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Improvement Framework (Tacoma)

Bonnie Integration Application Programming Interface (API) Instructions

Draft

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Record of Changes

Version	Date	Author / Owner	Description of Change
1.0	August 7, 2018	Chris Hossenlopp, Jason Walonoski, Peter Krautscheid, Lizzie Charbonneau	Initial documentation for the Bonnie Integration API v1

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1. Background

The Centers for Medicare & Medicaid Services (CMS) and the Office of the National Coordinator for Health Information Technology (ONC) have collaborated to develop an alpha release of the Bonnie Integration Application Programming Interface (API). This API will enable applications to interact directly with Bonnie without using the user interface. The API is targeted for use by the Measure Authoring Tool (MAT), but could be used by any authorized application.

Currently, the Bonnie testing tool is only loosely integrated with the MAT through a manual export and import process. To test a measure in the MAT, the measure developer must first package and export the measure to their local file system via a measure bundle [in which the measure is expressed in a common digital format for encoding electronic clinical quality measures (eCQM)]. Once the file is exported, the developer then logs into the Bonnie application to load the bundle for testing. Figure 1 depicts the current integration process.

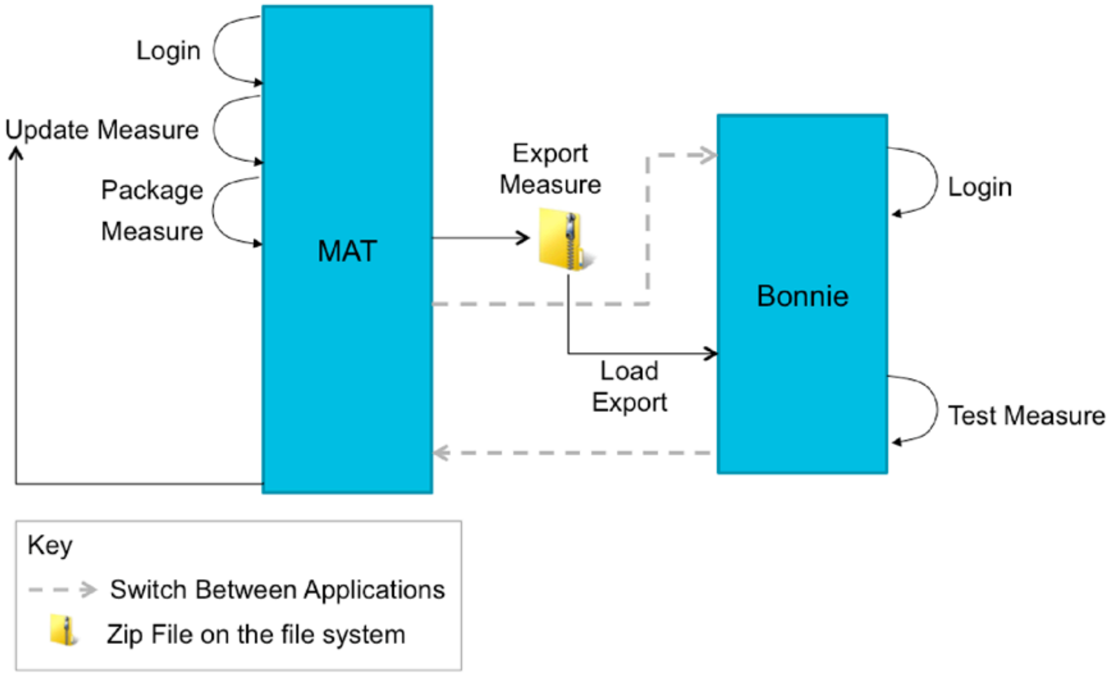


Figure 1. Manual Bonnie/MAT Integration

Manually exporting a measure from the MAT and importing it into Bonnie requires several steps, can be time consuming, and can fail because of user error. Given the need for iterative measure development, which can involve several cycles of updating a measure in the MAT and then testing the updated measure in Bonnie, the current process exponentially increases the time of measure development.

