HEALTH IT
STANDARDS TESTING INFRASTRUCTURE

An Interoperability Test Bed for Distributed Healthcare Applications

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Interoperability for Enterprises System and Applications
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Overview

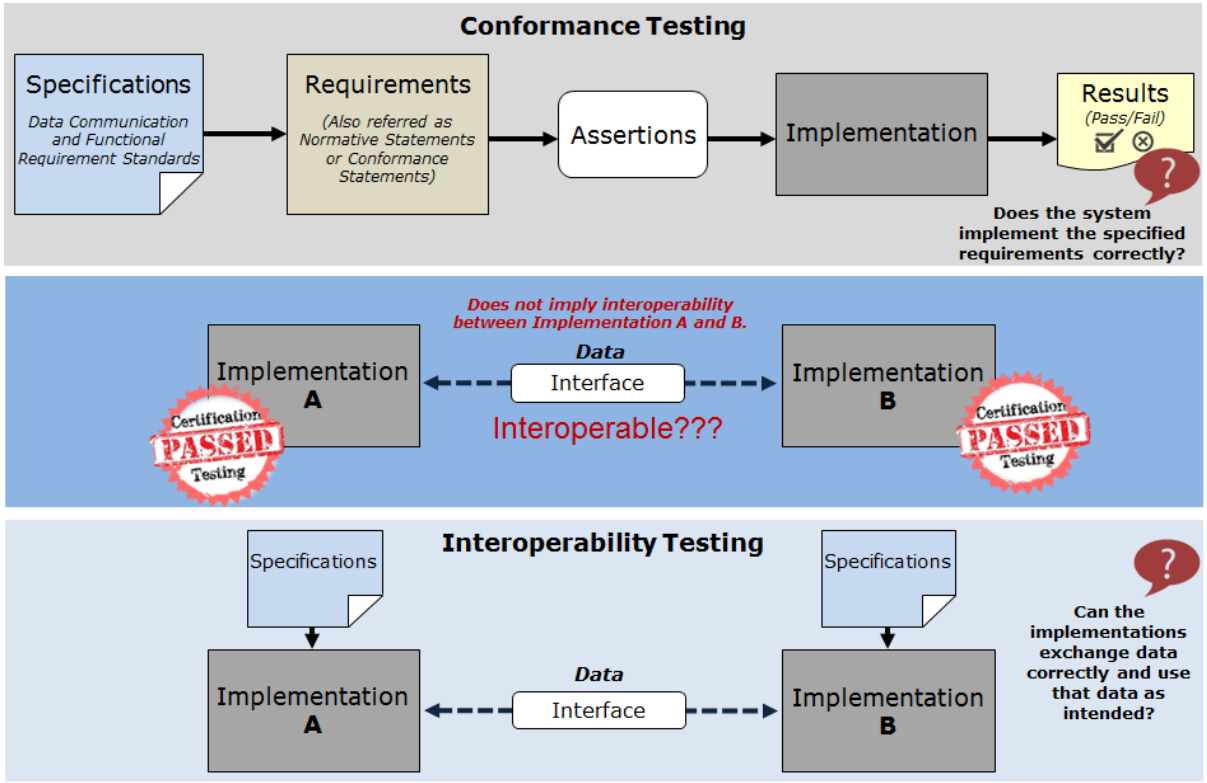
- Present an overview of the Interoperability Test Bed
  - Focus on Healthcare Standards
  - Depict a standards based approach to testing
  - Focus on the need for accurate conformance and interoperability requirements
  - Approach is Broadly Applicable
- Describe the Testing Environments
  - Illustrate the use of multiple testing environments
- Identify key aspects of the NIST Testing Infrastructure
  - Depict testing-related capabilities and services
- Present a case study for Patient Identification Cross-referencing
  - Examine the nature of disparate healthcare information technology systems
  - No national ID in the U.S.
  - Demonstrate the operational functionality of the interoperability test bed (ITB) through centrally managed test cases, test flows, test analysis, and test validation reports

NIST – National Institute of Standards and Technology

- U.S. Government Agency under the Department of Commerce
- Information Technology Laboratory (ITL)
  - To promote U.S. innovation and industrial competitiveness by advancing:
    - Measurement science; Standards; and Technology.
  - *through* the research and development in:
    - Information technology; Mathematics; and Statistics.
- Focus on Conformance and Interoperability
  - Specification and Testing of Standards
  - Healthcare Domain
  - Recent mandates within the U.S. to push for interoperability
    - Meaningful Use of EHR Technology (CMS – Center of Medicaid and Medicare)
    - EHR Certification
    - $40 Billion Dollar Program to promote *meaningful use* of EHR technology
    - Multiple stages (early stages focus is on system capabilities)
    - Later stages to focus on Interoperability—testing platform needed
    - NIST has built numerous conformance testing tools
    - Need for interoperability testing platform

Standards, Conformance, and Testing

- Important of Standards and Testing for Achieving Interoperability
  - "Not just standards but good standards"
  - Clear specification of requirements uses standard conformance constructs
- To achieve interoperability, testing must be an integral part of the process and must be continuous



IHE – Integrating the Healthcare Enterprises

- International organization promoting the use of healthcare standards **integration**
- Integration Profiles (Implementation Guides) that define the workflows in the healthcare domain
  - Data Communication Standards (HL7 V2, V3, CDA, DICOM, etc.)
  - Functional Requirements
- Many Domains
  - Laboratory Orders and Results
  - Infrastructure (e.g., Patient Identification, Document Sharing, etc.)
  - Public Health (Immunization, Syndromic, Reportable Labs, etc.)
  - Etc.
- Testing
  - Pre-connectathon
  - Connectathon
  - Gazelle Test Management Tool

IHE Testing

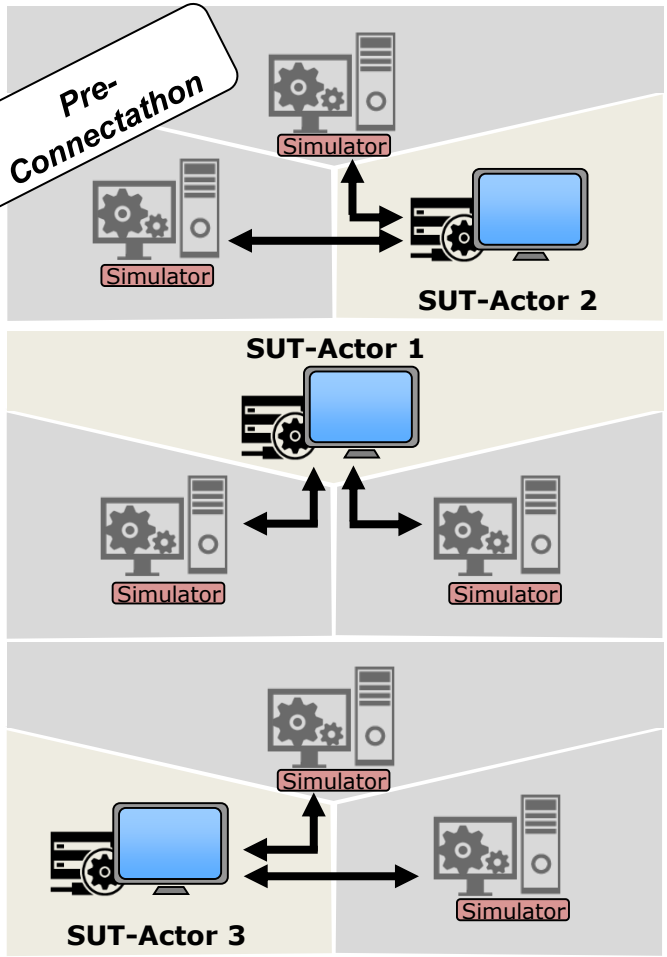
- Pre-Connectathon
  - Isolated Testing of Vendor's Capabilities
  - Conformance Testing
- Connectathon
  - Peer-to-Peer Testing
  - Interoperability Testing
  - Single Physical Location (U.S., Europe, Japan, etc.)
  - Large Room on closed network
  - Vendor selects domains (Integration Profiles) they wish to test
  - Monitors are used to verify tests (Some automation of tests)
  - Occurs once a year and costly
- IHE Gazelle Test Management Tool
  - Focuses on mostly organizing the test event (not actual testing)
  - Knowledge of systems, integration profiles, creating tests, running tests, evaluating test, evaluating vendors coverage and proficiency of profiles, etc.
  - Some utility to perform some automated testing

Interoperability Test Bed

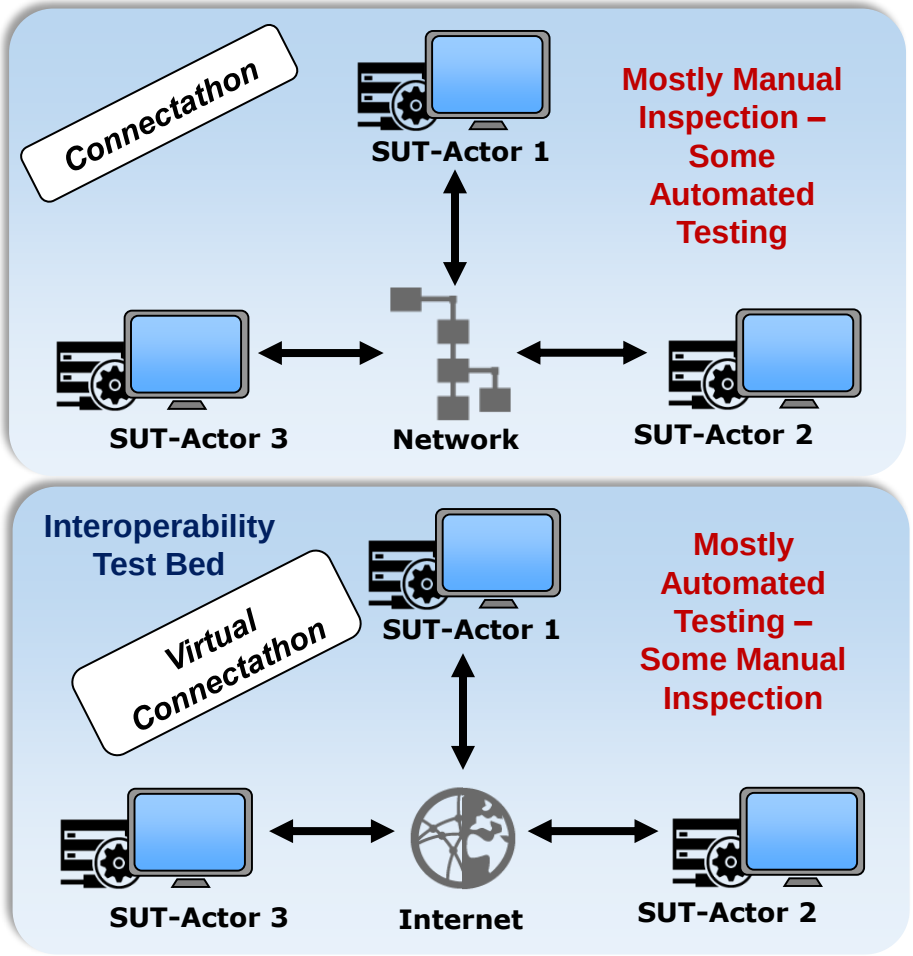
- Integrated into Gazelle Test Management Tool
- Support Pre-connectathon, Connectathon, and Virtual Connectathon Conformance
- Virtual Connectathon
  - High availability (Internet Based)
  - Leverages Gazelle's utilities to manage test cases
  - Leverages Gazelle's system registration
    - Users can find partners to test with (vendors that implement the same profiles)
    - Publish availability
    - Schedule testing time
  - Integrates testing capabilities and leverages Pre-connectathon conformance test tools and test cases
    - Leverages NIST Testing Infrastructure (used to build standalone conformance test tools)
  - Simulators can be substituted for vendor systems
    - Simulators provide functionality of real system (scaled down reference implementation)
    - Considering stored events of vendors to simulate interoperability testing using simulators
  - Dedicated proxy simplifies test execution

Testing Environments

Isolated System Testing (Conformance Testing)

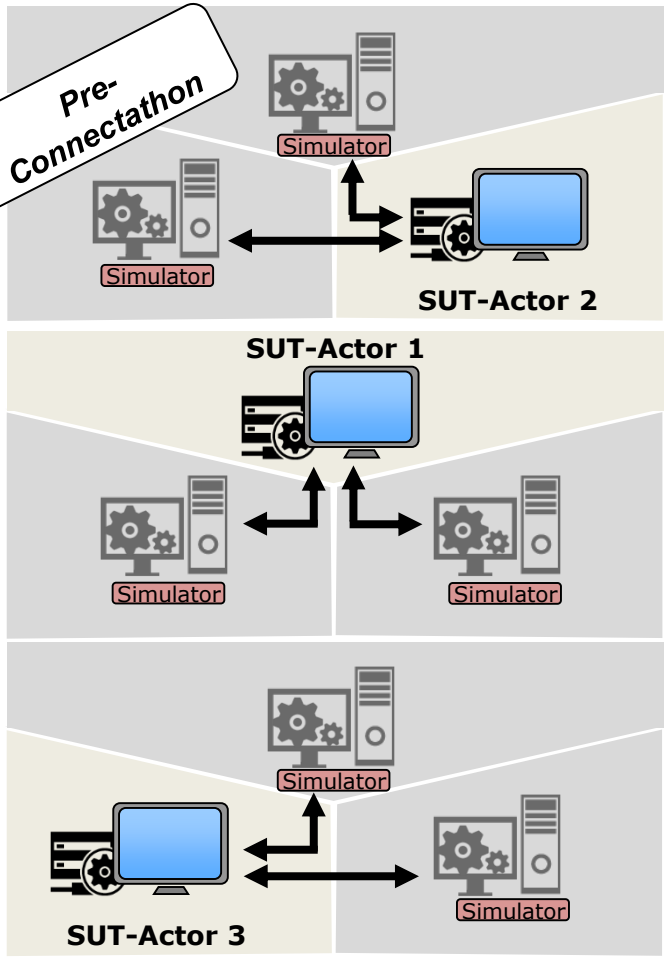


Peer-to-Peer System Testing (Conformance & Interoperability Testing)



Testing Environments (Replace SUT with Simulator)

Isolated System Testing (Conformance Testing)



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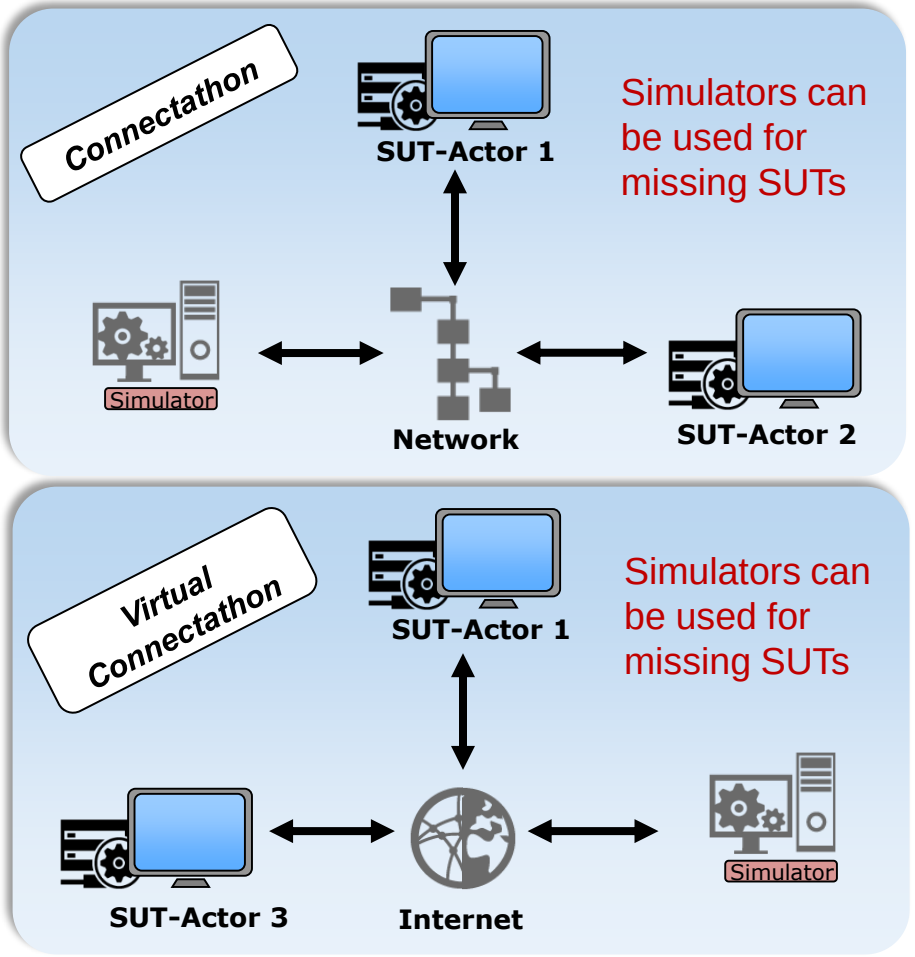

