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Nationwide Health Information Network (NHIN)
Cooperative Testing Workgroup

NHIN Test Approach & Test Materials

Submitted to:
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Submitted by:
NHIN Cooperative Testing Workgroup

DOCUMENT CHANGE HISTORY

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1.0	Draft version	Amy Phelps	November 18, 2008
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1.0 INTRODUCTION

This Nationwide Health Information Network (NHIN) Test Approach and Test Materials document has been developed by the NHIN Trial Implementation Cooperative Testing Workgroup to describe the testing approach used by the NHIN trial implementations. The NHIN Test Approach includes the following sections:

- ***Section 1.0 Introduction*** – Provides an introduction to this NHIN Test Approach and Test Materials document and background information.
- ***Section 2.0 Scope of Testing*** – Describes the items to be tested, the requirements to be tested against as well as the test phases and test methods used.
- ***Section 3.0 Conformance Testing Plan*** – Describes the test objectives, procedures and responsibilities as well as the methods and tools required to conduct conformance testing.
- ***Section 4.0 Interoperability Testing Plan –*** Describes the test objectives, procedures and responsibilities, methods and tools, and HIE test obligations required to conduct interoperability testing.
- ***Section 5.0 Cooperative Testing Event Plan –*** Describes the objectives, test planning activities and HIE test obligations required to conduct scenario testing at the test events.
- ***Section 6.0 Appendix –*** Contains the final packaged test materials including test data anonymization process, sample documents as well as core service and use case test scenarios and test cases.

1.1 TESTING TERMINOLOGY

The NHIN Test Approach laid the groundwork for many of the activities that the NHIN contractors performed to implement the NHIN trial implementations. As such, it was critical that a common set of testing related terms be established to facilitate communication around the testing event and demonstration. The following provides definitions of the key testing related terminology:

Health Information Exchange (HIE) – An entity that enables the movement of health related data among entities within a state, a region or a non-jurisdictional participant group

- "Classic" RHIOs at regional and state levels
- Integrated delivery systems and health plans
- Health data banks that support health information exchange

NHIN Health Information Exchange (NHIE) – An HIE that implements the NHIN architecture, processes and procedures and participates in the NHIN Cooperative

- Certification
- Accreditation

Conformance Testing – Conformance testing validates single systems to single standards. This testing primarily deals with insuring that systems correctly encode the syntax and structure of a given data standard in the physical files or transactions that a system produces and receives.

Interoperability Testing – Interoperability testing validates that multiple systems that implement a particular standard, or set of standards, can all communicate with each other.

Test Scenario: A set of test cases that ensures that all the conditions related to business process flows and system designs are tested in its entirety.

Test Data: A set of data that is used as input values for test execution purposes. The test data utilized within the NHIN project will be synthetic data and could contain both valid as well as invalid values.

Test Tools: A set of software tools that will be used to maintain and speed the execution and tracking of test scenarios, and to help and support the testing process.

1.2 TESTING GOALS & OBJECTIVES

The broad goals of the NHIN Testing Workgroup were to develop, coordinate and implement the testing of ONC's "Core Services" with the other NHIN workgroups; to demonstrate and execute those test plans at an NHIN cooperative testing event; and to package the resulting testing information and process for public use. The testing must be as comprehensive as is practical. It is anticipated that in the future, HIE organizations that pass all core tests will be designated as NHIE organizations; however processes involved with formal certification are not part of this first year effort.

