

# Crucible: A FHIR Testing Tool

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4:30 – 5:00



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# MITRE Open Source Testing Tools

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- Analyzed EHR interoperability via the C32
- Data display and validation
- Provided an “Interoperability report card”
- Open Source



- **Certification tool for all EHR systems for Meaningful Use Stage 2**
- **CQM certification:**
  - **Capture and Export** - the capability of EHR technology to create a data file (QRDA) that can be incorporated by another EHR technology which could be used to calculate CQMs
  - **Import and Calculate** - the capability of EHR technology to incorporate data (from other EHR technology where necessary) and correctly calculate the result for CQMs
  - **Submission**- the capability of EHR technology to create a standard data file that can be electronically accepted by Centers for Medicaid & Medicare Services (CMS)

# BONNIE

- **Bonnie allows CQM developers to:**

- Independently load quality measure definitions from the Measure Authoring Tool (MAT)
- Convert measure definitions into a format allowing execution of the measure logic
- Rapidly craft synthetic test patients
- Provide expected results for the test patients and evaluate if the defined logic behaves as expected, or deviates from the intent of the measure



- **Provides a comprehensive testing framework for FHIR**
- **Establishes a Common FHIR Test Catalog**
- **Endeavors to make testing a core element of the FHIR specification**

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# Crucible FHIR Test Catalog

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# Why is testing important?

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- **A critical part of any software development activity**
- **Key to interoperable implementations**
  - Small inconsistencies lead to big problems
  - Fully implementing an API without tests is difficult
- **Provides executable documentation via test logic**
- **Establishes a common benchmark across implementations**



# Common Test Catalog

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- **FHIR test artifacts defined in XML (TestScript Resource)**
  - Still in the initial stages
  - 193 test suites with 3535 Tests
  - Encouraging community participation
  - <https://github.com/furore-fhir/Fhir.TestCatalog>

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# TestScript FHIR Resource

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# TestScript

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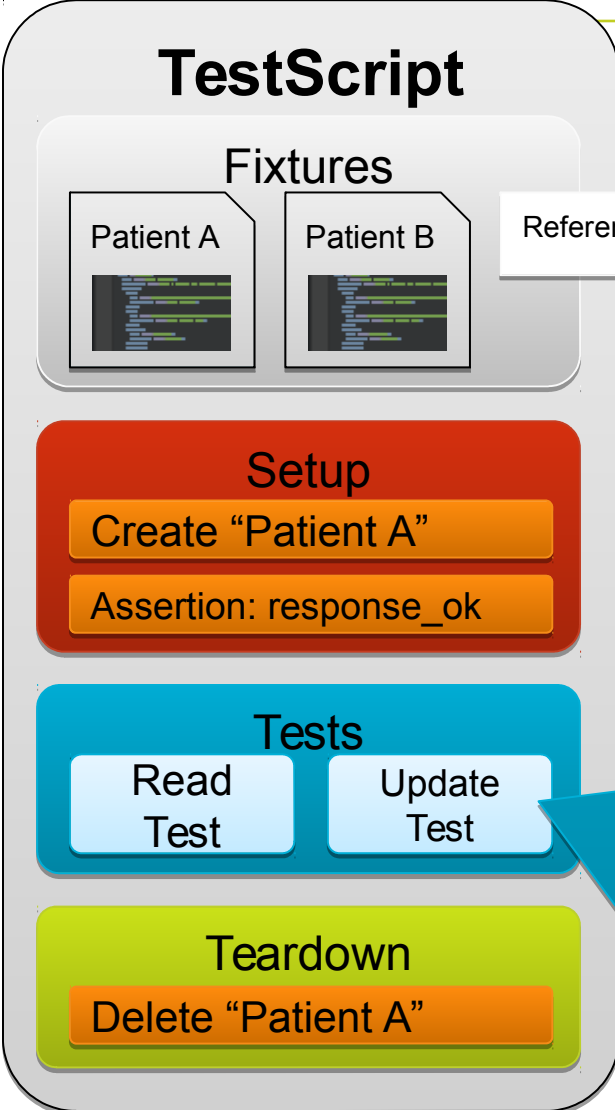
- **Standardized testing requires standard test scripts**
  
- **Core FHIR team expressed desire to make these standard test scripts first-class FHIR resources**
  - So they can be RESTfully exchanged and interpreted like all other FHIR resources
  - Testing adherence to the FHIR specification becomes part of the specification itself
  