It is possible to simplify the iterative process of developing and then testing measures by improving the integration between the MAT and the Bonnie testing tool. By allowing the direct transmission of eCQMs between the tools, either by allowing Bonnie to pull eCQMs from the MAT ("pull integration") or by allowing the MAT to push eCQMs into Bonnie ("push integration"), an integrated measure development process saves time, consequently lowering costs and increasing efficiency. In addition to these high-level integration approaches, other more minor integration improvements will further simplify the measure development process.

2. Integration Application Programming Interface

The Bonnie team implemented an application programming interface (API) to enable push integration from the MAT (or other communicating system) to Bonnie. The Bonnie Integration API is a RESTful interface for authorized and authenticated clients to create, update, and read Measures, Patients, and calculated results. Once released, the primary documentation for the API will be available as an online reference: https://bonnie.healthit.gov/api.[1]

This section addresses the Bonnie Integration API and Security. The API subsection describes the RESTful service, operations, end-points, and formats. The Security subsection describes the use and configuration of OAuth2, an open standard for authentication, to secure and access the service.

Figure 2 depicts the high-level system architecture from the perspective of the Bonnie infrastructure. A measure author interacts with both the MAT to create new measures and Bonnie to test those measures. Figure 4 shows two pathways—the Bonnie web access pathway on the reader's left and the MAT pathway on the right. The MAT and other clients can access the same measures, patients, and calculated results available within Bonnie using OAuth2 security.