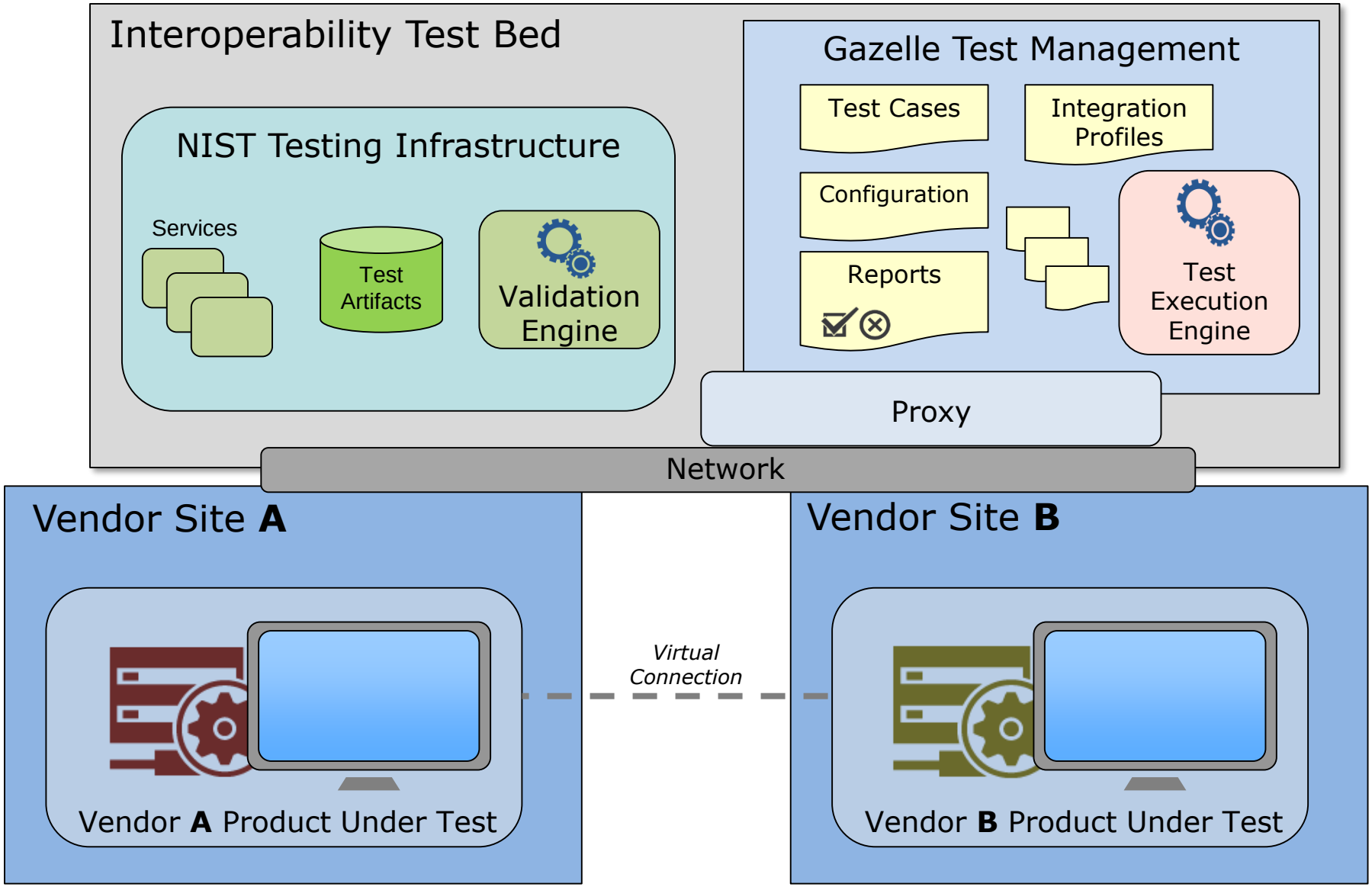
Interoperability Test Bed
NIST Testing Infrastructure
Services
Test Artifacts
Validation Engine
Gazelle Test Management
Test Cases
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Proxy
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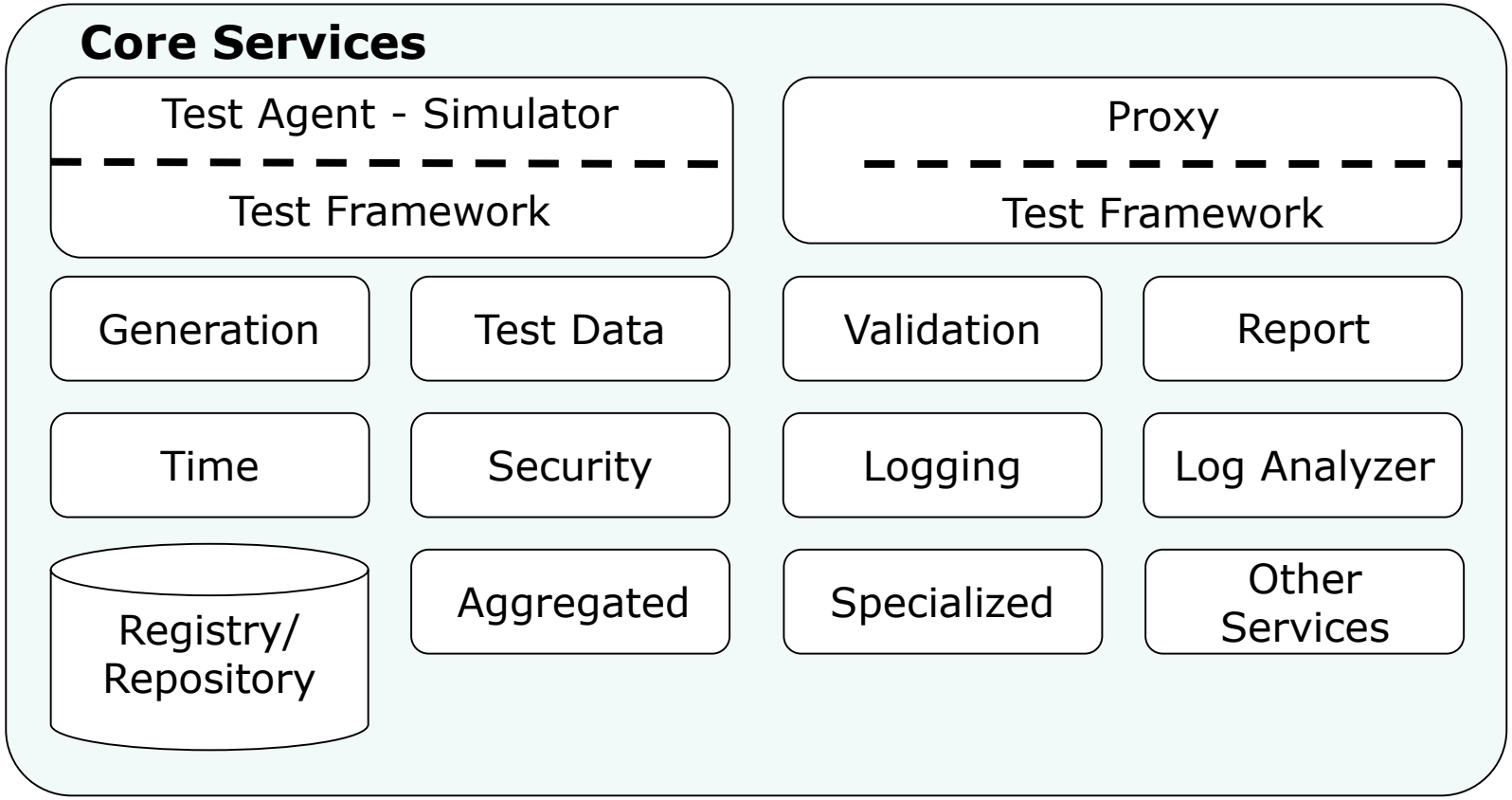
Vendor Site A
Vendor A Product Under Test
Virtual Connection
Vendor Site B
Vendor B Product Under Test

NIST Testing Infrastructure Core Services

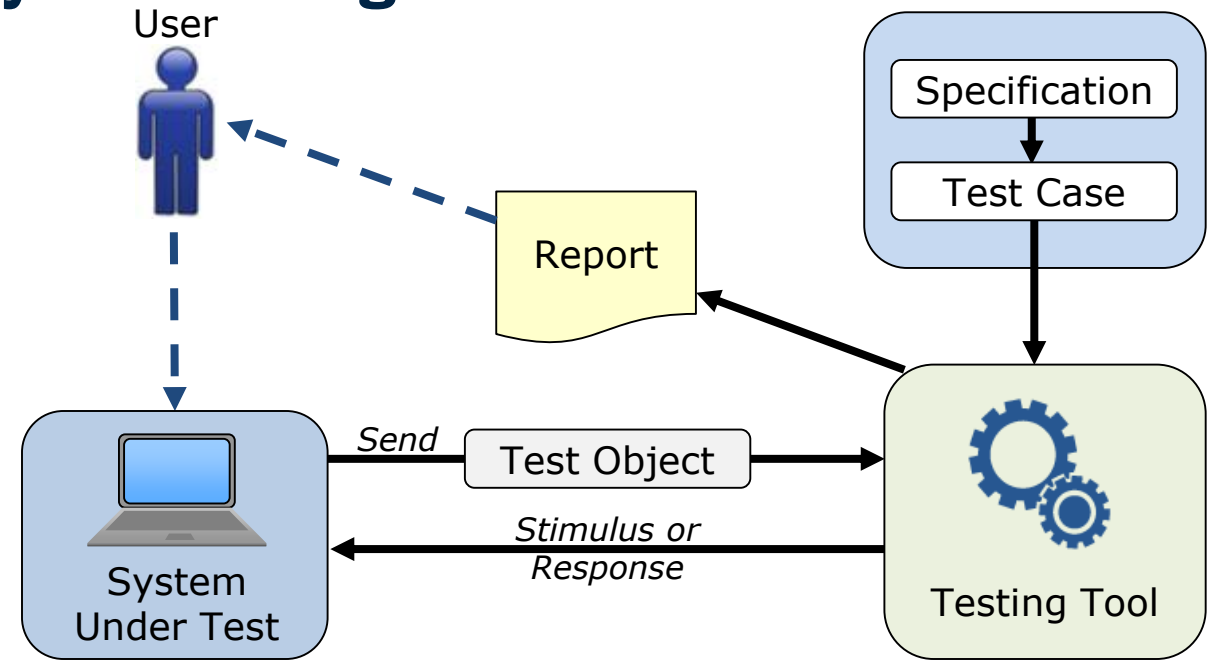


- Provide a portfolio of testing-related capabilities
  - Supported functions include
    - Validation of testing objects
    - Logging of test results
    - Deployment of test agents (Simulators)
    - Generation of test reports
- Preform unique functions
- Well-defined responsibilities and authority
- Multiple Services collaboratively work to support test case execution

NIST Testing Infrastructure

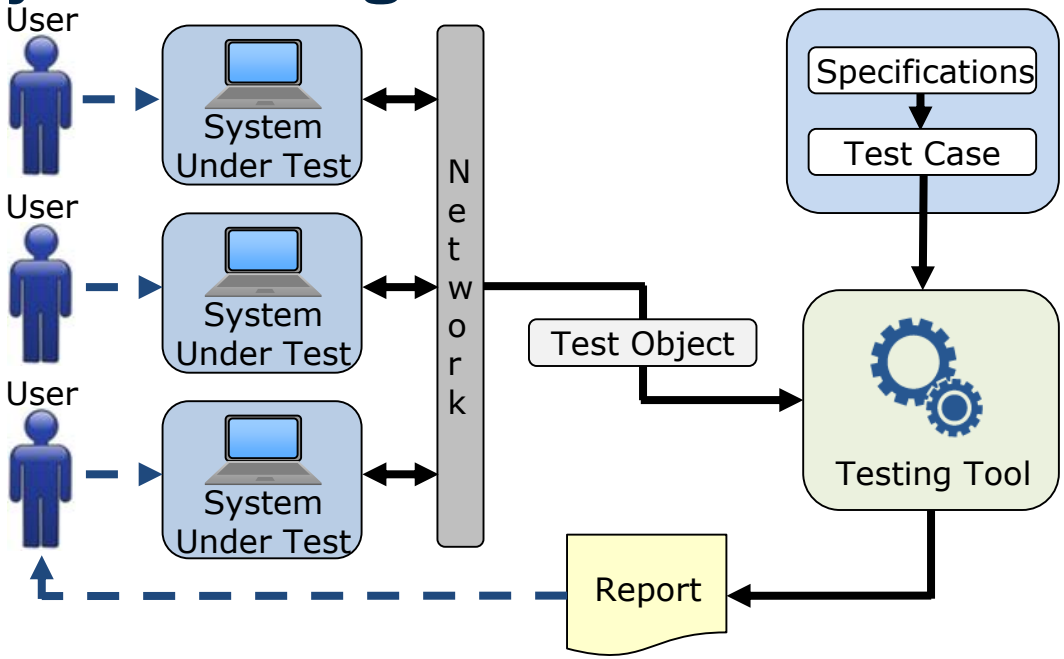
- Centralize health information technology testing resources
- Services-Provide robust support conformance and interoperability testing capability
- Supports a modular test system design
- Flexibility
  - Reusable components
  - Well-defined interfaces
  - Ad-hoc utilization
  - Customizable user defined configurations
- Extensibility
  - Independently ran and operated system components
  - Quick addition of new services
- Scalability
  - Distribution of resource requirements across multiple discrete systems

Isolated System Testing Environment



- Main objective: Conformance testing
  - Conducted with a system under test (SUT) and a testing tool
- Functional behavior assessment
  - Test scenario creates a sequence of transactions to validate requirements
- Test tool
  - Application functionality in normal SUT operational environment
- Upon successful conformance testing, interoperability testing proceeds

Peer-to-Peer System Testing Environment



- Main Objective: Interoperability Testing
  - Conducted with one or more SUTs and a testing tool
- Data Exchange Among a Group of Systems
  - Proxy employed to intercept, log, and rout messages
- Can Leverage Isolated (Conformance) Test Cases
  - Differing test steps, configuration requirements, and assertion assessment
- Interoperability Capability Declarations

CASE STUDY: PATIENT IDENTIFICATION CROSS-REFERENCING

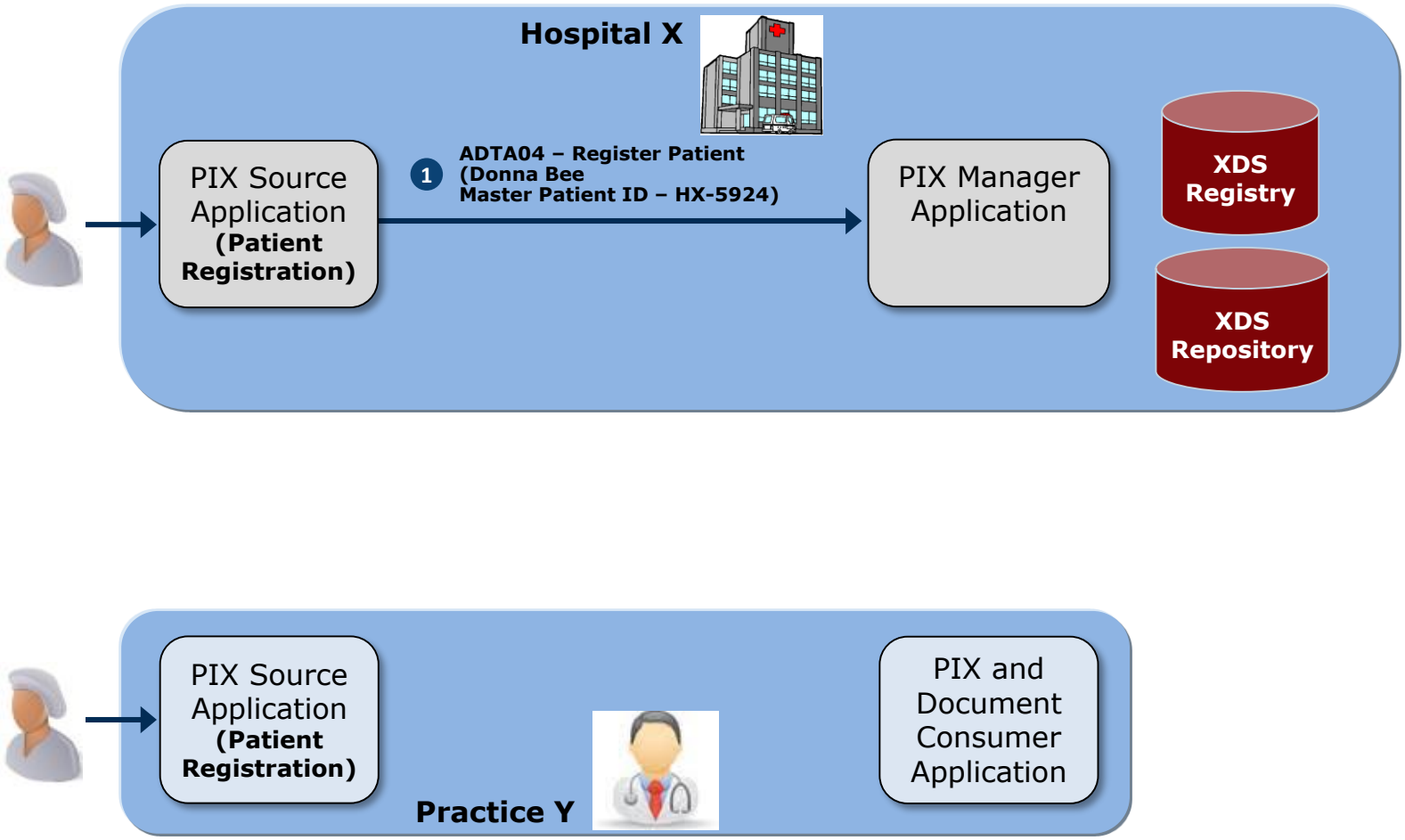
Case Study Overview

- Example case study and workflow that demonstrates typical transactions among disparate healthcare IT systems
- Healthcare systems manage patient data among multiple administrative domains
  - U.S. Patients have many patient identifiers (no national ID)
  - Patients require services in different domains
  - Records may exist across domains
  - Single (master) patient identifier used for document repository retrieval
- Patient identification cross-references is Integration Profile in the IHE infrastructure technical framework
- Case study focuses on using a local patient ID to obtain a master index patient ID to retrieve patient documents from a repository that references the patient information only with the master patient ID
- Resolving patient IDs is used often in practice. One example is querying for a Patient's Immunization Records where the records were submitted to the IIS by multiple sources—getting the correct Patient ID to access the records is the first step of this workflow.
- The Interoperability Ted Bed is design to support workflows for many of the IHE Integration Profiles (e.g., Lab Orders and Results, etc.)

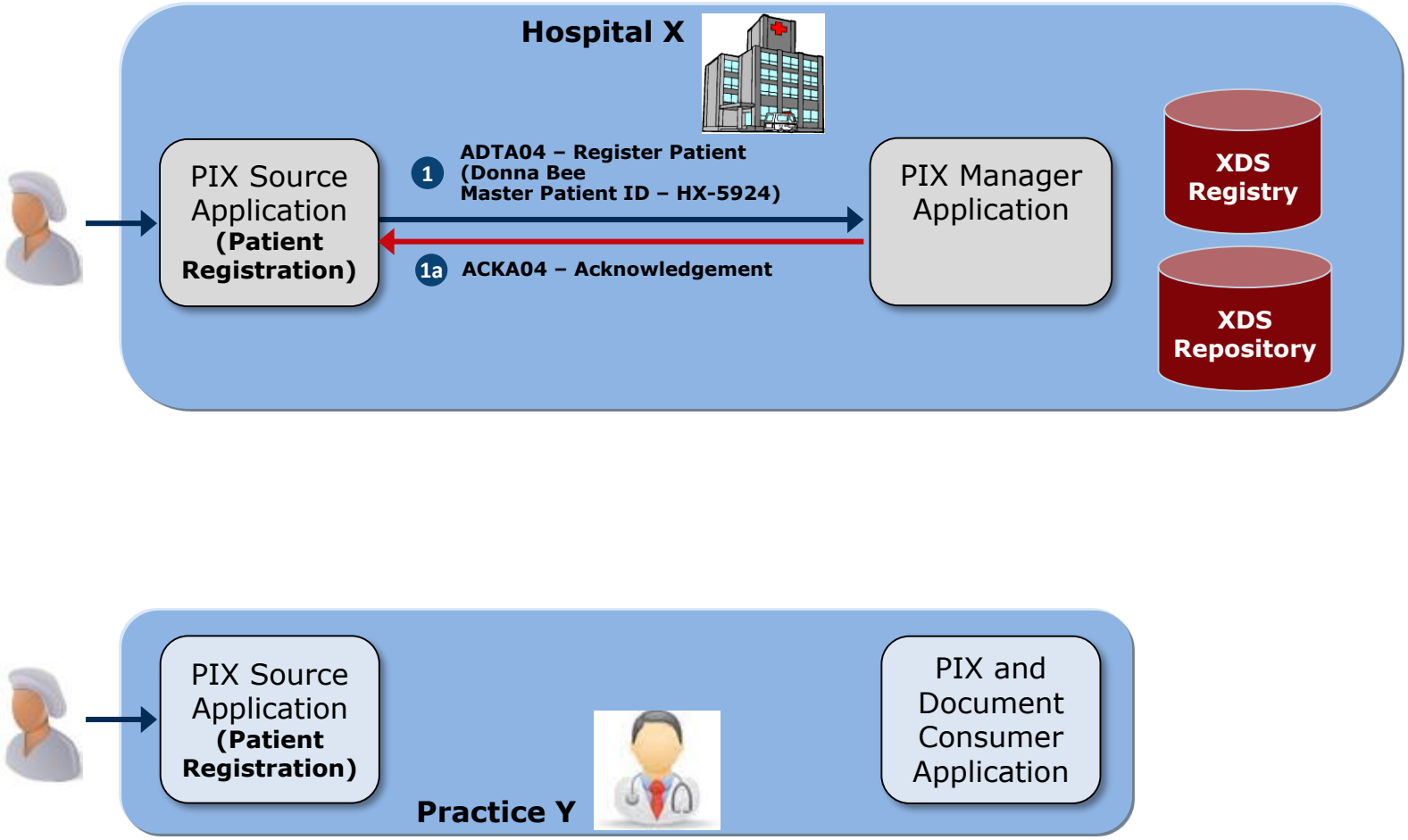
Case Study – Key Components

- Patient identifier and document management systems
  - Patient Identifier Cross-referencing (PIX) Domain
  - Cross-Enterprise Document Sharing (XDS) System
    - Support registering and retrieving documents across enterprise with an administrative domain
- Patient identifier cross-referencing manager (PIX Manager)
  - HL7 V2 data exchange standard
    - Messages enable actor communication
- Actors
  - PIX Source
    - Used for adding and modifying patient demographic data
  - PIX Manager
    - Used for managing and cross-referencing patient identifiers from different domains
  - PIX Consumer
    - Used for querying a PIX Manager for patient identifiers