- **MITRE TestScript proposal accepted by the FHIR core team**
  - Implementation agnostic testing for FHIR
  - Proposal accepted May 10, 2015
  - <http://hl7-fhir.github.io/testscript.html>

# TestScript Structure

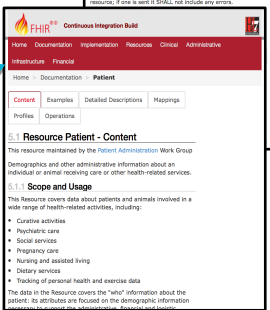
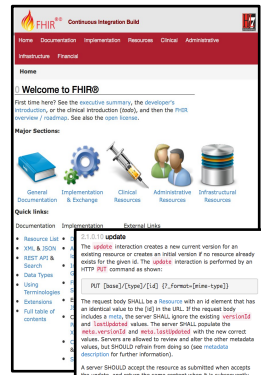
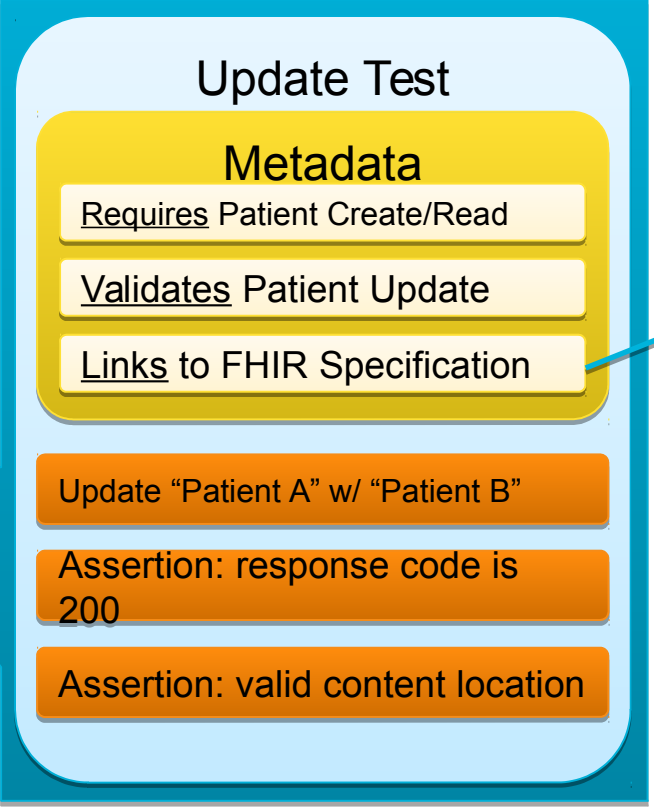
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- **TestScript**
  - **Fixtures:** The data for the test
  - **Setup:** establishes the test environment
  - **Tests:** The operations and assertions aligned with the specification
  - **Teardown:** Cleaning up anything created by the tests

# TestScript Structure



Reference



# TestScript

## Fixtures

Patient A

Patient B

Reference

Reference

## Setup

Create "Patient A"

Assertion: response\_ok

## Update Test

### Metadata

Requires Patient Create/Read

Validates Patient Update

Links to FHIR Specification

Update "Patient A" w/ "Patient B"

