S02: Presentations - Population Health

Querying Electronic Health Data for Population Health Activities using PopMedNet™

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PopMedNet™

DEPARTMENT OF POPULATION MEDICINE

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Disclosure

I and my partner have no relevant relationships with commercial interests to disclose.

Learning Objective

After the presentation, the participant should be better able to describe key challenges and features of implementing a query tool for distributed health data that is scalable for implementation in various settings.

Agenda

- Describe how PopMedNet (PMN) powers distributed research networks (DRN)
- Describe PMN software design & features
- Review Menu-Driven Query (MDQ) tool
  - Problem & use cases
  - Solution & Challenges
- Current status, opportunities & next steps

PopMedNet (PMN) Platform: Powering Distributed Data & Distributed Analysis

- Mature architecture using an approach shown to be **accepted by health plans, clinical sites and other data holders**
- Data partners **maintain control** over their own data
- **Distribute code** to partners for local execution
- **Sites Provide results**, not data, to the requestor
- Standardize the data using a **common data model**
- All activities **audited** and **secure**
  - Meets the **privacy, proprietary, security, and research integrity** demands of health plans and other data holders institutions' IT departments
- Especially well suited for **multi-site, multi-use networks**
- **Contribute to the Learning Health System** by providing a socio-technical platform to support the people, process, technology contributing to knowledge generation

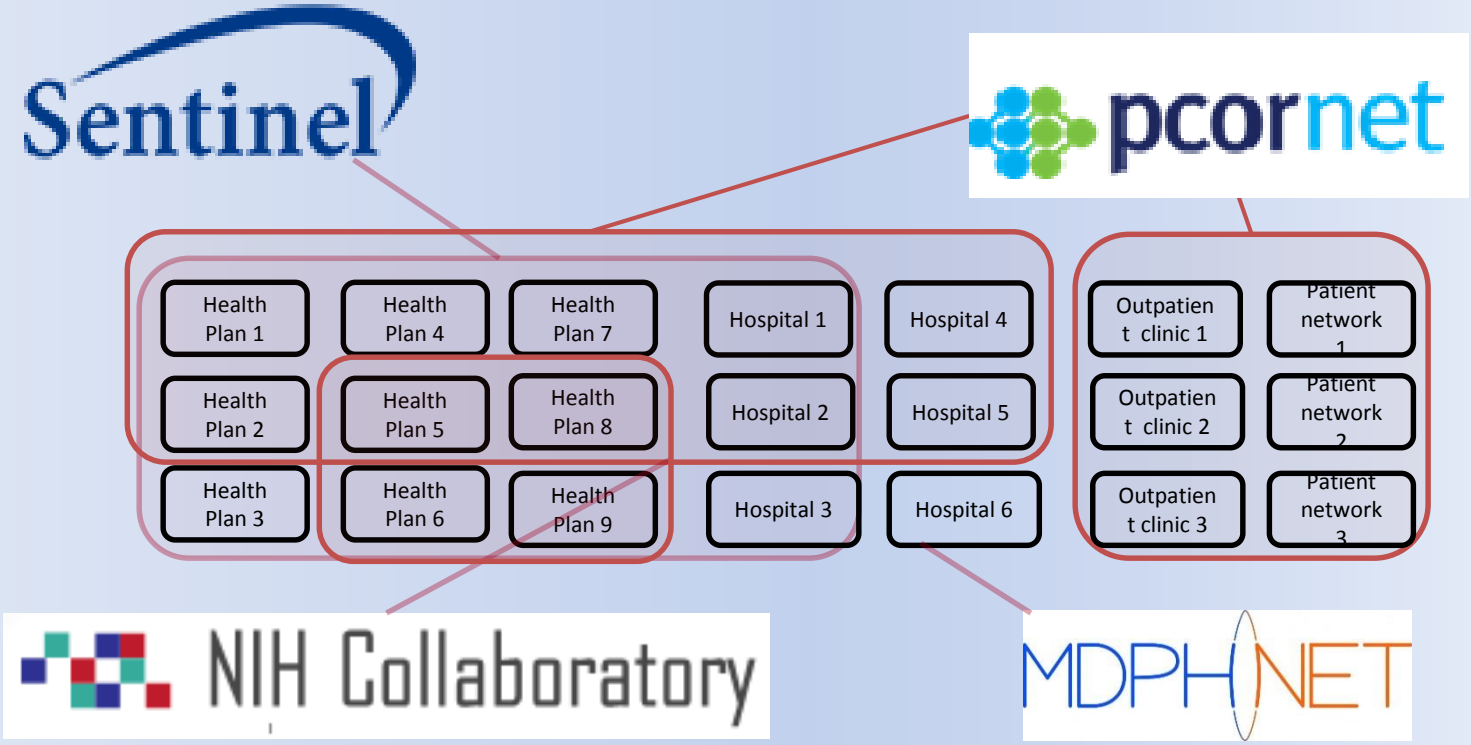
How it works: A Common Data Model

- Common Data Models (CDM) provide a **mechanism for efficient sharing of health data for secondary uses** – research and public health surveillance
- Agreed upon **structure for capturing data**
- Data owners **map their source data** (e.g. EHR, registry data, administrative claims data) into the CDM format including
  - Table names
  - Variable names
  - Value sets
  - Data formatting specifications
  - Database or data repository implementations
- Typically leverage **health IT standard coding systems and vocabularies**

Multiple Networks Sharing PMN Infrastructure

- Each organization can **participate in multiple networks**
- Each network **benefits from architecture and security improvements** while **maintaining their unique governance and policies**
- Networks **share** analytic tools, lessons learned, and system improvements
- Each network **controls its governance** and coordination
- **Funding from each network is leveraged** across initiatives to contribute to the core PMN platform

Multiple Networks Sharing PMN Infrastructure



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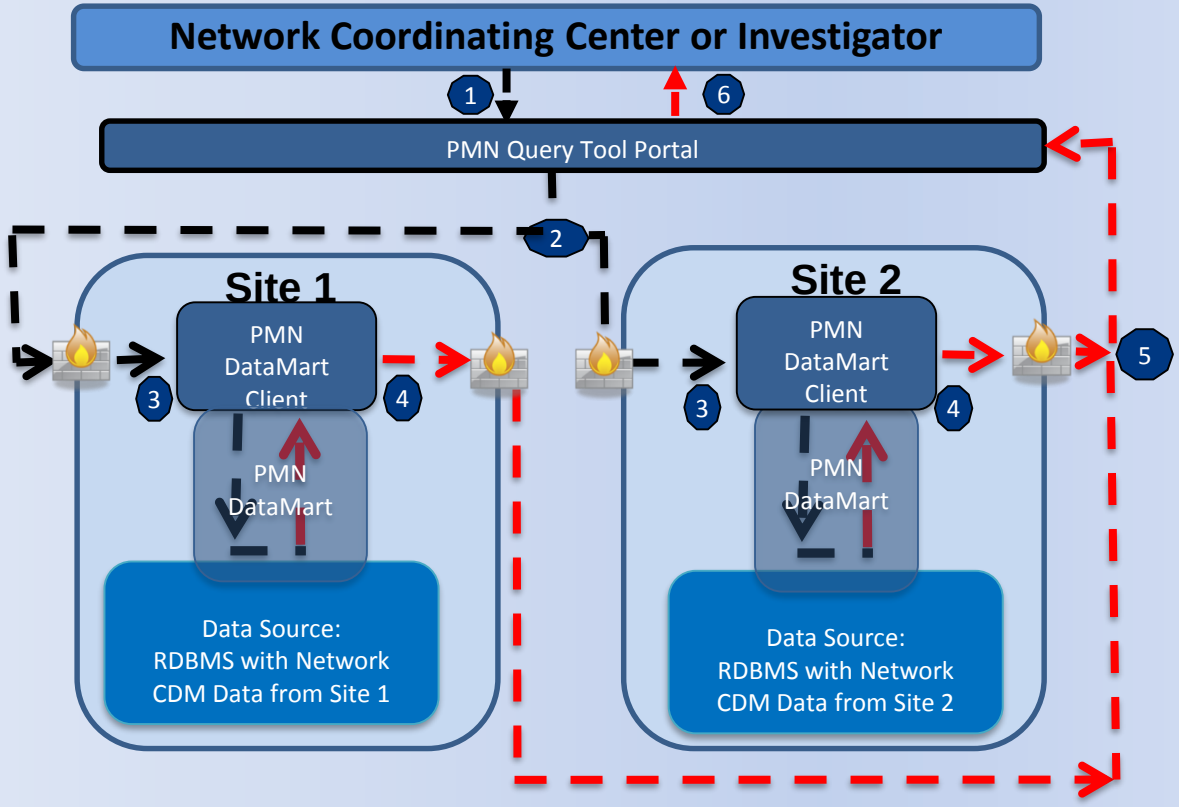
PMN Request Cycle: Menu Driven Query