Patient Identification Cross-Referencing



“Donna Bee” Scenario, continued



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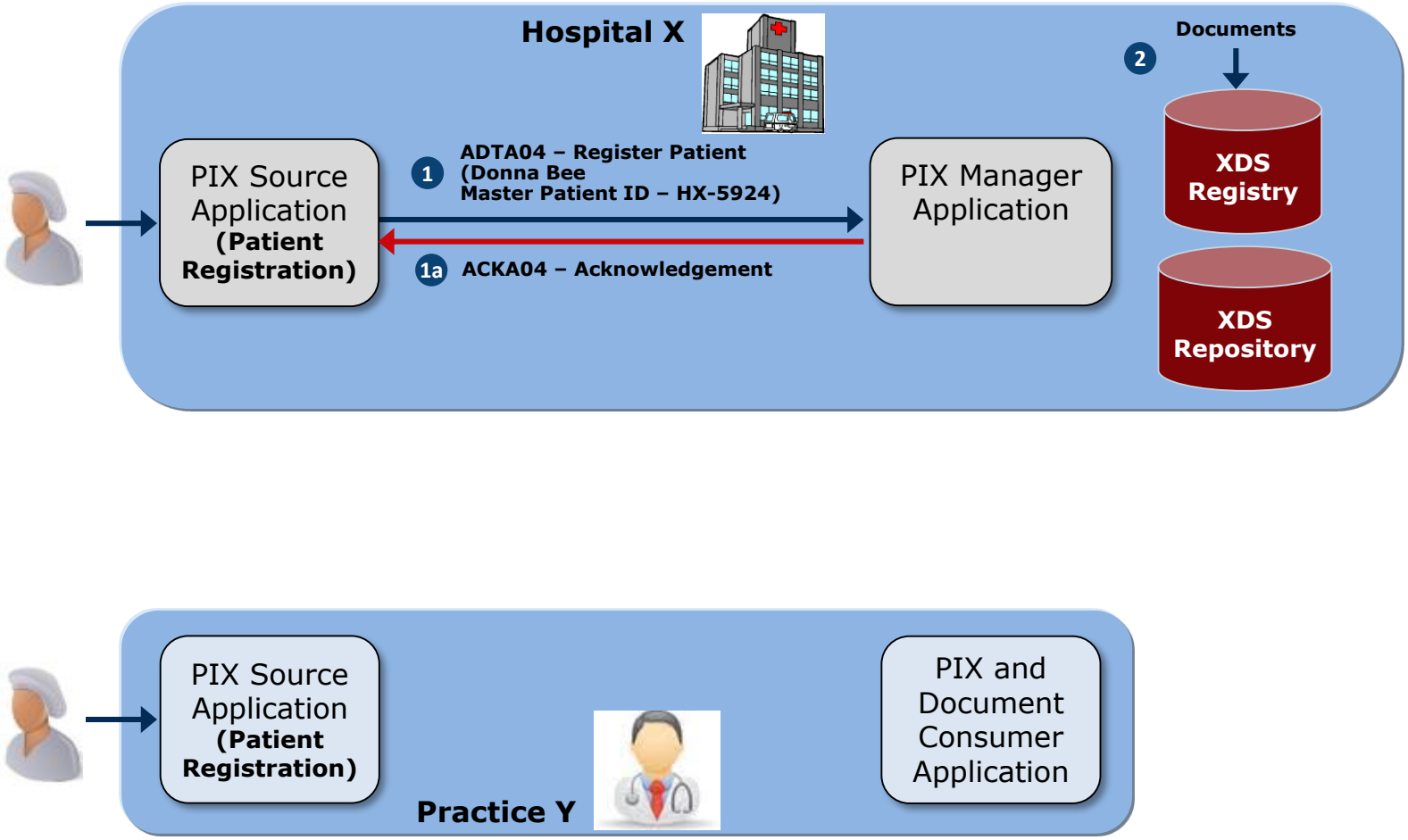

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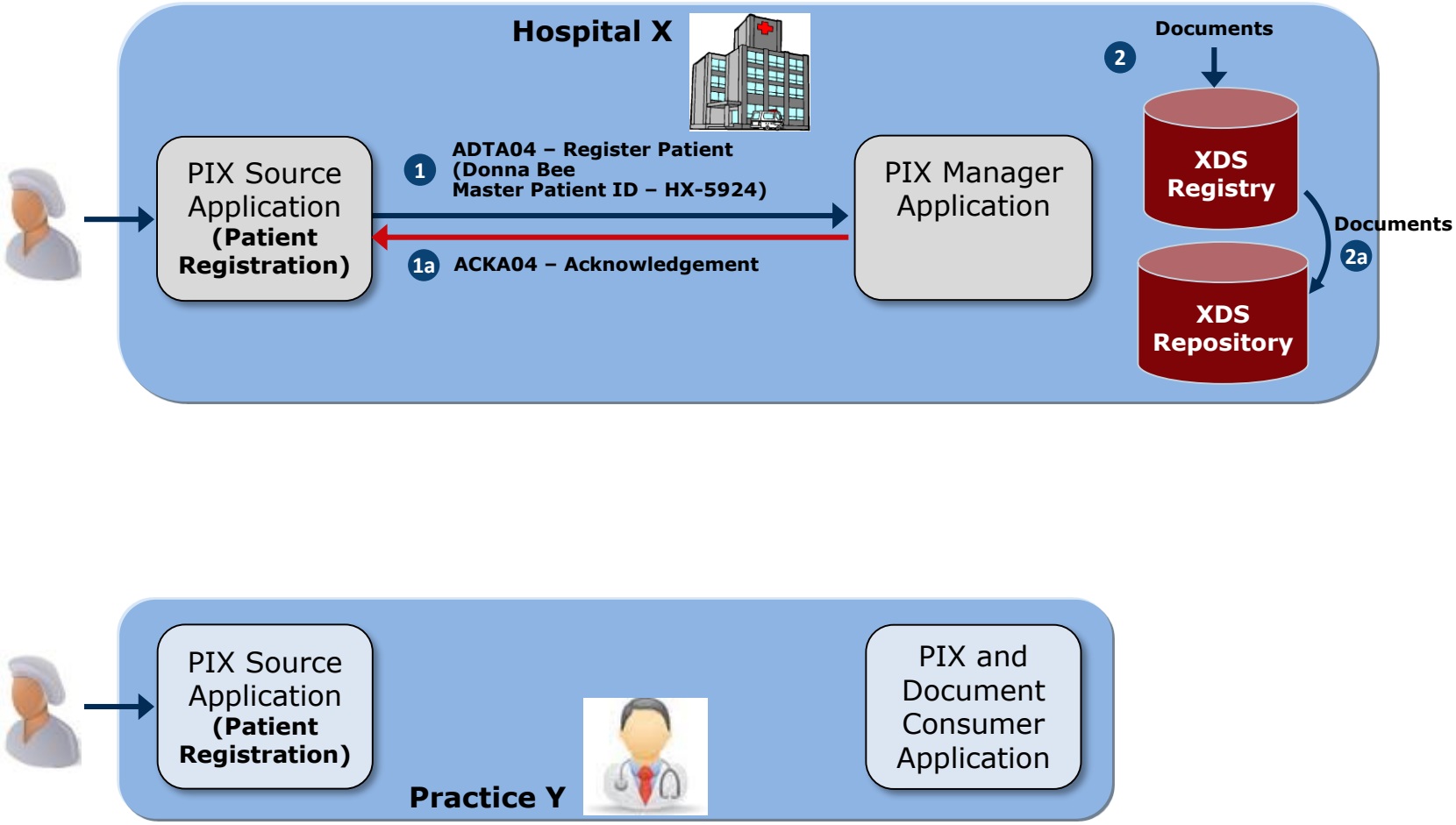

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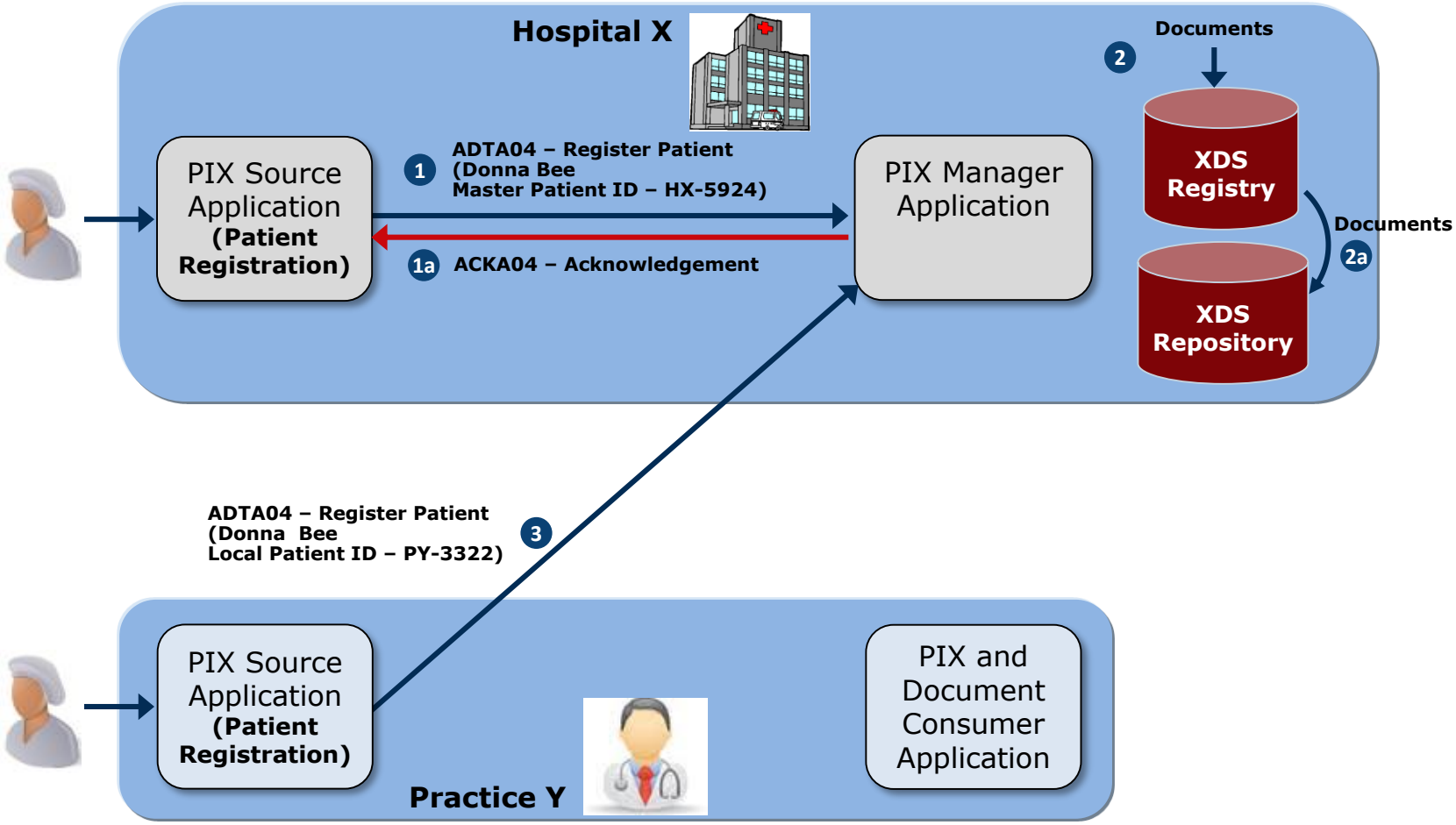

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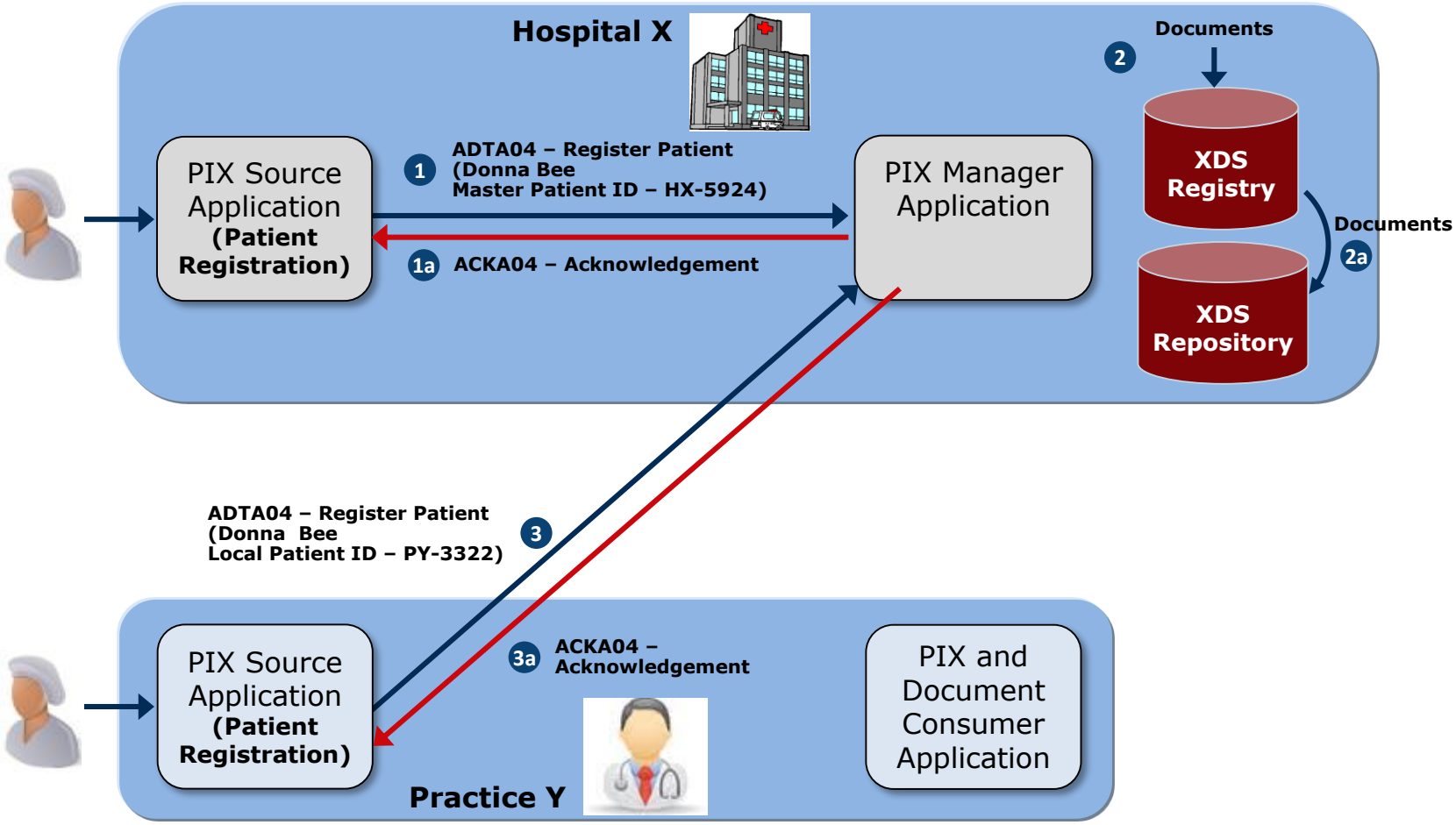

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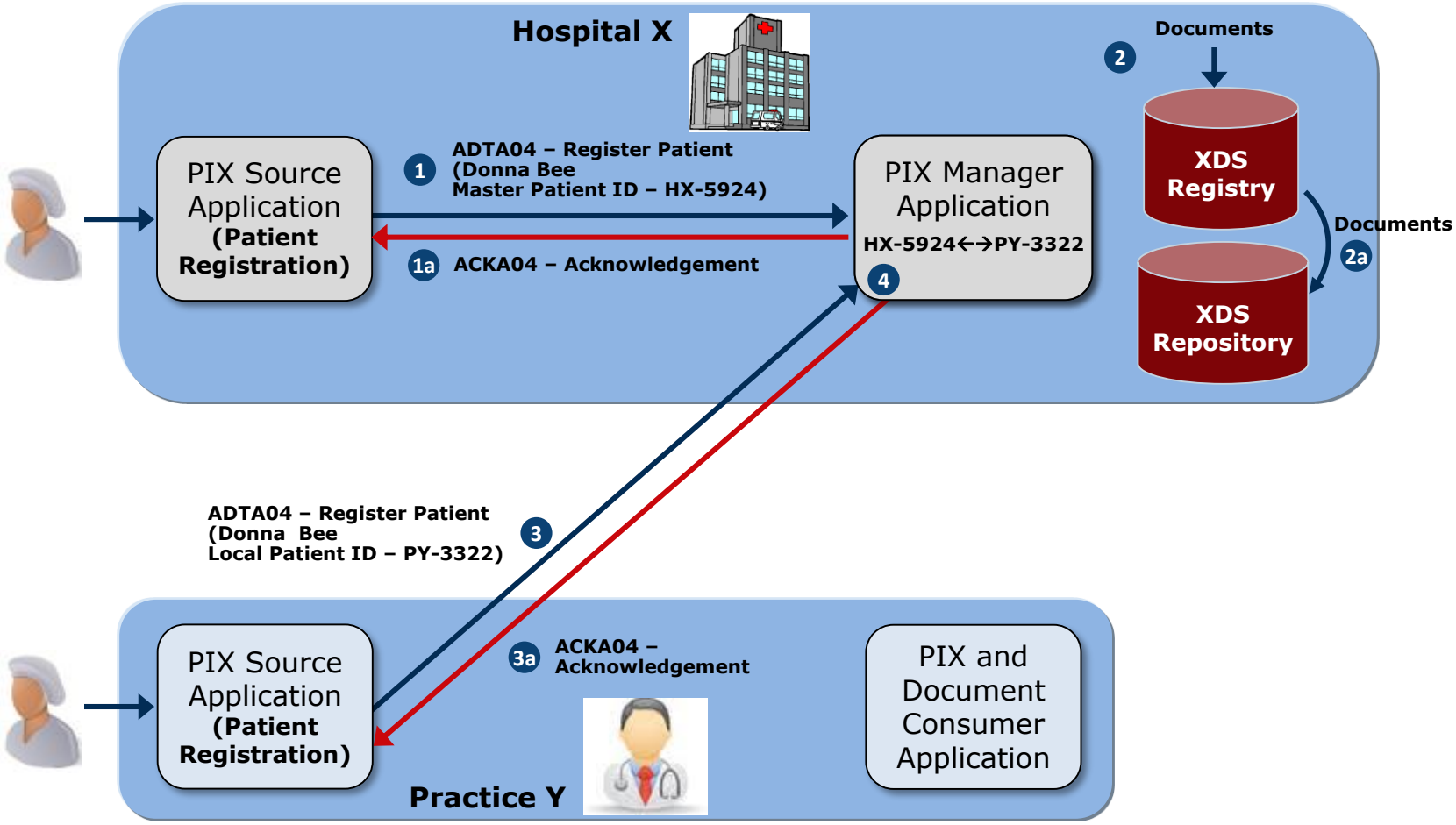

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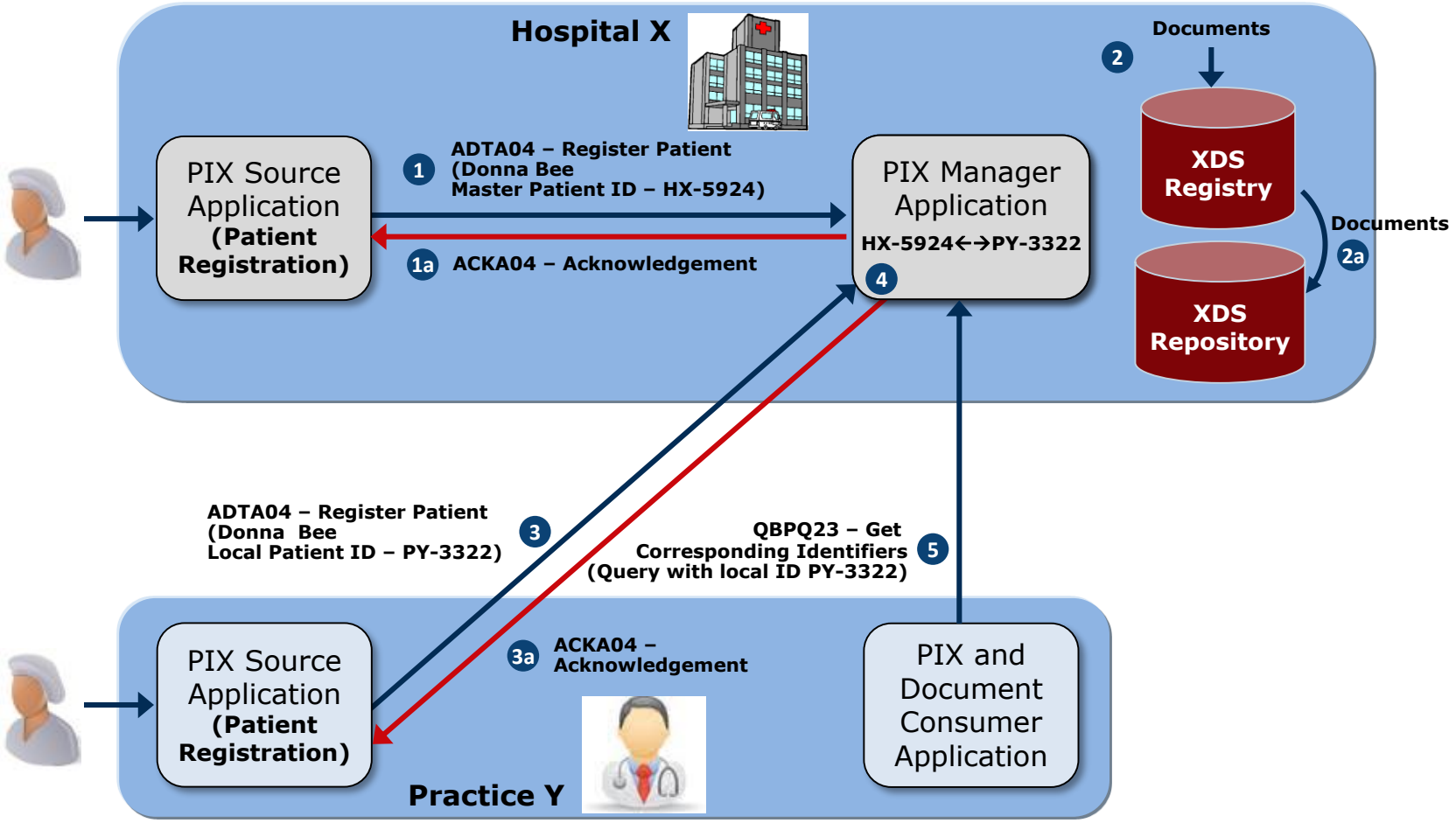

