Open Source
for
Immunization Information Systems

AIRA National Meeting

August 13, 2019

Amy Metroka, Angel Aponte, Steven Bors, Nathan Bunker,
Rick Hall, Noam Arzt

NYC Health

Outline

- Introduction
- Panel
  - Overview of Open Source Software – Noam Arzt
  - Current Use of Open Source in IIS
    - Message Quality Evaluation (MQE) Tool – Nathan Bunker
    - Examples from States, New York City (NYC)
      - New Jersey – Alok Patra
      - Utah – Jon Reid
      - NYC – Angel Aponte
- Interactive Discussion
- Closing and Next Steps

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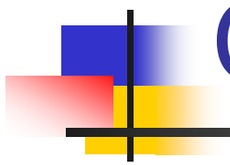
Introduction

- Open source software offers the opportunity to share solutions to challenges common to all IIS
  - Potential to improve IIS scalability and security at reduced costs
  - Important strategy for ensuring long-term sustainability of IIS
- Purpose of today's session
  - Learn about open source software in use in IIS now
    - Benefits and Challenges
  - Discuss overcoming challenges to broader implementation of open source solutions in IIS

Panel Presentations



Overview of Open Source

Noam H. Arzt, PhD
President, HLN Consulting, LLC

Definitioning Open Source

- Open source is an easing of default copyright for software
- Open source concept is about right to *modify source code* as well as the right to *use* software
- Many variations and conditions possible
- Open source can promote sharing, but also inhibit sharing through potential loss of intellectual property rights
- Mixing open source and proprietary products can have important impacts on a software developer

SWOT Analysis: Proprietary

Strengths • Source code remains unified • Vendor bears the burden of enhancements • Software support usually easy to secure • Software is relatively mature and well tested	**Weaknesses** • License fee to use • Only vendor can make changes • Potential loss of access to source code if developer stops work • Users may or may not get the enhancements they want • May or may not enable modular IIS deployment
Opportunities • CDC NCIRD IDIQs/BPAs may fund and facilitate product-specific enhancements • Vendors of these products may more readily support external hosting	**Threats** • Small IIS market may see fewer vendors over time • Vendor reaction to encroachment of Open Source is hard to predict • Agency funding continues to be constrained

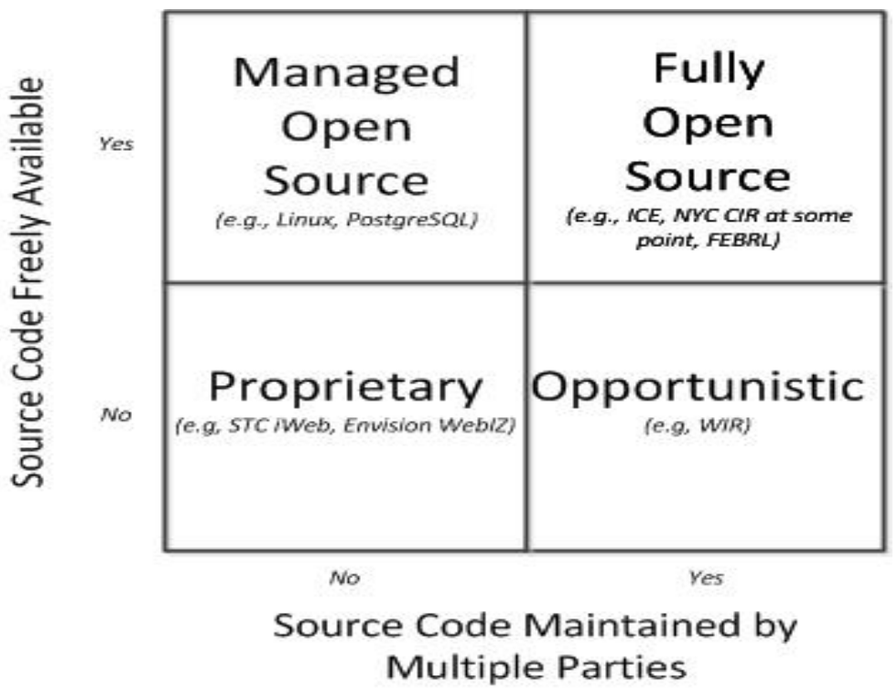
SWOT Analysis: Open Source

Strengths • No license fee to use • No loss of access to source code if developer stops work • Freedom to make/share changes • Transparency in governance • Enables modular IIS deployment	**Weaknesses** • Risk of *detrimental* source code "forking" • Burden of enhancements may fall to individual users/organizations • Software support may be harder to secure
Opportunities • "Joint development" can reduce cost of enhancements & support • Commercial vendors often provide solid support • More modular IIS might enable more Open Source component use	**Threats** • IIS community will not financially support product development • IIS community expects open source market to behave like commercial market • Commercial vendor reactions

Examples from IIS World

- PostgreSQL (RDBMS)
- Choicemaker (patient matching)
- Message Quality Evaluation Tool (MQE)
- FEBRL (patient matching)
- HAPI (HL7 Parser)
- Immunization Calculation Engine (ICE)
- NextGen Connect (Interface Engine)