1. Investigator creates and submits query to selected sites

2. Individual sites retrieve query

3. Sites review and run query directly against the CDM via the PMN DataMart Client

4. Sites review results

5. Individual site returns results via secure network

6. Requestor views results in PMN Portal

--Users have options to receive notifications throughout request cycle; various automation and approval workflows available

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Problems Identified with the Initial MDQ Tool

- Legacy Query Composer: Developed for limited use resulting in scalability issues
  - Each query tool was hardcoded for use against a single CDM and RDBMS
    - The MDPHnet network's data model and PostgreSQL
    - FDA's Sentinel System Summary Table data model and MS Access database
  - All changes required manual and redundant hard-coding
  - Queryable terms could not be shared across networks (e.g. if 2 networks wanted to query race data, each query tool needed to be developed separately, even if the field names and value sets were the same)
  - Changes required the sites to download a new version of the PMN DataMart Client software in order to respond to a query

Challenges to Distributed Querying

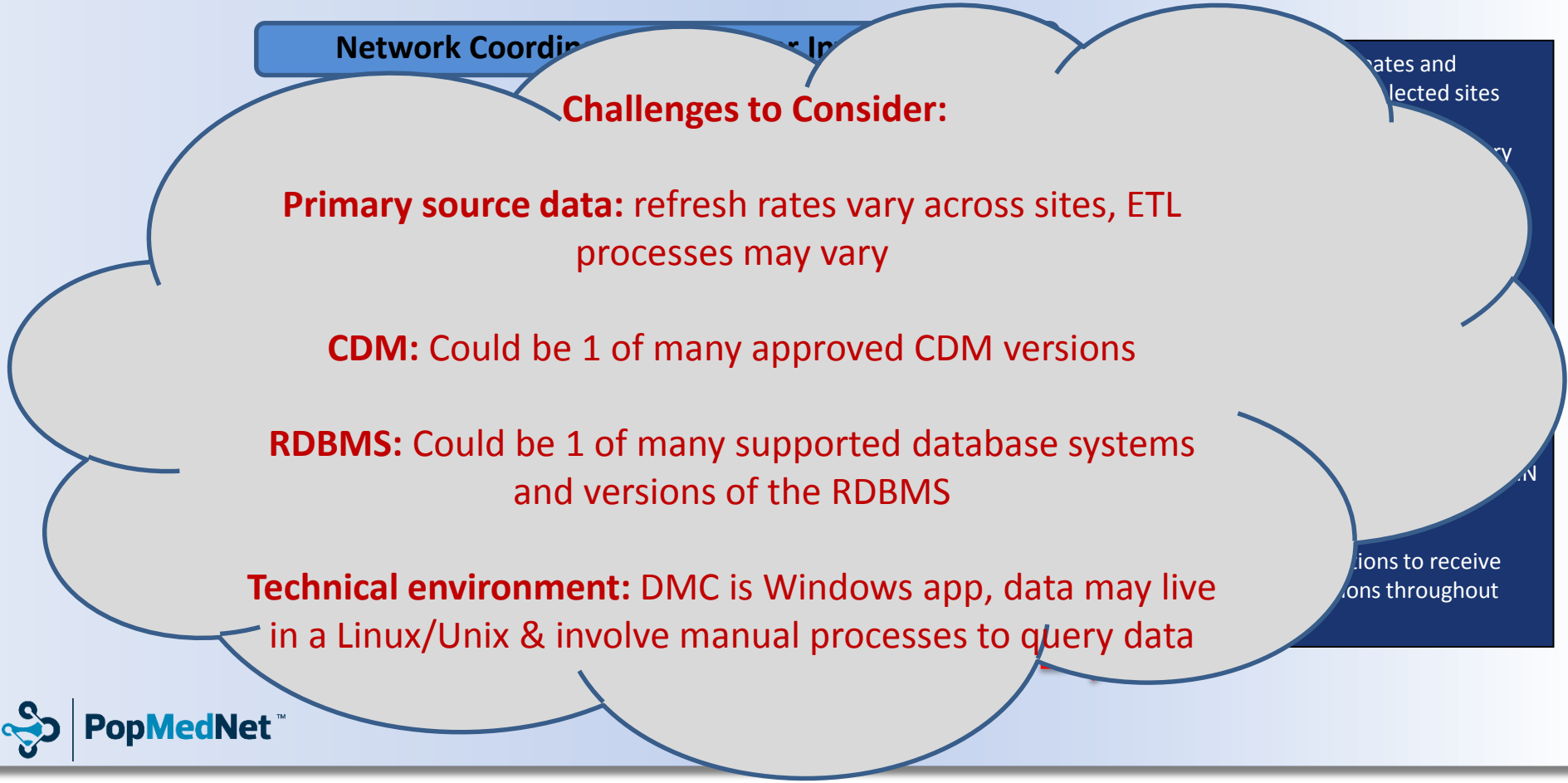
- Heterogeneity of technical environments (e.g. Windows, Linux/Unix)
- Source data systems and refresh cycles populating the CDMs vary
- Database management system (i.e. RDBMS) flavors and versions that store the CDM data vary across sites
- Data holders have local IT policies and procedures for how and where data are stored and accessed

(of course these are just a select list of challenges that need to be considered)

Challenge: Develop a One Size Fits All MDQ Tool

- End users want a simple query tool interface and workflow
- Infrastructure should be re-usable and easily extensible and scalable, limiting CDM-specific coding
- Address the heterogeneity of technical environments across the large-scale distributed networks PMN supports
- Consider workflows for full request lifecycle including integration points with external systems