Assertion: response code is 201

Assertion: valid content location

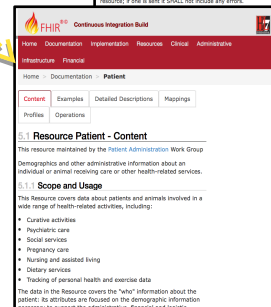
## Teardown

Delete "Patient A"

```

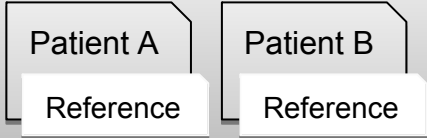
1 <?xml version="1.0" encoding="UTF-8"?>
2 <TestScript xmlns="http://hl7.org/fhir">
3   <id value="update"/>
4   <name value="Update Test Script"/>
5   <description value="Test Script for update of the pati
6   <fixture id="example-patient"><uri value="/patient/pat
7   <fixture id="example-patient-updated"><uri value="/pat
8   <setup>
9     <operation>
10    <type value="create"/>
11    <source value="example-patient"/>
12    </operation>
13  </setup>
14  <test id="UPDATE01">
15    <name value="Update Patient"/>
16    <description value="Update a patient and validate re
17    <metadata>
18      <link>
19        <url value="http://www.hl7.org/implement/standar
20        <description value="Update Operation"/>
21      </link>
22      <link>
23        <url value="http://www.hl7.org/implement/standar
24        <description value="Patient Resource"/>
25      </link>
26      <requires>
27        <type value="Patient"/>
28        <operations value="create, read"/>
29      </requires>
30      <validates>
31        <type value="Patient"/>
32        <operations value="update"/>
33      </validates>
34    </metadata>
35    <operation>
36      <type value="update"/>
37      <source value="example-patient-updated"/>
38      <target value="example-patient"/>
39    </operation>
40    <operation>
41      <type value="assertion"/>
42      <parameter value="response_code"/>
43      <parameter value="201"/>
44    </operation>
45    <operation>
46      <type value="assertion"/>
47      <parameter value="valid_content_location"/>
48    </operation>
49  </test>
50  <teardown>
51    <operation>
52      <type value="delete"/>
53      <target value="example-patient"/>
54    </operation>
55  </teardown>
56 </TestScript>

```



# TestScript

## Fixtures



## Setup

- Create "Patient A"
- Assertion: response\_ok

## Update Test

### Metadata

- Requires Patient Create/Read
- Validates Patient Update
- Links to FHIR Specification

- Update "Patient A" w/ "Patient B"
- Assertion: response code is 201
- Assertion: valid content location

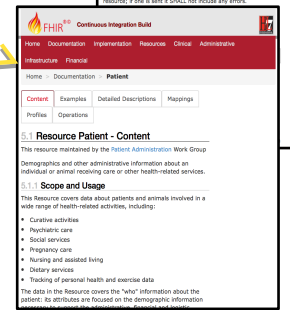
## Teardown

- Delete "Patient A"

```

1  {
2  "resourceType": "TestScript",
3  "id": "update",
4  "name": "Update Test Script",
5  "description": "Test Script for update of the patient"
6  "fixture": [{
7    "id": "example-patient",
8    "uri": "/patient/patient-example.xml"
9  }],
10 }
11 {"id": "example-patient-updated",
12 "uri": "/patient/patient-example-updated.xml"}
13 }
14 "setup": {
15 "operation": [{
16 "type": "create",
17 "source": "example-patient"
18 }]}
19 "test": [{
20 "id": ["UPDATE01",
21 "name": "Update Patient",
22 "description": "Update a patient and validate re
23 "metadata": {
24 "link": [{
25 "url": "http://www.hl7.org/implement/stand
26 "description": "Update Operation"
27 }],
28 "url": "http://www.hl7.org/implement/stand
29 "description": "Patient Resource"
30 }]}
31 "requires": [{
32 "type": "Patient",
33 "operations": "create, read"
34 }],
35 "validates": [{
36 "type": "Patient",
37 "operations": "update"
38 }]}
39 "operation": [{
40 "type": "update",
41 "source": "example-patient-updated",
42 "target": "example-patient"
43 }],
44 "type": "assertion",
45 "parameter": ["response_code", "201"]
46 }],
47 "type": "assertion",
48 "parameter": ["valid_content_location"]
49 }]}
50 "teardown": {
51 "operation": [{
52 "type": "delete",
53 "target": "example-patient"
54 }]}
55 }

```



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# Crucible FHIR Testing Tool

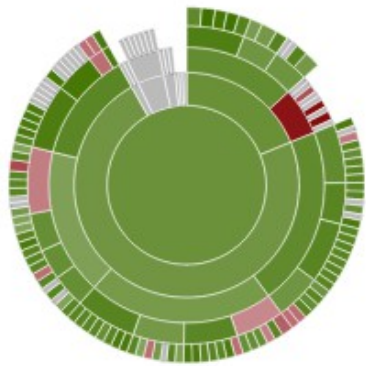
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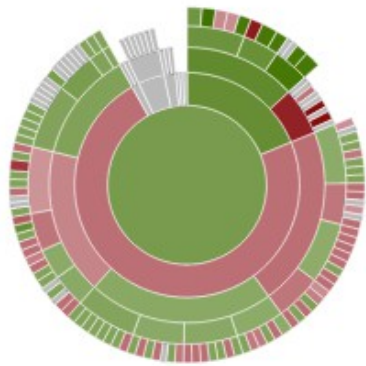


