Publius
A Robust, Tamper Evident, Censorship Resistant WWW Based Publishing System

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Proc. 9th USENIX Security Symposium, 2000

Presented by Anyi Liu

Dec. 2, 2004

Acknowledgments

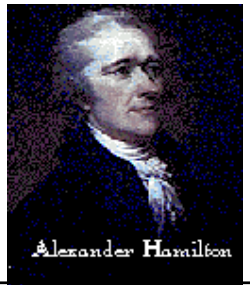
- Some of the following slides are adapted from the slides created by the authors of the paper, and the following link
- http://www-net.cs.umass.edu/cs791n/marc.ppt

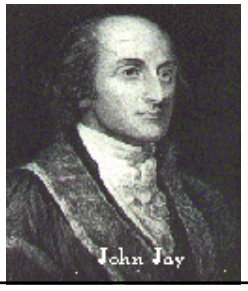
Agenda

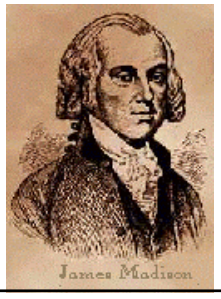
- Motivations and Design Goals
- Main Ideas
- Implementation Details
- Security Challenges

What is Publius in History?

- Publius is the *pen name* used by three authors of Federalist Papers
- Authors may publish their papers without worrying about been disclosed of real-world identities.







Design Goals

- Censorship resistant
  - Difficult for a third party to modify or delete content
- Tamper evident
  - Unauthorized changes should be detected
- Source anonymous
  - No way to tell who published the content
- Updateable
  - Changes or deletion of content should be possible for publishers

Design Goals (cont)

- Deniable
  - Involved third parties should be able to deny knowledge of what is published
- Fault Tolerant
  - System remains functional, even if some third parties are faulty or malicious
- Persistent
  - No expiration date on published materials

Related Works

- Connection Based Anonymity
  - Hide identity of requestor
    - Anonymizing proxies (for example Anonymizer.com)
    - Freedom (Zero-Knowledge Systems)
    - Crowds (AT&T Labs-Research)
- Location or Author Based Anonymity
  - Hide identity of author or WWW server
    - USENET Eternity System
    - Freenet
    - Intermemory
    - Rewebber

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Theoretical Foundation

- *Shamir secret sharing theorem*
  - Suppose Alice wants to share a secrete among *n* agents. Any subset of *n* agents(say, *k*) can use their shares to reconstruct the secrete
  - No subset of size < *k* learns anything
  - Assume that up to *n-k* agents may be "bad", and may not reveal their shares. The rest of the agents are "good", and follow the protocol
  - The bad agents can't prevent the good agents from reconstruct the secrete

Publius System Roles

Publius is a Client-Server paradigm

- Publishers
  - Post Publius content to the web
- Servers
  - A set of hosts that store random-looking content
- Retrievers
  - Browse Publius content on web

Publius System Operations

There are basically four type of operations

- Publish
  - A publisher posts content across multiple servers in a source-anonymous fashion
- Retrieve
  - A retriever gets content from multiple servers
- Delete
  - The original publisher of a document removes it from the Publius servers
- Update
  - The original publisher modifies a document

Publius Publish Operation

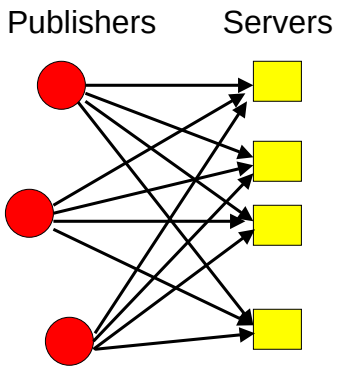
- Alice generates a random *symmetric* key K
- She encrypts message M with key K, producing $\{M\}_K$
- She splits K into n shares, using *Shamir secret sharing theorem*, such that any k can reproduce K
- Each share is uniquely named:

$$name_i = wrap(H(M \cdot share_i))$$

MD5

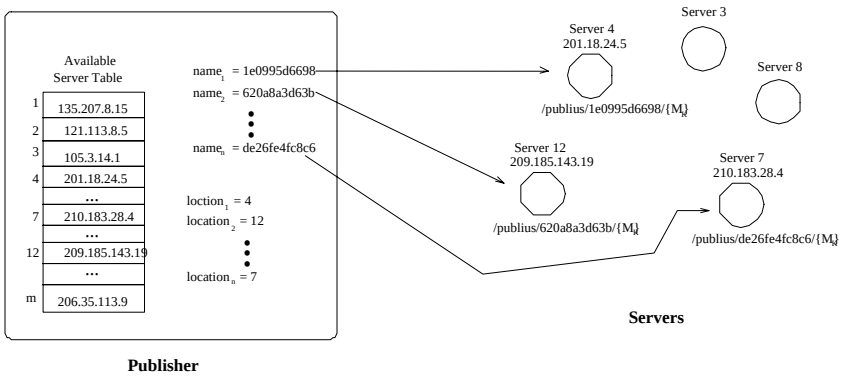
Publius Publish Operation(Cont')

- A set of locations is chosen:
  $location_i = (name_i \ MOD \ m) + 1$
- Each $location_i$ indexes into the list of m servers
- If sizeof(location) $< d$, start over again
- Otherwise, Alice publishes $\{M\}_K$ and $share_i$ into a directory $name_i$ on the server at $location_i$
- A URL containing at least the d $name_i$ values is produced



Note: d represents the minimum number of unique server that will hold the Publius content.