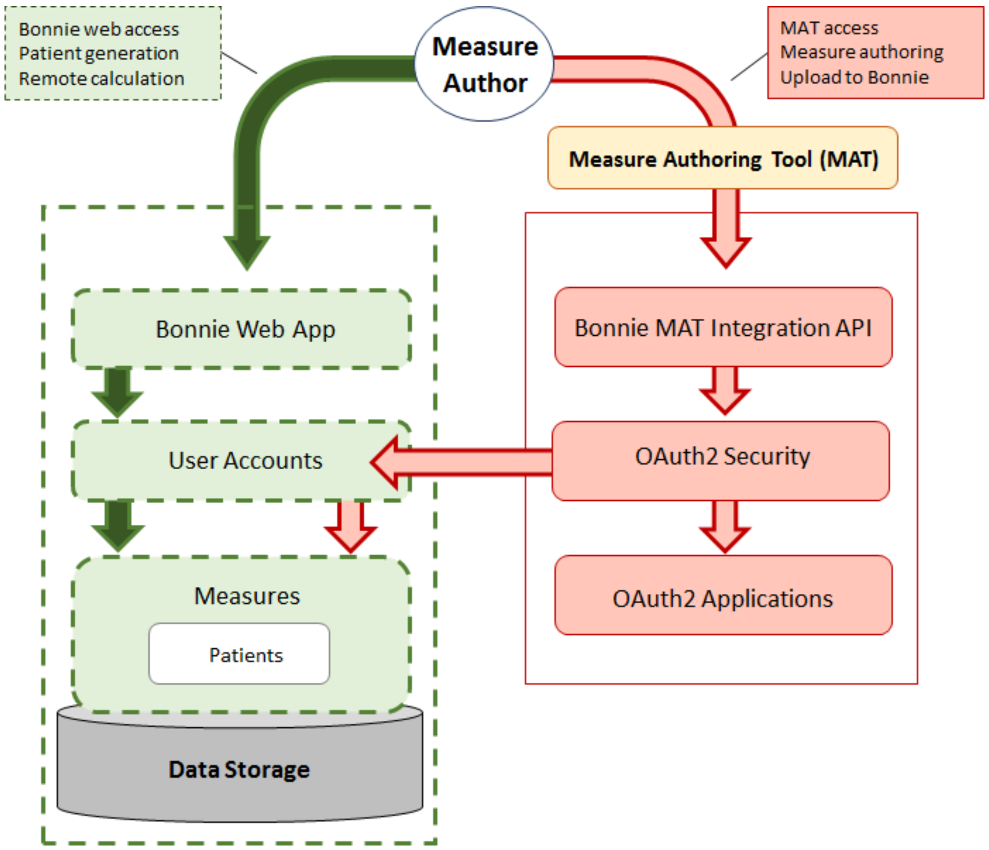


Figure 2. Bonnie Integration API

[1] This link will be active when the API is released to the Production server. A release date has not yet been scheduled as of the latest version of this document.

2.1 API

The Bonnie Integration API is RESTful: clients use HTTP verbs (e.g., GET, POST, PUT) on various endpoints (e.g., Measures) to create, update, and read resources. After a RESTful request is received, Bonnie will respond with the standard HTTP response status codes.[2] If the response includes an error code, Bonnie will include an error message in the body of the response.
Measures are the top-level resource in the Bonnie Integration API structure. Clients may access a list of measures (filtered by their user credentials, as described in subsection on Security); create a new measure; update an existing measure; or drill down into a specific measure. Given a measure, a client can access the patient records associated with the measure or view the associated calculated results for each patient record.
This structure results in the following RESTful endpoints:

- {base}/api_v1/measures
- {base}/api_v1/measures/{id}
- {base}/api_v1/measures/{id}/calculated_results

For this list of endpoints, {base} should be substituted with the base Uniform Resource Locator (URL) of Bonnie, normally "https://bonnie.healthit.gov" (unless the client is using a private instance) and {id} should be substituted with an actual Health Quality Measures Format (HQMF) Set ID (for example, "40280381-3D61-56A7-013E-5CC8AA6D6290").
The particular details associated with each endpoint follow in the Measures, Patient Records, and Calculated Results subsections, respectively.

2.1.1 Measures

The measures endpoint allows clients to create, update, and read measures. Currently, there is no capability to delete measures outside of Bonnie.
For a create or update, the client must supply the complete measure (no partial creates or updates are supported) as multipart/form-data in the POST or PUT request.[3] The multipart/form-data for the POST or PUT request should contain the MAT outputted measure package.
Table 1 lists the measure operations that are supported. Sample multipart/form-data examples are available on the official online reference documentation at: http://bonnie/healthit.gov/api.[4]

Table 1. Measure Operations

Operation	HTTP Verb	Endpoint	Request Body
Create	POST	{base}/api_v1/measures	multipart/form-data
Update	PUT	{base}/api_v1/measures/{id}	multipart/form-data
Read List	GET	{base}/api_v1/measures	
Read Details	GET	{base}/api_v1/measures/{id}	

[2] For more information on HTTP response codes, please see the Request for Comments (RFC) for HTTP, section 6: https://tools.ietf.org/html/rfc7231#section-6.

[3] For more information on multipart/form-data, please see the RFC for multipart/form-data located here: https://www.ietf.org/rfc/rfc2388.txt.

[4] This link will be active when the API is released to the Production server. A release date has not yet been scheduled as of the latest version of this document.

Table 6 presents an outline description of the JSON data fields for measures that are returned after a GET request.

Table 2. Measure Data Fields

Field	JSON Data Type	Format	Description
id	String	UUID	The RESTful id used to read the details of this measure, access the associated patients, or view the calculated results.
nqf_id	String		An id assigned to this measure by the National Quality Forum.
hqmf_id	String	UUID	The HQMF version id
hqmf_set_id	String	UUID	The HQMF id for this measure
hqmf_version_number	String		The HQMF version number
cms_id	String		The id assigned to this measure by the Centers for Medicaid & Medicare Services.
title	String		The human-readable name.
description	String		A short or long human-readable description of this measure and logic.
type	String	“eh” or “ep”	eh – eligible hospital ep – eligible provider
continuous_variable	Boolean		Whether or not this is a continuous variable measure.
episode_of_care	Boolean		Whether or not this is an episode of care measure.
updated_at	String	iso8601	Date/Time stamp when this measure was last updated.