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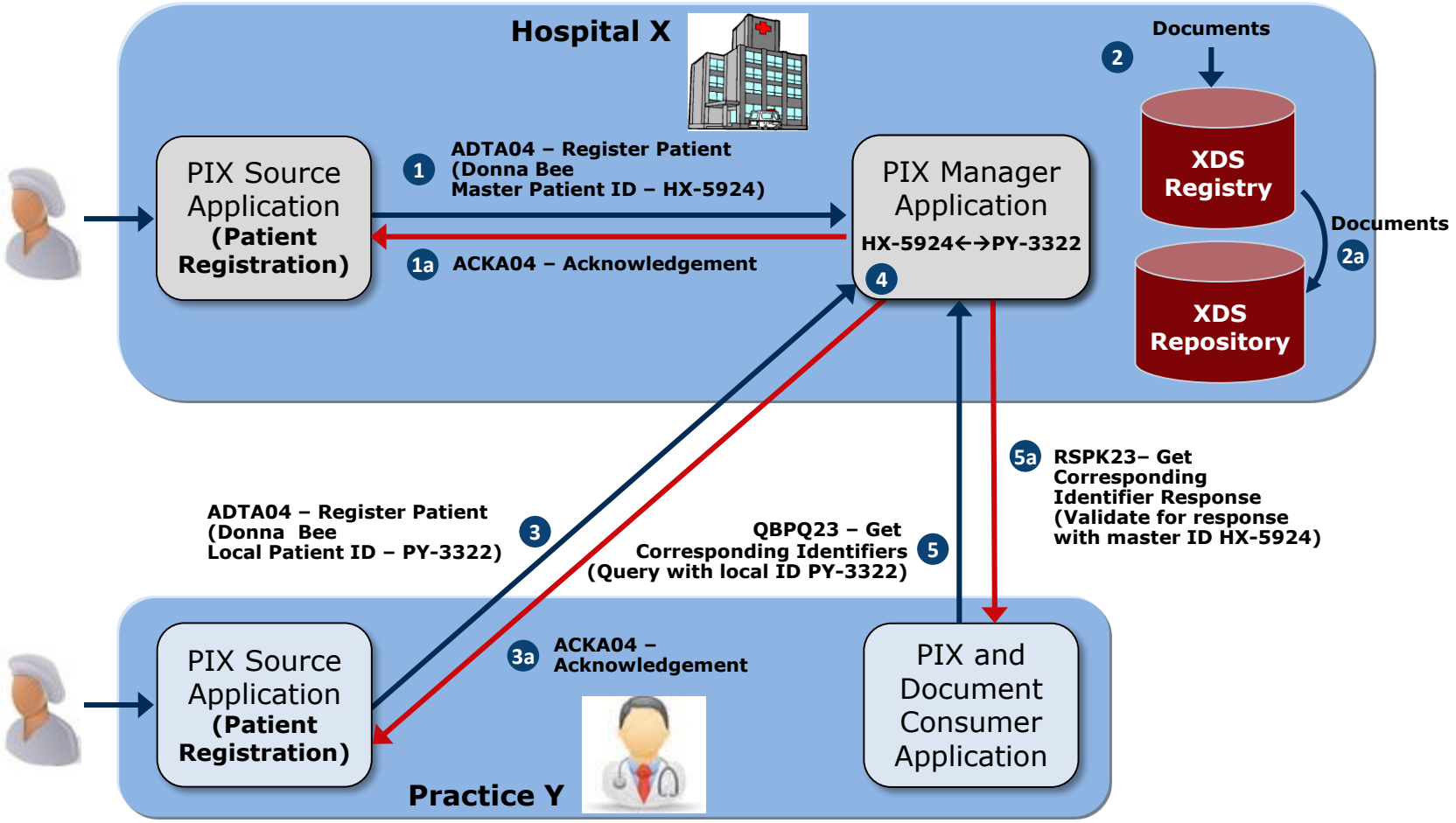

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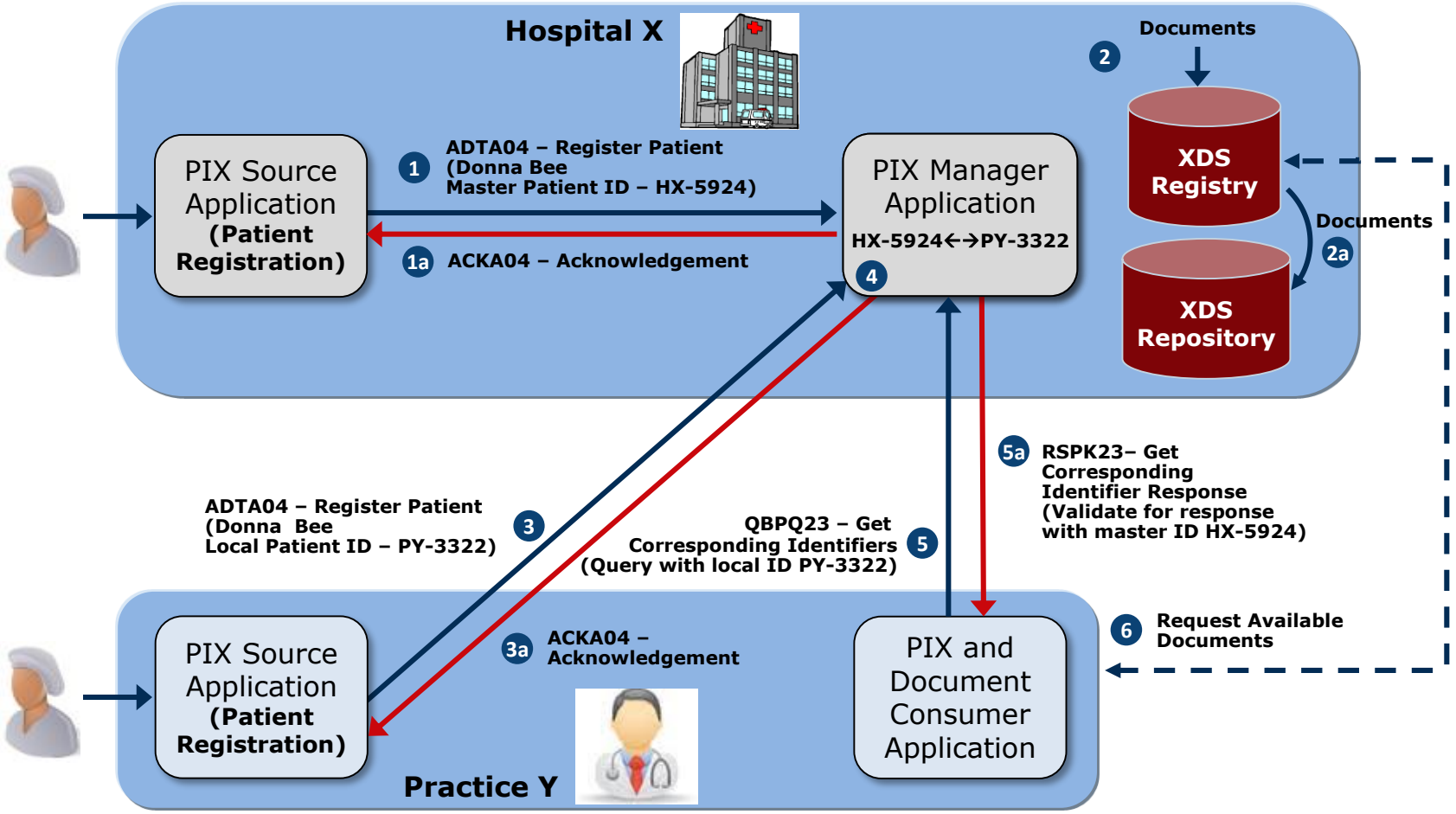

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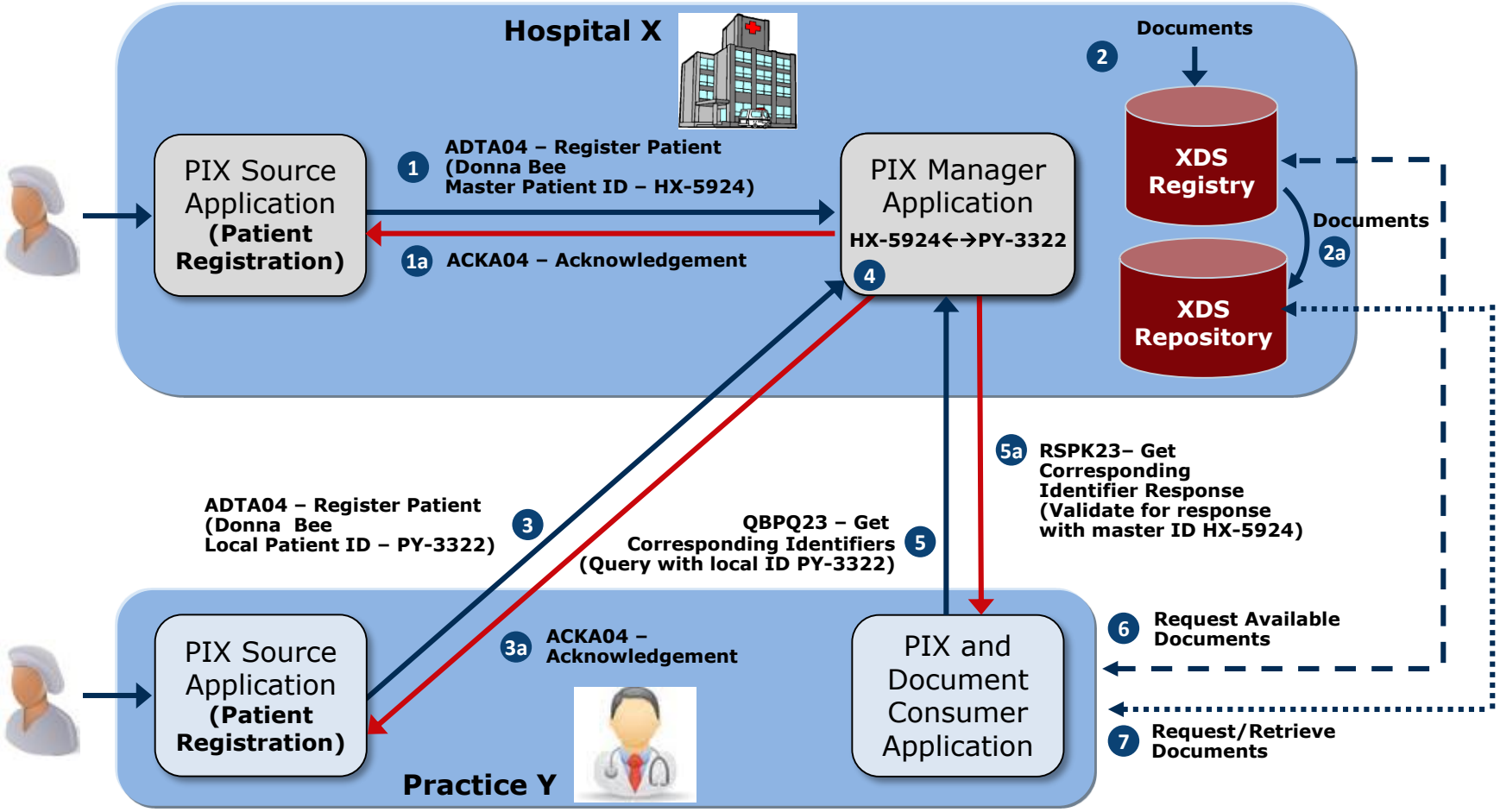

Testing Environments

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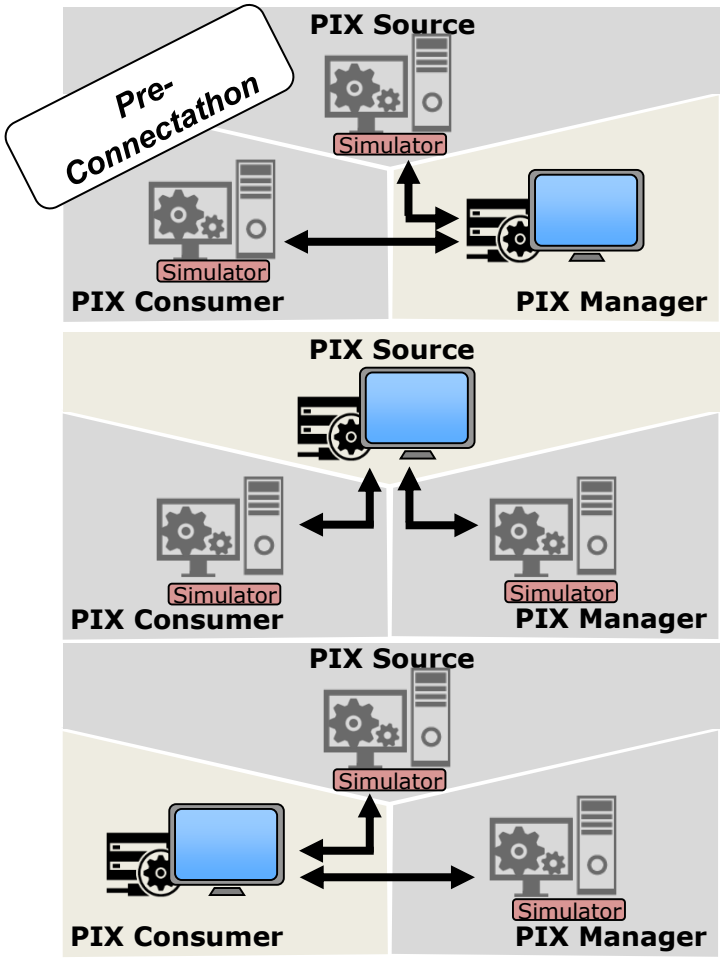

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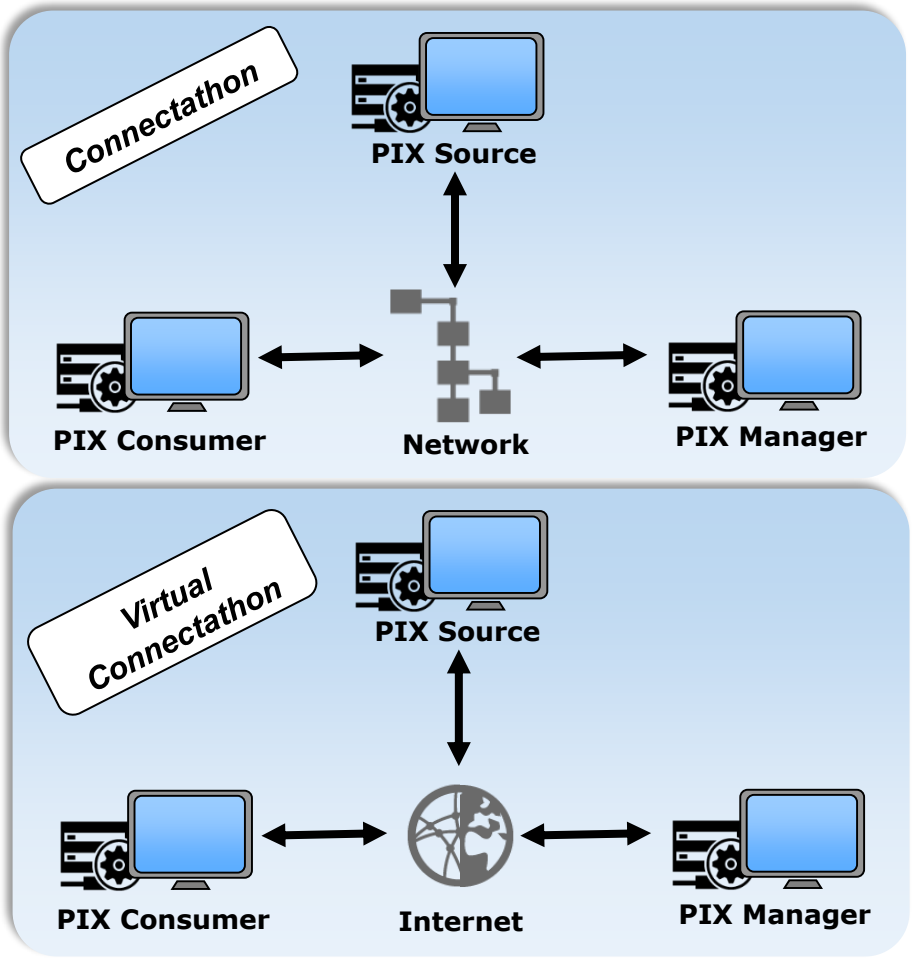

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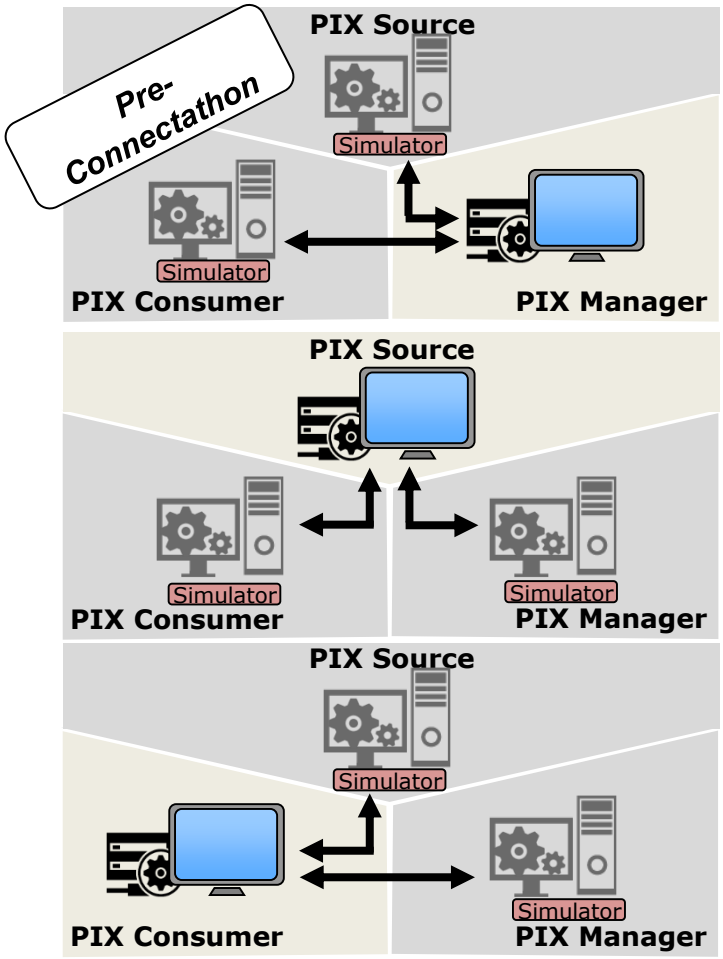