Publius Publishing



Publius Retrieve Operation

- Bob parses out each $name_i$ from URL, and for each, computes:

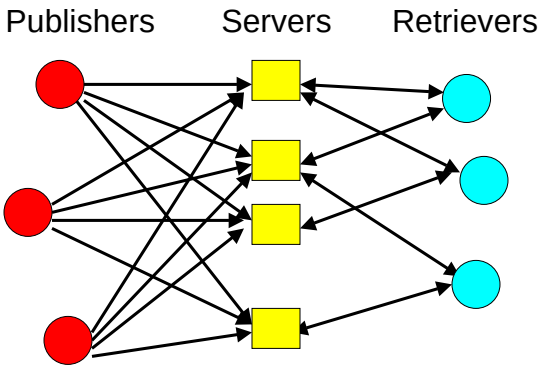
  $$location_i = (name_i \ MOD \ m) + 1$$

- Bob chooses k of these, and retrieves the encrypted file $\{M\}_K$ and $share_i$ at each server
- Bob combines the shares to get K, and decrypts the message M
- Bob verifies that each name value is correct:

  $$name_i = wrap(H(M \cdot share_i))$$

- If $name_i$ can't be reconstruct through M, $share_i$ →The content has been tampered.

Retrieving a Publius document



Publius Delete Operation

- Alice generates a password *PW* when publishing a file
- Alice includes *H(server_domain_name · PW)* in server directory when publishing
  - Note that each server does not store PW/H(PW), because it prevents malicious server operator from deleting content on all other servers
- Alice deletes by sending *H(server_domain_name · PW)* and $name_i$ to each of the *n* servers hosting content

Publius Update Operation

- Idea: change content without changing original URL, as links to that URL may exist
- In addition to the file, the share, and the password, there may be an update file in the $name_i$ directory
- This update file will not exist if Alice has not updated the content

Publius Update Operation(Cont')

- To update, Alice specifies a new file, the original URL, the original password *PW*, and a new password
- First, the new content is published, and a new URL is generated
- Then, each of the *n* old files is deleted, and an update file, containing the new URL, is placed in each $name_i$ directory of each servers

Publius Update Operation (Cont')

- When Bob retrieves updated content, the server returns Bob the updated URL
- Bob receive all the updated URL from k servers, and checks if all of the new URLs are identical
- If yes, Bob will retrieves the content at the new URL

Other Features

- Entire directories can be published by exploiting the updateability of Publius
- Mechanism exists to encode MIME type into Publius content
- Publius URLs include option fields and other flags, the value of *k*, and other relevant values
  - Older broswers prohibit URLs of length >255 characters
  - Once this limitation is removed, URLs can include server list, making this list non-static

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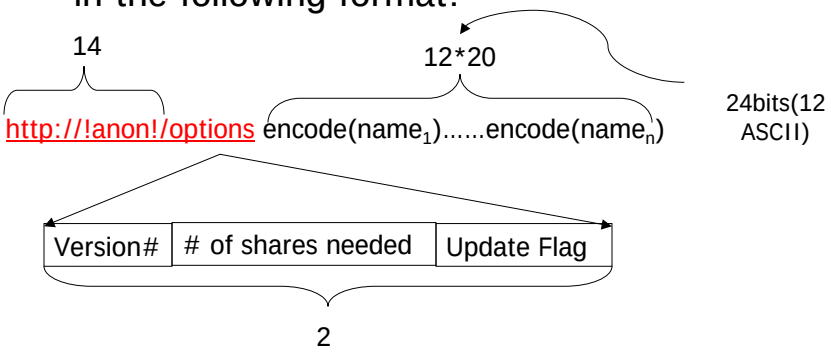
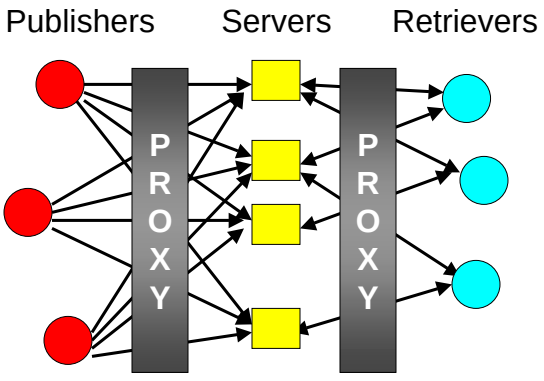
Publius URLs