The overall goals of the entire NHIN Trial Implementation effort have previously been listed as:

- Demonstrate in-situ, interoperable and secure health information exchange based on common specifications
- Build a foundation for production level services and initiatives to come
- Demonstrate the Core Services, including

Data Services

- Secure data delivery, and confirmation of delivery, to EHRs, PHRs, other systems and networks
- Data look - up, retrieval and data location registries
- Support for notification of the availability of new or updated data
- Subject - data matching capabilities
- Summary patient record exchange
- Data integrity and non-repudiation checking
- Audit Logging and error handling for data access and exchange
- Support for secondary use of clinical data including data provisioning and distribution of data transmission parameters
- Data anonymization and re-identification as well as HIPAA de-identification

Consumer Services

- Management of consumer identified locations for the storage of their personal health records
- Support of consumer information location requests and data routing to consumer identified personal health records

- Management of consumer-controlled providers of care and access permissions information
- Management of consumer choices to not participate in network services
- Consumer access to audit logging and disclosure information for PHR and HIE data
- Routing of consumer requests for data corrections

User and Subject Identity Management Services

- User identity proofing, and/or attestation of third party identity proofing for those connected through that HIE
- User authentication, and/or attestation of third party authentication for those connected through that HIE
- Subject and user identity arbitration with like identities from other HIEs
- Management of user credentialing information (including medical credentials as needed to inform network roles)
- Support of a HIE-level, non-redundant methodology for managed identities

Management Services

- Management of available capabilities and services information for connected user organizations and other HIEs
- HIE system security including perimeter protection, system management and timely cross-HIE issue resolution
- Temporary and permanent de-authorization of direct and third party users when necessary
- Emergency access capabilities to support appropriate individual and population emergency access needs

- Demonstrate Use Cases as individually identified

The Goals of the NHIN Testing effort were to:

1) Confirm that the NHIE interfaces satisfy the requirements of the NHIE Interface Specifications
2) Work with other Workgroups to obtain a concrete definition of the NHIN Interface specifications necessary to implement the NHIN Core Services and Use Cases
3) Confirm that the NHIEs, when implemented according to the NHIE Interface Specification, can be used to demonstrate interoperable and secure health exchange for the NHIN Core Services and Use Cases
4) Improve the quality of the NHIE Interface Specifications so that they may be used for future NHIN and other HIT initiatives
5) Establish a baseline of test materials that can be used for future NHIN and other HIT initiatives

These goals were outcome statements that defined what an organization was trying to accomplish. The objectives associated with each goal were precise, time-based, measurable actions that supported the completion of a goal. The following table defines the specific objectives for each of the NHIN Testing Goals.

Table 1.2-1 NHIN Testing Objectives (mapped to Testing Goals)