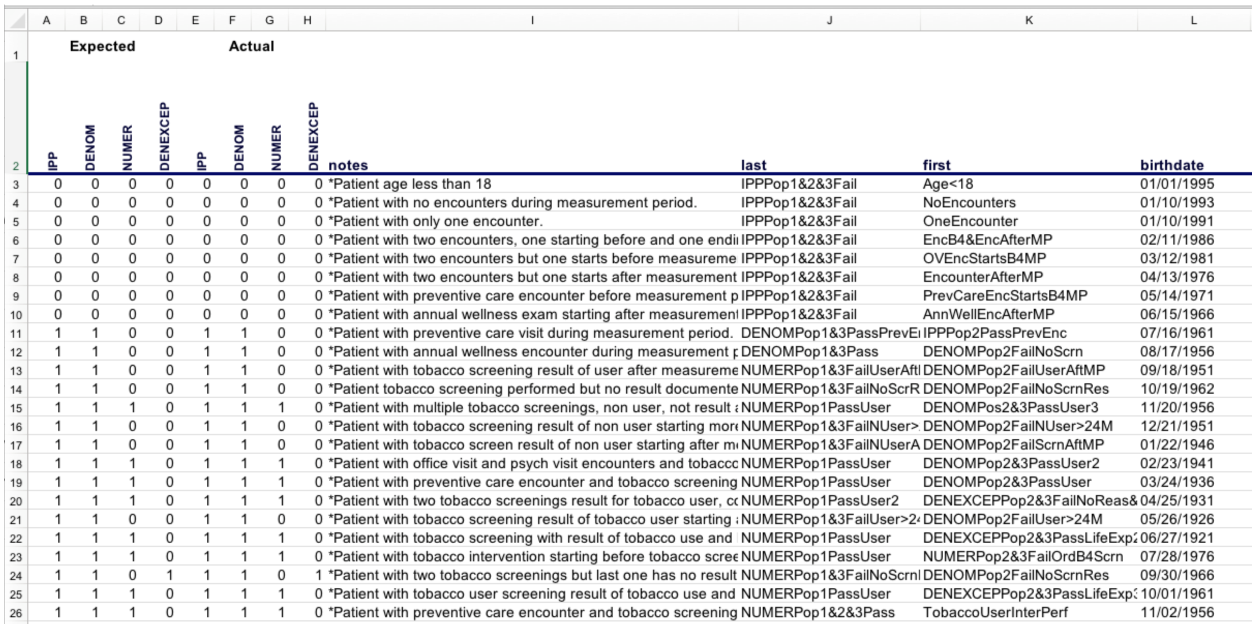
2.1.2 Calculated Results

The calculated results of a measure on the associated patient records are only accessible within the context of a measure. Calculated results are available as an Excel document, with each population or stratification corresponding to a sheet within the document. Table 3 depicts a sample calculated results operation.

Table 3. Calculated Results Operations

Operation	HTTP Verb	Endpoint	Request Body
Read	GET	{base}/api_v1/measures/{id}/calculated_results	

The request header should have an Accept parameter as follows: "Accept: application/vnd.openxmlformats-officedocument.spreadsheetml.sheet".
Figure 3 shows a portion of an example Excel document containing patient calculation results.