Policy Models



Strategies for Success

- Begin to move IIS to modularity and SOA
- Leverage widely-used Open Source products where feasible (*e.g.,* Linux, PostgreSQL, HAPI)
- Jointly develop/support more specialized products when necessary (*e.g.,* forecaster, QA tools)
- Look beyond IIS community for collaboration (*e.g.,* EHRs, PHRs)
- Encourage one organization to maintain stewardship over and support each product to prevent "detrimental" forking (Managed Open Source)
- Recognize and manage any turbulence this may cause in the commercial product marketplace

Resources

- Open Source Initiative
  http://opensource.org/
- Open Source Electronic Health Record Alliance
  http://opensource.org/
- OSEHRA License Terms Document
  https://www.osehra.org/sites/default/files/osehra_licensing_terms_v.1.0.pdf
- Draft Federal Source Code Policy
  https://github.com/WhiteHouse/source-code-policy/blob/gh-pages/SourceCodePolicy.pdf

Open Source in IIS: MQE Tool

Nathan Bunker, Senior Technical Project Manager
AIRA

20th ANNIVERSARY

What is the MQE Tool?

- Designed to assist sites in **consistently evaluating and improving the quality of data** coming into their IIS

- Allows users with varying levels of expertise to quickly and easily generate a series of reports that describe the quality of incoming immunization data

Technical Architecture Goals

- Open-source and freely available to the IIS community
  - Pre-configured to be ready to process data
  - Intuitive user interface
  - Quick installation on modern OS
  - Quickly create an easy to read/easy to navigate data quality report
- Identify data quality issues in a batch of HL7 messages
  - Based on business rules/needs of IIS
  - Not primarily focused on message conformance (NIST Integration)
  - Evaluate data quality in a batch messages by submitter
  - Allow data quality analyst to get above the weeds and see the big picture

National Standards and Local Variation

Pre-configured

- CDC Implementation Guide HL7 2.5.1 r1.5 and addendum
  - VXU will be used to accept data
- AIRA ACK Guidance document
  - ACK will indicate the results of the analysis of single message
- MIROW guidance on Data Quality
- CDC Vaccine Code Sets

Configurable

- Status of coded values and additional local codes
- Issue level setting for validation detections (errors vs warnings)
- Report weight and section enabling configuration

Documentation and Resources

Documentation

- Business Case (and the “pitch”)
- Functional Requirements
- Resource Planning
- Implementation Guide
- User Guide
- Testing Guidance
- Decision Framework & Sustainability Plan

Other Technical Resources

- https://github.com/immregistries/mqe
  - Anyone can download the app or source code
  - Account needed to branch code or edit issues (with approval of Tech Team)
- Communication
  - Slack (https://slack.com) – developer communication
  - Uberconference.com (need Google Chrome to screen share)

SWOT Analysis of MQE: Strengths

- No license fee to use – Yes
- No loss of access to source code if developer stops work – Yes
- Freedom to make/share changes
  - Git technology allows for easy copying and sharing
- Transparency in governance
  - AIRA is providing the current governance structure
- Enables modular IIS deployment
  - MQE is actually a set of components which now support at least three other open source projects: AIRA AART, AIRA Codeset Project, NIST Immunization Data-at-Rest Tool

SWOT Analysis of MQE: Weaknesses

- Risk of detrimental source code “forking”
  - GitHub makes copying code extremely easy
  - We are not aware of any forking that has been done yet
- Burden of enhancements may fall to individual users/organizations
  - This is the primary challenge that MQE faces
- Software support may be harder to secure

SWOT Analysis of MQE: Opportunities

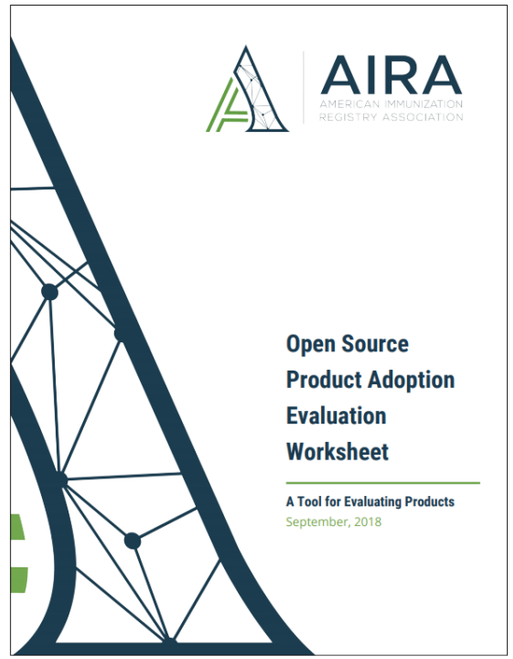
- "Joint development" can reduce cost of enhancements & support
  - Requirements for MQE have had a very high degree of overlap
- Commercial vendors often provide solid support
  - Hope to have future involvement from commercial vendors
- More modular IIS might enable more open source component use
  - Parts of the MQE could be used in more modular IIS architectures

SWOT Analysis of MQE: Threats

- IIS community will not financially support product development
  - A lot of interest in using the MQE
  - Less capacity to help in the development and improvement of MQE
- IIS community expects open source market to behave like commercial market
  - Primary challenge for adoption and use of MQE
- Commercial vendor reactions

Adopting Open Source

- Are you looking to adopt open source?
  - Take a look at the Open Source Product Adoption Worksheet
  - https://repository.immregistries.org/resource/mqe-project-tools-and-documents/



NJIIS ICE Implementation

Presented By:
Alok Patra
NJIIS Data Coordinator
Vaccine Preventable Disease Program
New Jersey Department of Health

Introduction

- NJIIS had a home grown engine for vaccine validation and forecasting dating back to 2002
- With evolving ACIP recommendations, it became difficult to align the engine to display accurate forecasting
- Providers routinely use the NJIIS forecasting capability, so it became necessary to replace the existing engine with a more robust, accurate and low maintenance engine with the NJIIS 2.0 release in 2018.