Begin

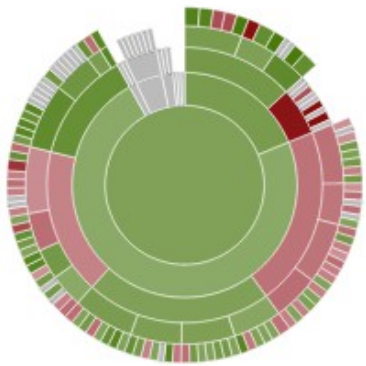
+ Add A Server



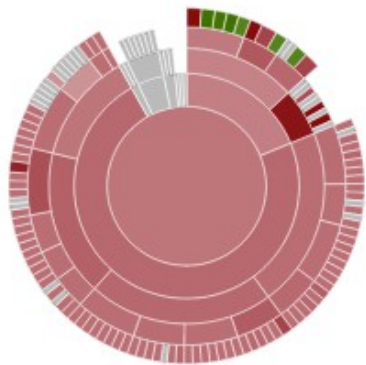
WildFHIR - 80%



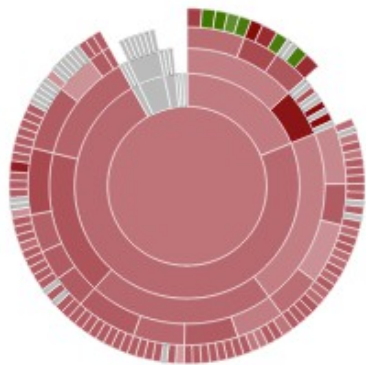
HAPI - 75%



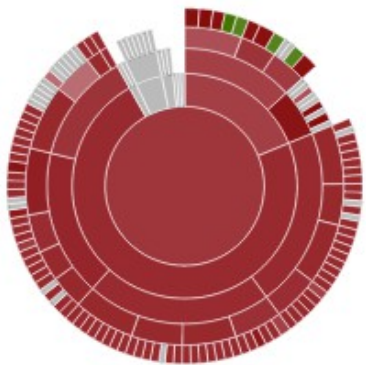
HealthIntersections - 71%



SMART on FHIR - 38%



Oridashi Best Practices - 37%



RelayHealth - 16%

# Review Conformance and Select Tests

**RUN**

Each FHIR Interface will first generate a conformance statement. Based on the conformance, a given set of recommended tests will be shown to the user.


**Test FHIR Server**   
[bonfire.mitre.org:8090/fhir-dstu2](http://bonfire.mitre.org:8090/fhir-dstu2)

Tests

Conformance

Resource Type	Read	VRead	Update	Delete	History	Validate	History Type	Create	Search Type
Alert	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Allergy Intolerance	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Appointment	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Appointment Response	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Basic	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Binary	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Bundle	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Care Plan	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Care Plan2	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Claim Response	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Clinical Assessment	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Communication	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Communication Request	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Composition	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Concept Map	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

## Review Conformance and Select Tests

RUN

Each FHIR Interface will first generate a conformance statement. Based on the conformance, a given set of recommended tests will be shown to the user.



Test FHIR Server

bonfire.mitre.org:8090/fhir-dstu2

Tests

Conformance

Select All

Expand All

- Track One Test (more)
- Track Two Test (more)
- Track Three Test (more)
- Format Test (more)
- History Test (more)
- Read Test (more)
- Resource Test Alert (more)
- Resource Test Allergy Intolerance (more)
- Search Test Allergy Intolerance (more)
- Resource Test Appointment (more)
- Resource Test Appointment Response (more)
- Resource Test Basic (more)



# Review Test Results


Executing...

Each of the run tests provide details on the results of the test along with information about how the test relates to the specification and the server's conformance document.