PMN Request Cycle: Menu Driven Query



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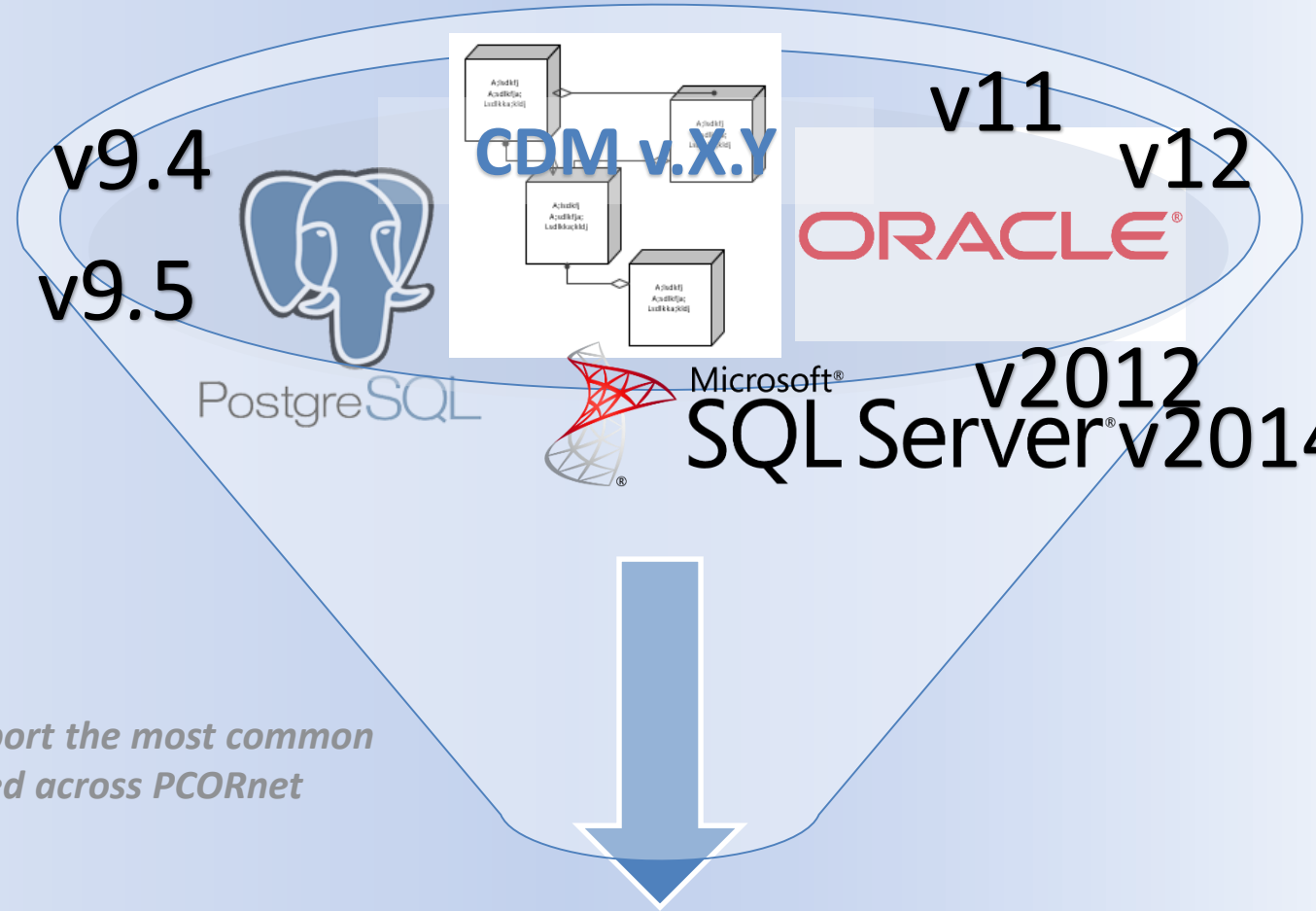
One Size fits Most* MDQ Tool



**Committed to support the most common RDMBS versions used across PCORnet*

Single MDQ Tool

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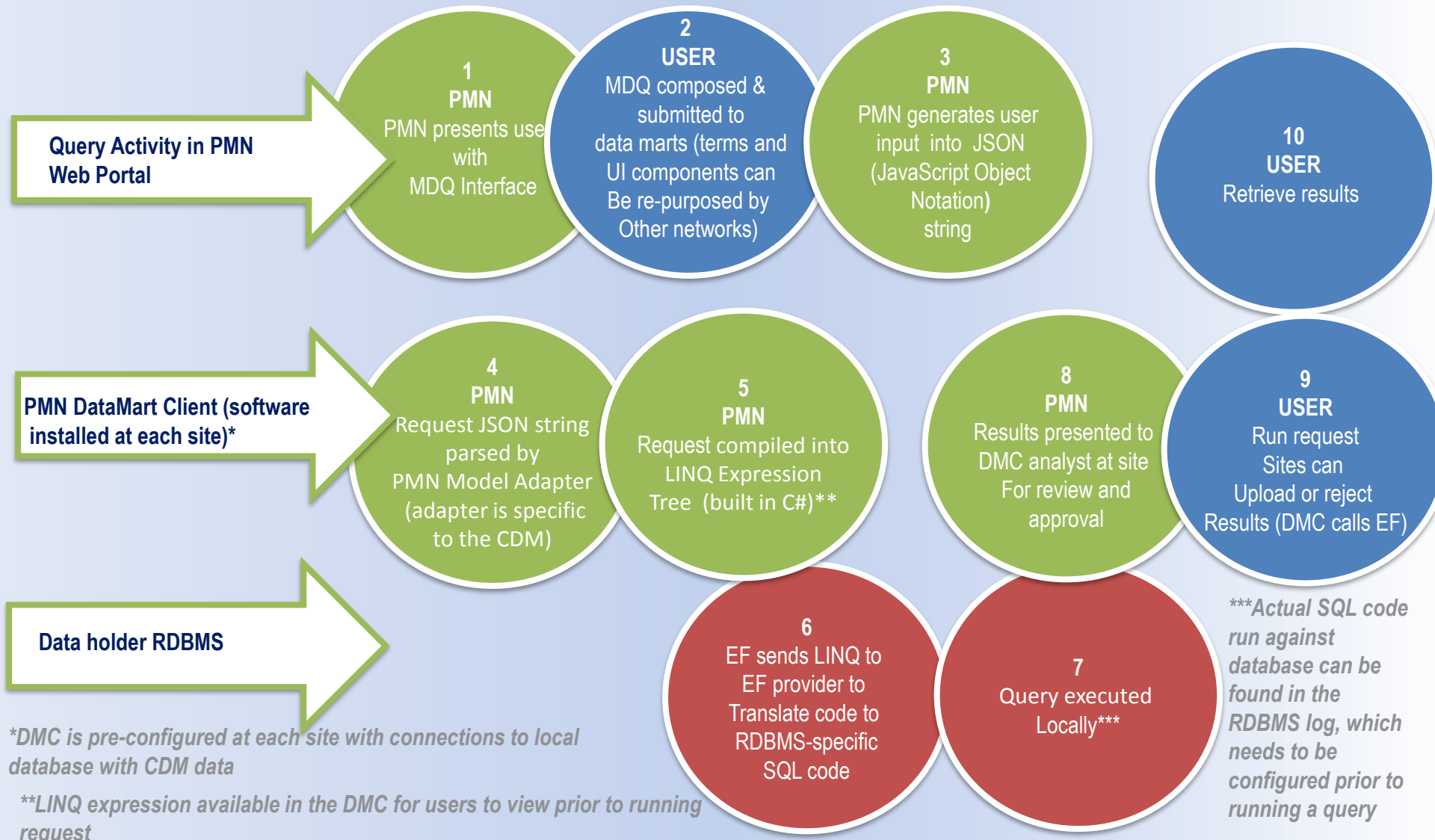
MDQ Approach

- Leverage new, established technologies for query processing
  - .NET LINQ to Entities query
  - Microsoft Entity Framework
  - Most major database managers have providers for Entity Framework
- Develop mechanisms for queryable Terms (e.g. Race field) to be easily re-purposed for use against multiple data models and in multiple networks
- Re-design the query architecture to limit the requirements for sites to download new DataMart Client software for routine upgrades

MDQ Cycle



*DMC is pre-configured at each site with connections to local database with CDM data

