Can Digital Evidence Endure the Test of Time?

By

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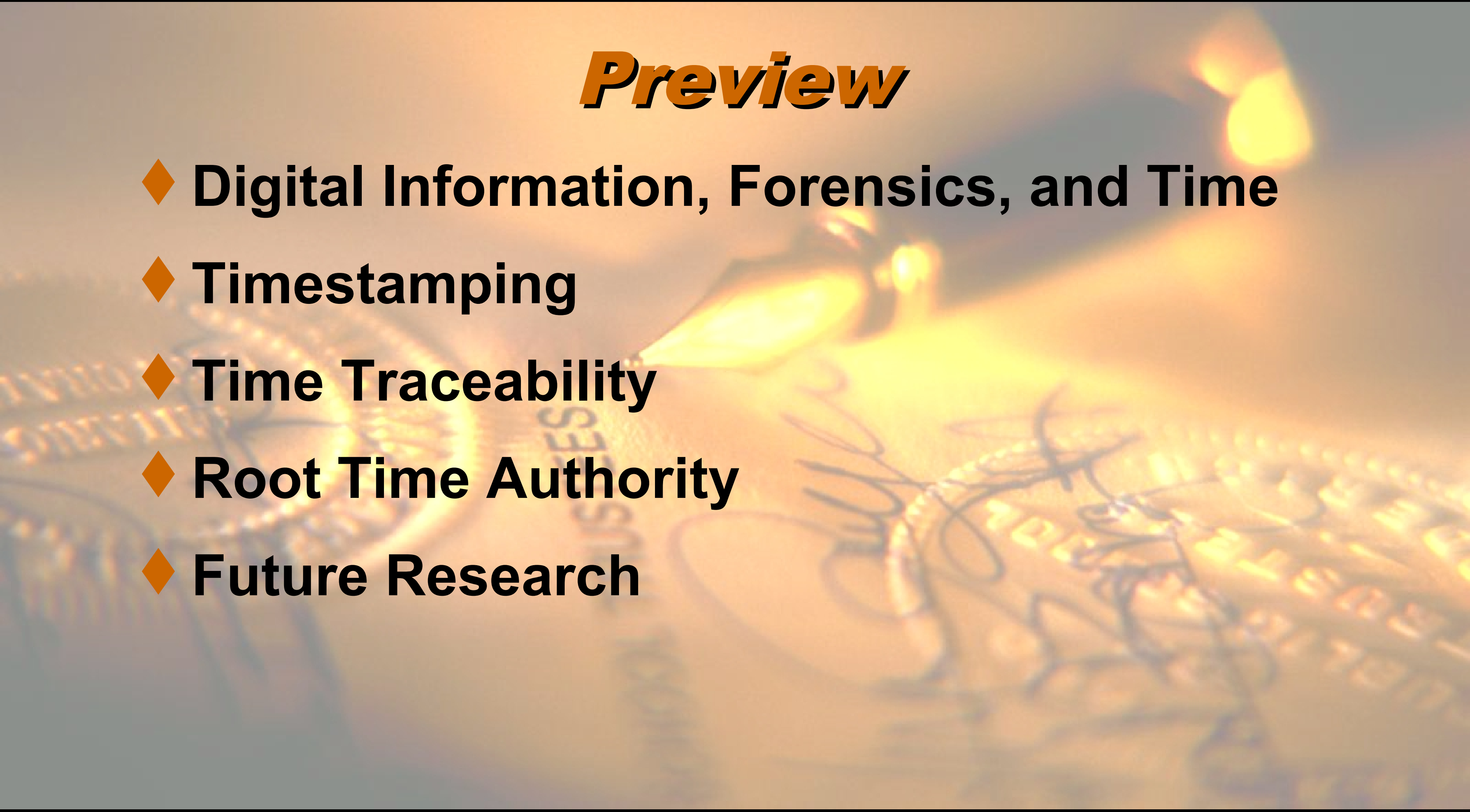

Preview

- Digital Information, Forensics, and Time
- Timestamping
- Time Traceability
- Root Time Authority
- Future Research

Digital Information

- Amount of digital information generated on a daily basis is unfathomable
- The impact on forensics is profound
- Likelihood that a case involves digital information is very high
  - Phone records, email, transaction logs, accounting data, etc.
- Digital data integrity must be maintained for effective analysis and possible presentation in court

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Integrity

Integrity can be defined as:

"the property whereby digital data has not been altered in an unauthorized manner since the time it was created, transmitted, or stored by an authorized source". [1]

What about the "When"?

- Cryptographic algorithms can be used to ensure that data has not been altered
  - Digital hashes such as SHA-1 and SHA-2 ensure "content integrity"
  - Asymmetric cryptography and Digital Signing ensure "identity integrity"
- We know how to protect the "who" and the "what"
- What about the "when"?