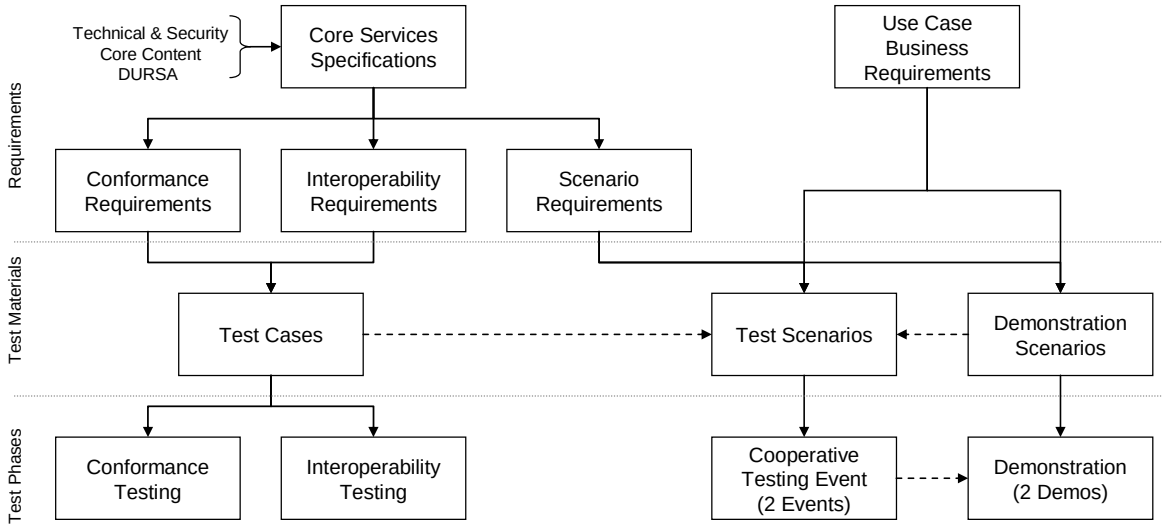
NHIN Testing Goals	Objectives
Confirm that the NHIE interfaces satisfy the requirements of the NHIE Interface Specifications.	Conduct conformance testing on all interfaces. Implement automated tests that can be used by any candidate NHIE organizations.
Work with other Workgroups to obtain a concrete definition of the NHIN Interface specifications necessary to implement the NHIN Core Services and Use Cases.	Define the interoperability requirements explicitly. Once these are defined, develop the explicit data exchanges required to test those Core Services and Use Cases. Subsequently, define the testing methodology (automated testing procedures) that will be used to evaluate these data exchanges.
Confirm that the NHIEs, when implemented according to the NHIE Interface Specifications, demonstrate the interoperable and secure health exchange of data required for the Core Services and Use Cases, and for any further purposes later deemed necessary by the other Workgroups.	Conduct interoperability testing on the Core Services and Use Case scenarios. Where possible, there should also be an automated evaluation of the systems' ability to interoperate with other NHIE organizations. For example, if system A should accept and store a patient's data, we would make a subsequent NHIE query to system A to ensure that the targeted data was properly found and returned. These tests must include response time requirements in addition to data requirements.
Improve the quality of the NHIE Interface Specifications so that they may be used for future NHIN and other HIT initiatives.	Review all NHIE specifications during their development and provide feedback to the Workgroups about the testability of the specification, about the expected response time characteristics associated with the specification, the ability of the initial test systems to satisfy the requirements of the specification, the preciseness (or lack thereof) of the specification, and about any unanticipated specification implicitly required.
Establish baseline of test materials that can be used for future NHIN and other HIT initiatives.	We assume that the only kind of testing that can be supported on an ongoing basis is automated testing. Hence, the ultimate goal is to automate as many test scenarios as possible and to define the data needed for those test scenarios. Where that is not possible in the current timeframe will define manual testing procedures.

2.0 SCOPE OF TESTING

This section describes the approach to the NHIN testing activities including an overview of the testing activities, a description of the items that were tested, the requirements that they were tested against, the phases as well as methods that were used to execute each phase.

2.1 TESTING OVERVIEW

The following diagram illustrates the testing approach and relationship between the requirements, test materials and test phases.



2.2 REQUIREMENTS

The Testing Workgroup culled requirements from the available proxies for this information, namely the interface specifications and privacy/security constraints published by other WGs, the core service definitions published for the project, and the contractual obligations levied on all contract awardees. Further, inasmuch as these sources were not written as explicit system requirements, the Testing Workgroup judiciously extrapolated requirements from these sources to form statements that are testable.

The Testing Workgroup enumerated the system requirements that were tested into three categories:

- Conformance requirements
- Interoperability requirements
- Scenario requirements

Where requirements are extrapolated, it is so noted, and each cites its source. In addition to these requirements, requirements and conformance methods from any included third-party documents (e.g. – HITSP specifications) were also used for testing purposes.

2.3 TEST PHASES AND METHODS

The Testing Workgroup designed tests that exercise every requirement, test scenarios that integrate requirements into various operational contexts, and test cases that detail how (i.e. – the exact procedures) a tester will execute all tests within their respective scenarios and how to record and evaluate results of that testing. The test cases also enjoin specific data to be used during testing. Some results may be evaluated at the point of testing while others may need to be recorded for a more analytical evaluation post-testing. The test cases are clear about these details.