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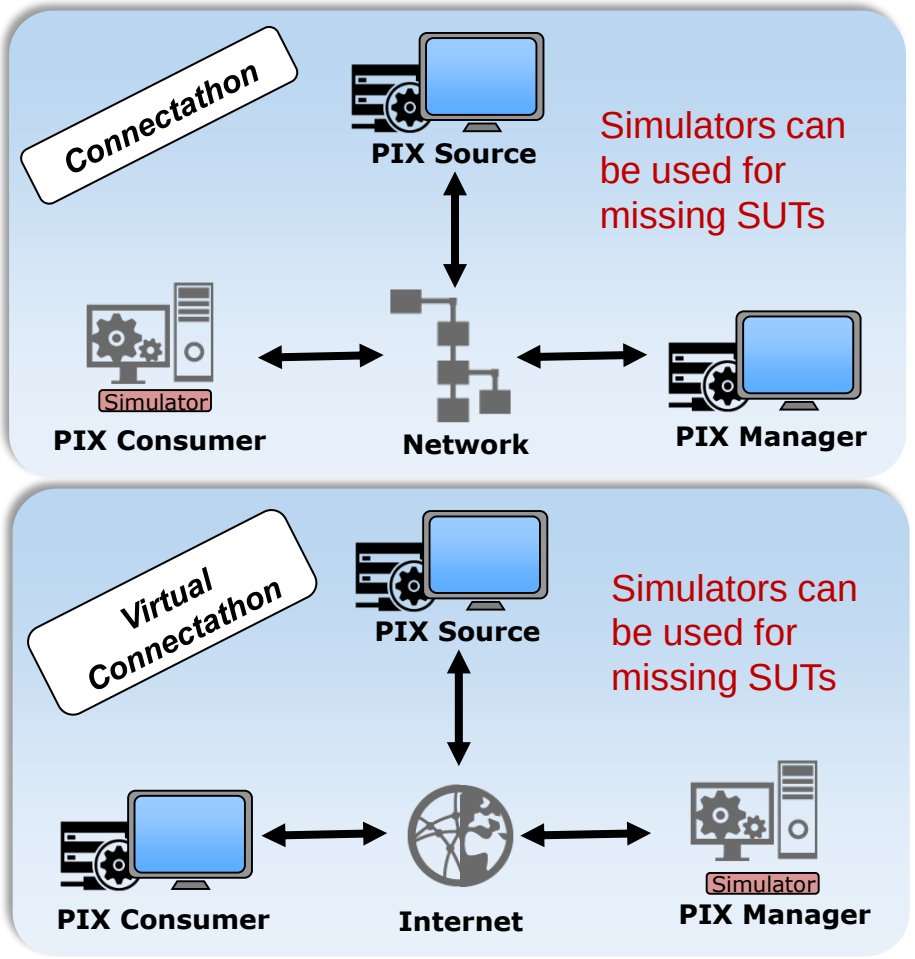
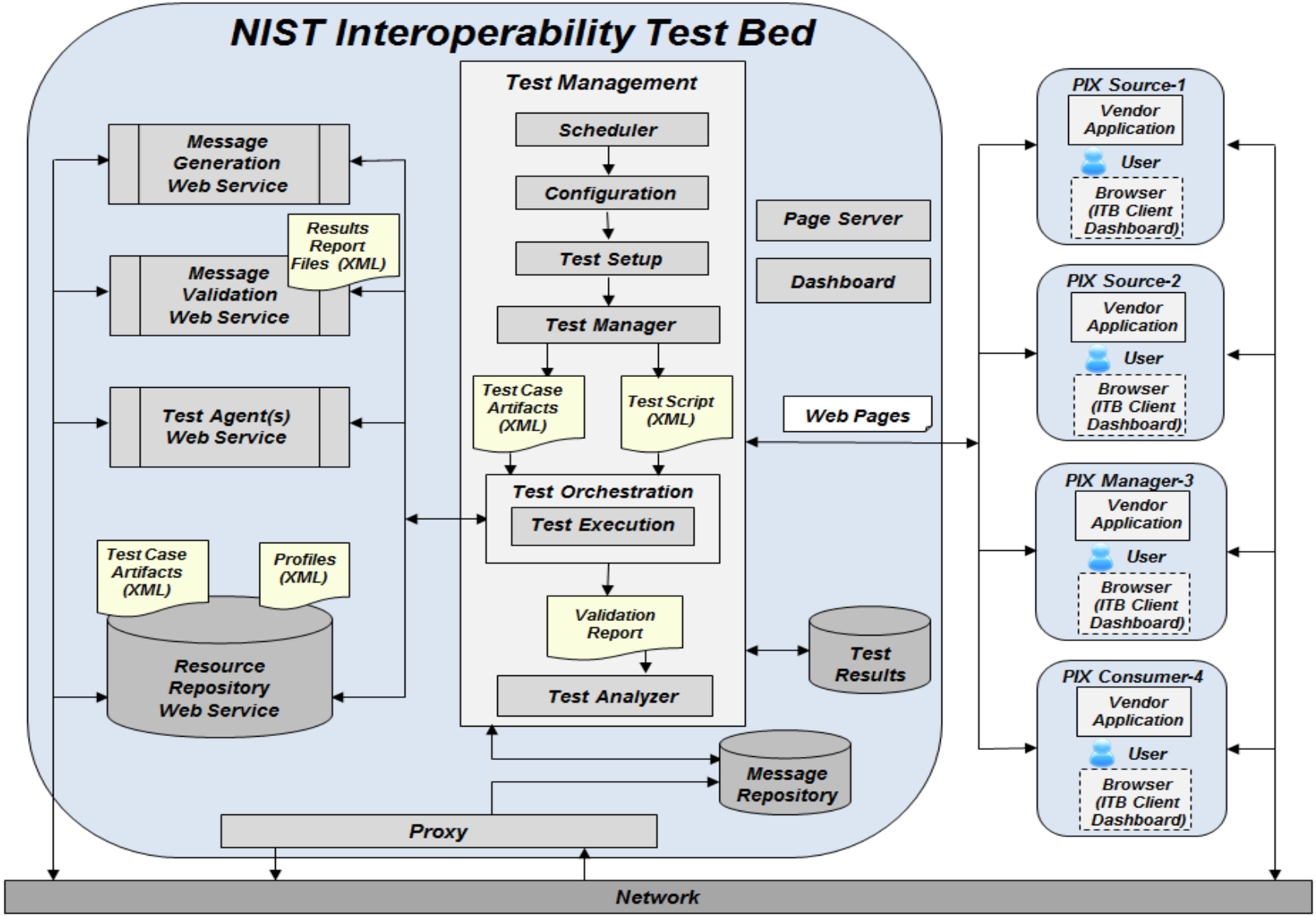


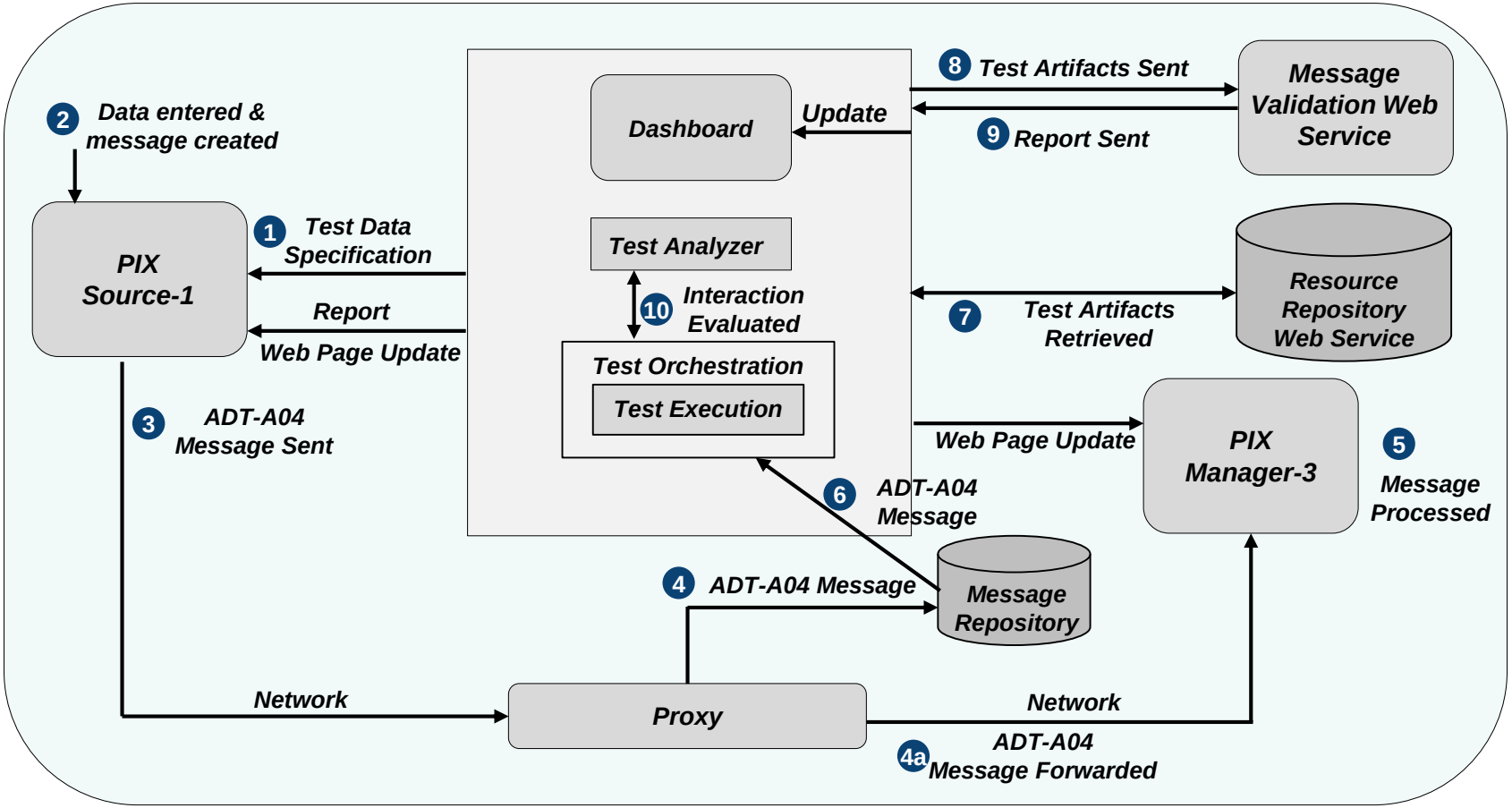
INTEROPERABILITY TEST BED

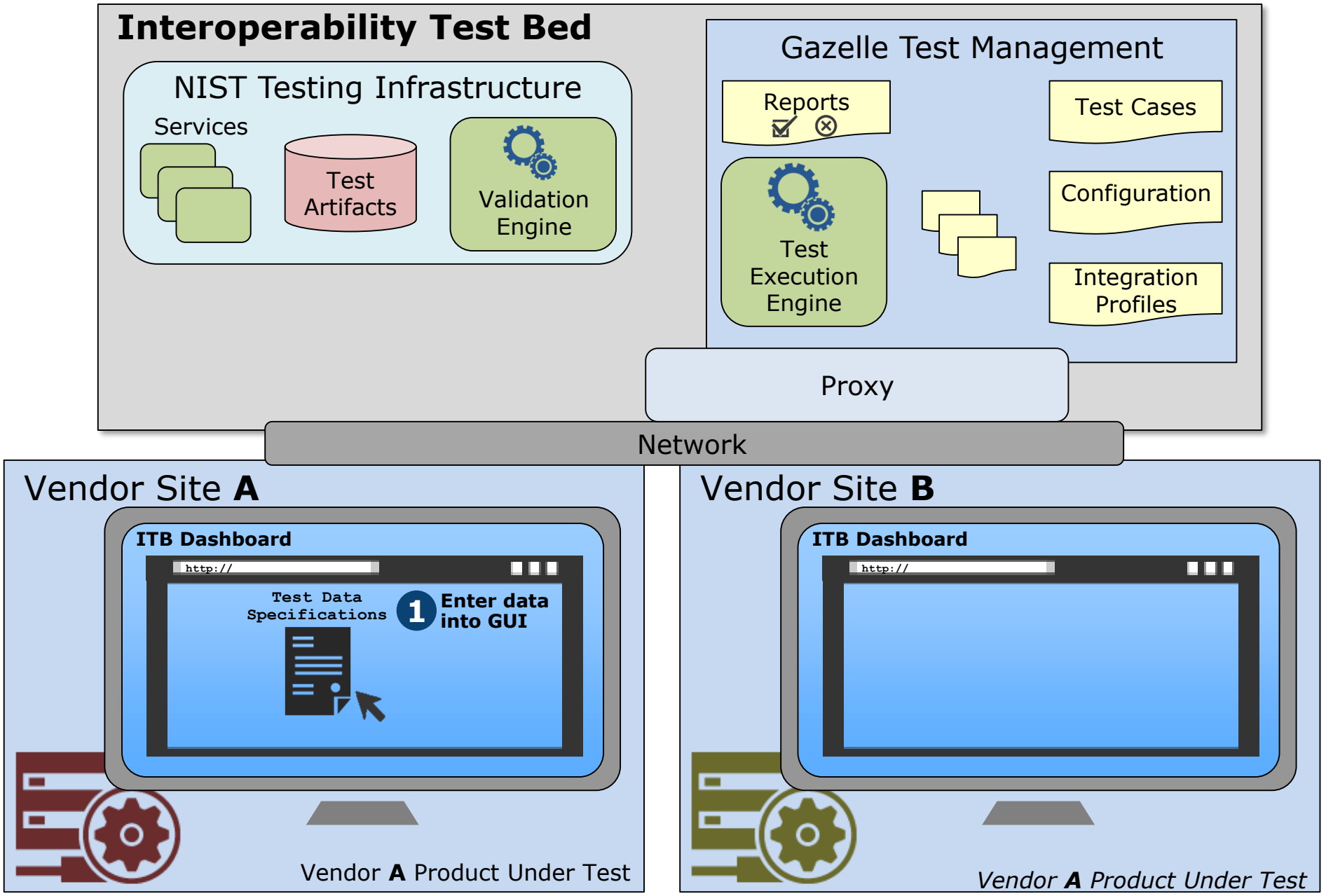

NIST Interoperability Test Bed
Test Management
Scheduler
Configuration
Test Setup
Test Manager
Test Case Artifacts (XML)
Test Script (XML)
Test Orchestration
Test Execution
Validation Report
Test Analyzer
Message Generation Web Service
Message Validation Web Service
Results Report Files (XML)
Test Agent(s) Web Service
Test Case Artifacts (XML)
Profiles (XML)
Resource Repository Web Service
Page Server
Dashboard
Web Pages
Test Results
Message Repository
Proxy
Network
PIX Source-1
Vendor Application
User
Browser (ITB Client Dashboard)
PIX Source-2
Vendor Application
User
Browser (ITB Client Dashboard)
PIX Manager-3
Vendor Application
User
Browser (ITB Client Dashboard)
PIX Consumer-4
Vendor Application
User
Browser (ITB Client Dashboard)

Logical Operational Divisions / Functions

- **Scheduling:**
  - Coordinates the vendors and aligns interest in test selection, actors, and time availability
- **Configuration:**
  - Records required communication, connection, and addressing for participants
- **Test Setup:**
  - Informs participates of the test case instructions
- **Test Manager:**
  - Controls the overall ITB operation
- **Test Orchestration:**
  - Organizes and coordinates vendor and the test system activities
- **Test Execution:**
  - Workflow management tool; directs test case execution through testing services
- **Status Broadcasting:**
  - Status update broadcast, through served pages, to participants for each performed task
- **Message Handling:**
  - The capturing, storing, analyzing, and forwarding of messages as the progress through the system
- **Singular Analysis:**
  - Each system interaction (message) is assembled and evaluated; a report is rendered and delivered to participants
- **Collective Analysis:**
  - The test analyzer uses the test script for navigating, linking, and analyzing individual validation reports
- **Storing Test Results:**
  - Test results are stored for analysis and auditing purposes