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What time was it?

- Time Questions:
  - When was the data created?
  - When was the data modified?
  - When was data collected as evidence?
  - How long did the collection process take?
  - When was the data catalogued?
  - When was it analyzed?
- These questions may seem easy to answer, but how do you prove the answers?

Time Integrity

- Time has been largely overlooked in integrity solutions
- Time is often assumed to be accurate and trusted
  - Amazing to consider everyone’s watch is synchronized within a few minutes
  - You probably know if your watch is a few minutes fast or a few minutes slow
- System clocks are not accurate and are very easily modified

Timestamping

- Computer security experts have recognized the importance of time in security systems
- Public Key Infrastructure (PKIX) working group of the Internet Engineering Task Force (IETF) recognized this as an issue
  - Public Key Cryptosystems require trustworthy time for expiration of certificates and CRL’s
  - Published RFC-3161, “Internet X.509 Public Key Infrastructure Time-Stamp Protocol”

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Timestamping

- RFC-3161 binds time and digital content using digital signatures
- Timestamps are issued by a Time Stamp Authority (TSA)
- Specification requires the relying party to trust the TSA through the application of policy
- There is no defined mechanism to convey traceability of timestamp’s time

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Timestamping

RFC 3161 Timestamp:

UTC Time:
August 1, 2002 21:26:46 UTC

Message
Imprint

```
30 82 02 85 06 09       48 86 f7 0d 01 07 02 a0 82 02 76    82 02 72 02 01 03 31 0b 30 09 06 05
2b 0e 03 02 1a 05    30 81 e9 06 0b 2a 86 48 86 f7 0d 01 09 10 01 04 a0 81 d9 04 81 d6 30 81 d3
02 01 01 06 0a 2b 06 01 04 01 84 59 0a 03 01 30 21 30 09 06 05 2b 0e 03 02 1a 05 00 04 14 b7 b8
eb ba 1c 96 76 e  bf 32 e3 e8 18 18 e2 1c c0 93 9c 90 02 04 00 06 38 01 18 13 32 30 30 32 30 38
30 31 32 31 32 36 34 36 2e 38 30 34 5a 30 0a 02 01 00 80 02 01 f4 81 01 00 01 01 ff 02 08 dc a9
a0 eb c8 2e ce ef a0 6b a4 69 30 67 31 0b 30 09 06 03 55 04 06 13 02 55 53 31 11 30 0f 06 03 55
04 0a 13 08 57 65 74 53 74 6f 6e 65 31 33 30 31 06 03 55 04 0b 13 2a 44 61 74 75 6d 20 54 72 75
73 74 65 64 20 54 69 6d 65 20 53 74 61 6d 70 53 65 72 76 65 72 20 53 4e 3a 39 30 44 30 30 32 34
38 31 10 30 0e 06 03 55 04 03 13 07 50 61 75 6c 33 31 39 31 82 01 72 30 82 01 6e 02 01 01 30 47
30 42 31 0b 30 09 06 03 55 04 06 13 02 55 53 31    30 0c 06 03 55 04 0a 13 05 44 61 74 75 6d 31
13 30 11 06 03 55 04 0b 13 0a 46 61 63 74 6f 72 79       41 31 0e 30 0c 06 03 55 04 03 13 05 44
61 74 75 6d 02 01 02 30 09 06 05 2b 0e 03 02 1a 05          30 1a 06 09 2a 86 48 86 f7 0d 01
09 03 31 0d 06 0b 2a 86 48 86 f7 0d 01 09 10 01                                        04 31 16
04 14 ae 88 f1 e5 65 f8 1c 06 b0 ab 54 da ba                                           86 f7
0d                         30 7f 30 7d 30 63                                           97 5c
9f                         a4 44 30 42 31 0b                                           06 03
55                         6d 31 13 30 11 06 03                                     43 41 31
0e 30 0c 06 03 55 04 03 13    44 61 74 75 6d 02 01 02 30 16 04 14 ac 61 74 39 00 4f 9b 1b 4f af
33 97 4e d6 ba 3e 5f 6a 1d 1e 30 0b 06 07 2a 86 48 ce 38 04 03 05 00 04 30 30 2e 02 15 00 a9 1e
dc e4 a9 1d 74 05 7f 02 fb b6 a1 4f fd 13 e0 5d 98 c3 02 15 00 b9 b0 63 4b 32 fb 60 3c 65 b7 1a
37 29 90 27 71 85 73 a7 dc
```

TSA Name:
C=U;O=WetStone;OU=Datum Trusted Time
StampServer SN:90D00248;CN=Paul319