  [bonfire.mitre.org:8090/fhir-dstu2](http://bonfire.mitre.org:8090/fhir-dstu2)



Tests      Conformance

Format Test		
History Test		
Read Test		
Resource Test Alert		

Format Test ✔ ➤History Test ✘ ➤Read Test ✘ ➤Resource Test Alert ✘ ▼

Basic operations for FHIR Alert resource (CREATE, READ, VREAD, UPDATE, DELETE, HISTORY, SEARCH, VALIDATE)

X000_Alert	Alert: Read Type	PASS
X010_Alert	Alert: Create New	PASS
X020_Alert	Alert: Read Existing	PASS
X030_Alert	Alert: Update Existing	FAIL
X040_Alert	Alert: Read History of existing	PASS
X050_Alert	Alert: Version read existing	PASS
X055_Alert	Alert: Previous version read existing	PASS
X060_Alert	Alert: Validate	FAIL
X065_Alert	Alert: Validate Existing	FAIL
X067_Alert	Alert: Validate against a profile	FAIL
X070_Alert	Alert: Delete Existing	FAIL

### X030\_Alert

#### Message

The Alert was successfully updated, but the server responded with the wrong code (201, but should have been 200).

#### Links

[Related FHIR Spec Location](#)

[Related FHIR Spec Location](#)

#### Test Validates

Alert: update

#### Data

```
<?xml version="1.0" encoding="UTF-8"?> <Alert xmlns:
<id value="54ca83c4341123abf93ca7eb"/> <meta
id="5Ufeap9y2TYSFwK_JMIYZg"> <versionId value="1
value="2015-04-07T14:54:14"/> <security id="VHI3Y4-
<system value="iLZjG424B0Da06HAcV4KWw"/> <ver:
value="t1jVwyqyycKwD6HkXKI9oA"/> <code
value="pa5TVGep6i4KVOFKy3zzAQ"/> <display
value="CDXw5P7ylcpzAKeRMKQyRQ"/> <primary vc
```

## 2.1.8 update 🌐

The update interaction creates a new current version for an existing resource or creates a new resource if no resource already exists for the given id. The update interaction is performed by an HTTP PUT command as shown:

```
PUT [base]/[type]/[id] {?_format=[mime-type]}
```

If the interaction is successful, the server SHALL return either a 200 OK if the resource was updated, or a 201 Created if the resource was created, with a Last-Modified header, and a Location and Content-Location header that refers to the specific version created by the update interaction. The server MAY send an OperationOutcome resource with hints and warnings about the resource; if one is sent it SHALL not include any errors.

# Review Test Results

Rerun

Each of the run tests provide details on the results of the test along with information about how the test relates to the specification and the server's conformance document.

