Conformance Test Suite for CBEFF Biometric Information Records

Yooyoung Lee, Fernando L. Podio, and Mark Jerde

***Abstract*—Deployment of standards-based biometric technologies is expected to significantly raise levels of security for critical infrastructures that has not been possible to date with other technologies. These systems require a comprehensive set of technically sound standards that meet the customer's needs. The existence of standards alone, however, is not enough to demonstrate that products meet the technical requirements specified in the standards. Conformance testing captures the technical description of a standard and measures whether an implementation faithfully implements the standard. Conformity assessment provides confidence to users through programs that demonstrate the conformity of products to specific standards. This paper discusses a Conformance Test Suite (CTS) for Biometric Information Records (BIRs) claiming conformance to data structures specified in Common Biometric Exchange Formats Framework (CBEFF) standards. The paper summarizes conformance testing procedures and criteria for testing these data structures. A conformance testing architecture and a CTS implementation developed at the National Institute of Standards and Technology (NIST) to assess conformance to these CBEFF data structures is described. Ongoing and future work is discussed.**

I. Introduction

The deployment of standards-based biometric technologies is expected to significantly raise levels of security for critical infrastructures that has not been possible to date with other technologies. Deploying these systems requires a comprehensive set of technically sound biometric standards that meet the customer's needs. These standards promote the availability of multiple sources for comparable products in the marketplace. The existence of standards alone, however, is not enough to demonstrate that products meet the technical requirements specified in the standards. Conformance testing captures the technical description of a standard and measures whether an implementation faithfully implements the standard. A precise notion of correctness of an implementation derived from using formal testing methods is needed [1].

Conformity assessment[1] of a product to a given set of standard(s) and/or technical requirements enhances the developer's and end-user's confidence that the product will perform as expected. Conformance testing methodology standards, testing protocols and conformance test suites for testing the technical requirements of specific standards are needed for the development, implementation and sustainability of effective conformity assessment programs. For biometric technologies these programs should be based on existing ISO conformity assessment standards and relevant biometric standards. Accreditation of testing laboratories through formal programs, such as NIST's National Voluntary Laboratory Accreditation Program (NVLAP), creates a competent, vibrant and competitive environment for testing of biometric equipment and software.

Common Biometric Exchange Formats Framework (CBEFF) standards specify data structures designed to encapsulate biometric data independently of the modality of these data. They support biometric data exchange by describing characteristics of the biometric data contained in these data structures such as the modality and format of the biometric data. They can also convey information useful to support protection of the biometric data such as whether the data is encrypted or signed, their creation date and their validity period. These data structures are called CBEFF Biometric Information Records or BIRs. Currently, there are no standardized testing methodologies in support of conformance testing of CBEFF BIRs.

We discuss below ongoing research and standard efforts towards the development of these conformance testing methodology standards and we describe a conformance testing architecture and testing suite developed at NIST to test the components of these CBEFF BIRs. We also address the characteristics of an initial conformance test suite (CTS) implementation developed to test specific instantiations of CBEFF BIRs and briefly discuss related ongoing and future work at NIST on the development of advanced conformance testing architectures.

The paper is structured as follows: Section 2 provides a brief description of CBEFF data structures and the rationale for the use of these structures for data interchange and the protection of biometric data. Section 3 discusses CBEFF conformance testing methodologies, characteristics of the conformance testing architecture developed at NIST and the initial conformance test suite implementation. Section 4 discusses results. The final section briefly discusses conclusions, ongoing and future work.

Manuscript received August 20, 2007. Yooyoung Lee is with the Department of Computer Engineering, University of Chung-Ang, Korea. She is currently a guest researcher with the Computer Security Div. of the National Institute of Standards and Technology, Information Technology Laboratory, Gaithersburg, MD 20899-8930, USA, (e-mail: yoo.lee@nist.gov).

Fernando Podio is with the Computer Security Div. of the National Institute of Standards and Technology, Information Technology Laboratory, Gaithersburg, MD 20899-8930, USA (e-mail: fernando.podio@nist.gov)

Mark Jerde is with ID Technology Partners and collaborated in this project through a contract with NIST, North Potomac, MD 20878-2064 (e-mail: mjerde@idtp.com).

[1] Conformity assessment is defined in ISO/IEC 1700:2004 as: "demonstration that specified requirements (3.1)relating to a product (3.3), process, system, person or body are fulfilled."