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NJ Health New Jersey Department of Health

Why ICE?

- Adheres to appropriate clinical guidelines (ACIP)
- Standards-based technical architecture and Application Programming Interface (API)
- Forecasting is accurate and up to date
- Supports routinely administered vaccine groups, from cradle to grave
- Manageable implementation and maintenance with program resources
- Available under a standard permissive open source license

NJIIS
NEW JERSEY
IMMUNIZATION INFORMATION SYSTEM

NJ Health
New Jersey Department of Health

Implementation

- NJIIS developers implemented and integrated ICE in lower testing environment as a Proof Of Concept (POC)
- NJIIS Program did regressive validations using a test client page developed by NJIIS team
- NJIIS Program approved ICE based on the validations
- ICE implementation steps:
  - ❖ Implemented ICE as a webservice in lower environments (staging & pre-production)
  - ❖ Subsequent releases into Production, Training and User Acceptance Testing (UAT)

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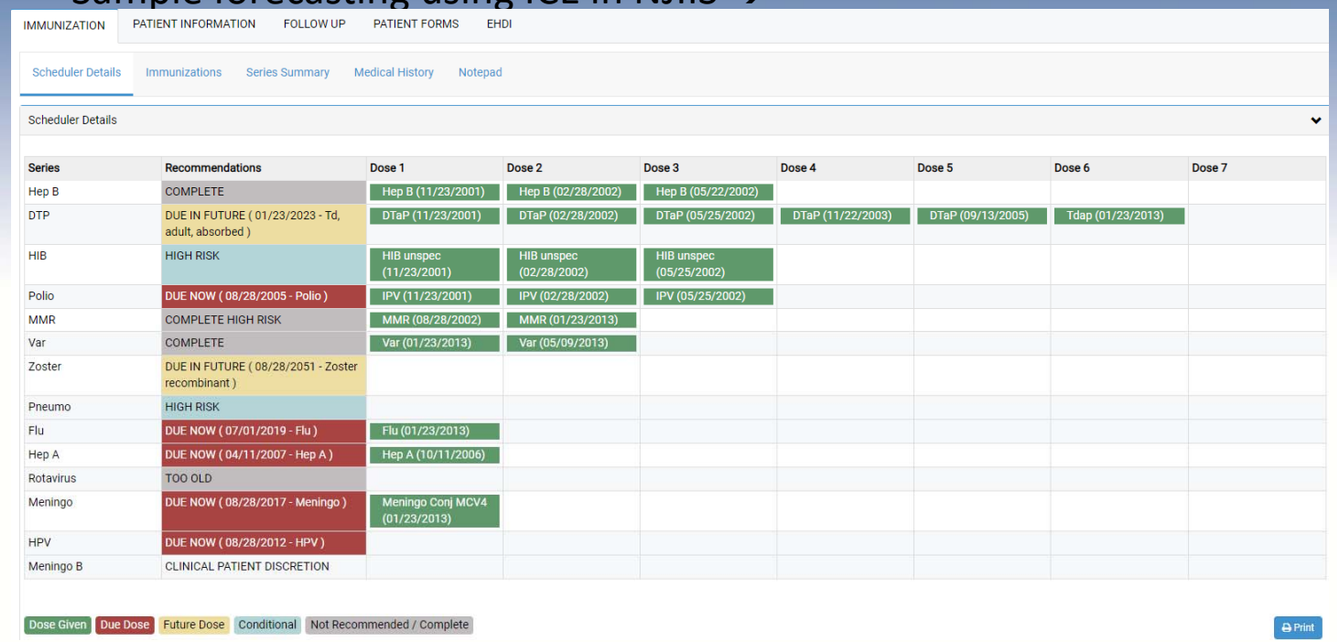
Sample NJIIS Forecasting Using ICE