**LINQ expression available in the DMC for users to view prior to running request

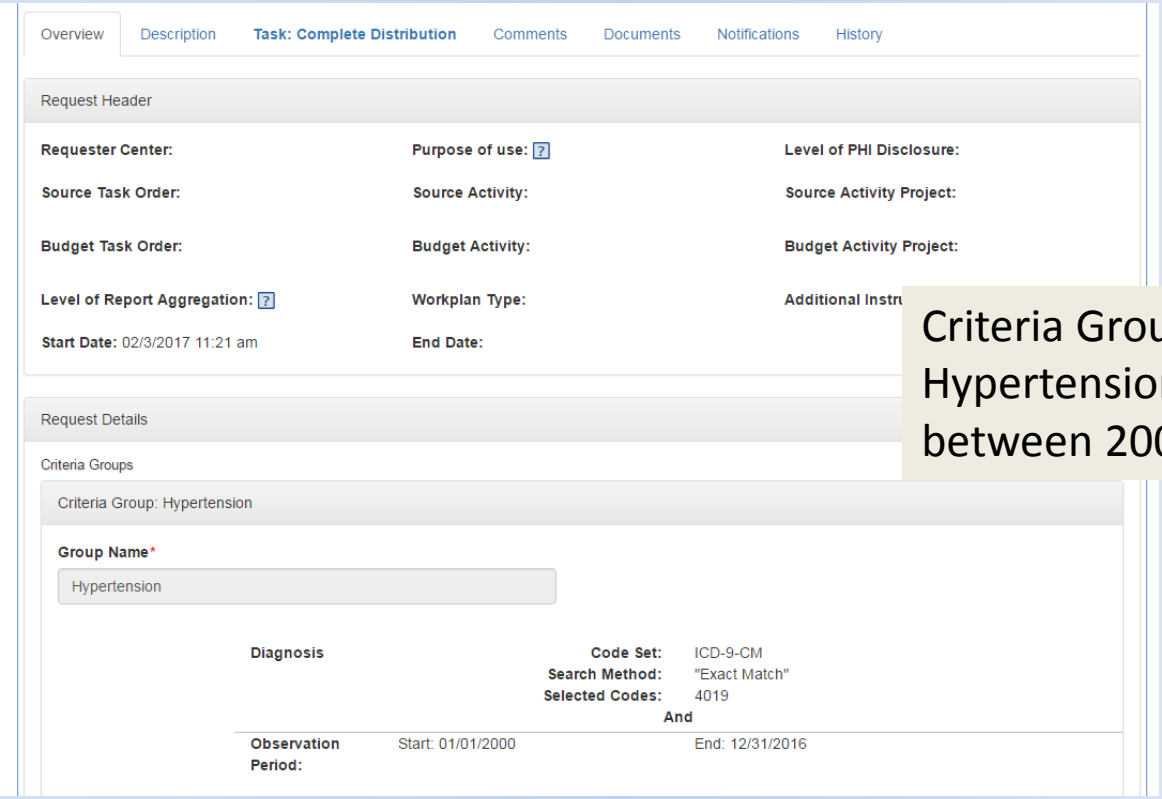
***Actual SQL code run against database can be found in the RDBMS log, which needs to be configured prior to running a query

Use Case 1: Investigator Composes the MDQ Query: Why don't all people with high blood cholesterol and blood pressure get heart disease?

Use MDQ to find patients of interest

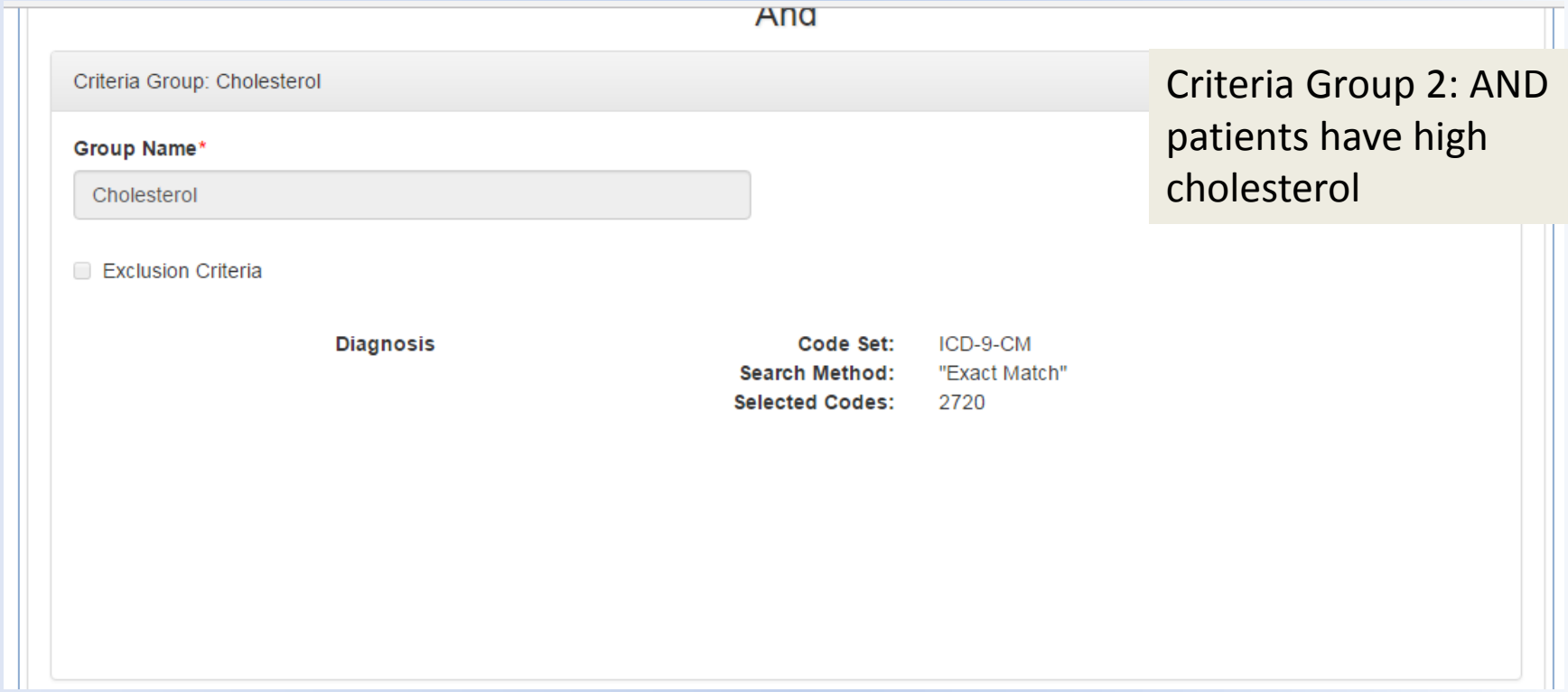
Terms are added to the PMN MDQ interface according to the data model. Terms can be re-purposed for other data models.

