 | 1 | 12 | ca68b514... |
| 685568 | 325 | 82 | 0 | 6 | 999-86-4854 |
| 685568 | 325 | 82 | 0 | 12 | ca68b514... |

Indexes

CLUSTERED INDEXES

```
CREATE CLUSTERED INDEX IXC_TokenSearchParam
ON dbo.TokenSearchParam
(
    ResourceSurrogateId,
    SearchParamId
)
WITH (DATA_COMPRESSION = PAGE)
```

NONCLUSTERED INDEXES

```
CREATE NONCLUSTERED INDEX
IX_TokenSeachParam_SearchParamId_Code_SystemId
ON dbo.TokenSearchParam
(
    SearchParamId,
    Code,
    SystemId
)
INCLUDE
(
    ResourceType
)
WHERE IsHistory = 0
WITH (DATA_COMPRESSION = PAGE)
```


A Few Other Considerations

COMPOSITE SEARCH PARAMETERS

Observation?component-code-value-quantity=http://loinc.org|8480-6\$gt140

Join between entries in existing tables?

Create dedicated tables for each type?

We chose the second option

NUMERIC RANGES

Numbers and quantity values *can* be ranges

But they are usually a single value

Have SingleValue, LowValue, and HighValue columns

Use filtered indexes to partition

```
WHERE SingleValue IS NOT NULL
```

```
WHERE SingleValue IS NULL
```

RESOURCE SURROGATE ID

Monotonically increasing

Pros: pages fill up, "very close" to last modified ordering

Cons: page latch contention on insert

To get alignment between surrogate ID and last modified:

- Truncate actual time to millisecond precision
- Add cycling sequence value to make unique

Demo time!

Implementation

NO ORM

RESOURCE INGESTION USING TABLE- VALUED PARAMETERS

SQL STATEMENT GENERATION

TREE REWRITING (1)

`/Patient?identifier=http://hl7.org/fhir/sid/us-ssn|999-46-5185`

```
(And
  (Param _type (StringEquals TokenCode 'Patient'))
  (Param identifier
    (And
      (StringEquals TokenSystem 'http://hl7.org/fhir/sid/us-ssn')
      (StringEquals TokenCode '999-46-5185'))))
```

TREE REWRITING (2)

/Patient?identifier=http://hl7.org/fhir/sid/us-ssn|999-46-5185

```
(SqlRoot
  (TableExpressions
    (Table
      Normal
      dbo.TokenSearchParam
      (Normalized
        (Param identifier
          (And
            (StringEquals TokenSystem 'http://hl7.org/fhir/sid/us-ssn')
            (StringEquals TokenCode '999-46-5185')))))
      (Denormalized (Param _type (StringEquals TokenCode 'Patient'))))
```

TREE REWRITING (3)

`/Patient?identifier=http://hl7.org/fhir/sid/us-ssn|999-46-5185`

```
(SqlRoot
  (TableExpressions
    (Table
      Normal
      dbo.TokenSearchParam
      (Normalized
        (Param identifier
          (And
            (StringEquals TokenSystem 'http://hl7.org/fhir/sid/us-ssn')
            (StringEquals TokenCode '999-46-5185'))))
        (Denormalized (Param _type (StringEquals TokenCode 'Patient'))))))))
```

TREE REWRITING (4)

/Patient?identifier=http://hl7.org/fhir/sid/us-ssn|999-46-5185

```
(SqlRoot
  (TableExpressions
    (Table
      Normal
      dbo.TokenSearchParam
      (Normalized
        (Param identifier
          (And
            (StringEquals TokenSystem 'http://hl7.org/fhir/sid/us-ssn')
            (StringEquals TokenCode '999-46-5185'))))
        (Denormalized (Param _type (StringEquals TokenCode 'Patient'))))
      (Table Top)))
```

Roadmap

ROADMAP

Reverse chaining (ETA this week)

_include/_reinclude

Transactions

Sorting

Statement caching

More efficient paging

Bulk insertion

Memory-optimized landing pad

Performance, performance, performance...

TRY IT OUT

GIVE US FEEDBACK

CONTRIBUTE

JOIN US

<https://github.com/Microsoft/fhir-server>