bonfire.mitre.org:8090/fhir-dstu2

Tests

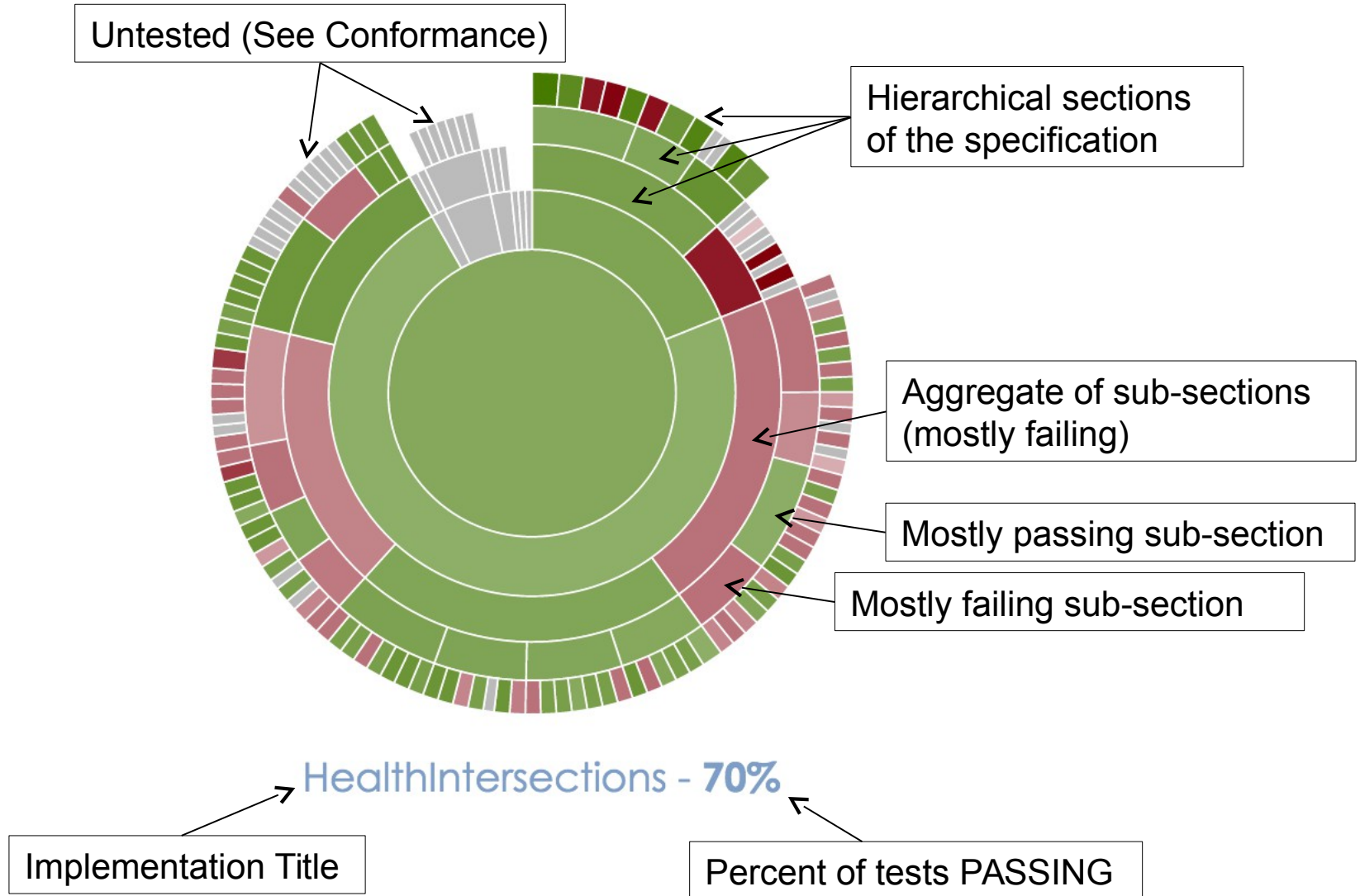
Conformance

X010: Alert: Create New

Resource Type	Read	VRead	Update	Delete	History	Validate	Alert	Other
Alert	●	●	●	●	●	●	●	●
Allergy Intolerance	●	●	●	○	●	○	●	●
Appointment	●	●	●	○	●	○	●	●
Appointment Response	●	●	●	○	●	○	●	●
Basic	●	●	●	○	●	○	●	●
Binary	●	●	●	○	●	○	●	●
Bundle	●	●	●	○	●	○	●	●
Care Plan	●	●	●	○	●	○	●	●
Care Plan2	●	●	●	○	●	○	●	●
Claim Response	●	●	●	○	●	○	●	●
Clinical Assessment	●	●	●	○	●	○	●	●
Communication	●	●	●	○	●	○	●	●
Communication Request	●	●	●	○	●	○	●	●
Composition	●	●	●	○	●	○	●	●
Concept Map	●	●	●	○	●	○	●	●