	A	B	C	D	E	F	G	H	I	J	K	L
1		Expected				Actual						
2	IPP	DENOM	NUMER	DENEXCEP	IPP	DENOM	NUMER	DENEXCEP	notes	last	first	birthdate
3	0	0	0	0	0	0	0	0	*Patient age less than 18	IPPPop1&2&3Fail	Age<18	01/01/1995
4	0	0	0	0	0	0	0	0	*Patient with no encounters during measurement period.	IPPPop1&2&3Fail	NoEncounters	01/10/1993
5	0	0	0	0	0	0	0	0	*Patient with only one encounter.	IPPPop1&2&3Fail	OneEncounter	01/10/1991
6	0	0	0	0	0	0	0	0	*Patient with two encounters, one starting before and one endi	IPPPop1&2&3Fail	EncB4&EncAfterMP	02/11/1986
7	0	0	0	0	0	0	0	0	*Patient with two encounters but one starts before measureme	IPPPop1&2&3Fail	OVEncStartsB4MP	03/12/1981
8	0	0	0	0	0	0	0	0	*Patient with two encounters but one starts after measurement	IPPPop1&2&3Fail	EncounterAfterMP	04/13/1976
9	0	0	0	0	0	0	0	0	*Patient with preventive care encounter before measurement p	IPPPop1&2&3Fail	PrevCareEncStartsB4MP	05/14/1971
10	0	0	0	0	0	0	0	0	*Patient with annual wellness exam starting after measurement	IPPPop1&2&3Fail	AnnWellEncAfterMP	06/15/1966
11	1	1	0	0	1	1	0	0	*Patient with preventive care visit during measurement period.	DENOMPop1&3PassPrevE	IPPPop2PassPrevEnc	07/16/1961
12	1	1	0	0	1	1	0	0	*Patient with annual wellness encounter during measurement p	DENOMPop1&3Pass	DENOMPop2FailNoScrn	08/17/1956
13	1	1	0	0	1	1	0	0	*Patient with tobacco screening result of user after measureme	NUMERPop1&3FailUserAft	DENOMPop2FailUserAftMP	09/18/1951
14	1	1	0	0	1	1	0	0	*Patient tobacco screening performed but no result documente	NUMERPop1&3FailNoScrR	DENOMPop2FailNoScrnRes	10/19/1962
15	1	1	1	0	1	1	1	0	*Patient with multiple tobacco screenings, non user, not result a	NUMERPop1PassUser	DENOMPos2&3PassUser3	11/20/1956
16	1	1	0	0	1	1	0	0	*Patient with tobacco screening result of non user starting more	NUMERPop1&3FailNUser>	DENOMPop2FailNUser>24M	12/21/1951
17	1	1	0	0	1	1	0	0	*Patient with tobacco screen result of non user starting after m	NUMERPop1&3FailNUserA	DENOMPop2FailScrnAftMP	01/22/1946
18	1	1	1	0	1	1	1	0	*Patient with office visit and psych visit encounters and tobacco	NUMERPop1PassUser	DENOMPop2&3PassUser2	02/23/1941
19	1	1	1	0	1	1	1	0	*Patient with preventive care encounter and tobacco screening	NUMERPop1PassUser	DENOMPop2&3PassUser	03/24/1936
20	1	1	1	0	1	1	1	0	*Patient with two tobacco screenings result for tobacco user, cc	NUMERPop1PassUser2	DENEXCEPPop2&3FailNoReas&	04/25/1931
21	1	1	0	0	1	1	0	0	*Patient with tobacco screening result of tobacco user starting a	NUMERPop1&3FailUser>2	DENOMPop2FailUser>24M	05/26/1926
22	1	1	1	0	1	1	1	0	*Patient with tobacco screening with result of tobacco use and	NUMERPop1PassUser	DENEXCEPPop2&3PassLifeExp	06/27/1921
23	1	1	1	0	1	1	1	0	*Patient with tobacco intervention starting before tobacco scree	NUMERPop1PassUser	NUMERPop2&3FailOrdB4Scrn	07/28/1976
24	1	1	0	1	1	1	0	1	*Patient with two tobacco screenings but last one has no result	NUMERPop1&3FailNoScrn	DENOMPop2FailNoScrnRes	09/30/1966
25	1	1	1	0	1	1	1	0	*Patient with tobacco user screening result of tobacco use and	NUMERPop1PassUser	DENEXCEPPop2&3PassLifeExp	10/01/1961
26	1	1	1	0	1	1	1	0	*Patient with preventive care encounter and tobacco screening	NUMERPop1&2&3Pass	TobaccoUserInterPerf	11/02/1956

Figure 3. Patient Results

The Excel document will contain:

- expected and actual results for each population or stratification within the measure
- notes
- first and last names
- birthdate
- deathdate if applicable
- ethnicity, race, and gender
- calculation results for each definition statement within the CQL for each population or stratification within the measure.