Note that these example queries are based on the PCORnet Common Data Model



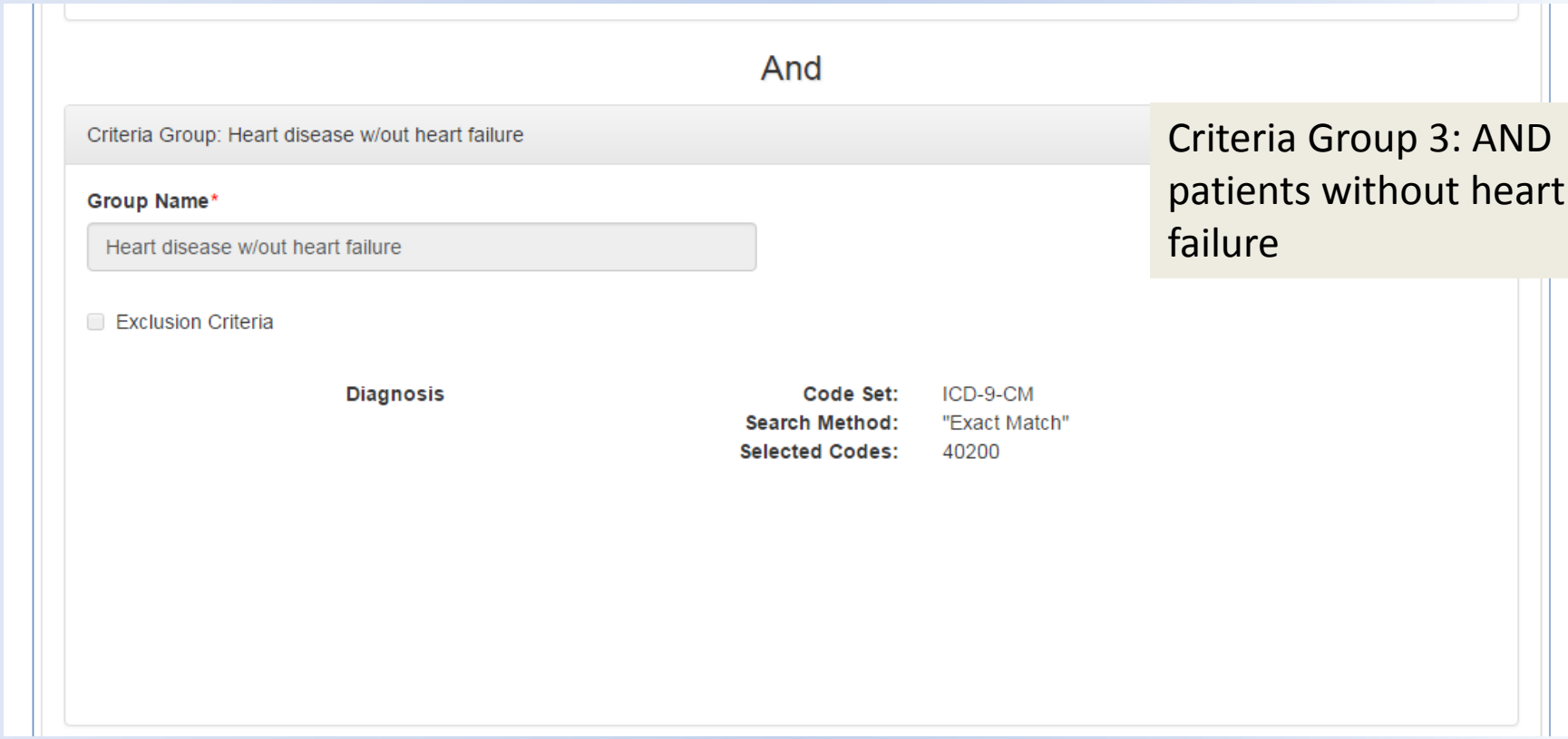
Criteria Group 1: Hypertension with visits between 2000-2016

Use Case 1: Investigator Composes the MDQ Query: Why don't all people with high blood cholesterol and blood pressure get heart disease?



Criteria Group 2: AND patients have high cholesterol

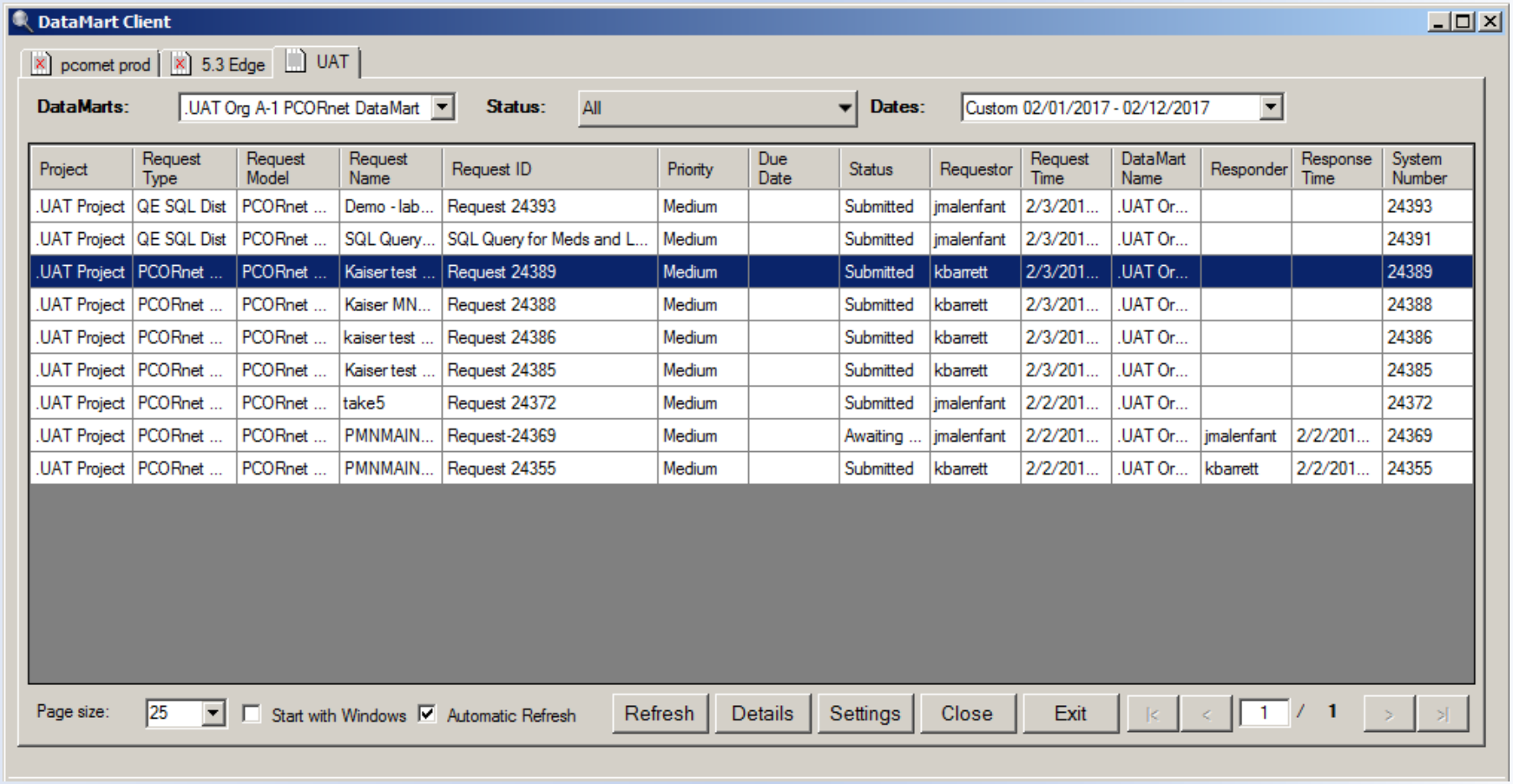
Use Case 1: Investigator Composes the MDQ Query: Why don't all people with high blood cholesterol and blood pressure get heart disease?