II. COMMON BIOMETRIC EXCHANGE FORMATS FRAMEWORK (CBEFF)

CBEFF standards describe a set of abstract data elements necessary to support biometric technologies in a common way. BIRs defined in CBEFF standards [2]-[5] promote interoperability of biometric-based application programs and systems by specifying metadata that describes specific characteristics of the biometric data contained in these BIRs such as the modality and format of the biometric data and its creation date. As discussed below, these BIRs can also convey information useful to support security of the biometric data. The set of abstract data elements and values specified in these standards can be used to generate the headers of BIRs conforming to CBEFF.

CBEFF BIRs can reveal the format and other attributes of their biometric-specific data without having to expose the biometric data itself to applications. The metadata contained in these BIRs provide, for example, means for applications to efficiently determine whether a particular biometric data record is of interest, and if so, which biometric services to call to process the biometric-specific data. As shown in Fig. 1, CBEFF BIRs define three major sections in a single structure. The Standard Biometric Header (SBH) includes required data elements (e.g., format and modality of the biometric data, product identifier) and any necessary optional data element(s) such as security/integrity options, biometric data creation date and validity period. These Headers can also contain user-defined payload and challenge-response data. The Biometric Data Block (BDB) contains processed or unprocessed biometric data. The Security Block (SB) can contain algorithm identifier information and/or any parameters needed to perform the Signature or the MAC generation function.

Fig. 1. CBEFF Biometric Information Record

Clearly specified instantiations of these BIRs are called "patron formats". These patron formats are fully-defined by a standards development organization (which can be a standards body, working group or industry consortium). Organizations such as a government agency could develop specific patron formats if available ones do not fully meet their needs. These organizations are called "CBEFF patrons". ISO/IEC JTC 1 SC37, the international standards committee responsible for the development of biometric standards, defines "CBEFF patrons" in [5] as organizations that have been accepted for registration with the Biometric Registration Authority in accordance with [6], and that can therefore specify one or more CBEFF patron formats.

A number of standards and user's organizations have defined CBEFF patron formats or have adopted CBEFF patron formats developed by other organizations. Examples can be found in [4], [7]. In addition to the mandatory data elements specified in CBEFF standards, each patron format specification defines which CBEFF optional data elements are present, its format and how the data elements are extracted and processed (details such as the data encoding scheme are the responsibility of the CBEFF patrons).

The conformance testing module discussed in the following section was developed to test conformance of binary files (BIRs) claiming conformance to a patron format specified in [4] (Patron Format A). An analysis is currently being performed on users' needs for testing modules for other existing patron formats.

Patron Format A is a single CBEFF BIR structure. It is a flexible and convenient format to use for situations where a CBEFF structure needs to be used, other existing patron formats are not adequate for the application (or domain of use) and it is not desirable to establish a new patron format. Length and encoding of each data field is specified, therefore facilitating decoding of data records conforming to this patron format. The required and optional CBEFF data elements present in the data header follow a pre-determined sequence indicated in the standard further facilitating decoding of these records. A field specified in the format (Optional Data Element Present Mask) provides information to the decoder on what optional fields are present in the record header. Applications and system specifications based on this format are permitted to exclude optional CBEFF data elements from the record header that are not required for the application. The format and length of each portion of the Biometric Information Record is also specified.

III. CBEFF CONFORMANCE TESTING

There is a need for developing conformance testing methodologies and associated testing tools for CBEFF BIRs. The purpose of CBEFF conformance testing is to determine whether an implementation faithfully implements BIRs conforming to a CBEFF patron format specification or standard or whether a product is able to generate these BIRs. CBEFF conformance testing methodologies provide the basis for the development of Conformance Test Suite (CTS) implementations to test these BIRs. One such standard is under development in the InterNational Committee for Information Technology Standards (INCITS) Technical Committee M1-Biometrics.

A. A Conformance Testing Process for CBEFF BIRs

A conformance testing process is the complete range of testing-related activities that ultimately lead to the assessment of conformity of an Implementation Under Test (IUT) to a specification or standard and therefore, it includes at a minimum:

1) Analysis of the specification or standard that defines the BIRs to be tested including:

- Identification of the data elements to be tested (e.g., fields in a CBEFF BIR Header)
- Additional requirements (e.g., consistency of the BIR)

2) Development or analysis of an existing conformance testing methodology specification or standard including:

- Scope of tests

- Development of the required test purposes and test cases
- Development of a vendor implementation declaration format

3) CTS implementation including:

- Development of the test plan
- Design of a detailed architecture
- Generation of required Manifests, Test Cases and binary data to test the CTS implementation
- Development of test logs/test report formats
- Execution of the tests
- Generation of test logs and test reports

The testing methodology (and associated Conformance Test Suite) addressed in this paper focuses on the extent to which an IUT satisfies both level 1 and 2 testing requirements. Level 1 and 2 testing are described below. For the purpose of this paper IUTs are BIRs that are instantiations of Patron Format A (PFA) data structures specified in [4]. Level 1 testing addresses testing that verifies field by field and byte by byte conformance of the CBEFF BIR header with respect to what is specified in the standard, both in terms of field values and the ranges of values for those fields. Level 2 testing implies testing of the internal consistency of the BIR header relating values from one field to other(s) in the header as discussed in [8]. Consistency of the BIR structure (e.g., length of each main element against length information provided in the BIR header) is also addressed.