2.2 Security

The Bonnie Integration API is secured using OAuth2[5]. To assure client access to measure and patient data, the client application must be pre-configured on the Bonnie server. When the user uses the client application to access Bonnie, they must present valid Bonnie user credentials. The server-side and client-side configuration and workflows are explained separately.
For an application to gain access to Bonnie through the Bonnie Integration API, they should email the Bonnie development team at bonnie-feedback-list@mitre.org to start the process and receive the appropriate credentials.

5 RFC6749 provides the details of the OAuth2 specification

2.2.1 Server-side (Bonnie) Configuration

To authorize a client application to access the Bonnie Integration API, a Bonnie Administrator needs to create a record of the client application using the following steps:

1. Administrator logs into Bonnie.
2. Administrator navigates to https://bonnie.healthit.gov/oauth/applications[6].
3. Administrator clicks the "New Application" button.
4. Administrator fills out the new application form:
    - **Name:** enter the application name, e.g., "MAT"
    - **Redirect Uniform Resource Identifier (URI):** enter "https://bonnie.healthit.gov/api_v1/measures" if using Resource Owner Password Credentials flow. Otherwise, when using Authorization Code flow, enter the application URI where Bonnie will redirect the web browser to finish authorization.
    - **Confidential:** check the checkbox.
    - **Scopes:** leave blank for default scopes.
5. Administrator clicks the "Submit" button.
6. The Application is created, providing an "Application Id" and "Secret". These alphanumeric fields should be securely provided to the client application development team.

2.2.2 Client Integration

If a client application has been granted an Application ID and Secret, and valid Bonnie user credentials are available, a client can access data for that one user.
The OAuth2 specification defines four authorization grant types:

1. Authorization Code
2. Implicit
3. Resource Owner Password Credentials
4. Client Credentials

The Bonnie Integration API requires authorization grant type #1, Authorization Code, as measures and patients are scoped within a user account.

2.2.3 Authorization Code Grant Type

The authorization code grant type[7] allows for the client application of the Bonnie Integration API to avoid direct access to the user's Bonnie username and password. This grant type flow is what is commonly considered the OAuth flow. The following overview demonstrates how the flow works:

6 This link will be active when the API is released to the Production server. A release date has not yet been scheduled as of the latest version of this document.

7 RFC6749§4.1 provides details.

5. The client application begins by directing the user's browser to the Bonnie API OAuth authorization endpoint.
   - https://bonnie.healthit.gov/oauth/authorize?response_type=code&client_id=CLIENT_ID&redirect_uri=REDIRECT_URI[8]
   - The *CLIENT_ID* is the Application Id provided by the Bonnie OAuth admin (see Step 6 of the Server-side (Bonnie) Configuration subsection).
   - The *REDIRECT_URI* must match the redirect URI configured for the application (see Step 4 of the Server-side (Bonnie) Configuration subsection).
6. The user will authenticate with Bonnie if they are not already authenticated. The user will be asked to approve the application for access if this is their first time connecting the application to the Bonnie Integration API.
7. Bonnie will redirect the user's browser to the client application's authorization *REDIRECT_URI* with the authorization code provided in the URL parameters.
8. The client application will send a request to the Bonnie OAuth token endpoint (https://bonnie.healthit.gov/oauth/token) providing the authorization code received in the request URL parameters along with the *REDIRECT_URI* and *CLIENT_ID*. The token endpoint returns the OAuth Access Token and the OAuth Refresh Token. See section 2.2.4 for further explanation.