Sample forecasting using ICE in NJIIS →



IMMUNIZATION | PATIENT INFORMATION | FOLLOW UP | PATIENT FORMS | EHDI

Scheduler Details | Immunizations | Series Summary | Medical History | Notepad

Scheduler Details

Series	Recommendations	Dose 1	Dose 2	Dose 3	Dose 4	Dose 5	Dose 6	Dose 7
Hep B	COMPLETE	Hep B (11/23/2001)	Hep B (02/28/2002)	Hep B (05/22/2002)				
DTP	DUE IN FUTURE (01/23/2023 - Td, adult, absorbed)	DTaP (11/23/2001)	DTaP (02/28/2002)	DTaP (05/25/2002)	DTaP (11/22/2003)	DTaP (09/13/2005)	Tdap (01/23/2013)	
HIB	HIGH RISK	HIB unspec (11/23/2001)	HIB unspec (02/28/2002)	HIB unspec (05/25/2002)				
Polio	DUE NOW (08/28/2005 - Polio)	IPV (11/23/2001)	IPV (02/28/2002)	IPV (05/25/2002)				
MMR	COMPLETE HIGH RISK	MMR (08/28/2002)	MMR (01/23/2013)					
Var	COMPLETE	Var (01/23/2013)	Var (05/09/2013)					
Zoster	DUE IN FUTURE (08/28/2051 - Zoster recombinant)							
Pneumo	HIGH RISK							
Flu	DUE NOW (07/01/2019 - Flu)	Flu (01/23/2013)						
Hep A	DUE NOW (04/11/2007 - Hep A)	Hep A (10/11/2006)						
Rotavirus	TOO OLD							
Meningo	DUE NOW (08/28/2017 - Meningo)	Meningo Conj MCV4 (01/23/2013)						
HPV	DUE NOW (08/28/2012 - HPV)							
Meningo B	CLINICAL PATIENT DISCRETION							

Dose Given | Due Dose | Future Dose | Conditional | Not Recommended / Complete

Print

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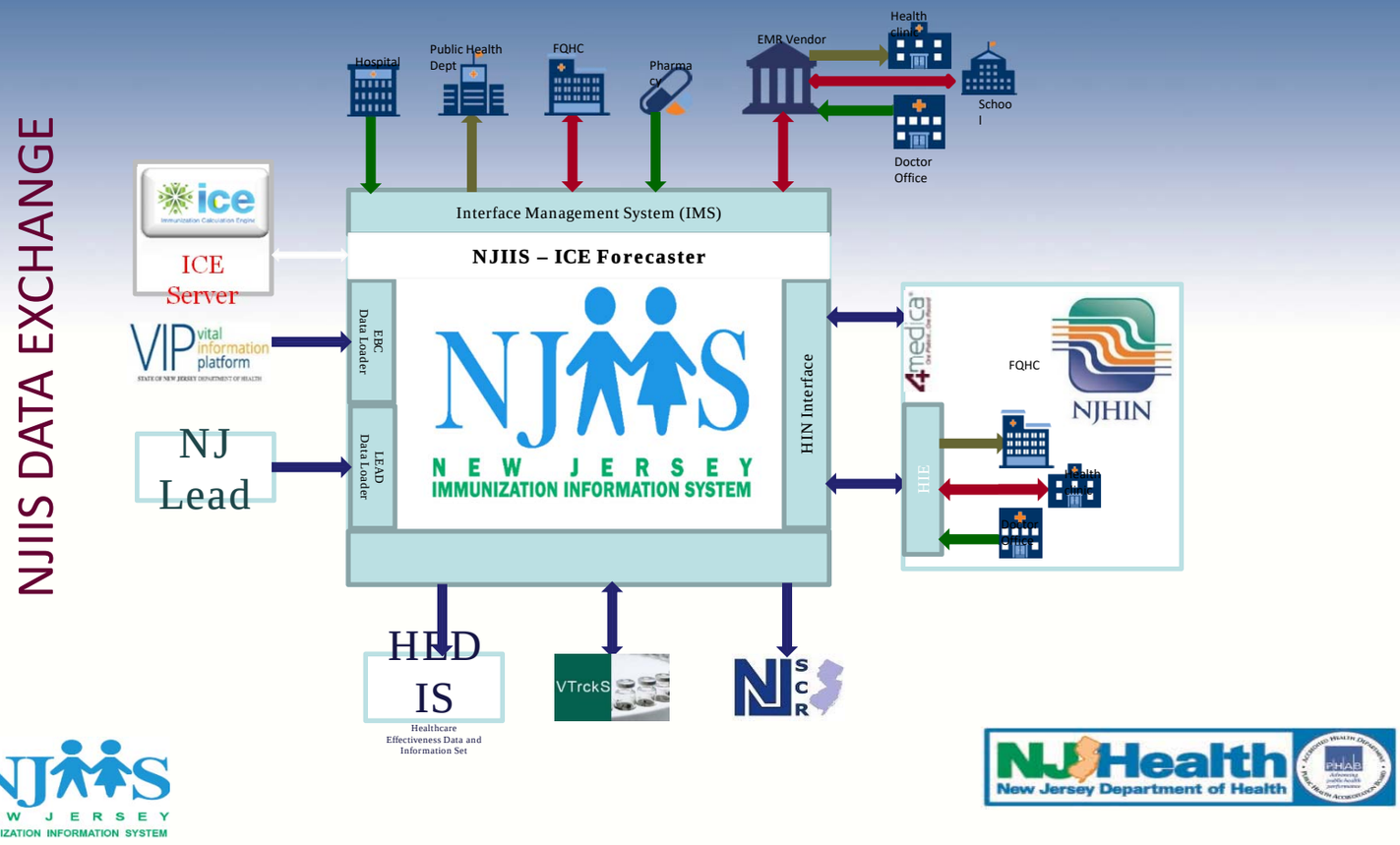
Architecture



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THANK YOU

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Implementing ICE in the Michigan Care Improvement Registry (MCIR)