Criteria Group 3: AND patients without heart failure

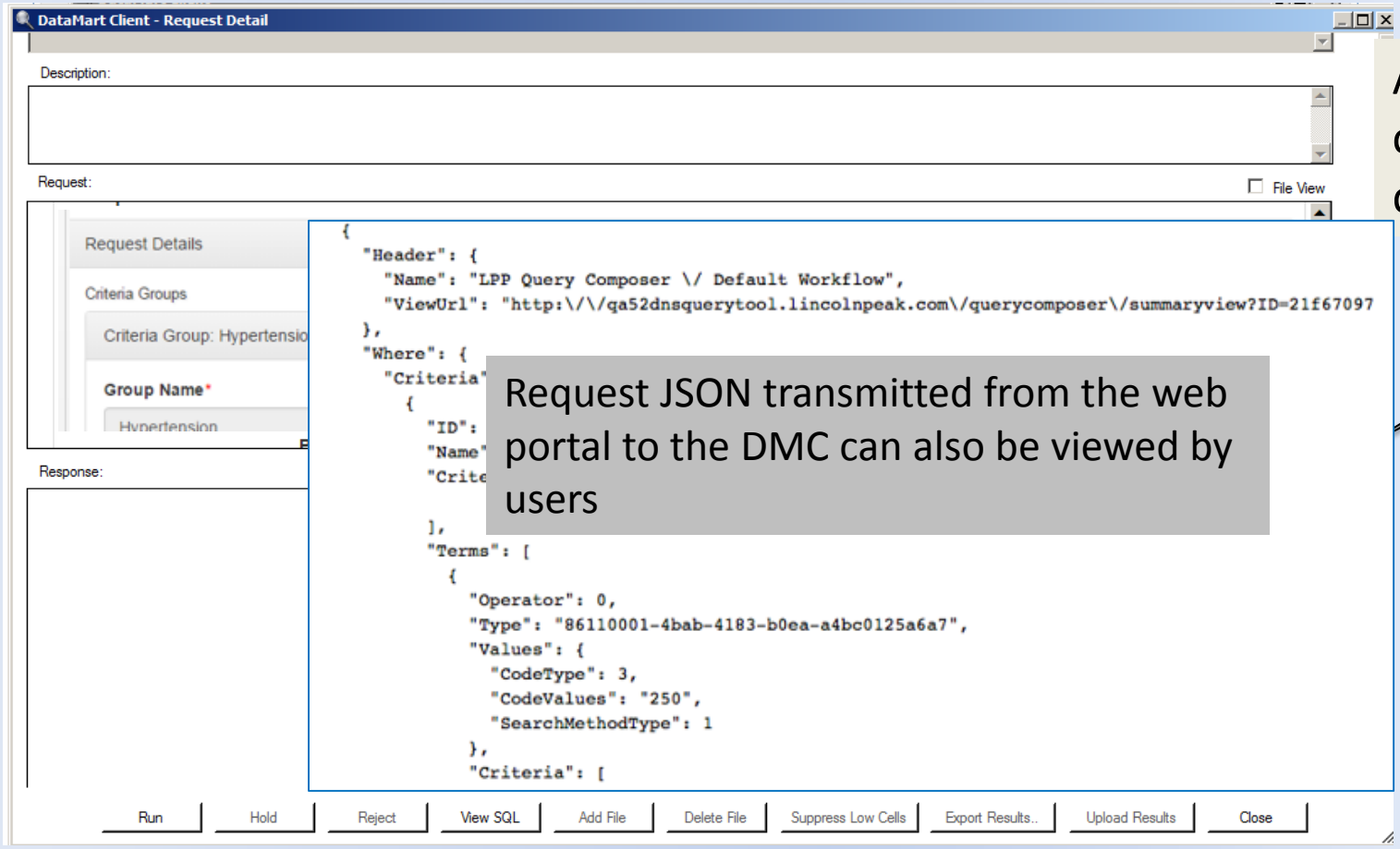
DataMart Administrator Receives the Query

DataMart Administrator Inbox – locally installed app at each site



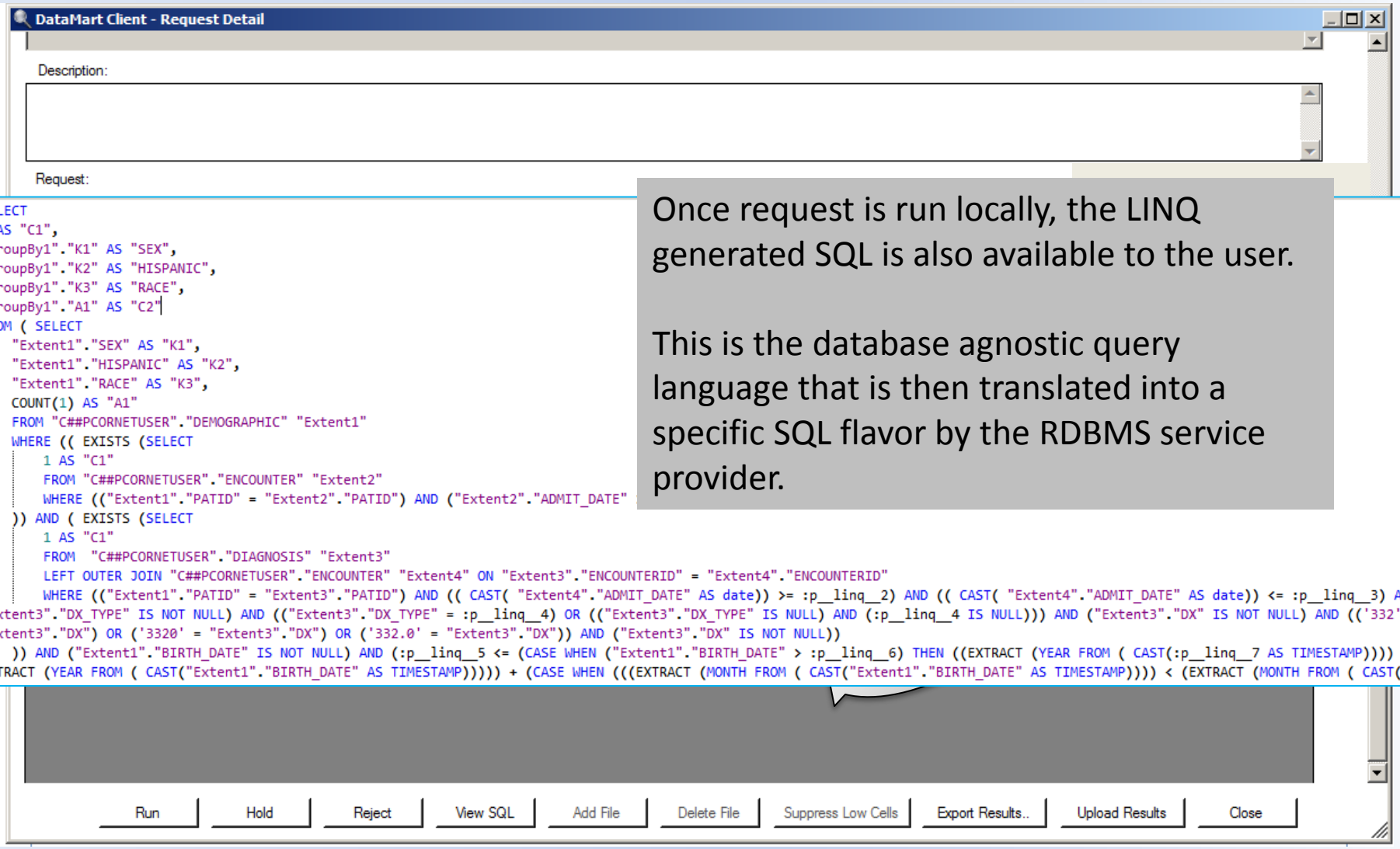
Project	Request Type	Request Model	Request Name	Request ID	Priority	Due Date	Status	Requestor	Request Time	DataMart Name	Responder	Response Time	System Number
.UAT Project	QE SQL Dist	PCORnet ...	Demo - lab...	Request 24393	Medium		Submitted	jmalenfant	2/3/201...	.UAT Or...			24393
.UAT Project	QE SQL Dist	PCORnet ...	SQL Query...	SQL Query for Meds and L...	Medium		Submitted	jmalenfant	2/3/201...	.UAT Or...			24391
.UAT Project	PCORnet ...	PCORnet ...	Kaiser test ...	Request 24389	Medium		Submitted	kbarrett	2/3/201...	.UAT Or...			24389
.UAT Project	PCORnet ...	PCORnet ...	Kaiser MN...	Request 24388	Medium		Submitted	kbarrett	2/3/201...	.UAT Or...			24388
.UAT Project	PCORnet ...	PCORnet ...	kaiser test ...	Request 24386	Medium		Submitted	kbarrett	2/3/201...	.UAT Or...			24386
.UAT Project	PCORnet ...	PCORnet ...	Kaiser test ...	Request 24385	Medium		Submitted	kbarrett	2/3/201...	.UAT Or...			24385
.UAT Project	PCORnet ...	PCORnet ...	take5	Request 24372	Medium		Submitted	jmalenfant	2/2/201...	.UAT Or...			24372
.UAT Project	PCORnet ...	PCORnet ...	PMNMAIN...	Request-24369	Medium		Awaiting ...	jmalenfant	2/2/201...	.UAT Or...	jmalenfant	2/2/201...	24369
.UAT Project	PCORnet ...	PCORnet ...	PMNMAIN...	Request 24355	Medium		Submitted	kbarrett	2/2/201...	.UAT Or...	kbarrett	2/2/201...	24355