Interoperability Test Bed: Test Flow




Interoperability Test Bed
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Services
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Validation Engine
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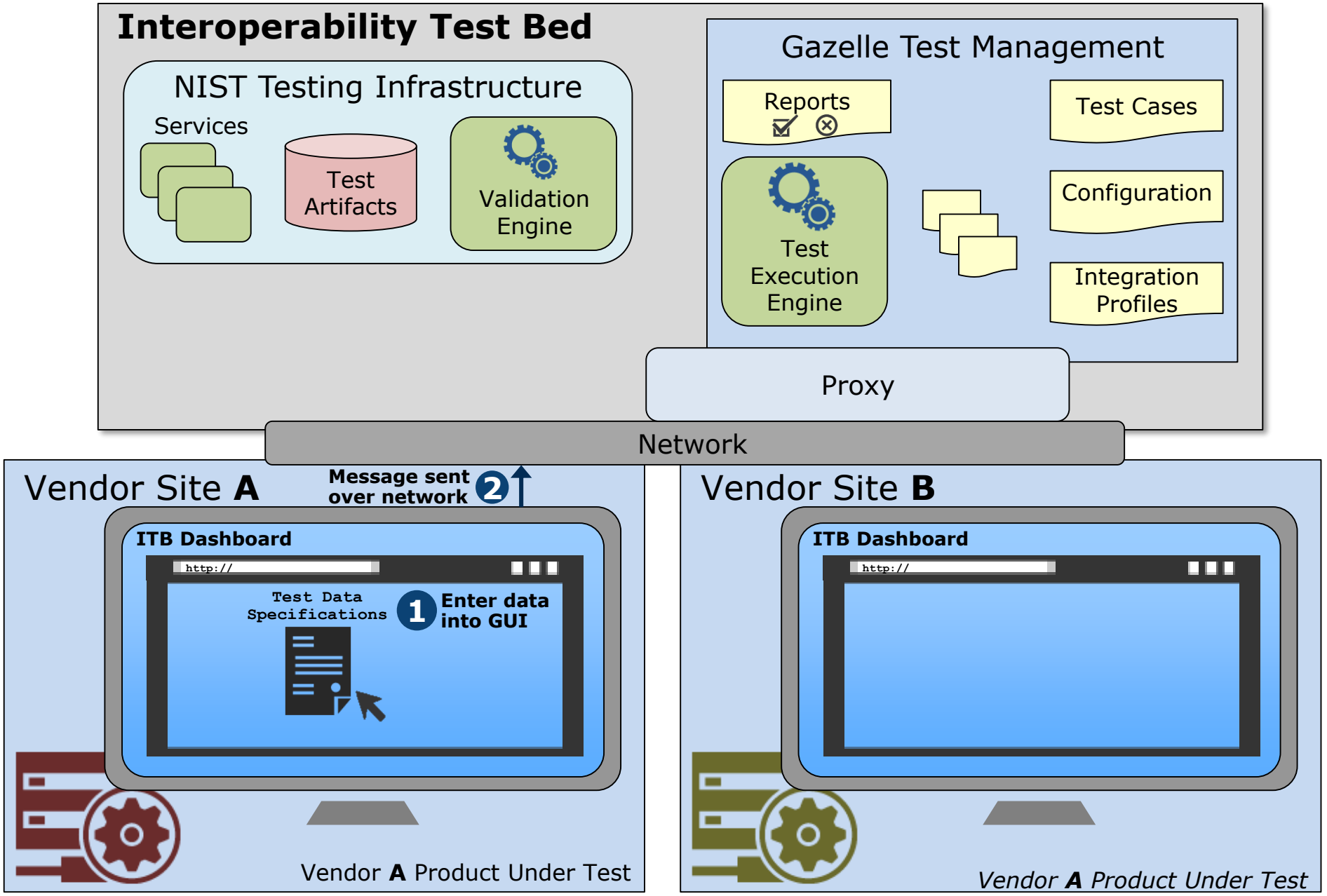
Reports
Test Cases
Test Execution Engine
Configuration
Integration Profiles
Proxy
Network
Vendor Site A
ITB Dashboard
http://
Test Data Specifications
1
Enter data into GUI
Vendor A Product Under Test
Vendor Site B
ITB Dashboard
http://
Vendor A Product Under Test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Message sent over network
2
ITB Dashboard
http://
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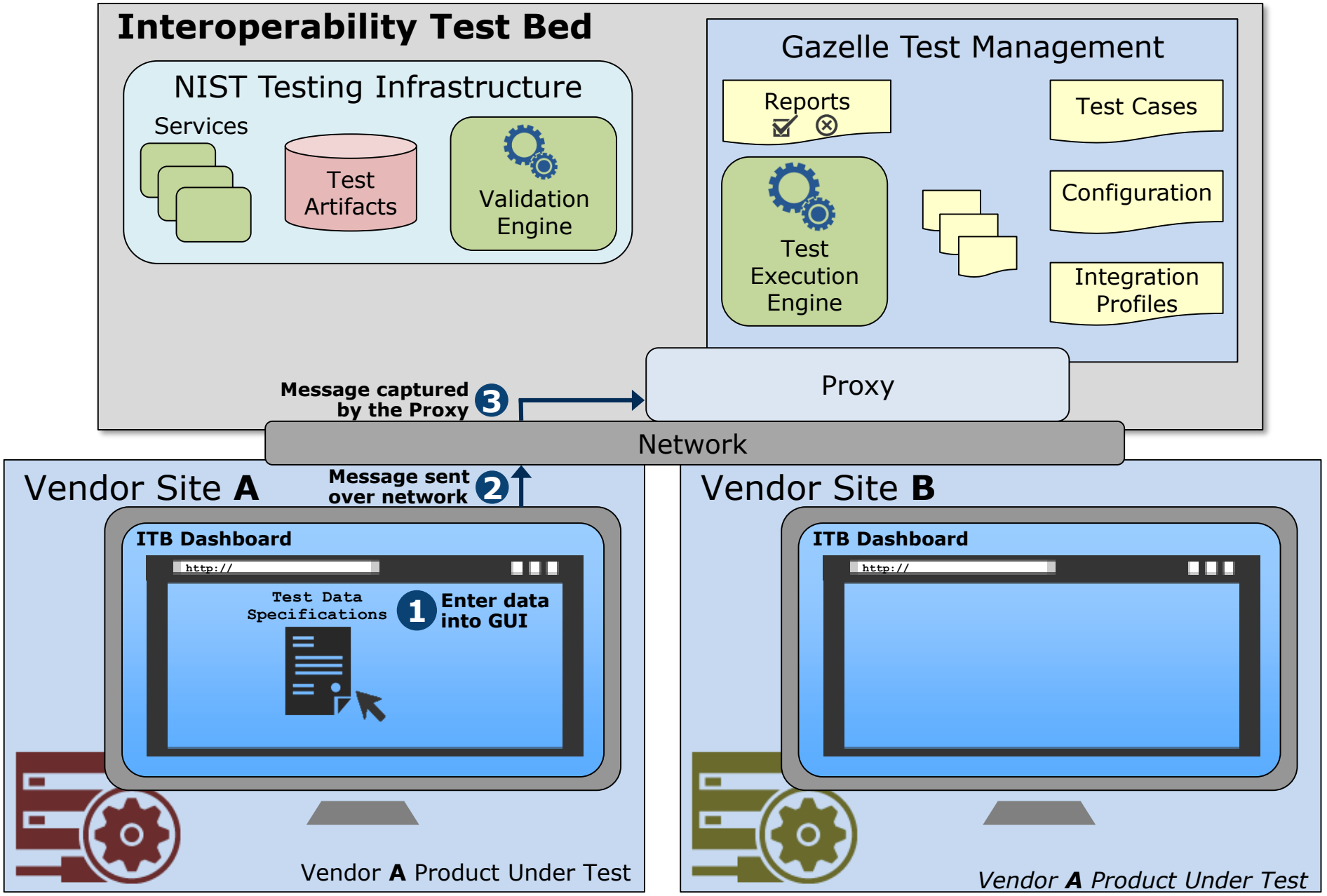
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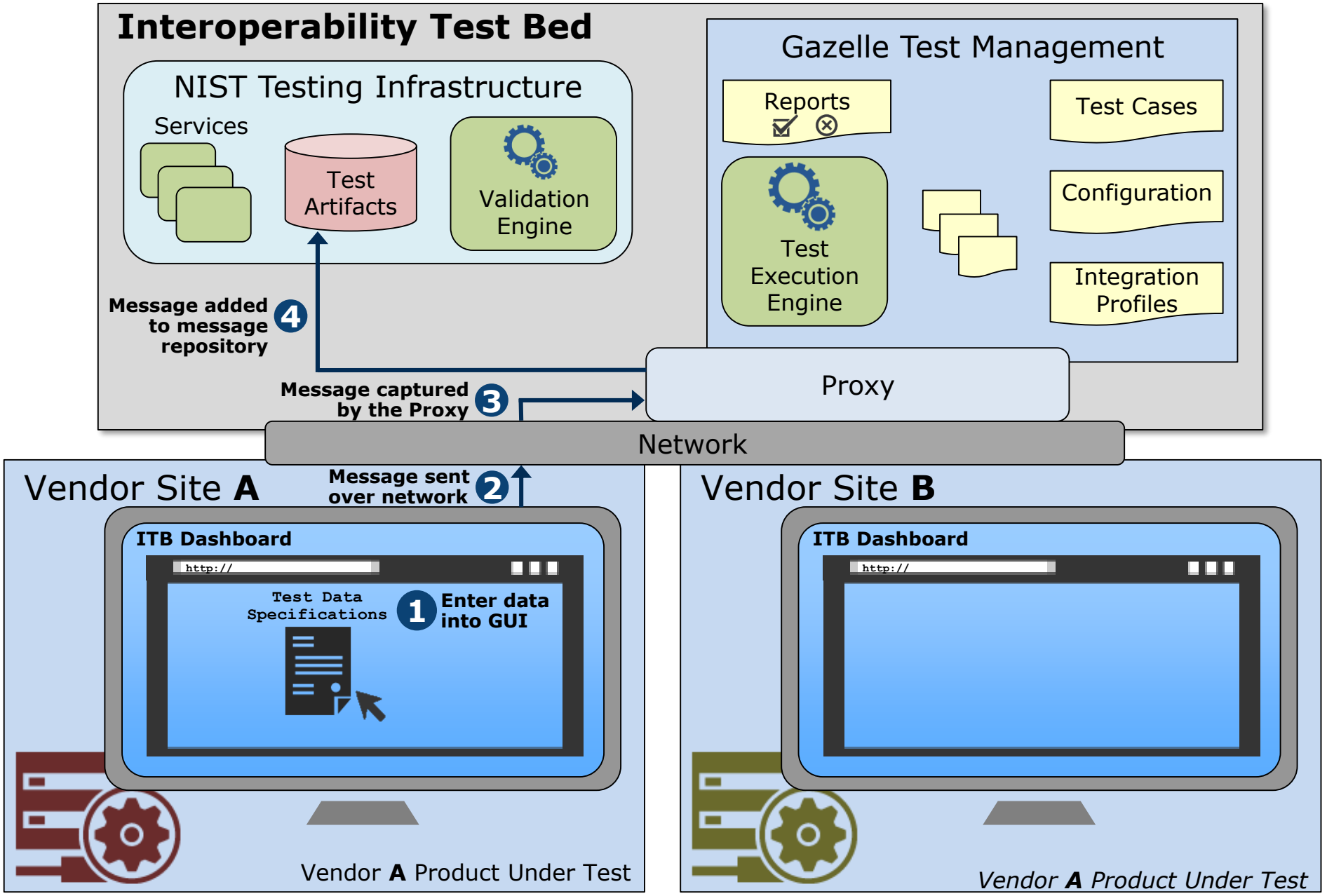
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Message added to message repository
4
Message captured by the Proxy
3
Proxy
Network
Vendor Site A
Message sent over network
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http://
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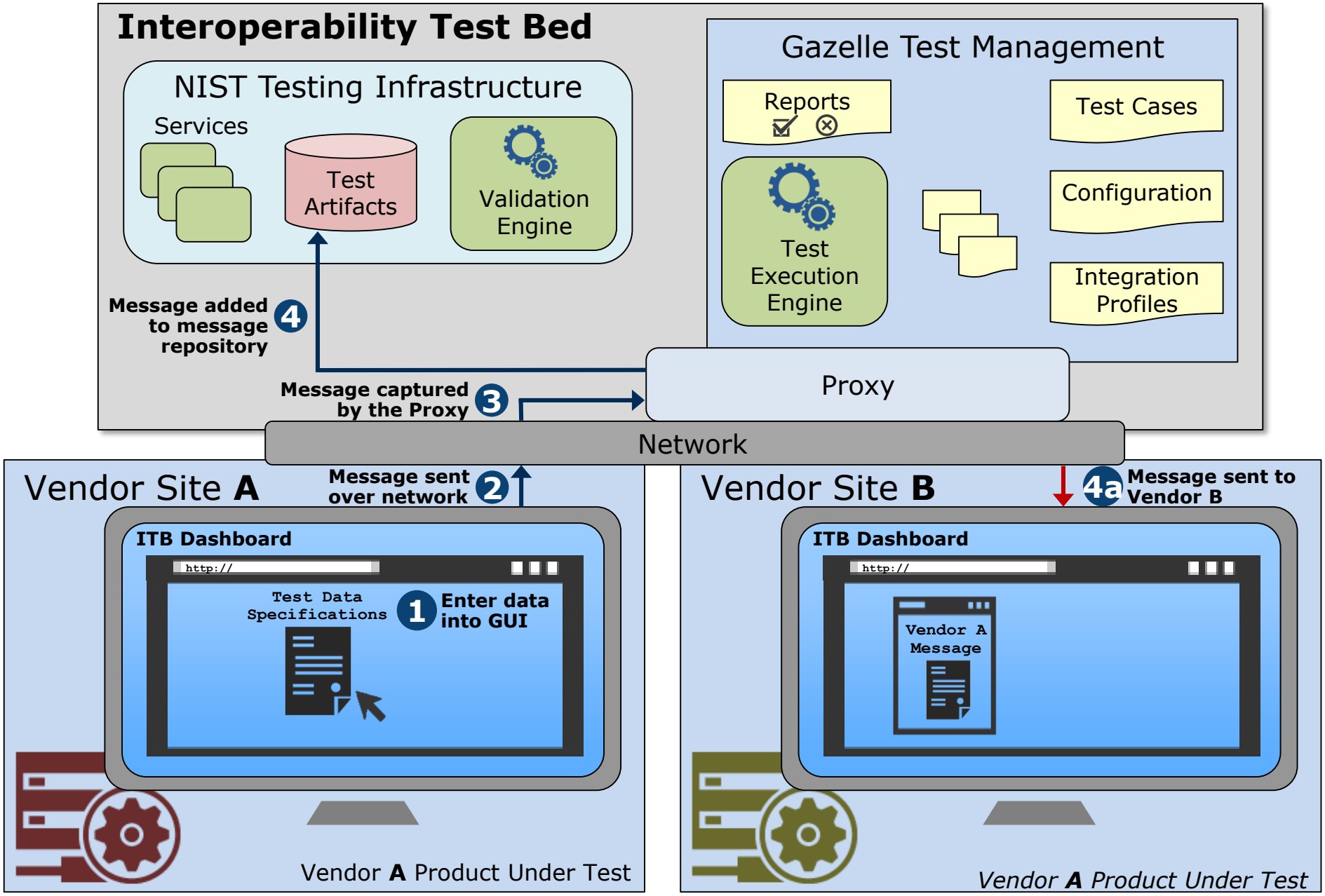
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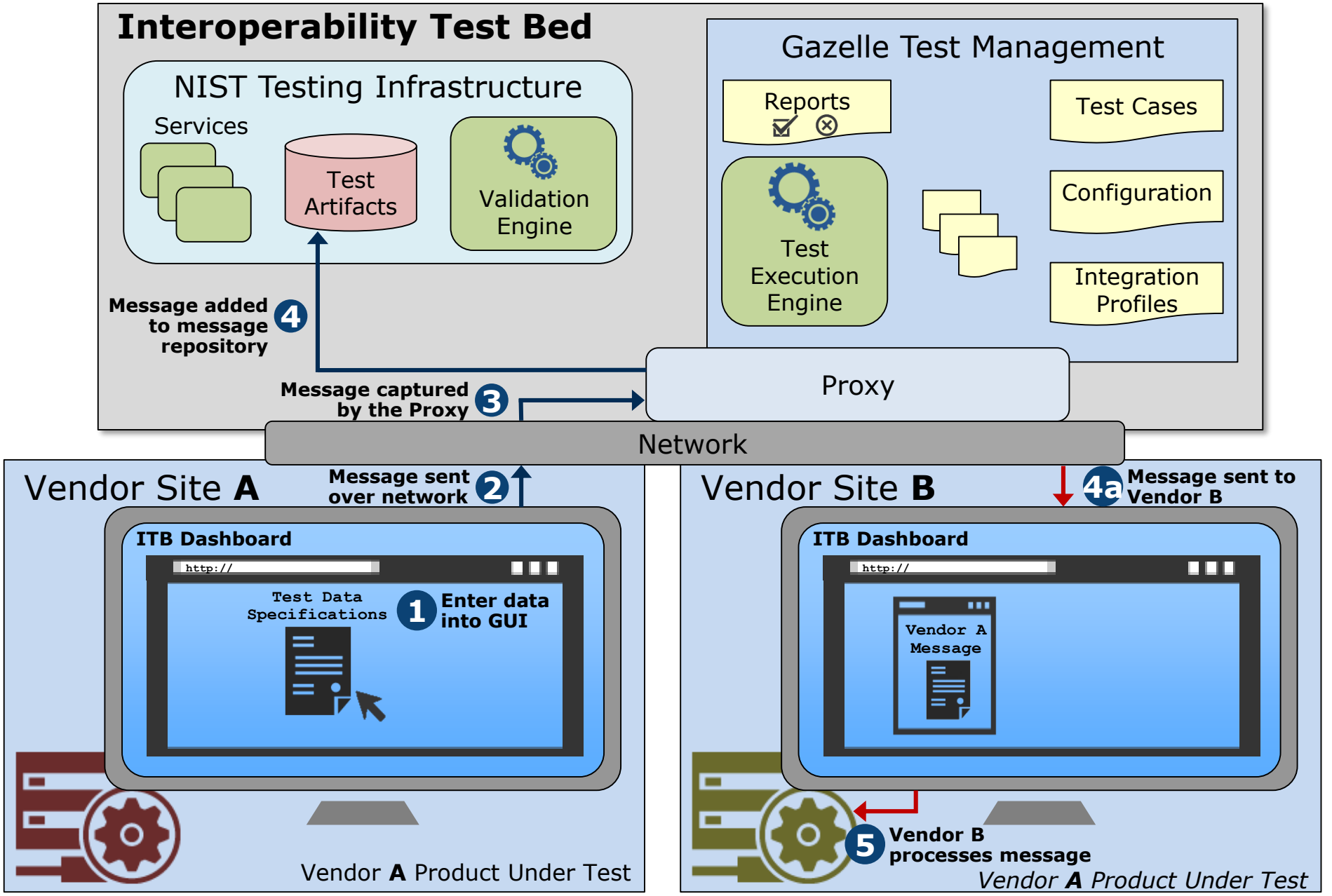
Vendor Site B
4a
Message sent to Vendor B
ITB Dashboard
http://
Vendor A Message
Vendor A Product Under Test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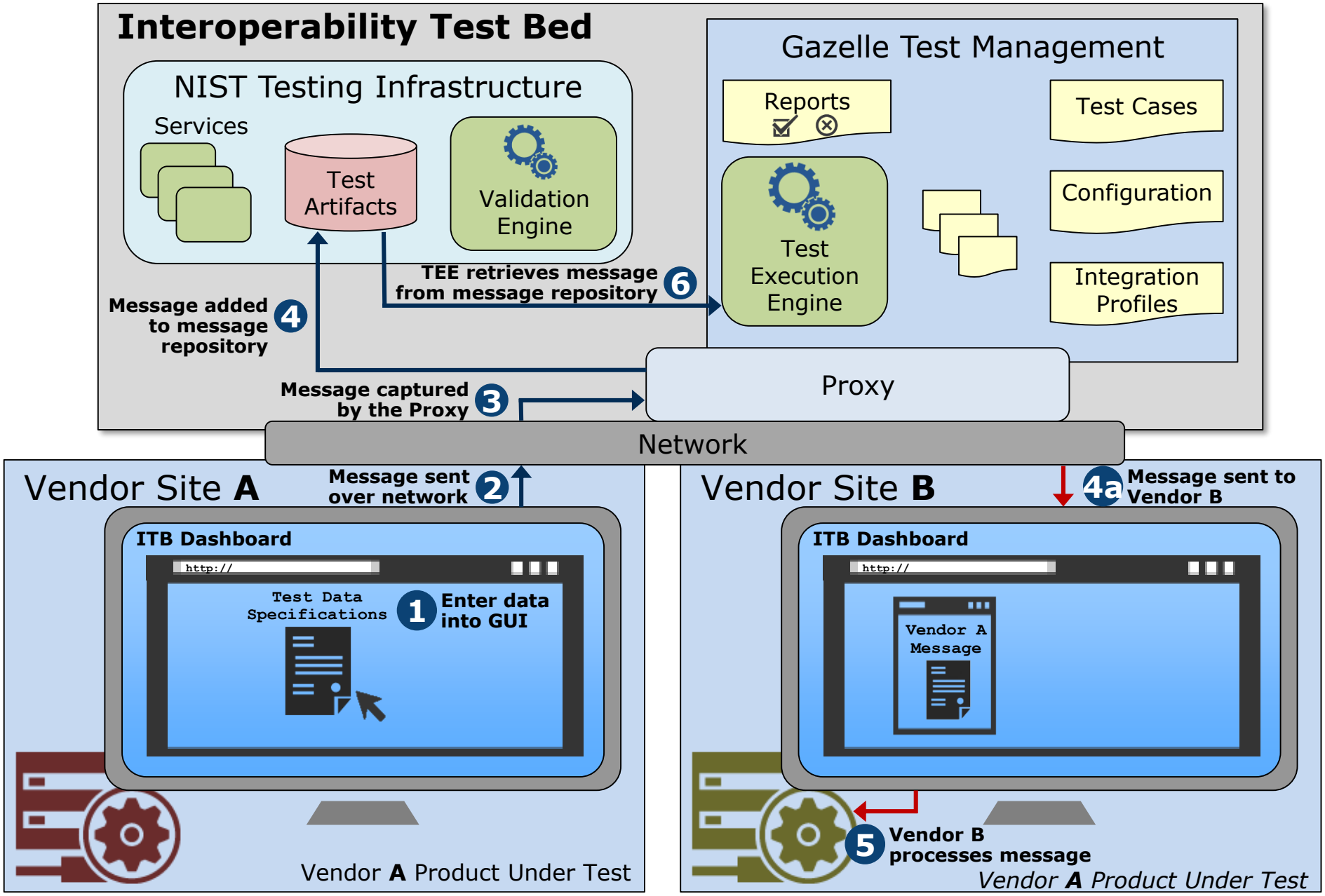
Message sent to Vendor B
ITB Dashboard
http://
Vendor A Message
5
Vendor B processes message
Vendor A Product Under Test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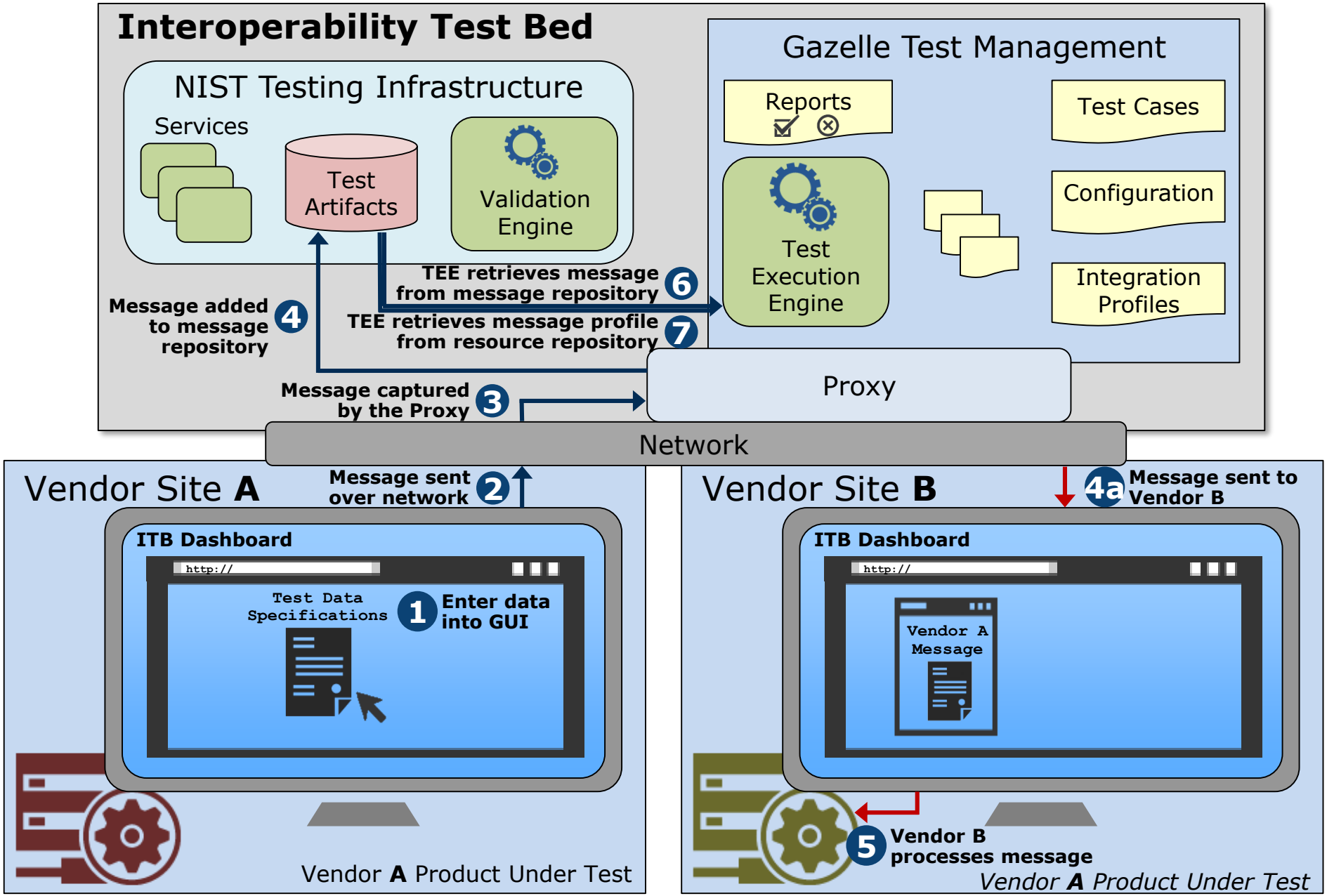
Configuration
Integration Profiles
TEE retrieves message from message repository 6
Message added to message repository 4
Message captured by the Proxy 3
Proxy
Network
Vendor Site A
Message sent over network 2
ITB Dashboard
http://
Test Data Specifications
1 Enter data into GUI
Vendor A Product Under Test
Vendor Site B
4a Message sent to Vendor B
ITB Dashboard
http://
Vendor A Message
5 Vendor B processes message
Vendor A Product Under Test