The relationship among requirements, tests, test scenarios, and test cases are as follows:

- Every requirement has one or more tests that, taken together, validates its correct implementation, and each test maps to a single requirement
- Every test will be executed within at least one test scenario, and test scenarios each will exercise at least one test
- Every test scenario has one or more test cases that, taken together, cover all aspects of the scenario and executes all of its assigned tests

There were three test phases that comprised the full NHIN testing program:

- Conformance (unit) testing – This refers to the self-validation by the NHIEs of their information exchange capabilities, primarily around syntactic conformance of core data and information constructs
- Interoperability (integration) testing – This refers to the peer-to-peer testing by the NHIEs of their information exchange capabilities
- Cooperative (scenario) testing – This refers to the orchestrated workflow testing overseen by the Testing Workgroup which tests the integrated function of the NHIN with participation of all NHIEs in an interactive fashion

2.4 ITEMS TO BE TESTED

The testing regimen employed here was designed to determine correct operation of the macro information-exchange portion of the NHIN. This means that the focus explicitly excludes examination of the internal operation of the individual NHIEs, and instead evaluates NHIE-to-NHIE interaction. While each NHIE will not be internally examined, each *will* be considered a black box within the scope of this testing, thus subjecting its inputs and outputs to examination and enabling it to be judged acceptable or unacceptable by this testing effort. For information-exchange testing, determining the correctness of operation requires that two aspects be examined: the content or payload of the information being trafficked (referred to as “Information”), and the behavior of the system in effecting the exchange (referred to as “Exchange”).

The testing of the Information aspects of the system will include the following categories of evaluation:

- Syntactic conformance – This refers to the system’s ability to ensure the correct form of the information being exchanged based on required standards and constraints. Examples of this type of conformance include adherence to the definitions of message or document specifications, such as element length, element order, inclusion of required elements, etc.

- Semantic conformance – This refers to the system's ability to ensure the syntactically-correct content of the information being exchanged accurately represents the intended concepts. Examples of this type of conformance include referential-integrity checking of informational elements against prescribed vocabulary standards (e.g. – a given five digit code is actually valid within the endorsed version of the ICD-9 code set).
- Logical conformance – This refers to the system's ability to ensure the semantically-correct content of the information being exchanged accurately fulfils the intention of the exchange. Examples of this type of conformance include queries for specific information engendering appropriate responses in kind (e.g. – ensuring a request for a lab result is not fulfilled with a medication history, or referencing the wrong patient).

The testing of the Exchange aspects of the system will include the following categories of evaluation:

- Functional correctness – This refers to the system's ability to ensure the required activities take place appropriately according to the requirements. Examples of this type of conformance include ensuring correct routing of information, actual delivery of information, employment of appropriate security measures, etc.
- Performance and usability – This refers to the system's employment of appropriate and reasonable methods to fulfill the requirements. Examples of this type of conformance include fulfilling service-level agreements for availability, responsiveness, transaction levels, etc., that ensure the overall usability of the system.
- Robustness and stability – This refers to the system's ability to appropriately handle exceptional operational conditions. Examples of this type of conformance include graceful handling of boundary conditions of correct operation (e.g. – high loads), negative cases, edge-system malfunction, attempted security breach, etc.

Each of these testing categories was employed as appropriate given the requirements and planned testing methods described above. The following table maps testing items to the various testing phases:

Test Phase	Syntactic Conformance	Semantic Conformance	Logical Conformance	Functional Correctness	Performance & Usability	Robustness & Stability
1. Conformance Testing	Extensive	Limited				
2. Interoperability Testing	Extensive	Limited	Extensive	Extensive	Limited	
3. Cooperative Testing	Extensive	Limited	Extensive	Extensive	Limited	
4. Demonstration	Limited		Limited to Demo	Limited	Limited	

Tests in each phase can use both black box inspection and white box inspection methods. The predominant form of testing will be black box where inputs are manipulated (typically through varying test data) and resulting outputs are observed to determine correct operation. White box methods may be used when it is impractical to judge correctness solely through the variation of input, or when the resulting output obfuscates correctness of internal behavior. In white box testing, the object of a test may be decomposed into key waypoints of the functionality and those waypoints are observed/tested and/or the

underlying algorithm is manually examined and judged.[1] One example where this technique might be used is to verify that the correct versions of vocabularies are being utilized to create the content to be exchanged.

