           Location-Independent Data/Software Integrity Protocol

Status of this Memo

Abstract

   This memo describes a protocol for adding integrity assurance to
   files that are distributed across the Internet. This protocol is
   intended for the distribution of software, data, documents, and any
   other file that is subject to malicious modification. The protocol
   described here is intended to provide assurances of integrity and
   time. A trusted third party is required.

Introduction

   One problem with any system for verifying the integrity of a file is
   that the verifying program itself may be attacked. Thus, although
   users may be reassured by their software that a file has not changed,
   in reality, the file, and the verifier might have both changed.
   Because of this danger, a protocol that does not rely on the
   distribution of some special software, but rather, is based entirely
   on widely used standards, is very useful. It allows users to build
   their own software, or obtain trusted copies of software to do
   integrity checking independently. Therefore, the protocol described
   in this memo is composed of ASCII messages that may be sent using e-
   mail or any other means. There is an existing implementation, Betsi
   [1], that is designed this way. Betsi has been in existence since
   August, 1994, and is operational on the Internet. It can be accessed
   by sending e-mail to certify@bellcore.com with subject 'help', or via
   the world wide web at http://info.bellcore.com/BETSI/betsi.html.

The purpose of the proposed protocol is for authors to be able to distribute their files to users on the internet with guarantees of time and integrity, by use of a trusted third party. The protocol is divided into several phases:

        I.   Author registration
        II.   Author verification
        III. File Certification
        IV.   File Distribution
        V.   File Integrity Verification

Phases I, III, IV, and V are defined in the protocol. Phase II is intentionally not defined. Author verification can be different for different applications, and the particular method chosen for phase II is identified in phases III and V. It is the hope that further Internet Drafts will describe the various possibilities for phase II. This memo describes the method for author verification in the Betsi system, and makes several recommendations.

Requirements

It is important that the integrity and time information be independent from the location of the file. Lowry [2] defines a syntax and protocols for location-independent objects. His system requires that end-users possess special software, and is still in the prototype stage. The protocol described in this memo has been implemented, and is already in wide-spread use across the Internet. It is simple, compact and easy to understand. The disadvantage of a very complex system is that users may not be inclined to trust the designers' claims if they cannot understand how it works.

Assumptions

The three entities in the protocol are Authors (A), Users (U), and a Trusted third party (T). The protocol described here is algorithm independent, and all of the messages are in ASCII. It is assumed that for each signature scheme used, there is a well-known verification key associated with T.

Any signature scheme may be used, as long as there is a standard ASCII representation of a digital signature. PGP [3] meets all of the above requirements, but it also requires encryption, and thus, export restrictions may deter some users. The DSS [4] is recommended, but some suspect that it contains a trapdoor [5] based on some results by Simmons [6]. It is also not clear that there is a standard for generating an ASCII signature using the DSS.

High level view

   The protocol works as follows. In the first phase, authors request to
   register with the trusted third party, T. Any registered author can
   distribute files with integrity and time assurance. Time assurance
   means that there is a guarantee that a file existed at a given time.
   In the second phase, T somehow verifies the identity of an author who
   requests to register. Registration is not complete until this
   verification takes place.

   To distribute a file, a registered author computes a cryptographic
   hash of the file, and sends it over an integrity protected channel to
   T. T then creates an object containing the hash, the current time,
   the name of the author, the name of the file, and some other
   information, seals the object, and returns it to the author. The
   author can then use the sealed object as a location-independent proof
   of the integrity and timeliness of the file.

   Any user who obtains the file and the sealed object, can compute the
   cryptographic hash of the file, check the seal on the object, and
   verify that the object has not changed.

   The trusted third party must maintain a widely available, dated, and
   signed, certificate revocation list (CRL). Users who access a file
   with a certificate must check that the CRL is current and complete,
   and that the certificate is not listed.

Author registration

   In the first phase, authors request to register with the trusted
   third party, T. The author sends an ASCII message to T containing
   keywords followed by values. Some of the fields are optional, and are
   marked with a *. The values are represented with angle brackets < >.

     AUTHOR-NAME= <first m. last>
   * AUTHOR-ORGANIZATION= <Company, school, etc.>
   * AUTHOR-EMAIL= <e-mail address>
     AUTHOR-LOCATION= <city, state>
   * AUTHOR-PHONE-1= <Home phone>
   * AUTHOR-PHONE-2= <Work phone>
     SIGNATURE-SYSTEM= <name of signature system>
   * MISC-FIELD-n= <Any number of additional fields can be defined here>
   * AUTHOR-PUBLIC-KEY=
   * <public key of author>

   Each of the fields contains the keyword and the value on the same
   line, except for the public key. An ASCII version of the key is
   pasted on the line after the AUTHOR-PUBLIC-KEY keyword. The format

of this ASCII key will depend on the signature system used. The
public key field is optional. The user may include his own, or one
can be supplied by T during phase II. T responds with a message that
the request was received, and that the user should wait for off-line
verification. If a user receives this confirmation message, and he
did not request to register, he knows that somebody may be attempting
to register on his behalf.