Bob Swanson, MPH
Michigan Immunization Program Manager

Why ICE for Michigan

- Valuable and expensive programmer time used to maintain our own immunization forecaster
- Reduce system maintenance and standardize methodologies
- Wanted the ability to do antigen level forecasting, M-M-R
- Need for a user interface front end to our forecaster, CAT Authorizing Tool
- Standardize assessment using national standards

MDHHS
Michigan Department of Health & Human Services

Gradual Transition to ICE

- Analysis of forecasting tools available on the market
  - Comparison of results from market tools to MCIR
- Program infrastructure in MCIR to allow ICE in the production environment and direct forecasting by vaccine series, not plug and play in our system
- Additional programming to manage Michigan specific exceptions and interpret ICE output to our system
- First put into production for adult flu forecast in the 2018/19 flu season
- Flu forecasting for all ages during the 2019/20 flu season

MDHHS
Michigan Department of Health & Human Services

Results/Conclusions

- Flu vaccine has been successfully implemented
- HLN has been very responsive to forecasting questions we have submitted to them as we test additional vaccine series
- Implementation of ICE into our system became more complex than anticipated but continue to move forward
- Compromised doses not sent to ICE forecaster
- Group think has been good

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Michigan Department of Health & Human Services

Next Steps

- Next vaccine series we are currently testing are Hepatitis A and B forecasting and then single antigen forecasting, M-M-R
- Looking forward to having an Authorizing Tool that we can use to maintain our own unique differences from ACIP and allow us to manage our school and childcare assessments. ICE does not currently support multiple schedules
- Looking forward to work using HALO rules that could forecast based on variables such as health status, lifestyle, or occupation

MDHHS
Michigan Department of Health & Human Services

MDHHS
Michigan Department of Health & Human Services

Thank you!

SwansonR@Michigan.gov

Use of Open Source Software in the Utah IIS

Jon Reid
USIIS Program Manager
Utah Department of Health

Current Open Source Software

Software:

Open JDK
Linux (CentOS)
PostrgreSQL
Mirth
MySQL
R Statistical Software
Drupal
PHP

Supports programs:

Immunization:
    IIS
Epidemiology:
    Disease Surveillance (NEDSS/ELR)
    Refugee Health
Vital Statistics:
    Birth/Death/OME
Public Health Assessment:
    IBIS (Public Health Indicators)

How Long: Using open source software since at least 2008

Why Use Open Source Software?

- Access to development community knowledge
- Ability to have multiple environments
  - (development, test, production)
- Total lower operating costs/pool resources
- Able to customize to own environment

Implementation

Department architecture standards committee/Security Office

- Reviews request for application
- Ensures project is active and has ongoing support
- Evaluates if existing software fulfills need
- Approves environment (internal/external)
- Approves data classification use (Public/Restricted)

- Backend software handled and managed by IT staff
- User groups created for front end software
  - R statistical software user group
  - Drupal/WordPress user groups
- Communities of practice
  - ELR/EMSA
  - IBIS
- Policies on state employees who contribute to open source projects

Results/Conclusions

- Overall cost to implement lower
  - More agile
  - Can try different software with little financial risk
- Time to implement
  - Faster to get applications out-the-door
  - Use knowledge from community to fix issues
    - Not limited to specific environment/configuration

Examples:

- Switch from Rhapsody to Mirth
  - Issue with limited com-points
  - Annual contract issues
- Move from Oracle/MSSQL to PostgreSQL
  - Lower cost (no license/maintenance)
  - Impacted development/product enhancements
- SAS to R
  - Allows more users/easy to learn

Next Steps

Future:

- Migrate existing commercial products to open source
  - IIS Forecasting
  - Person matching
- Create shared open source resources for use by other programs
  - Database servers (PostgreSQL)
  - Web servers (Drupal/Apache)
  - Web survey/data capture (RedCap)
- Create greater standardization on department level
  - Migrate other systems to shared open source resources
- Establish communities of practice
- Work with other states to adopt similar software and practices
- Promote use of open source software

THANK YOU!

Jon Reid
USIIS Program Manager
jreid@utah.gov
www.usiis.org

Use of open source software by the New York City Citywide Immunization Registry

Angel Aponte (aaponte@health.nyc.gov)

Computer Specialist, Software

Division of Disease Control

New York City Department of Health and Mental Hygiene

Citywide Immunization Registry (CIR)

- NYC's Immunization Information System
- Implemented Citywide in 1997
- Mandatory reporting of immunizations for patients < 19 years of age
- > 7 million patient records
- > 104 million immunizations
- Population-based
  - Birth certificates loaded twice a week
- Integrated with NYC's blood lead test database in 2004
  - Papadouka, et al. "Integrating the New York Citywide Immunization Registry and the Childhood Blood Lead Registry." Journal of Public Health Management and Practice, November 2004 - Volume 10 - Issue - p S72–S80, https://pdfs.semanticscholar.org/3a50/b3588b7b63668be86c4fbc812750c4d85fce.pdf