Interoperability Test Bed
NIST Testing Infrastructure
Services
Test Artifacts
Validation Engine
Gazelle Test Management
Reports
Test Cases
Test Execution Engine
Configuration
Integration Profiles
TEE retrieves message from message repository 6
Message added to message repository 4
TEE retrieves message profile from resource repository 7
Message captured by the Proxy 3
Proxy
Network
Vendor Site A
Message sent over network 2
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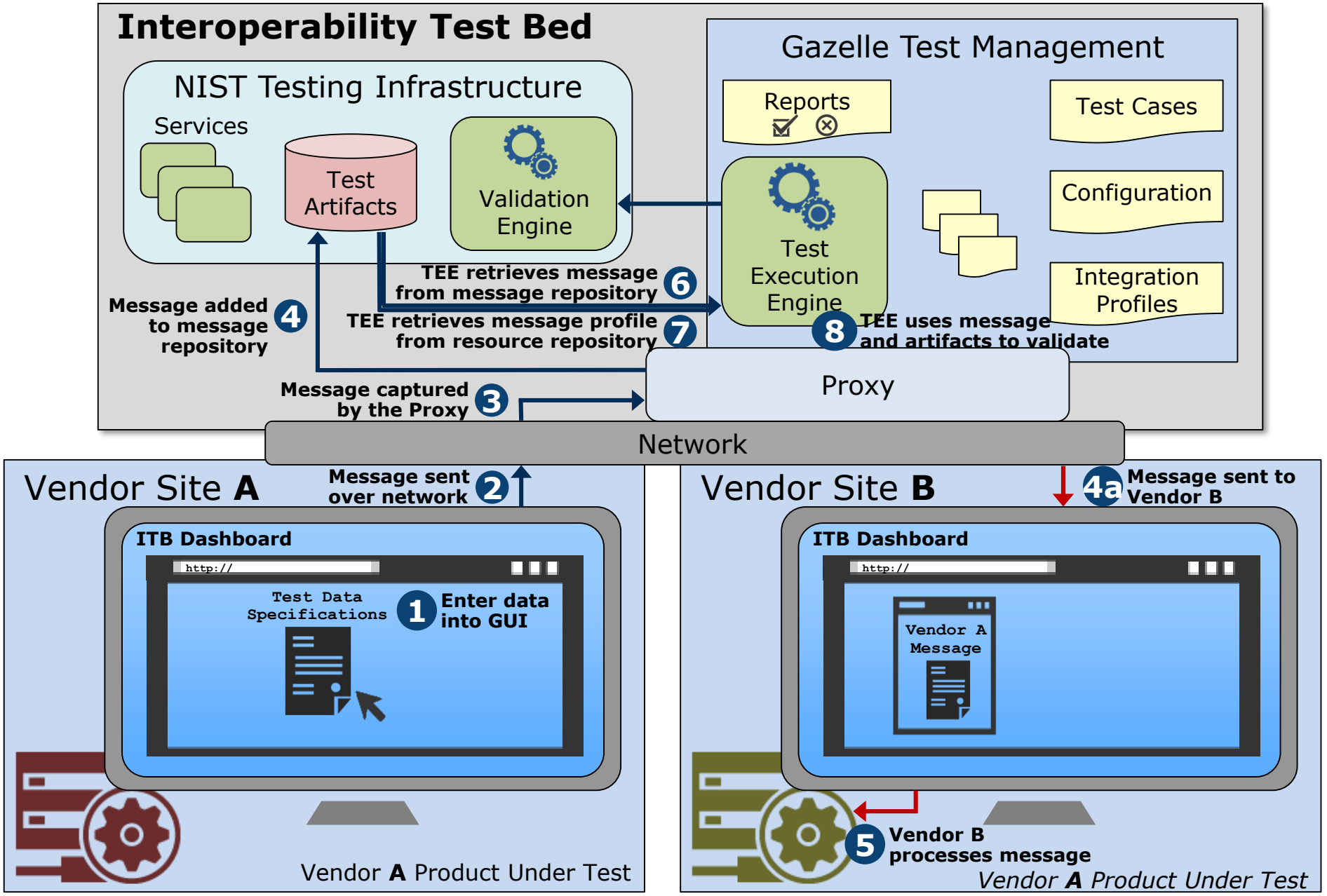
Interoperability Test Bed
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TEE retrieves message from message repository 6
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8 TEE uses message and artifacts to validate
Message captured by the Proxy 3
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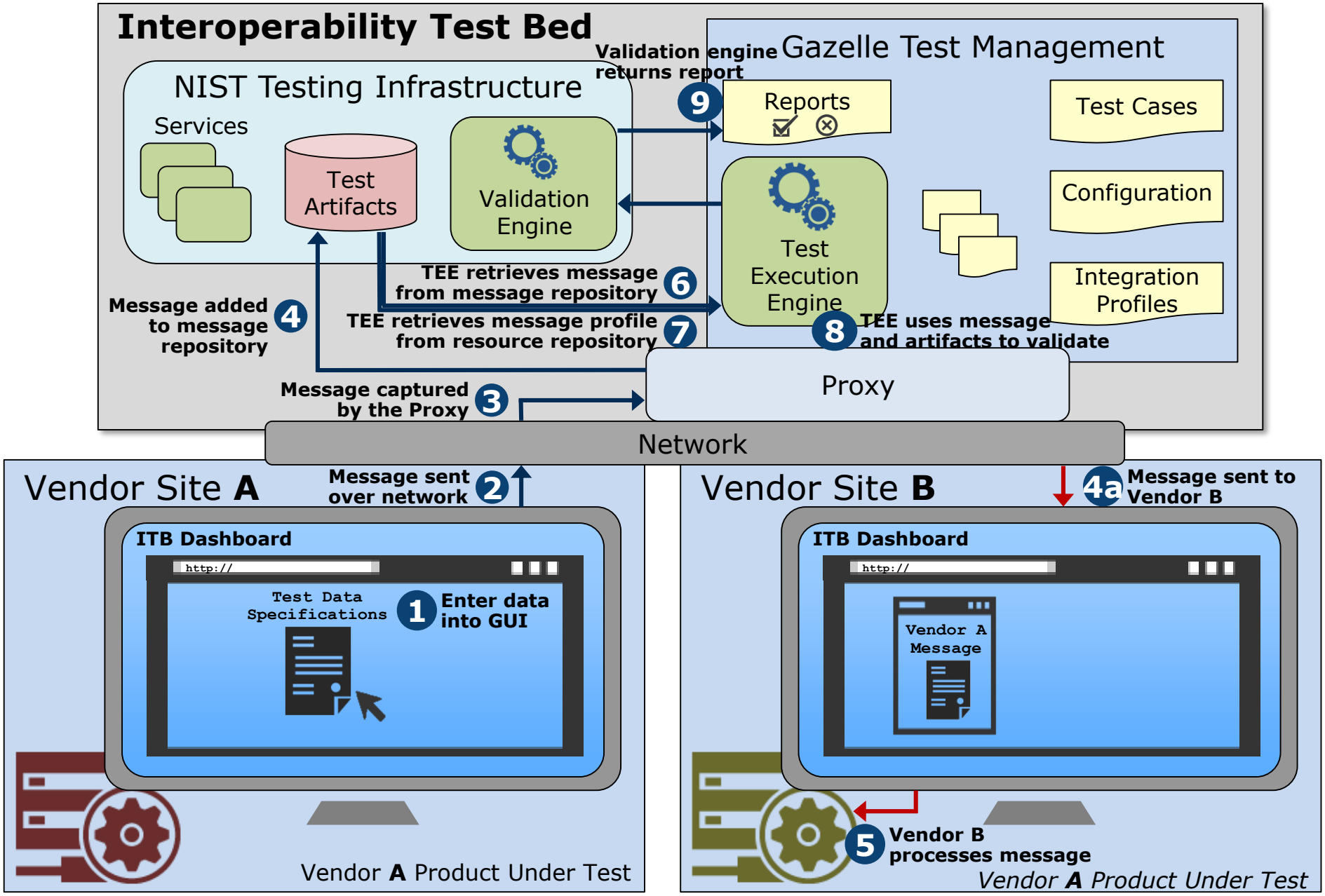
Interoperability Test Bed
NIST Testing Infrastructure
Services
Test Artifacts
Validation Engine
Gazelle Test Management
Validation engine returns report
9
Reports
Test Cases
Configuration
Integration Profiles
Test Execution Engine
TEE retrieves message from message repository
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Vendor A Product Under Test
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4a
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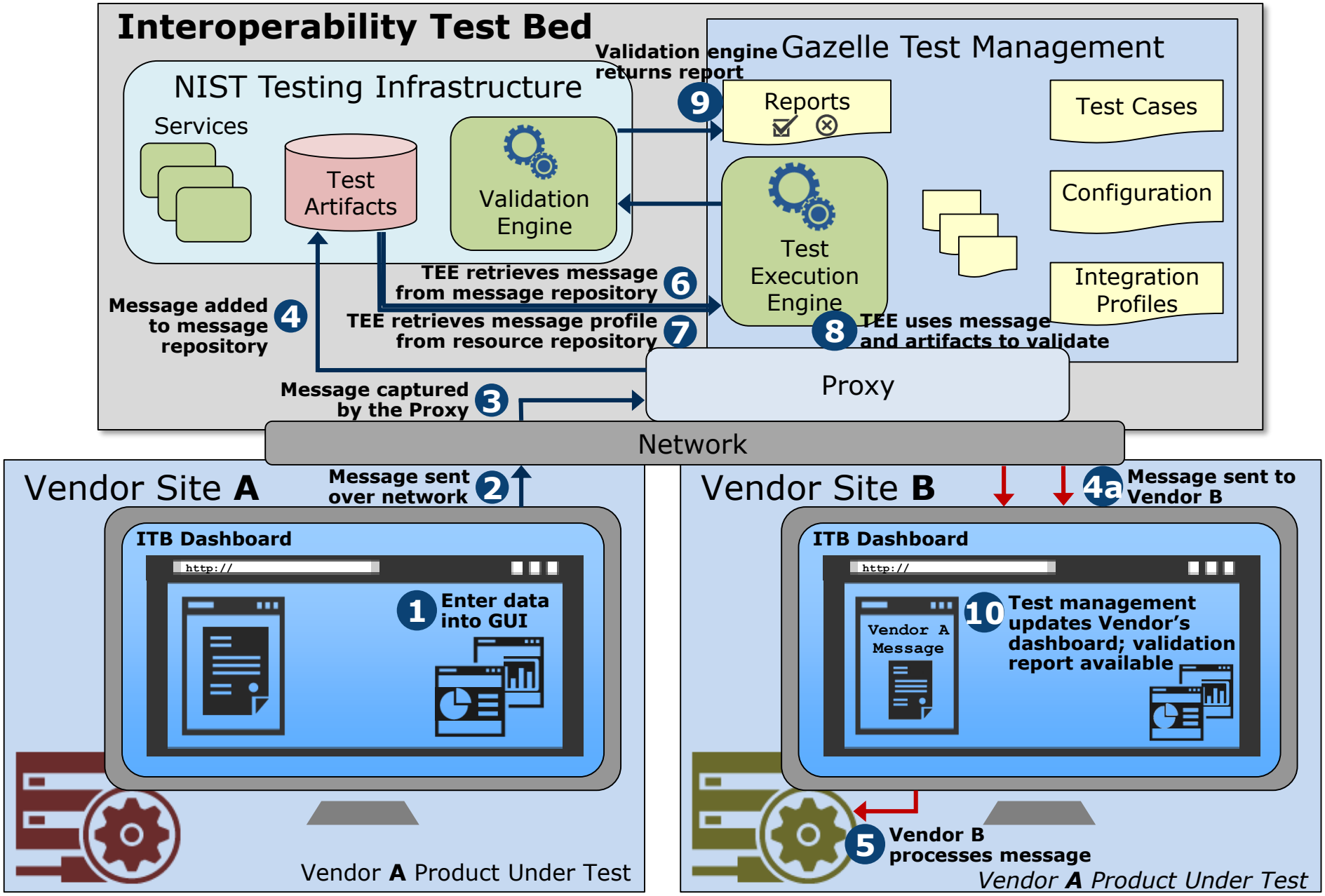
Vendor A Message
5
Vendor B processes message
Vendor A Product Under Test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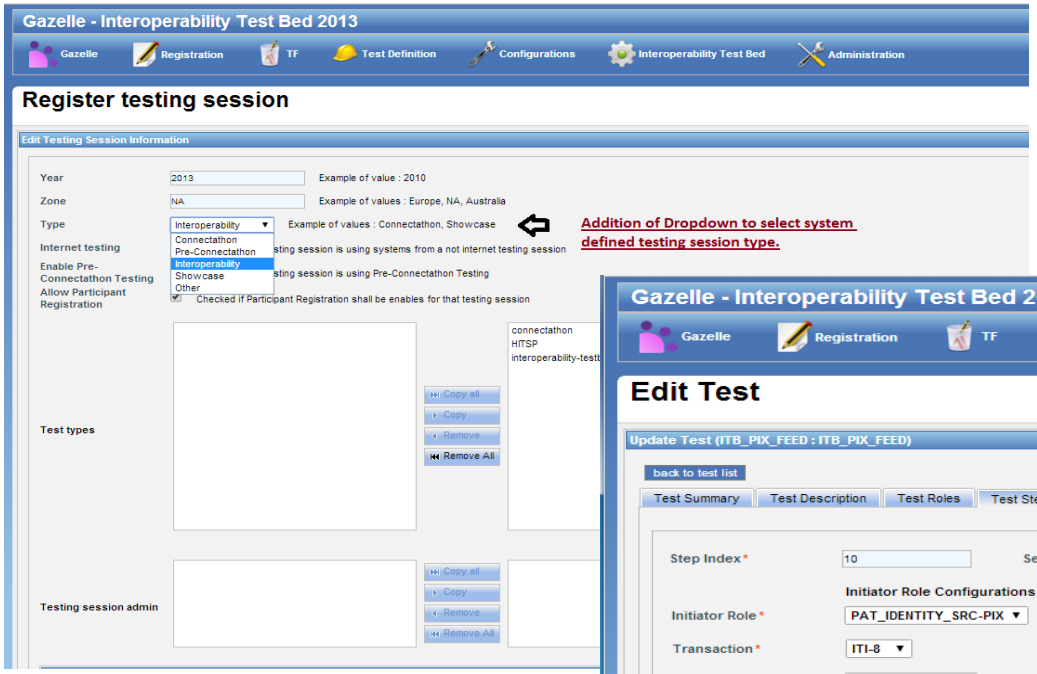
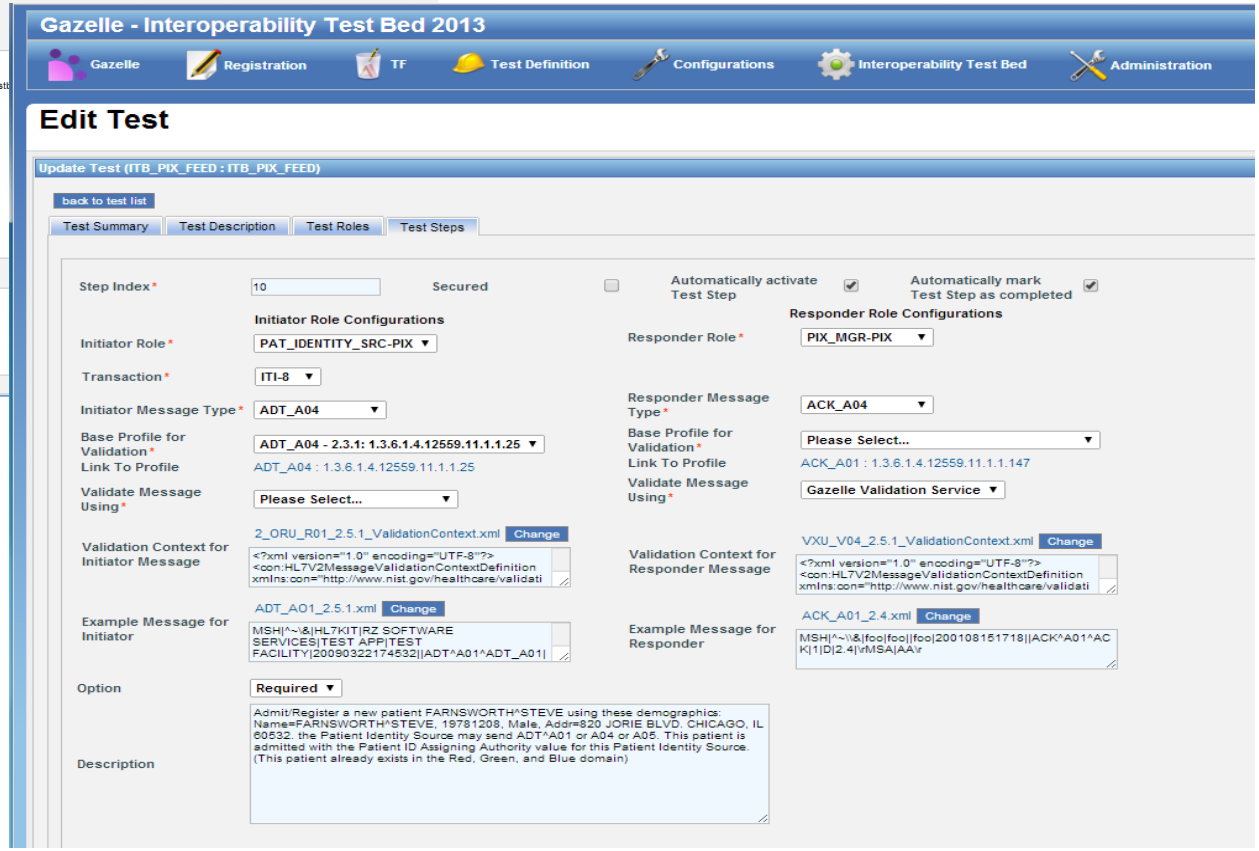
2
ITB Dashboard
http://
1
Enter data into GUI
Vendor A Product Under Test
Vendor Site B
4a
Message sent to Vendor B
ITB Dashboard
http://
Vendor A Message
10
Test management updates Vendor's dashboard; validation report available
5
Vendor B processes message
Vendor A Product Under Test