Author verification

   The trusted third party, T, must verify the identity of the author
   who sent the request message in phase I. The rest of the information
   in the request is also confirmed. This process takes place off-line.
   The method used is intentionally left open, but whatever technique is
   used must be identified in phases III and V.

   In the Betsi implementation, T uses the phone company infrastructure.
   T calls directory assistance (1-xxx-555-1212) in the city of the
   author and asks for the author's number. Then, that number is called,
   and T asks the author to verify the information sent in the request.
   In particular, T insures that the author has registered his correct
   public key. Or, in some cases, T assigns a public key to the author.
   As Betsi is only operational in the United States, other mechanisms
   need to be in place for verifying identities of people
   internationally. Hopefully, standards for doing this will arise. The
   rest of the protocol is independent of whatever mechanism is used for
   off-line identity and public key verification.

File certification

   Registered authors can obtain location-independent objects from the
   trusted third party, T, that vouch for the integrity and time of any
   file.

   An author generates the following ASCII message and signs it with the
   signature key that corresponds to the public key that was registered.

```
     AUTHOR-NAME= <first m. last>
     HASH-FUNCTION= <md5,sha, etc.>
   * FILE-LOCATION= <ftp site/directory>
     <list of hashes>
```

   Each entry in the <list of hashes> consists of two mandatory fields
   and one optional one, as follows:

```
     <fixed-length hash of file> <name of file> <version number>
```

The <fixed-length hash of file> is a fixed-length hexadecimal value
corresponding to the hash of the contents of the file. For MD5, the
output is 32 hexadecimal digits. There is one space between the
fields, and the name of the file contains no spaces. The <version
number> is optional. The <list of hashes> contains at least one
entry, and may contain as many as the author wants. The message is
signed and sent to the trusted third party, T.

When T receives the request for file certification, he verifies the
signature on the request and creates a location-independent
certificate for the request. The certificate is signed by T, and
contains the following information:

```
  TRUSTED-PARTY= <identity of T>
  AUTHOR-VERIFICATION-METHOD= <how authors are verified off-line>
  AUTHOR-NAME= <first m. last>
  AUTHOR-ORGANIZATION= <company, school, etc.>
  HASH-FUNCTION= <md5,sha, etc.>
  DATE= <date>
  <list of hashes>
```

The <list of hashes> is the same as the one in the author's request.
T signs the message and sends it to the author, who verifies the
signature and the contents of the certificate. Note that the method
for off-line author verification is included in the certificate.

File distribution

   In the file distribution phase, the author distributes his file,
   along with the certificate from T. The file and certificate are
   location-independent. That is, the integrity and timeliness of the
   file can be verified independently from the location of the file and
   the certificate. This means that files can be distributed from
   insecure sites, and over insecure networks.

File integrity verification

   The final phase is file integrity verification. A user obtains the
   public key of the trusted third party, T, from several independent
   sources, until he is convinced of its authenticity. The user then
   verifies the certificate for a file, and decides whether or not he
   trusts the method of off-line verification that was used by T. If so,
   then he extracts the name of the hash function in the certificate,
   and performs the hash function on the actual file. Finally, the user
   compares the hash of the file to the hash in the certificate. The
   user also checks the date in the certificate if he is concerned with
   this information. As a last step, the user checks the highly
   available certificate revocation list of T, to see if the current

certificate is listed. When all of this has concluded, if none of
the assumptions of the system has been violated, then the user is
assured of the integrity and timeliness of the file.

References

   [1] Rubin, A., "Trusted Distribution of Software over the Internet",
       Internet Society Symposium on Network and Distributed System
       Security," pp. 47-53, 1995.

   [2] Lowrey, J., "Location-Independent Information Object Security",
       Internet Society Symposium on Network and Distributed System
       Security," pp. 54-62, 1995.

   [3] Zimmerman, P., "PGP User's Guide", 1992.

   [4] National Institute for Standards and Technology, Digital
       Signature Standard (DSS), Federal Register 56(169), 1991.

   [5] Schneier, B., "Applied Cryptography", ISBN 0-471-59756-2.

   [6] Simmons, G., "The Subliminal Channels of the U.S. Digital
       Signature Algorithm (DSA)", Proceedings of the 3rd Symposium on:
       State and Progress of research in Cryptography, pp. 35-54, 1993.

Security Considerations

   Security issues are discussed throughout this memo.

Author's Address

   Aviel D. Rubin
   Bellcore
   Morristown, NJ 07960
   USA

   Phone: +1 201 829 5922
   Fax: +1 201 829 2645
   EMail: rubin@bellcore.com