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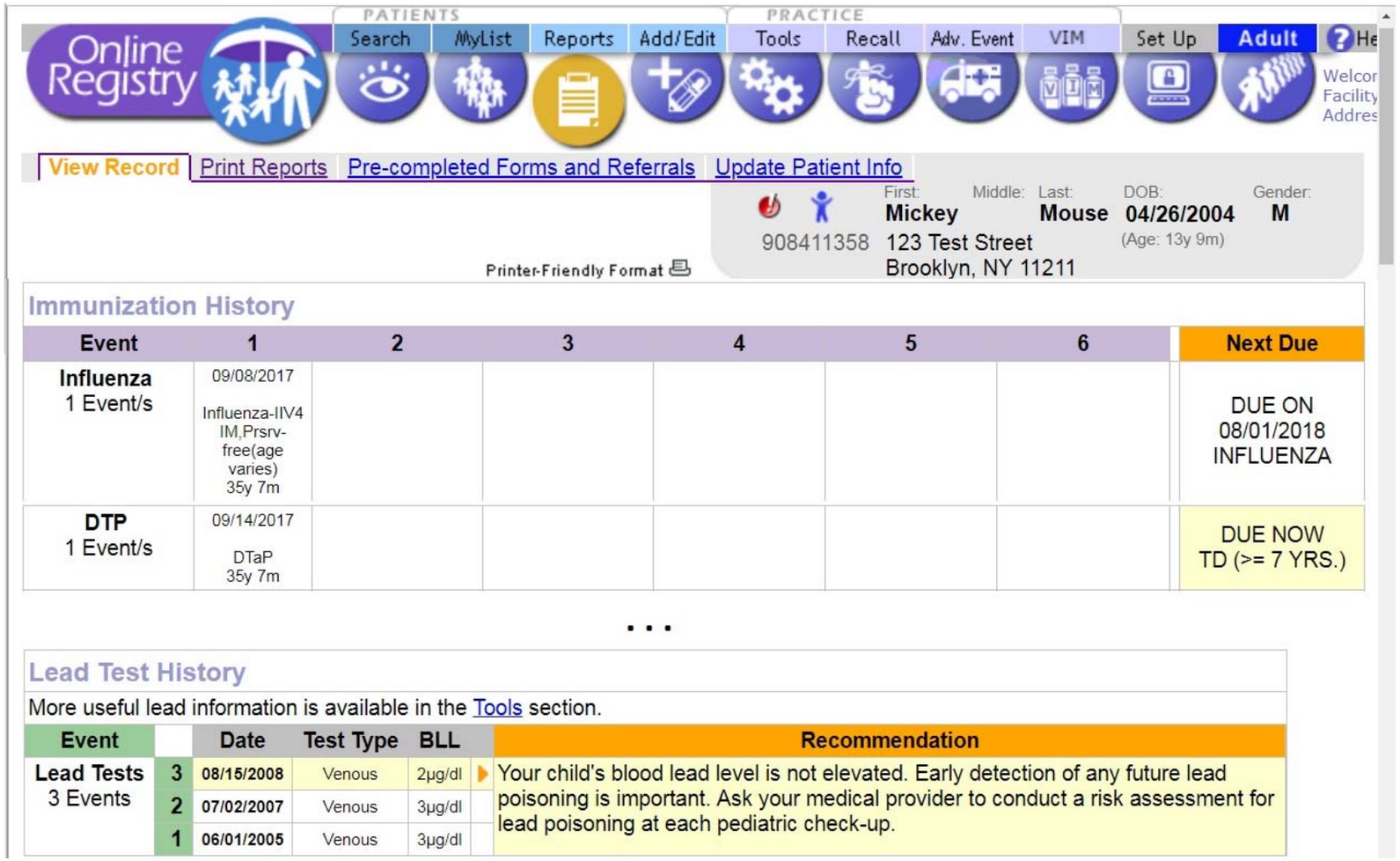
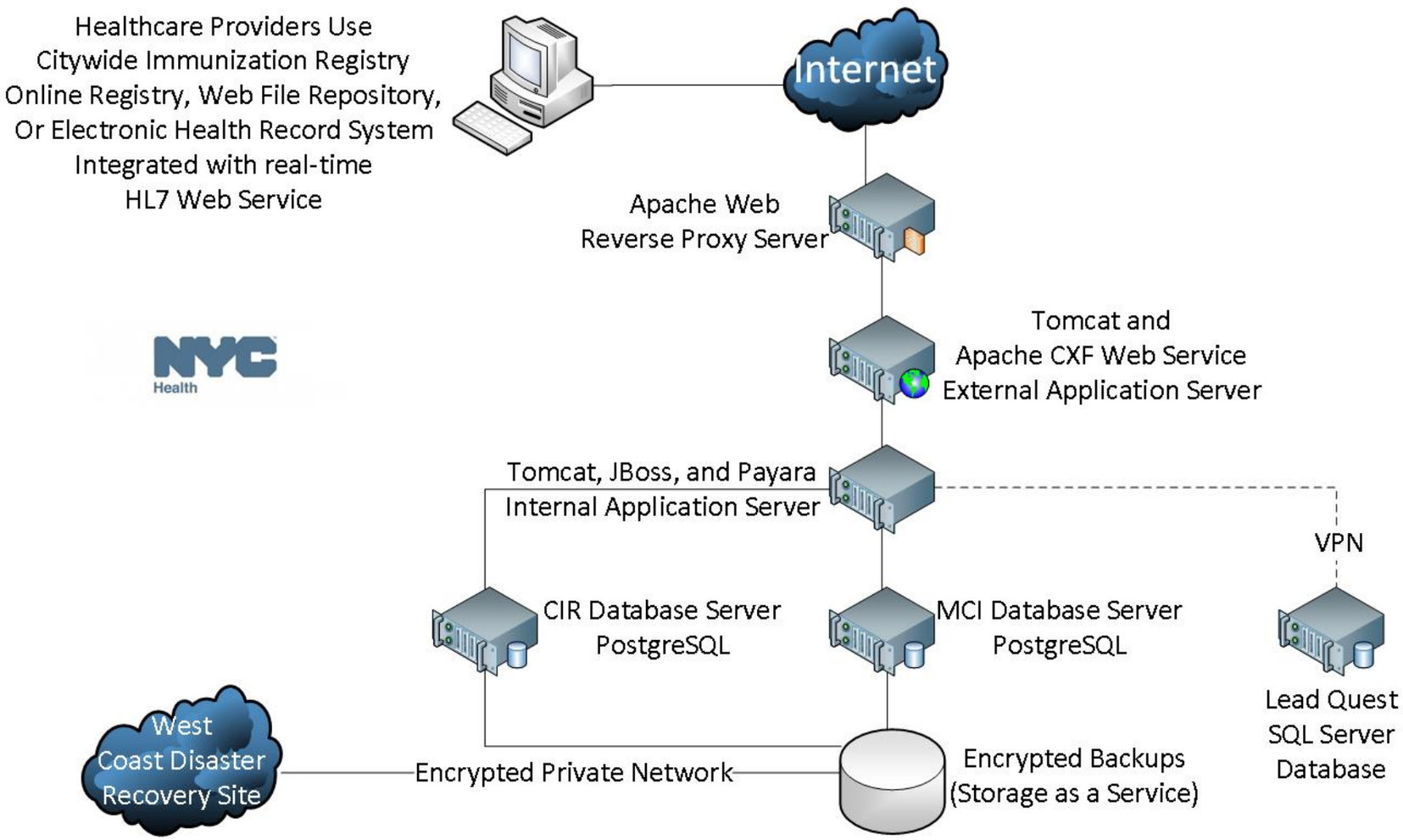