INTEROPERABILITY TEST BED DEVELOPMENT

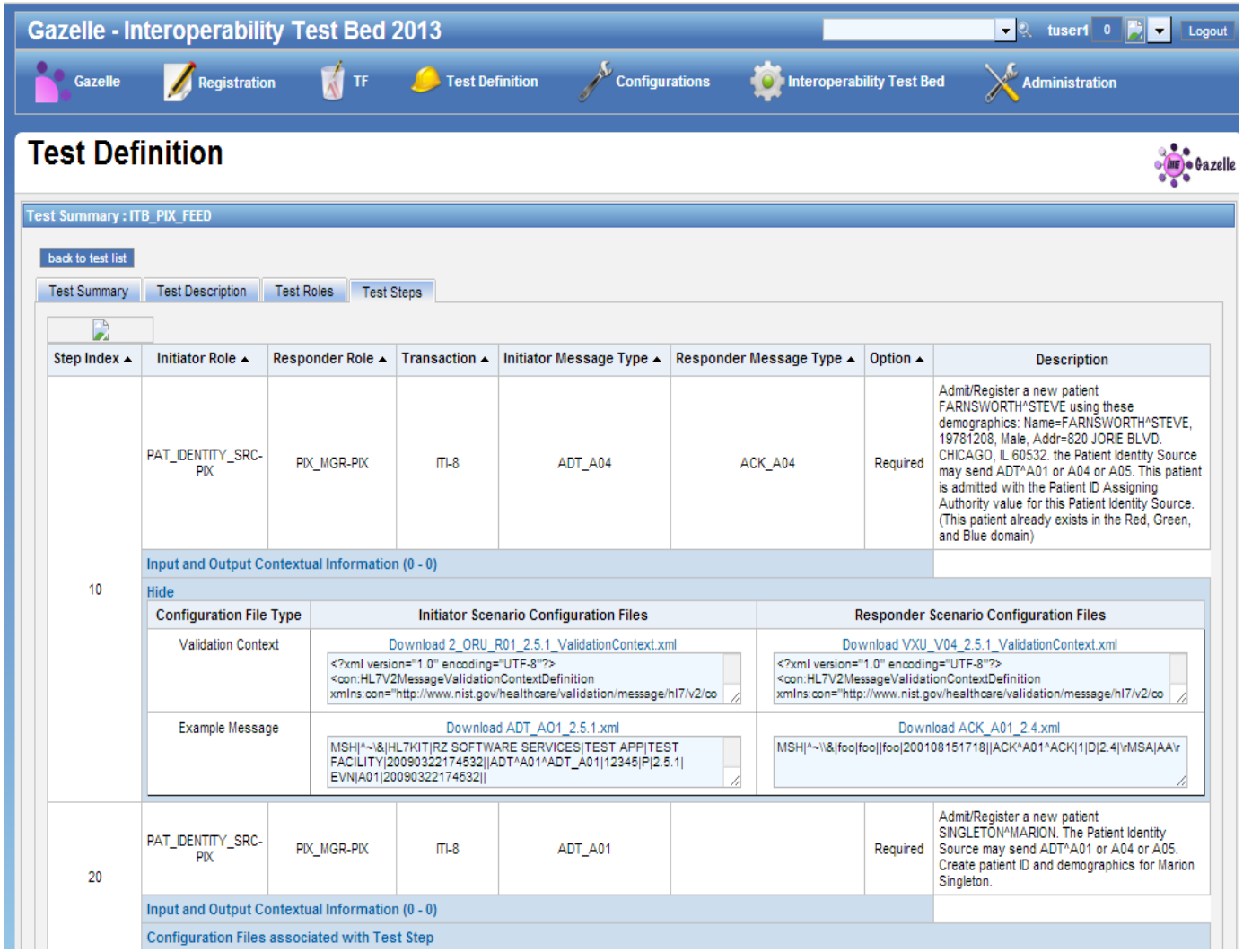
Integrated ITB Functionality into Gazelle



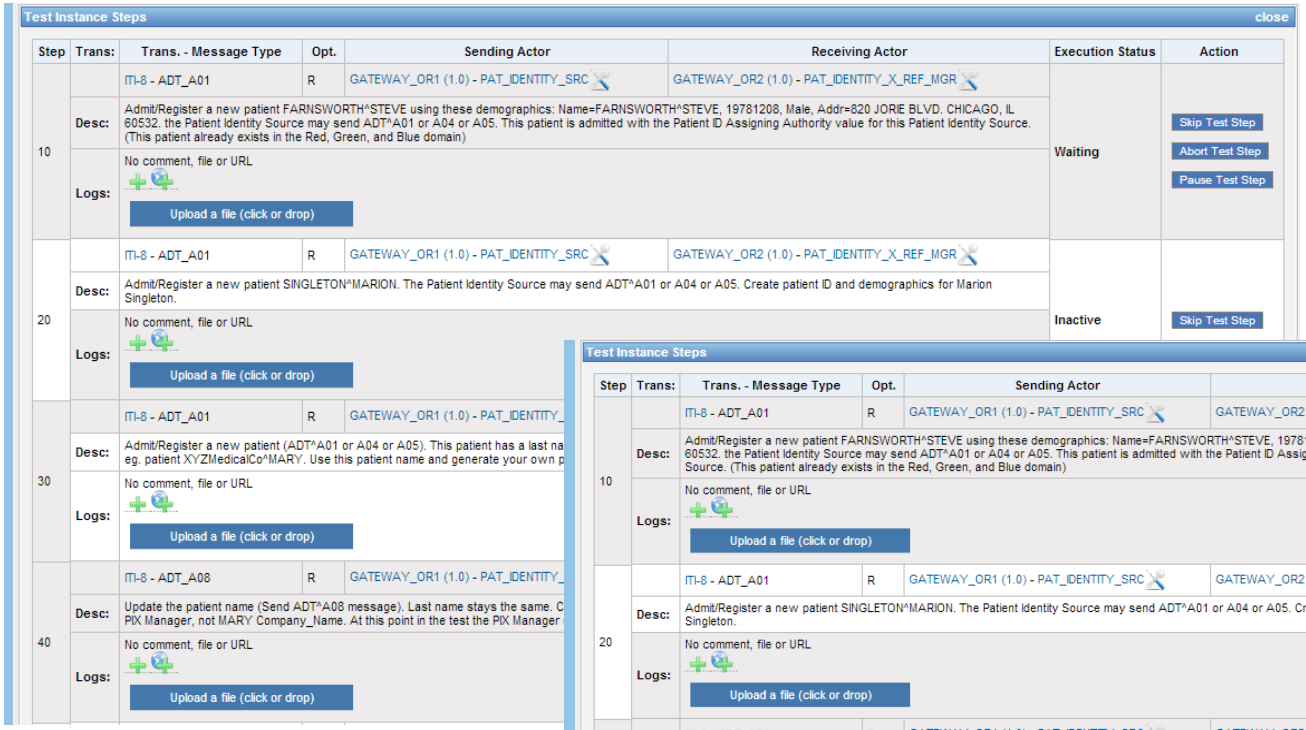
Test Case Definition Setup



Associating Testing Artifacts to Test Step



User Feedback on the Gazelle Dashboard



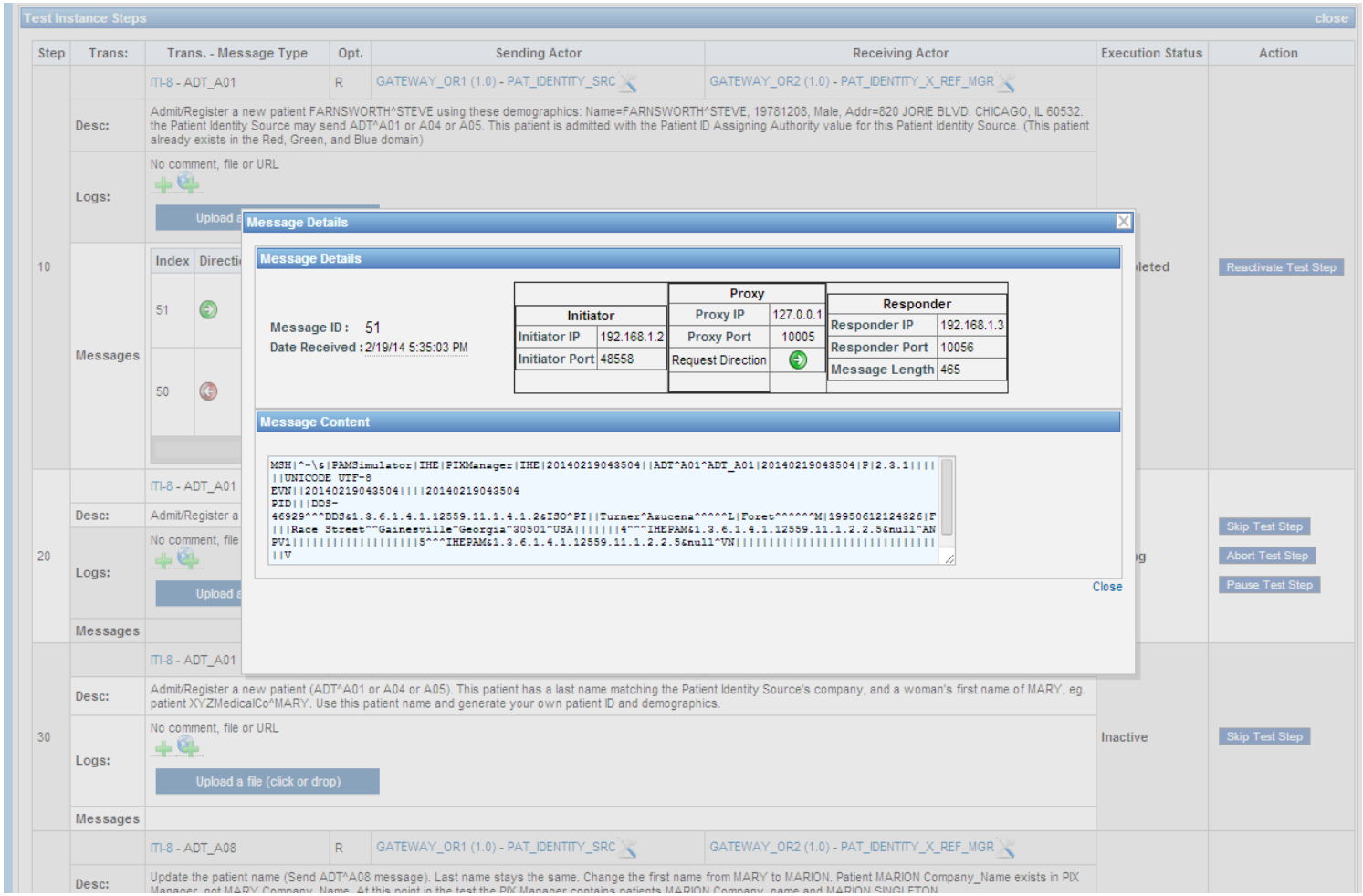
Test Instance Steps — close

Step	Trans:	Trans. - Message Type	Opt.	Sending Actor	Receiving Actor	Execution Status	Action
10		ITI-8 - ADT_A01	R	GATEWAY_OR1 (1.0) - PAT_IDENTITY_SRC	GATEWAY_OR2 (1.0) - PAT_IDENTITY_X_REF_MGR	Waiting	Skip Test Step Abort Test Step Pause Test Step
	Desc:	Admit/Register a new patient FARNSWORTH^STEVE using these demographics: Name=FARNSWORTH^STEVE, 19781208, Male, Addr=820 JORIE BLVD. CHICAGO, IL 60532. the Patient Identity Source may send ADT^A01 or A04 or A05. This patient is admitted with the Patient ID Assigning Authority value for this Patient Identity Source. (This patient already exists in the Red, Green, and Blue domain)					
	Logs:	No comment, file or URL Upload a file (click or drop)					
20		ITI-8 - ADT_A01	R	GATEWAY_OR1 (1.0) - PAT_IDENTITY_SRC	GATEWAY_OR2 (1.0) - PAT_IDENTITY_X_REF_MGR	Inactive	Skip Test Step
	Desc:	Admit/Register a new patient SINGLETON^MARION. The Patient Identity Source may send ADT^A01 or A04 or A05. Create patient ID and demographics for Marion Singleton.					
	Logs:	No comment, file or URL Upload a file (click or drop)					
30		ITI-8 - ADT_A01	R	GATEWAY_OR1 (1.0) - PAT_IDENTITY_			
	Desc:	Admit/Register a new patient (ADT^A01 or A04 or A05). This patient has a last na eg. patient XYZMedicalCo^MARY. Use this patient name and generate your own p					
	Logs:	No comment, file or URL Upload a file (click or drop)					
40		ITI-8 - ADT_A08	R	GATEWAY_OR1 (1.0) - PAT_IDENTITY_			
	Desc:	Update the patient name (Send ADT^A08 message). Last name stays the same. C PIX Manager, not MARY Company_Name. At this point in the test the PIX Manager					
	Logs:	No comment, file or URL Upload a file (click or drop)					

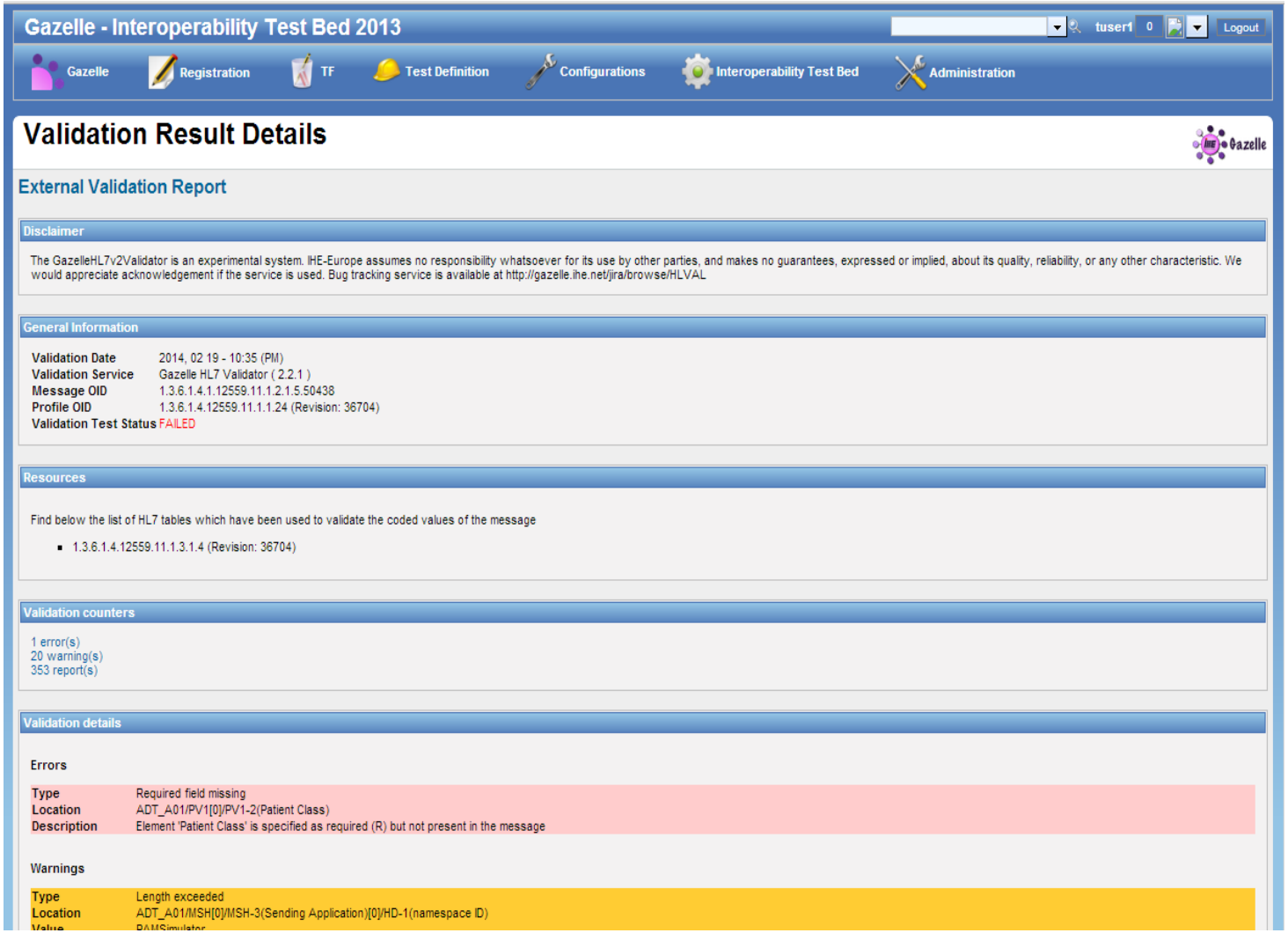
Test Instance Steps — close

Step	Trans:	Trans. - Message Type	Opt.	Sending Actor	Receiving Actor	Execution Status	Action
10		ITI-8 - ADT_A01	R	GATEWAY_OR1 (1.0) - PAT_IDENTITY_SRC	GATEWAY_OR2 (1.0) - PAT_IDENTITY_X_REF_MGR	Skipped	Reactivate Test Step
	Desc:	Admit/Register a new patient FARNSWORTH^STEVE using these demographics: Name=FARNSWORTH^STEVE, 19781208, Male, Addr=820 JORIE BLVD. CHICAGO, IL 60532. the Patient Identity Source may send ADT^A01 or A04 or A05. This patient is admitted with the Patient ID Assigning Authority value for this Patient Identity Source. (This patient already exists in the Red, Green, and Blue domain)					
	Logs:	No comment, file or URL Upload a file (click or drop)					
20		ITI-8 - ADT_A01	R	GATEWAY_OR1 (1.0) - PAT_IDENTITY_SRC	GATEWAY_OR2 (1.0) - PAT_IDENTITY_X_REF_MGR	Inactive	Activate Test Step Skip Test Step
	Desc:	Admit/Register a new patient SINGLETON^MARION. The Patient Identity Source may send ADT^A01 or A04 or A05. Create patient ID and demographics for Marion Singleton.					
	Logs:	No comment, file or URL Upload a file (click or drop)					
30		ITI-8 - ADT_A01	R	GATEWAY_OR1 (1.0) - PAT_IDENTITY_SRC	GATEWAY_OR2 (1.0) - PAT_IDENTITY_X_REF_MGR	Inactive	Activate Test Step Skip Test Step
	Desc:	Admit/Register a new patient (ADT^A01 or A04 or A05). This patient has a last name matching the Patient Identity Source's company, and a woman's first name of MARY, eg. patient XYZMedicalCo^MARY. Use this patient name and generate your own patient ID and demographics.					
	Logs:	No comment, file or URL Upload a file (click or drop)					
40		ITI-8 - ADT_A08	R	GATEWAY_OR1 (1.0) - PAT_IDENTITY_SRC	GATEWAY_OR2 (1.0) - PAT_IDENTITY_X_REF_MGR	Inactive	Activate Test Step Skip Test Step
	Desc:	Update the patient name (Send ADT^A08 message). Last name stays the same. Change the first name from MARY to MARION. Patient MARION Company_Name exists in PIX Manager, not MARY Company_Name. At this point in the test the PIX Manager contains patients MARION Company_name and MARION SINGLETON.					
	Logs:	No comment, file or URL Upload a file (click or drop)					
		ITI-8 - ADT_A40	R	GATEWAY_OR1 (1.0) - PAT_IDENTITY_SRC	GATEWAY_OR2 (1.0) - PAT_IDENTITY_X_REF_MGR		Activate Test Step
	Desc:	SINGLETON^MARION is the maiden name of the patient just registered and updated. Merge SINGLETON^MARION into the last patient updated, eg "XYZmedical^MARION". SINGLETON is subsumed; the patient Marion with the last name that matches your patient name survives (i.e, patient MARION System_name eixsts in PIX Manager; patient SINGLETON no longer exists).					

Browsing the Proxy for Message Capture



Validation Results of a Message Instance



Summary: To achieve interoperability, testing must be an integral part of the standards and development process and testing must be continuous.