These BIRs are expected to conform to all the requirements specified in the standard for this patron format. They include the mandatory requirements (including the required header fields), the required conditional fields specified in the CBEFF PFA Header and the optional fields selected for the specific PFA instantiation.

B. Conformance Test Suite Implementation

Based on the discussion above, the CTS implementation tests the following:

- All the BIR header mandatory, conditional and optional fields included in specific instantiations of CBEFF PFA
- All required interrelationships between the header fields
- The required sequence of fields in the patron format
- The length of the full BIR (Standard Biometric Header, Biometric Data Block and Security Block)
- The consistency of the full BIR in terms of length specified in the BIR header for each session of the BIR versus the expected and real length of the BIR sections

Test results, generated by the CTS implementation are evaluated using “Pass”/”Fail” criteria. To evaluate conformance of BIRs, the testing method relies on a statement that we call a “Manifest”. This document (formatted in XML) describes the characteristics of the IUT.

CTS implementations use this Manifest to test the IUT only against the characteristics implemented in the IUT and not against the entire range of features and possible values specified in the standard for the specific patron format.

The Test Cases developed for the CTS were realized in the form of executable test scripts, which, in combination with applicable data files, constitute elements of the CTS.

1) CTS Controller/GUI and Testing Module

A shown in Fig. 2, the CTS architecture developed at NIST consists of a controller/Graphical User Interface (GUI) and CTS module implementations developed to test CBEFF BIRs for conformance to different CBEFF patron formats.

The CTS Controller is responsible for handling the tests, tracing and logging test results, test suite parameterization, selection and handling the GUI and the interface with the appropriate testing module. The architecture is extensible to CTS modules developed to test for conformance to other CBEFF patron formats or Biometric Data Blocks that include data of any biometric modality. Support for CTS implementations testing conformance to Security Blocks is also provided.

The controller/Graphical User Interface (GUI) and PFA testing module were implemented in C#.

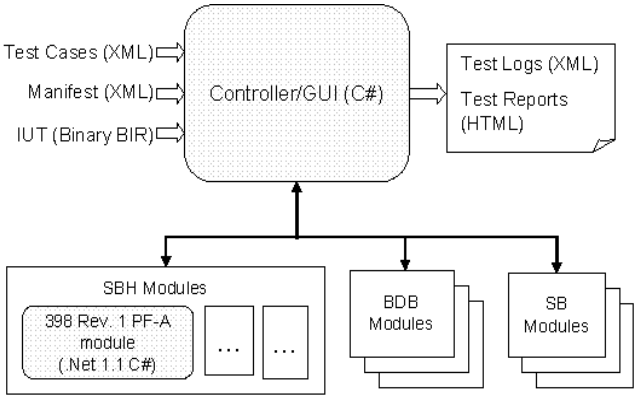

Fig.2. Conformance Testing Architecture

An interface was designed with properties that allow the controller to communicate with the testing modules. The current CTS implementation allows the user to perform the following tasks/tests:

- Generation/editing of Manifests representing the characteristics of specific binary files (Biometric Information Records under test).
- Generation/editing/testing of single Test Cases and binary files
- Simultaneous testing of large number of Test Cases or binary files (over 400 simultaneous files are supported in the current CTS version). These features are shown in Fig. 3.