2.5 TESTING PROCESS

The Testing Workgroup developed test scenarios for each Perspective Use Case based on the functional requirements defined from each Perspective Workgroup as well as the data content specifications.

- Consumer Access to Clinical Information
- Registration and Medication History
- Emergency Responder
- Lab Results Reporting
- Medication Management
- Quality
- Biosurveillance

The test scenarios for each use case include actors involved, scenario pre-conditions, traceability to the use case requirements, and specific test case names (i.e. - peer-to-peer or cooperative test cases and inter HIE or intra HIE flow).

For the core services, test scenarios have been developed for each interface specification, which include the actors involved, scenario pre-conditions, and specific test case names. The core service interface specifications include:

- Health Information Exchange Message (HIEM)
- Consumer Preference Profile
- Service Registry
- Subject Discovery
- Query for Documents
- Retrieve Documents
- Audit Log

2.6 TEST DATA

For core service testing, each HIE contributed test patients compliant with the NHIN patient summary record as well as with the test data anonymization process. The patients were then normalized and ten test patients were defined for interoperability and cooperative testing. The patients were distributed across the HIEs to ensure adequate coverage for both positive and negative test cases.

For use case testing, each use case perspective group developed their own test patient including demographics and necessary data elements based on the data content specifications and use case requirements.

[1] Note that code walkthroughs are a form of white box inspection, but are not usually performed/verified by QA teams

3.0 CONFORMANCE TESTING PLAN

This section describes the activities within conformance testing including the overall objectives, procedures and responsibilities, methods and tools, and HIE test obligations.

3.1 OBJECTIVES

Conformance testing focused on validating a single system to single standards. This testing primarily dealt with ensuring that systems correctly encode the syntax and structure of a given data standard in the physical files or transactions that a system produces and receives.

3.2 PROCEDURES AND RESPONSIBILITIES

Before interoperability testing began, each HIE ensured their individual systems were compliant with the NHIN Specifications that had been defined by the Core Content Workgroup. This was accomplished by validating data specifications against existing conformance testing tools as defined in section 3.3.

3.3 METHODS AND TOOLS

The Trial Implementation Phase of the NHIN effort made use of existing conformance and interoperability test tools that, if necessary, had been modified to the delta of the NHIN Specification and its referenced standard.

The following test tools were available for the NHIN data content specifications:

Specification	Test Tool	Website
Query Documents	• XCA	• http://ihexds.nist.gov/nhin/
Retrieve Documents	• XCA • CDA – Guideline Validator	• http://ihexds.nist.gov/nhin/ • http://xreg2.nist.gov/cda-validation/index.html
NHIN Summary Patient Record	• CDA – Guideline Validator	• http://xreg2.nist.gov/cda-validation/index.html
Lab Document	• C37 – Guideline Validator	• http://xreg2.nist.gov/cda-validation/index.html

3.4 HIE CONFORMANCE TEST OBLIGATIONS

For Core Services conformance testing, each HIE was required to complete conformance tests for each core service specification. Information regarding the conformance test cases for each core service specification can be found in the Conformance Test Definition spreadsheets (Appendix Section 6.0).

For Use Case conformance testing, HIEs were responsible for ensuring C37 and C32 NHIN documents were conformant using the NIST validator depending on the use case assignment. Test data created for the Cooperative use case testing was also validated against the NIST tools.

4.0 INTEROPERABILITY TESTING PLAN

This section describes the activities within interoperability testing including the overall objectives, procedures and responsibilities, methods and tools and HIE test obligations.

4.1 OBJECTIVES

Interoperability testing focused on peer-to-peer testing. This testing primarily dealt with validating that multiple systems that implement a particular standard or set of standards can all communicate with one another.

4.2 PROCEDURES AND RESPONSIBILITIES

Prior to the Test Event, each HIE ensured that their individual systems could communicate with other HIEs. This was accomplished by performing peer-to-peer tests against other HIEs, the Federal Connect Gateway for core service testing, and with use case perspective groups for use case testing.