DataMart Administrator Reviews Query Details



Administrator can review query input

DataMart Administrator Executes the Query and Reviews Results

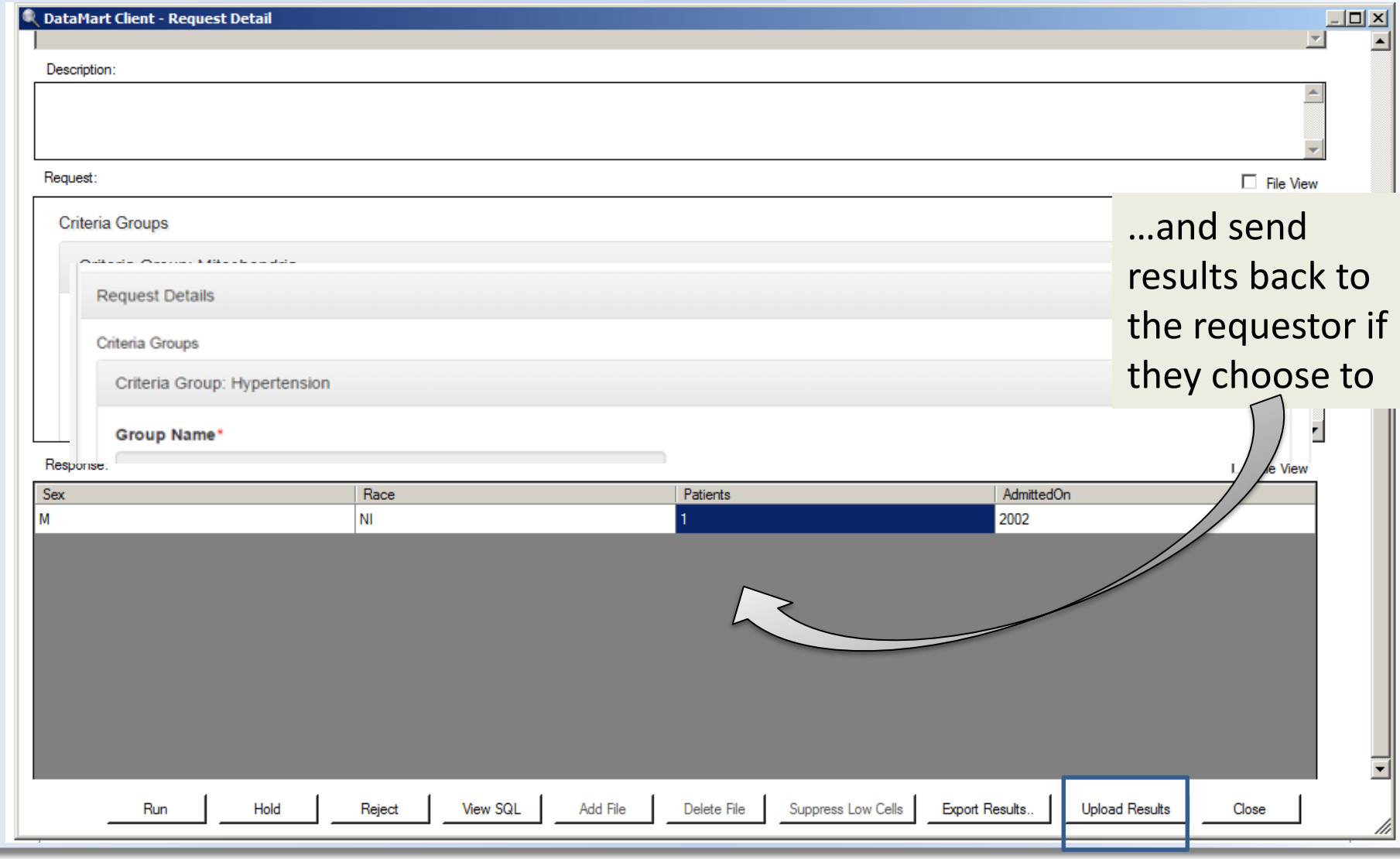



```
SELECT
1 AS "C1",
"GroupBy1"."K1" AS "SEX",
"GroupBy1"."K2" AS "HISPANIC",
"GroupBy1"."K3" AS "RACE",
"GroupBy1"."A1" AS "C2"
FROM ( SELECT
    "Extent1"."SEX" AS "K1",
    "Extent1"."HISPANIC" AS "K2",
    "Extent1"."RACE" AS "K3",
    COUNT(1) AS "A1"
    FROM "C##PCORNETUSER"."DEMOGRAPHIC" "Extent1"
    WHERE (( EXISTS (SELECT
        1 AS "C1"
        FROM "C##PCORNETUSER"."ENCOUNTER" "Extent2"
        WHERE (("Extent1"."PATID" = "Extent2"."PATID") AND ("Extent2"."ADMIT_DATE"
    )) AND ( EXISTS (SELECT
        1 AS "C1"
        FROM  "C##PCORNETUSER"."DIAGNOSIS" "Extent3"
        LEFT OUTER JOIN "C##PCORNETUSER"."ENCOUNTER" "Extent4" ON "Extent3"."ENCOUNTERID" = "Extent4"."ENCOUNTERID"
        WHERE (("Extent1"."PATID" = "Extent3"."PATID") AND (( CAST( "Extent4"."ADMIT_DATE" AS date)) >= :p__linq__2) AND (( CAST( "Extent4"."ADMIT_DATE" AS date)) <= :p__linq__3) AND (
"Extent3"."DX_TYPE" IS NOT NULL) AND (("Extent3"."DX_TYPE" = :p__linq__4) OR (("Extent3"."DX_TYPE" IS NULL) AND (:p__linq__4 IS NULL))) AND ("Extent3"."DX" IS NOT NULL) AND (('332' =
"Extent3"."DX") OR ('3320' = "Extent3"."DX") OR ('332.0' = "Extent3"."DX")) AND ("Extent3"."DX" IS NOT NULL))
    )) AND ("Extent1"."BIRTH_DATE" IS NOT NULL) AND (:p__linq__5 <= (CASE WHEN ("Extent1"."BIRTH_DATE" > :p__linq__6) THEN ((EXTRACT (YEAR FROM ( CAST(:p__linq__7 AS TIMESTAMP)))) - (
EXTRACT (YEAR FROM ( CAST("Extent1"."BIRTH_DATE" AS TIMESTAMP))))) + (CASE WHEN (((EXTRACT (MONTH FROM ( CAST("Extent1"."BIRTH_DATE" AS TIMESTAMP)))) < (EXTRACT (MONTH FROM ( CAST(:
```