Online Registry
PATIENTS
Search
MyList
Reports
Add/Edit
PRACTICE
Tools
Recall
Adv. Event
VIM
Set Up
Adult
View Record
Print Reports
Pre-completed Forms and Referrals
Update Patient Info
First: Mickey
Middle:
Last: Mouse
DOB: 04/26/2004
Gender: M
908411358
123 Test Street
Brooklyn, NY 11211
(Age: 13y 9m)
Printer-Friendly Format
Immunization History
Event
1
2
3
4
5
6
Next Due
Influenza
1 Event/s
09/08/2017
Influenza-IIV4 IM,Prsrv-free(age varies)
35y 7m
DUE ON 08/01/2018 INFLUENZA
DTP
1 Event/s
09/14/2017
DTaP
35y 7m
DUE NOW TD (>= 7 YRS.)
Lead Test History
More useful lead information is available in the Tools section.
Event
Date
Test Type
BLL
Recommendation
Lead Tests
3 Events
3
08/15/2008
Venous
2µg/dl
2
07/02/2007
Venous
3µg/dl
1
06/01/2005
Venous
3µg/dl
Your child's blood lead level is not elevated. Early detection of any future lead poisoning is important. Ask your medical provider to conduct a risk assessment for lead poisoning at each pediatric check-up.


Healthcare Providers Use
Citywide Immunization Registry
Online Registry, Web File Repository,
Or Electronic Health Record System
Integrated with real-time
HL7 Web Service
Internet
Apache Web
Reverse Proxy Server
Tomcat and
Apache CXF Web Service
External Application Server
Tomcat, JBoss, and Payara
Internal Application Server
VPN
CIR Database Server
PostgreSQL
MCI Database Server
PostgreSQL
Lead Quest
SQL Server
Database
West
Coast Disaster
Recovery Site
Encrypted Private Network
Encrypted Backups
(Storage as a Service)

Open source software technology stack

- Operating System: Red Hat Enterprise Linux
- Remote access: Secure shell (ssh) and OpenVPN
- Encryption: OpenSSL (in transit) and LUKS (at rest and in use)
- Internet security: Apache, ModSecurity, mod_proxy, mod_ssl
- Load balancing and fault tolerance: HAProxy
- Application servers: Tomcat, Payara, JBoss
- Programming languages: Java, R, Python
- Server monitoring/alerts: Nagios and Postfix
- Database: PostgreSQL – migrated 7/20/2019

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Implementation and support model

- Pay Red Hat $1,499 to $2,499 per server, per year to support full technology stack
- Red Hat bundles software components into a distribution and makes them easy to install and update for security/stability
- Hire and train technical staff in public health agency to support, maintain, and improve CIR servers, network, and monitor security
- Contract with software development vendor (HLN Consulting) to enhance software and respond to support escalation requests