2.2.4 Security Tokens

There are two types of tokens that Bonnie provides to the client application: OAuth Access Tokens and OAuth Refresh Tokens. The OAuth Access Tokens are used for requests to the API. The OAuth Access Tokens will expire after some set amount of time, currently configured for 15 minutes. The OAuth Refresh Tokens are issued at the same time as the OAuth Access Tokens. The OAuth Refresh Tokens are used to retrieve a new OAuth Access Token. The OAuth Refresh Tokens are currently configured to last for five days, and are revoked after first use.
The Bonnie token revocation process follows the OAuth 2.0 revocation specification[9]. A user of a client application can also revoke access of the client application to their Bonnie account by navigating to https://bonnie.healthit.gov/oauth/authorized_applications.

2.2.5 Token Information Endpoint

Bonnie has implemented a Token Information Endpoint, accessible at https://bonnie.healthit.gov/oauth/token/info. This endpoint provides information about the resource owner (the user of the Bonnie account that the token is associated with) including the first name, last name, and email; when the token was created; the length of time in seconds until the OAuth Access Token expires; and the length of time in seconds until the OAuth Refresh Token expires.

[8] The base URL and path will be active when the API is released to the Production server. A release date has not yet been scheduled as of the latest version of this document.

[9] RFC7009 provides details.

3. Feedback and Support

An issue tracker and feedback email list are available to support the resolution of issues and to answer questions related to the Bonnie Integration API. The Bonnie issue tracker is available on the ONC Jira system at: https://oncprojecttracking.healthit.gov/support/projects/BONNIE. Users can also reach out to the Bonnie team through the Bonnie feedback list at bonnie-feedback-list@mitre.org. The Bonnie feedback list email can be accessed using the "Contact" link in the main Bonnie navigation menu at the top of every page.

Appendix A. Code Samples

A.1 Java Sample

The Java Sample uses the Apache Oltu library to execute the Resource Owner Password Credentials grant flow. For illustration purposes, in the following Listing 1 example of a Java client, the OAuthAccessTokenResponse class is extended to override the JSON response parsing:

```
package org.mitre.bonnie;

import org.apache.oltu.oauth2.client.OAuthClient;
import org.apache.oltu.oauth2.client.URLConnectionClient;
import org.apache.oltu.oauth2.client.request.OAuthBearerClientRequest;
import org.apache.oltu.oauth2.client.request.OAuthClientRequest;
import org.apache.oltu.oauth2.client.response.OAuthResourceResponse;
import org.apache.oltu.oauth2.common.OAuth;
import org.apache.oltu.oauth2.common.exception.OAuthProblemException;
import org.apache.oltu.oauth2.common.exception.OAuthSystemException;
import org.apache.oltu.oauth2.common.message.types.GrantType;

public class Client {

  private static final String client_id = "******";
  private static final String secret = "******
  private static final String email = "bonnie@example.com";
  private static final String password = "*****";
  private static final String server_base = "https://bonnie.healthit.gov";
  private static final String api_url = "/api_v1/measures";
  private static final String token_url = "/oauth/token";

  public static void main(String[] args)
  {
    try {
      // Create an OAuth2 request for a token
      OAuthClientRequest request = OAuthClientRequest
        .tokenLocation(Client.server_base + Client.token_url)
        .setGrantType(GrantType.PASSWORD)
        .setClientId(Client.client_id)
        .setClientSecret(Client.secret)
        .setUsername(Client.email)
        .setPassword(Client.password)
        .setRedirectURI(Client.server_base + Client.api_url)
        .buildBodyMessage();

      // Create an OAuth2 client
      OAuthClient client = new OAuthClient(new URLConnectionClient());
      // And send the token request...
      BonnieAccessTokenResponse tokenResponse = client.accessToken(request, BonnieAccessTokenResponse.class);
      // With the token response, we can now make requests against the MAT API...
      OAuthClientRequest measuresRequest = new OAuthBearerClientRequest(Client.server_base + Client.api_url)
        .setAccessToken(tokenResponse.getAccessToken()).buildQueryMessage();
      // Use the client to send the MAT API request...
      OAuthResourceResponse resourceResponse = client.resource(measuresRequest, OAuth.HttpMethod.GET,
OAuthResourceResponse.class);
      // Dump the response to the console...
      System.out.println(resourceResponse.getBody());
    } catch (OAuthSystemException e) {
      e.printStackTrace();
    } catch (OAuthProblemException e) {
      e.printStackTrace();
    }
  }
}
```