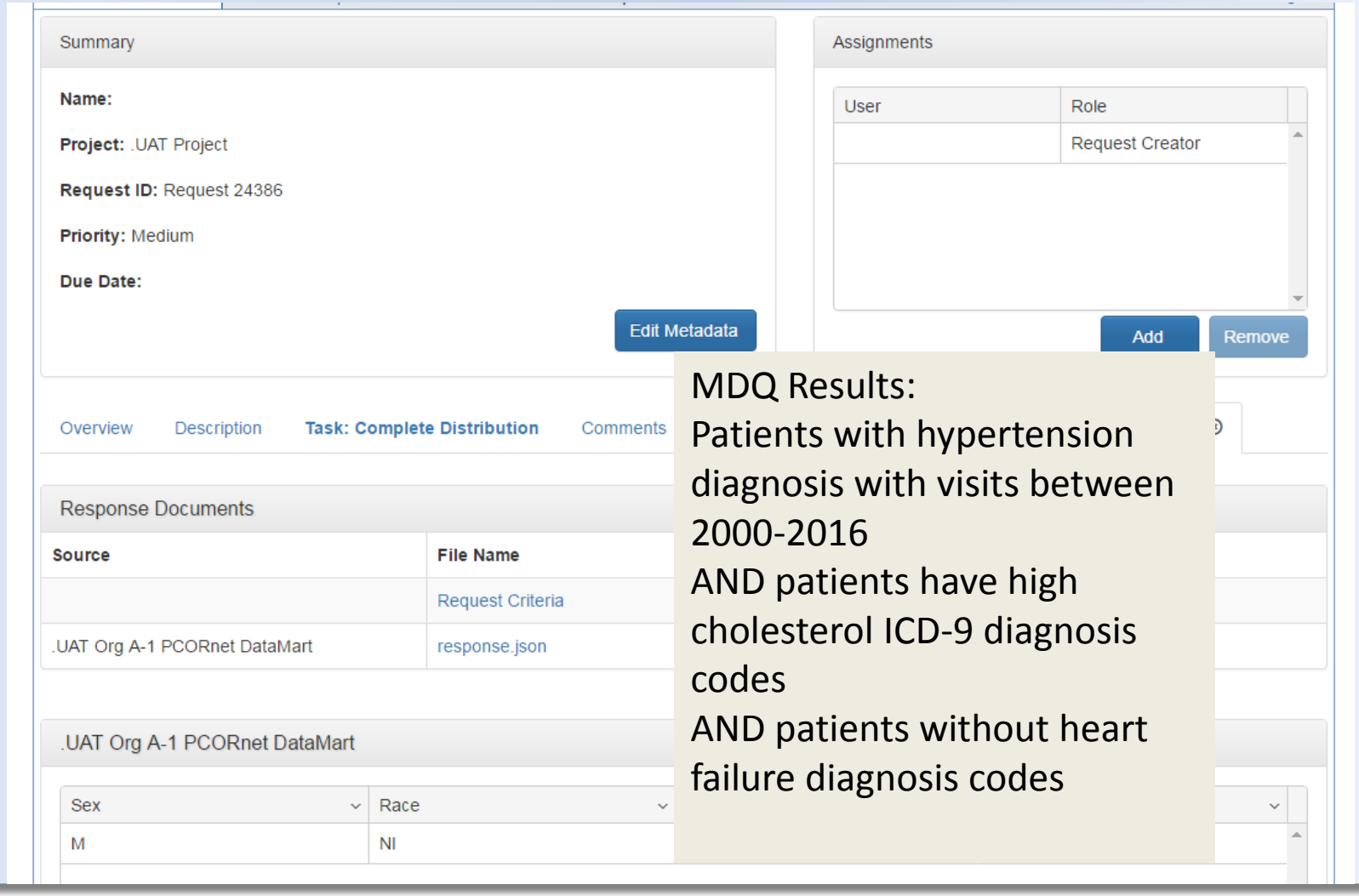
Once request is run locally, the LINQ generated SQL is also available to the user.

This is the database agnostic query language that is then translated into a specific SQL flavor by the RDBMS service provider.

DataMart Administrator Uploads Results



Investigator Reviews Site-Specific Results on Web Portal



MDQ Results:
Patients with hypertension diagnosis with visits between 2000-2016
AND patients have high cholesterol ICD-9 diagnosis codes
AND patients without heart failure diagnosis codes

Current Status

- **Multiple terms have been added to the MDQ tool** for several fields including Race, Sex, Observation Period, Diagnosis and Procedure Codes, Height, Weight, Age, etc.
- The **PCORnet data adapter has been updated** to process queries with the new terms and stratification options
- Testing has verified that **ad hoc data models that share PCORnet CDM fields can use the MDQ out-of-the box.**

Current Status

- **Investigating issues with SQL code matching request parameters**
- **Validation and performance testing** is in progress to evaluate how complex queries behave
- Enhancing automation functionality
- Ability to **expose the actual SQL to a user prior to running a query** is under investigation. The request JSON and the LINQ code are currently available to end users but require manual steps to piece the query languages together, for example:

```
-- PrimaryObservationStart: '10/15/2013 12:00:00 AM' (Type = DateTime2, IsNullable = false)

-- PrimaryObservationEnd: '10/14/2014 12:00:00 AM' (Type = DateTime2, IsNullable = false)

-- PrimaryObservationStart: '10/15/2013 12:00:00 AM' (Type = DateTime2)

-- PrimaryObservationEnd: '10/14/2014 12:00:00 AM' (Type = DateTime2)

-- CriteriaOneCodeType: '09' (Type = String, Size = 4000)

-- CriteriaOneMinimumAge: '65' (Type = Int32, IsNullable = false)
```

```
SELECT
    1 AS [C1],
    [GroupBy1].[K1] AS [SEX],
    [GroupBy1].[K2] AS [HISPANIC],
    [GroupBy1].[K3] AS [RACE],
    [GroupBy1].[A1] AS [C2]
    FROM (

        SELECT
        [Extent1].[SEX] AS [K1],
        [Extent1].[HISPANIC] AS [K2],
        [Extent1].[RACE] AS [K3],
        COUNT(1) AS [A1]
        FROM [dbo].[DEMOGRAPHIC] AS [Extent1]
        WHERE (
            -- where the patient has an encounter between the primary criteria dates
            EXISTS (SELECT
            1 AS [C1]
            FROM [dbo].[ENCOUNTER] AS [Extent2]
            WHERE ([Extent1].[PATID] = [Extent2].[PATID]) AND ([Extent2].[ADMIT_DATE] >= @PrimaryObservationStart) AND ([Extent2].[ADMIT_DATE] <= @PrimaryObservationEnd)
        ))

        AND (
            -- from diagnosis where the codes match the primary criteria code term values and code type, and the diagnosis has an encounter associated between the primary observation dates
            EXISTS (SELECT
                1 AS [C1]
                FROM [dbo].[DIAGNOSIS] AS [Extent3]
                LEFT OUTER JOIN [dbo].[ENCOUNTER] AS [Extent4] ON [Extent3].[ENCOUNTERID] = [Extent4].[ENCOUNTERID]
                WHERE ([Extent1].[PATID] = [Extent3].[PATID]) AND ([Extent4].[ADMIT_DATE] >= @PrimaryObservationStart) AND ([Extent4].[ADMIT_DATE] <= @PrimaryObservationEnd) AND ([Extent3].[
            )

        )
```

Current Status

- **Investigating issues with SQL code matching request parameters**
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- Ability to **expose the actual SQL to a user prior to running a query** is under investigation. The request JSON and the LINQ code are currently available to end users but require manual steps to piece the query languages together, for example:

Question

The PopMedNet™ (PMN) platform was enhanced to enable users to create and send custom data queries to multiple data sources using different database management systems (e.g. SQL server and Oracle). In what way does this new functionality facilitate a sharable, scalable query infrastructure?

A. PMN was extended to allow a single query to target multiple data models at once.
B. The tool was purpose-built to separate the front and back-end components to enable projects that use different data models to more easily leverage existing work (e.g. Race Term) to target additional data models.
C. The system now allows for users to see which database management system is used at each site.
D. Menu-driven queries can be used to generate patient lists that can be shared with the investigator who submitted a query.

Answer

A. PMN was extended to allow a single query to target multiple data models at once.

B. The tool was purpose-built to separate the front and back-end components to enable projects that use different data models to more easily leverage existing work (e.g. Race Term) to target additional data models.

C. The system now allows for users to see which database management system is used at each site.

D. Menu-driven queries can be used to generate patient lists that can be shared with the investigator who submitted a query.

Explanation: This project focuses on developing a new approach to Menu-Driven-Queries (MDQ) in PMN that is scalable, extensible and enables efficient querying within a diverse health data network. The legacy query composer in PMN built for a single network was not suitable for use in the diverse ecosystem because was not scalable and much of it was hardcoded for a specific RDBMS and could not easily be repurposed. With advancements in technology, the PMN platform was substantially enhanced to introduce the Microsoft Entity Framework and custom workflow engines to produce the new MDQ tools that enable querying across RDBMS.

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