Digital Signature

WetStone
Securing Digital Integrity

Timestamp Traceability

- Timestamps must be traceable!
- Traceability can be defined as:
  - *The property of a result of a measurement or the value of a standard whereby it can be related to stated references, usually national or international standards, through an unbroken chain of comparisons all having stated uncertainties. [4]*
- How can we demonstrate traceability of a timestamp?
- We must define:
  - Our national or international standard
  - An unbroken chain of comparisons

Time Reference

- Many calendars have been created and used over the centuries
- Early calendars where based on the moon
- The calendar used today is the Gregorian calendar and was created in 1582 by Pope Gregory XIII
- The second was defined in 1967 based on measuring the decay of the Cesium atom
- In 1972, the Treaty of the Meter was expanded to include Coordinated Universal Time (UTC) which replaced Greenwitch Mean Time (GMT)

Time Reference

- More than 40 countries contribute to UTC
- UTC is not maintained in a single location; it is virtual
- Contributors compare their clocks and then make appropriate adjustments
- UTC is coordinated in Paris by the International Bureau of Weights and Measures (BIPM)
- The US has two UTC contributors: NIST and USNO

Timestamping Solution

- WetStone has been working on this problem for more than four years
- Combined work with ARFL and our commercial partner Datum, Inc.
  - Phase I and II SBIR, Trusted Network Time
- Solution provides traceability of timestamps to UTC

Timestamping Solution

- TSAs cannot always be located remotely
  - Particularly in transaction based systems
- Assume a requirement for timestamps to be issued on site
- Considering the deployment environment, a basic principal of on-site timestamping device:
  - The Clock and the Cryptographics used in the timestamp must reside in the same cryptographic boundary.
- Problem reduced to showing the traceability of the clock

Timestamping Solution

- Secure Time Module (STM) was developed on the IBM 4758
  - Device is certified at FIPS 140-1 level 4
- Clock and the Crypto reside in the security boundary
- Software in the device follows strict rules for key usage and clock management

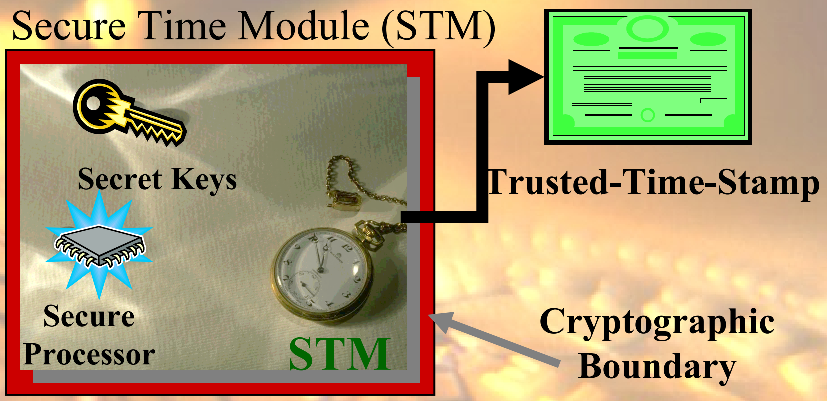

Figure 2. The Secure Time Module

Timestamping Solution

- Traceability can be accomplished through audit
- Defined a Trusted Third Party (TTP) called a Root Time Authority (RTA) that facilitates audits of STM clocks
- On a periodic basis, RTA measures remote STM and issues Time Attribute Certificate (TAC) that contains the results
- RTA plays the role of an Attribute Authority and issues X.509 compliant Attribute Certificates to attest to measurement results
- RTA acts like a Certificate Authority for time

Timestamping Solution

- RTA operates as a TTP with auditable practices and procedures
- RTA maintains traceability through multiple, redundant time sources and through measurement of its clocks by National Measurement Institutes (NMI)
- Timestamp consumers can operate their own STM and rely on RTA for traceability

Additional Research

- Implications, on a trusted system, of the uncertainty issues pertaining to the remote measurement of a clock over a network or the internet
  - Formally define security policies that incorporate the uncertainty of a measurement
- Clock trustworthiness and performance
  - Regardless of the level of precision, highly accurate and trustworthy time keeping with open up new avenues for the application of trusted time

Summary

- The forensic investigator must understand the issues regarding time integrity
- Secure Timestamping solutions are being adopted by industry
- Digital evidence integrity can be improved by the application of digital timestamps
- Additional research may yield significant advancements in trusted time keeping technology

Sources

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2. C. Adams, P. Cain, D. Pinkas, R. Zuccherato, “Internet X.509 Public Key Infrastructure Time-Stamp Protocol” RFC 3161, August 2001
3. NIST, “World Time Scales,” http://physics.nist.gov/GenInt/Time/world.html
4. Lombardi, Michael A., “Traceability in Time and Frequency,” NIST Time and Frequency Division Publication