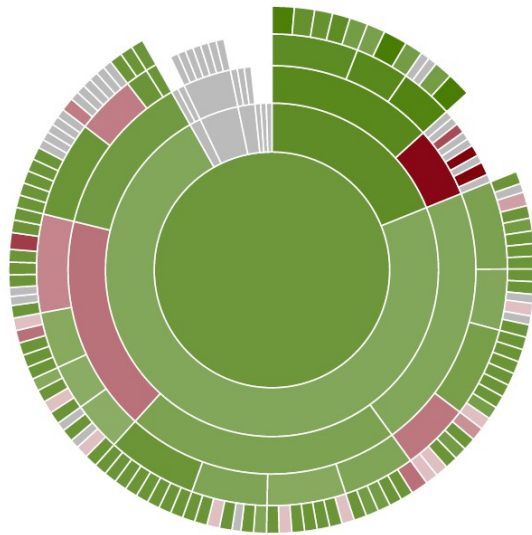


# Aggregate Results

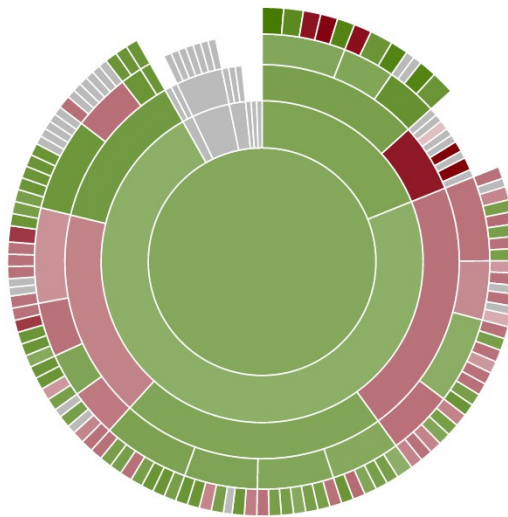




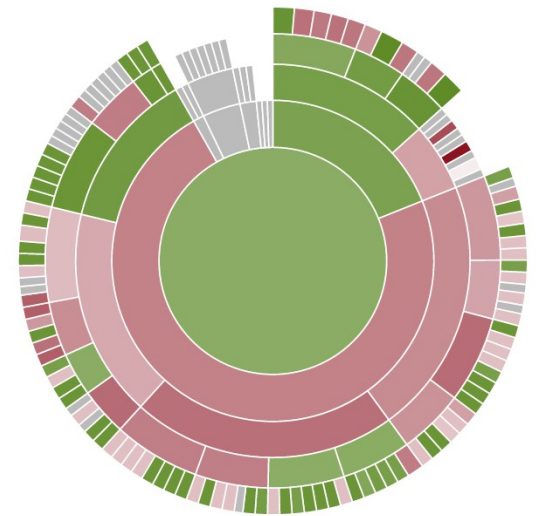
# Easily compare results



SMART on FHIR Open - **80%**



HealthIntersections - **70%**



HealthConnex sqlonfhir - **67%**

# Evaluate result details

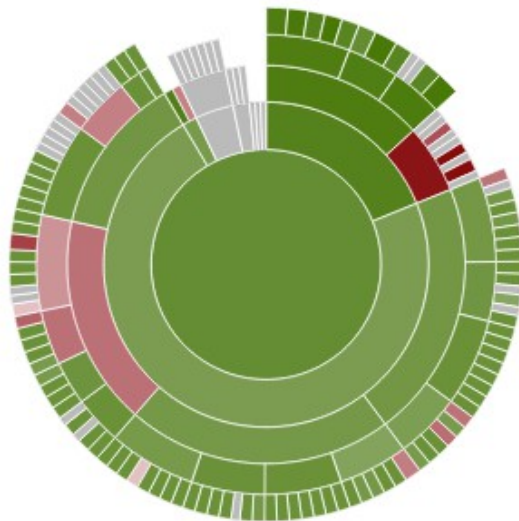
HAPI

<http://fhirtest.uhn.ca/baseDstu2>

Execute Tests

FHIR:  
2899 / 3473 passed (83%)

83% of the FHIR Specification is currently supported by this server



Specification	% Passing
<span style="color: red;">✖</span> Operations <div style="display: inline-block; width: 100px; height: 10px; background-color: green; margin-left: 10px;"></div>	90%
<span style="color: red;">✖</span> Resources <div style="display: inline-block; width: 100px; height: 10px; background-color: green; margin-left: 10px;"></div>	74%
<span style="color: red;">✖</span> Format <div style="display: inline-block; width: 100px; height: 10px; background-color: green; margin-left: 10px;"></div>	75%
<span style="color: gray;">✖</span> Security <div style="display: inline-block; width: 100px; height: 10px; background-color: gray; margin-left: 10px;"></div>	0%
<span style="color: gray;">✖</span> Messaging <div style="display: inline-block; width: 100px; height: 10px; background-color: gray; margin-left: 10px;"></div>	0%
<span style="color: gray;">✖</span> Documents <div style="display: inline-block; width: 100px; height: 10px; background-color: gray; margin-left: 10px;"></div>	0%
<span style="color: gray;">✖</span> Profiles <div style="display: inline-block; width: 100px; height: 10px; background-color: gray; margin-left: 10px;"></div>	0%
<span style="color: gray;">✖</span> Extensions <div style="display: inline-block; width: 100px; height: 10px; background-color: gray; margin-left: 10px;"></div>	0%

# Resources

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- **Website:** <http://projectcrucible.org>
- **Crucible Source Code:** <http://github.com/fhir-crucible>
- **Common Test Catalog:** <https://github.com/furore-fhir/Fhir.TestCatalog>
- **Questions?**