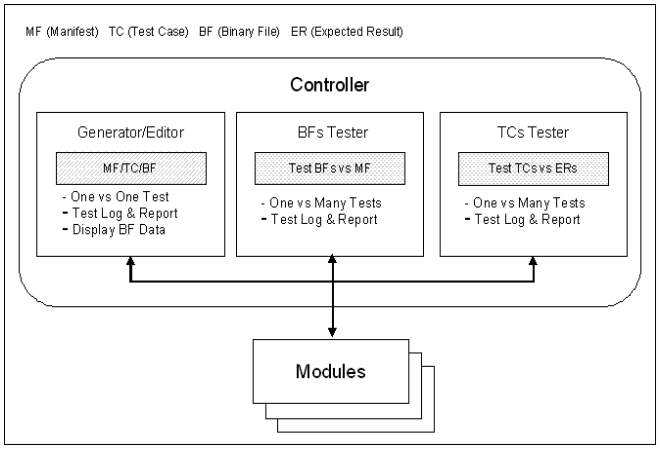

Fig.3. Controller

2) Test Cases

Test Cases describe the detailed steps that must be followed in order to achieve the stated purpose of each test. At the end of each test case, a verdict to the Test Case is included. These criterions are expressed as "Pass" or "Fail". Test Case generation is determined by the specification and the conformance requirements. A large number of Test Cases conforming and not conforming to PFA BIRs were developed to test the CTS implementation. The CTS implementation is evaluated by checking whether all generated Test Cases have been performed successfully. "Fail" verdicts may be caused by a fault or unexpected behavior in the CTS. Associated error messages help to determine what circumstance produced the fault. A Test Case is performed successfully when the test result is the same as the expected result. An additional benefit of these Test Cases is verifying the correctness of the standard [9].

3) Binary Files Tester

The objective of this CTS component is to test a number of binary BIRs against a Manifest that was generated based on a specific CBEFF patron format. Binary files are not expected to contain any information other than the BIR content. Level 1 and 2 tests are performed.

IV. Results

Over four hundred Test Cases representing different combinations of required and conditional/optional fields were developed. Testing CTS implementations with a large set of "Conformant" and "Non-conformant" Test Cases representing combinations of optional field subsets and different errors increase the error detecting capability during CTS development. A large number of binary files representing similar combinations of characteristics have been developed and successfully tested.

V. Conclusion, ongoing and future work

We have discussed the rational for the use of CBEFF Biometric Information Records to store and transport any type of biometric data independently of the format and modality of these data. Standard CBEFF BIRs support interoperability and data interchange. They also provide the means for supporting biometric data security. We discussed conformance testing for selected instantiations of CBEFF data structures conforming to a specific patron format specified in a standard (Patron Format A of INCITS 398, Revision of INCITS 398-2005). A Conformance Test Suite implementation was briefly discussed. Its design allows for efficient processing of a large number of Test Cases and binary files (PFA Biometric Information Records) in a very short amount of time. Test results are expressed in two formats. For easy human verification of single test results, Test Reports in HTML are generated. To facilitate automated verification and statistics generation over a large number of binary files tested, Test Logs encoded in XML are also generated. The controller/module interface allows easy integration of other testing modules for other patron formats. The conformance testing architecture supports testing modules for the three sessions of CBEFF BIRs including the headers conforming to different patron formats as well as Biometric Data Blocks and Security Blocks. These CTS modules can be easily integrated into the CTS implementation using a common interface. Tests are ongoing on other CTS modules. An advanced architecture to support multiple testing modules and a number of different interfaces for local or remote testing is being developed.

References

[1] Belinfante, J. Feenstra, R. d. Vries, J. Tretmans, N. Goga, L. Feijs, S. Mauw, and L. Heerink, "Formal test automation: A simple experiment", In G. Csopaki, S. Dibuz, and K. Tarnay, editors, *12 th Int. Workshop on Testing of Communicating Systems*, pages 179--196. Kluwer Academic Publishers, 1999.

[2] Fernando L. Podio, Jeffrey S. Dunn, Lawrence Reinert, Catherine Tilton, Bruno Struif, Fred Herr, Jim Russell, M. Paul Collier, Mark Jerde, Lawrence O. Gorman, Brigitte Wirtz, "Common Biometric Exchange Formats Framework (CBEFF 1.1)", NISTIR 6529-A, 2002.

[3] Common Biometric Exchange Formats Framework (CBEFF), ANSI/INCITS 398-2005.

[4] Common Biometric Exchange Formats Framework – INCITS 398, Revision of INCITS 398-2005, InterNational Committee for Information Technology Standards (INCITS), M1/06-0880, http://m1.incits.org/m1htm/2006docs/m1docreg_2006.htm

[5] Information technology - Common Biometric Exchange Formats Framework (CBEFF) - Part 1: Data Element Specification, ISO/IEC 19785-1: 2006.

[6] Information technology - Common Biometric Exchange Formats Framework (CBEFF) - Part 2: Procedures for the Operation of the Biometric Registration Authority, ISO/IEC 19785-1: 2006.

[7] Information technology - Common Biometric Exchange Formats Framework (CBEFF) - Part 3: Patron Format Specification, FDIS 19785-3.

[8] Conformance Testing Methodology Standard for Biometric Data Interchange Formats – Part 1: Generalized Conformance Testing Methodology, M1/06-0768. http://m1.incits.org/m1htm/2006docs/m1docreg_2006.htm

[9] P. Jalote, "Testing the completeness of specifications" *IEEE Transactions on Software Engineering*, 15(5):526-531, May 1989.