4.3 METHODS AND TOOLS

The Interoperability Testing Phase of the NHIN effort focused on peer-to-peer testing by NHIEs of their information exchange capabilities utilizing a set of interoperability test cases for core services as well as the use case perspectives.

For core services peer-to-peer testing, the steps for NHIN interoperability testing were developed by participants in the NHIN Testing Workgroup based on the defined interface specifications. Test cases were developed labeled ‘Peer-to-peer’ or ‘Interoperability’ for each core service specification. Peer-to-peer testing was conducted through self organization of HIE organizations based on readiness. Core service interoperability test cases are located in the Appendix.

For use case peer-to-peer testing, the steps for NHIN interoperability testing were developed by participants in each Use Case perspective. For each Use Case, a spreadsheet was created for both peer-to-peer and cooperative testing. Within each spreadsheet, peer-to-peer test cases are labeled ‘Peer-to-peer’ or ‘Interoperability’. All Use Case test cases can be found in the Appendix.

5.0 COOPERATIVE TESTING EVENT PLAN

This section defines the process and documents the testing requirements for the cooperative testing between each of the participants in the NHIN Trial Implementation project. Completion of the activities documented herein demonstrated the ability to exchange patient data among the HIEs involved as well as ensured that the data content and formats adhered to the required standards.

5.1 OBJECTIVES

The Cooperative Testing Events focused on scenario testing to test the ability of HIEs to successfully complete a pre-defined scenario showing interoperability and information sharing. Two testing events were held, each held several weeks prior to the corresponding NHIN demonstrations:

- Core Service Cooperative Testing Event – This event was held August 18th – 20th and focused on scenario testing of the core services
- Use Case Cooperative Testing Event -- The second event was held November 12th – 14th and focused on scenario testing of the use cases and new core services

The goal of the Cooperative Testing Events was to ensure a successful demonstration of the core services in September and to ensure a successful demonstration of the use cases at the NHIN public forum in December.

5.2 HIE COOPERATIVE TESTING OBLIGATIONS

The Cooperative test scenarios and cases for both Use Cases and Core Services are found in the Appendix. A zip file of test materials has been created for all of the Use Case Perspective as well as core service cooperative testing. The test cases labeled “Cooperative” are specific for this phase of testing. Each scenario identified the actor and steps required to complete the test. There could be multiple instances of a scenario depending on the actor. Each instance contained information on patient data and how to connect to other systems.

For the Use Case cooperative testing, there were two types of testing: inter-HIE testing and intra-HIE testing. Inter-HIE testing looked at the HIE to HIE exchanges for a given use case. The exchanges used the core services interface specifications. The intra-HIE testing looked at the functionality of a given system rather than testing to a specification or standard.

5.3 TEST RESULTS REPORTING

Two types of test results were tracked and reported at the event:

- Individual test results when performing workflow testing, which were tracked by the test monitors
- Summary matrix of the test results across HIEs, which was tracked by the Testing Workgroup

6.0 APPENDIX

This section contains the test materials developed by the NHIN Testing Workgroup including conformance, peer-to-peer, and cooperative test cases as well as the test data anonymization process and sample test data documents.

6.1 CORE SERVICES TEST MATERIALS

6.1.1 CONFORMANCE TESTING

Attached are the conformance test cases developed for the core service interface specifications.


Conformance Test Materials

6.1.2 INTEROPERABILITY AND COOPERATIVE TESTING

Attached are the interoperability and cooperative test cases developed for the core service interface specifications.


Core Services Test Materials

6.2 USE CASE TEST MATERIALS

Attached are the test cases for each Use Case perspective.


Use Case Test Materials

6.3 TEST DATA ANONYMIZATION PROCESS

Attached is the test data anonymization process developed by the Testing Workgroup for the creation of test data for the core service and use case peer-to-peer and cooperative testing.


Test Data Anonymization Pro

6.4 TEST DATA

Attached are sample documents used for core service and use case testing:

- C32 – Patient summary record, medication management, PHR summary record


C32 Sample Documents

- C37 – Lab results reporting


C37 Sample Documents