The following Listing 2 example demonstrates the Java Access Token Parser:

```
package org.mitre.bonnie;

import java.io.StringReader;

import javax.json.Json;
import javax.json.JsonObject;
import javax.json.JsonReader;

import org.apache.oltu.oauth2.client.response.OAuthAccessTokenResponse;
import org.apache.oltu.oauth2.common.exception.OAuthProblemException;
import org.apache.oltu.oauth2.common.token.BasicOAuthToken;
import org.apache.oltu.oauth2.common.token.OAuthToken;

public class BonnieAccessTokenResponse extends OAuthAccessTokenResponse {

		public String body = null;
		public String contentType = null;
		public int responseCode = 0;
		private String accessToken = null;
		private long expires_in = 0;
		private OAuthToken token = null;
		private String refreshToken = null;
		private String scope = null;

		@Override
		public String getAccessToken() { return this.accessToken; }
		@Override
		public Long getExpiresIn() { return this.expires_in; }
		@Override
		public OAuthToken getOAuthToken() { return this.token; }
		@Override
		public String getRefreshToken() { return this.refreshToken; }
		@Override
		public String getScope() { return this.scope; }
		@Override
		protected void setBody(String arg0) throws OAuthProblemException { this.body = arg0; }
		@Override
		protected void setContentType(String arg0) { this.contentType = arg0; }
		@Override
		protected void setResponseCode(int arg0) { this.responseCode = arg0; }

		protected void validate(){
				if(body!=null) {
						JsonReader reader = Json.createReader(new StringReader(this.body));
						JsonObject object = (JsonObject) reader.read();
						this.accessToken = object.getString("access_token");
						this.expires_in = object.getJsonNumber("expires_in").longValue();
						this.token = new BasicOAuthToken(this.accessToken,this.expires_in);
				}
```

```
        }
}
```

A.2 Ruby Sample

The following Ruby sample demonstrates the Resource Owner Password Credentials grant flow and requires the “oauth2” gem:

```
require 'oauth2'

client_id = "CLIENT_ID_GOES_HERE"
secret = "CLIENT_SECRET_GOES_HERE"
username = "bonnie@example.com"
password = "USER_PASSWORD_GOES_HERE"

options = {
  :site => "https://bonnie.healthit.gov",
  :authorize_url => "https://bonnie.healthit.gov/oauth/authorize",
  :token_url => "https://bonnie.healthit.gov/oauth/token",
  :raise_errors => true
}

client = OAuth2::Client.new(client_id,secret,options)
token = client.password.get_token(username,password)

response = token.get("https://bonnie.healthit.gov/api_v1/measures")
puts response.status
puts response.body
```

Acronyms

Acronym	Definition
API	Application Programming Interface
eCQM	Electronic Clinical Quality Measure
CMS	Centers for Medicare & Medicaid Services
FISMA	Federal Information Security Management Act
HCIS	Health Care Innovation Services
HQMF	Health Quality Measures Format
MAT	Measure Authoring Tool
OAuth	Open standard to authorization
ONC	Office of the National Coordinator for Health Information Technology
QDM	Quality Data Model
REST	Representational State Transfer
URI	Uniform Resource Identifier
URL	Uniform Resource Locator
XML	Extensible Markup Language