- Since most old browsers only accept URL with at most 256 characters, Publius defines URL in the following format:



Publius proxies



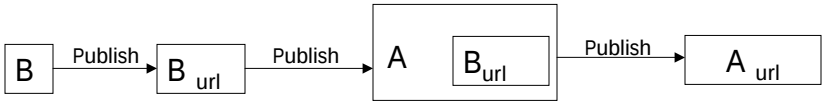
- Publius proxies running on a user's local machine or on the network handle all the publish and retrieve operations
- Proxies also allow publishers to delete and update content

Server/Client Side Software

- Server: Accept HTTP POST operation
  - Requested operation, file name, password, and other info are passed through POST request
- Client=Http Proxy+a set of publish tools
  - Return values: Success
    Unable to find M
    Update → Re-direct

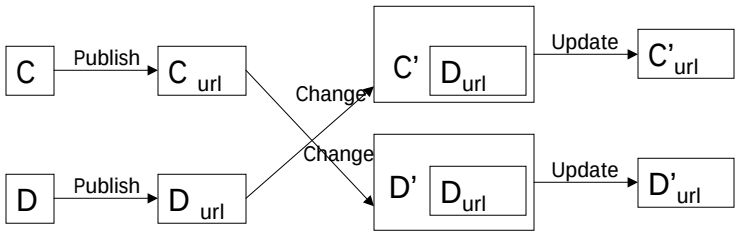
Publish Mutual Hyper-Links

- How to publish documents contains hyper-links. Let's discuss two cases:
- Case1: Alice trying to publish HTML file A and B, A contains a hyper-link to file B



Publish Mutual Hyper-Links(cont')

- Case2: Alice trying to publish HTML file C and D, C contains a hyper-link to file D, and D contains C



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Share deletion or corruption

- Share deletion or corruption
  - If all *n* copies of a file, or *n*-*k*+1 copies of the shares, are deleted, then the file is unreadable (less than k shares exist)

Solution: Increasing *n*, or decreasing *k*, makes this attack harder

Update file deletion or corruption

- Update file deletion or corruption (case1)
  - If there is no update file, malicious server operator, Mallory, could create one and pointing to bad content
  - This requires the accomplice of at least *k* other server.

Solution:

- This attack motivates a higher value of *k*
- If *update* flag was turned off, it will prevent this attack

Update file deletion or corruption(cont')

- Update file deletion or corruption (case2)
  - If Publius content has already been updated, Mallory must corrupt update files on *n*-*k*+1 servers
  - Of course, if Mallory can do this, she can censor any document
  - Larger *n* and smaller *k* make this more difficult

Update file deletion or corruption(cont')

- Update file deletion or corruption (case3)
  - If Mallory can delete the updated files on all servers to be deleted, he can restore the content to its previous state
  - This motivate client to retrieve from all n copies before perform verification
  - This solution seems impractical
- Deciding upon good values for *n* and *k* is difficult
  - Case1, 2 vs Case3
  - No suggestions from Waldman et al.

Denial of service attacks

- Publius, like all internet services, is subject to DoS attacks
  - Flooding is less effective, as *n*-*k*+1 servers must be attacked
  - A malicious user could attempt to fill disk space on servers
    - Some mechanisms in place to prevent this

Threats to publisher anonymity

- If the Publius content contains any identifying information, anonymity will be lost
- Publius does not provide any connection based anonymity. Eavesdrop is possible.
  - If you act as a publisher, you must anonymize your connections with the Publius servers

“Rubber-hose cryptanalysis”

- The technique of breaking a code or cipher by finding someone who has the key and applying a rubber hose vigorously and repeatedly to the soles of that luckless person's feet until the key is discovered.
- Even though some server could be forced to delete Publius content, to do it across the countries and jurisdictions is very expensive and impractical

Publius vs Freenet

- Both provide publisher anonymity, deniability, and censorship resistance
- Freenet provides anonymity for retrievers and servers, as well
  - Cost is high: data must be cached at many nodes
- Publius provides persistence of data
  - Freenet does not
  - Can any p2p system provide persistence?

Questions

- How do you publish Publius URLs anonymously?
  - The first person to publish a Publius URL must have some connection with the publisher of the content
  - If you have somewhere secure and anonymous to publish the Publius URLs, why do you need Publius?
    - One possible answer: censorship resistance
    - But server operators are then potentially liable

Questions

- How deniable is Publius?
  - Publius URLs are public
  - With minimal effort, a Publius server operator could determine the content being served

Questions

- Could Publius be made into a p2p service?
- Would it be appropriate to do so?

More questions?