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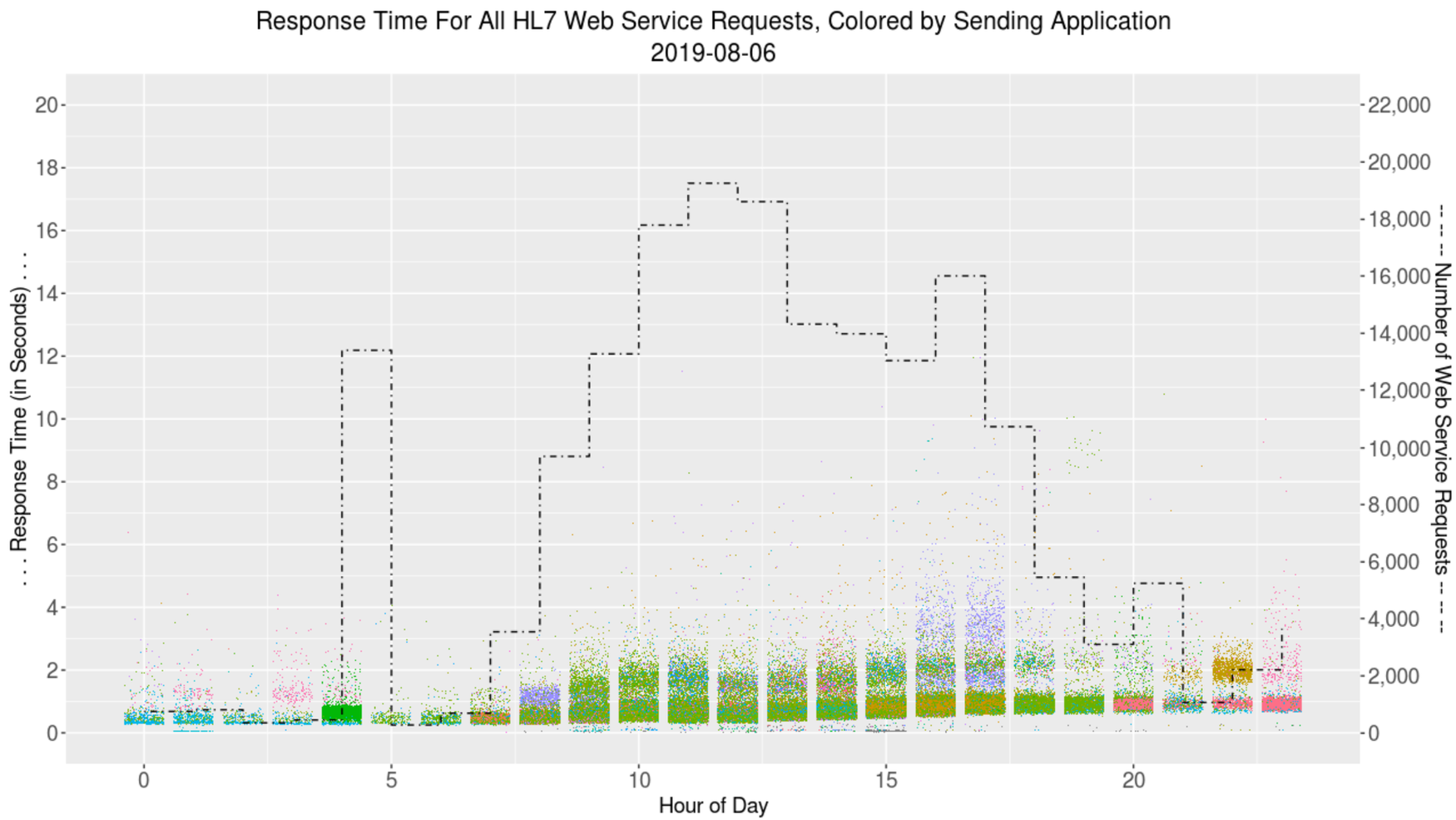
Response Time For All HL7 Web Service Requests, Colored by Sending Application
2019-08-06
. . . Response Time (in Seconds) . . .
0
2
4
6
8
10
12
14
16
18
20
0
5
10
15
20
Hour of Day
0
2,000
4,000
6,000
8,000
10,000
12,000
14,000
16,000
18,000
20,000
22,000
- - - Number of Web Service Requests - - -

Patient record search process using free, open source ChoiceMaker software

- Step 1, ~40 exact match queries take a fraction of a second
- Step 2, if a unique exact match is not found, perform a probabilistic search using a trained machine learning model using ChoiceMaker (www.choicemaker.com)
  - Blocking phase followed by scoring of pairs of records
  - Probabilistic search must find only one match above 90% match probability threshold
  - Match threshold set empirically, based on tests

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Challenge to production use of probabilistic record linkage with ChoiceMaker

- Small software vendor
  - Variety of customers
  - Limited number of technical staff
  - Can reduce risk by building a community of open source record matching experts

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Vision: Free, open source master patient index and immunization registry components

- 64 CDC Immunization grantees, 61 IIS
- International Immunization Programs
- Simplify accurate matching of disparate data sources
- Benefits:
  - No up-front cost for software
  - Community of experts
  - Vendor and platform agnostic
- To-do list:
  - Benchmark different matching software using real data
  - Improve documentation
  - Source code audit
  - Docker images with bundled applications and services
  - Release all source code on GitHub
- Challenges:
  - Build community of experts
  - Create free software governance process
  - Obtain funds for to-do list

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Interactive discussion

- Questions for panel members
- Sharing of interest in, experience, and challenges with using open source software in your IIS
- What are the challenges to broader implementation of open source solutions for IIS
  - How can we overcome these challenges?

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Closing and next steps