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Research Center for
Information Security

PAKE-based mutual HTTP authentication for preventing phishing attacks

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Our Proposal

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- Our proposal

  new mutual authentication protocol for Web systems against phishing attacks

  - Some of design goals are
    - Secure,
    - Easy to use, and
    - Generic.

  … details follow.

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Design Goals

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- Secure
  - detecting phishing websites reliably
    - Both users and servers are authenticated
  - no password information leaks
    for false websites
    - offline dictionary attack impossible

(↔DIGEST auth, PwdHash:
>20 chars required for password secrecy)

Design Goals

- Easy to use
  - using human-memorable passwords only
  - no need for personal secret storage
    (↔TLS client auth., password reminders)
- Generic
  - no whitelist (↔EV SSL)
  - no blacklist (↔IE/Firefox phishing warnings)
  - not site-specific

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Design Goals

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- *Aiming for long-term solution:*
  - *future replacement for form-based auth.*
  - Requires server modifications
    - Installation of the new authentication module.
  - Requires client modifications
    - Browsers must be modified to support this algorithm.

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Technology

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- Adopting PAKE for Web authentication
  - Mutual auth. with weak secret (password)
  - Password information is not leaked at all
    - Offline dictionary attack impossible
- Naturally extending RFC2617
  - Drop-in replacement for BASIC/DIGEST
  - Replacement for form-based authentication in web applications
  - Relying on TLS for secrecy of payload
    - Assume transport/DNS security
- Host-name based detection of phishing
  - avoiding man-in-the-middle phishing

Protocol details

- Based on ISO-defined variant of PAKE protocol (ISO 11770-4 KAM3)
  - Password is combined with hostname as "weak secret" to prevent MIM attack.

$$\pi = H(\text{password}, \text{host})$$

- Computational cost similar to TLS
  - Single public-key op. for 1st access
  - A few hash op. for 2nd access & more

Protocol details

- Some features
  - Session management
    - reuse negotiated key for several requests
      - reducing computational overhead
  - “Optional” authentication
    - Support guest/authenticated accesses in same URI
      - Like Yahoo! top-page and many other websites

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Sample Communication

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```
GET / HTTP/1.1
Host: www.example.com

HTTP/1.1 401 Authentication required
WWW-Authenticate: Mutual algorithm=iso11770-4-ec-p256,
      validation=host, realm="Protected Contents",
      stale=0
Content-Type: text/html; charset="ISO-8859-1"
Content-Length: 5163
……

GET / HTTP/1.1
Host: www.example.com
Authorization: Mutual algorithm=iso11770-4-ec-p256,
     validation=host, user=foobar,
     wa=xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

HTTP/1.1 401 Authentication required
WWW-Authenticate: Mutual sid=yyyyyyyy,
     wb=zzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzzz,
     nc-max=1024, nc-window=64, time=300, path="/"
Content-Length: 0

GET / HTTP/1.1
Host: www.example.com
Authorization: Mutual sid=yyyyyyyy, nc=0,
    oa=wwwwwwwwwwwwwwww

HTTP/1.1 200 OK
Authentication-Info: Mutual sid=yyyyyyyy,
            ob=vvvvvvvvvvvvvvv
Content-Type: text/html; charset="ISO-8859-1"
Content-Length: 7043
……
```

First request (w/o authentication)

Key exchange phase

Authentication confirmation phase

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First Request

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GET / HTTP/1.1

Host: www.example.com

HTTP/1.1 401 Auth. required

WWW-Authenticate: Mutual
algorithm=iso11770-4-ec-p256,
validation=host,
realm="Protected Contents",
stale=0

Content-Type: text/html;
charset="ISO-8859-1"

Content-Length: *5163*

- First request without auth.
  - 401 response
    (as in usual HTTP auth.)
  - Specify crypto. algorithm from server
  - Content body displayed
    - Requesting login
  - ID/Pass requested

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Variant to First Request

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GET / HTTP/1.1

Host: www.example.com

HTTP/1.1 200 OK

Optional-WWW-Authenticate:
Mutual
algorithm=iso11770-4-ec-p256,
validation=host,
realm="Protected Contents",
stale=0

Content-Type: text/html;
charset="ISO-8859-1"

Content-Length: *5163*

- Variant: 200 + optional auth.
  - New introduction in ours
- "Guest Contents" displayed with Optional-WWW-auth header
  - User can continue to be a guest

  Or
  - User can enter ID/Pass to login to the site

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Key exchange

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GET / HTTP/1.1
Host: www.example.com
Authorization: Mutual
algorithm=iso11770-4-ec-p256,
validation=host, user=*foobar*,
wa=*xxxxxxxxxxxxxxxxxxxxxxxxx*
xxxxxxxxxxxxxxxxxxxxx

HTTP/1.1 401 Authentication required
WWW-Authenticate: Mutual
sid=*yyyyyyyy*,
wb=*zzzzzzzzzzzzzzzzzzzzzzzzz*
zzzzzzzzzzzzzzzzzzzzz,
nc-max=1024, nc-window=64,
time=300, path="/"
Content-Length: 0

- PAKE Key exchange ongoing
  - Client/server exchanges key materials wa & wb, twisted by password-based weak secrets
- Session ID (sid) established
- Temporary key shared between client & server, *only if the weak secrets are generated from the same password*

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Final authentication

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GET / HTTP/1.1

Host: www.example.com

Authorization: Mutual
sid=*yyyyyyyy*, nc=0,
oa=*wwwwwwwwwwwwww*

HTTP/1.1 200 OK

Authentication-Info: Mutual
sid=*yyyyyyyy*,
ob=*vvvvvvvvvvvvvvv*

Content-Type: text/html;
charset="ISO-8859-1"

Content-Length: *7043*

- Checking proper key exchange using shared-key and hash functions
- Both clients and servers are authenticated (oa, ob)
  - Client MUST check the validity of ob

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Next request

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GET /logo.png HTTP/1.1

Host: www.example.com

Authorization: Mutual
sid=*yyyyyyyy*, nc=1,
oa=*uuuuuuuuuuuuuuuu*

HTTP/1.1 200 OK

Authentication-Info: Mutual
sid=*yyyyyyyy*,
ob=*sssssssssssssssssss*

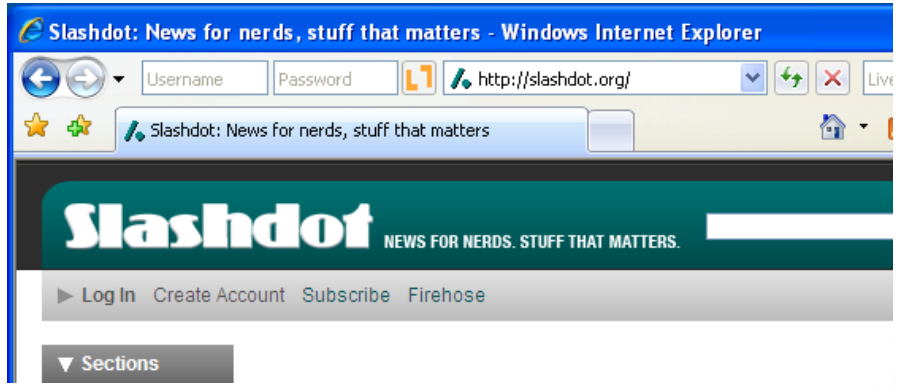
Content-Type: image/png

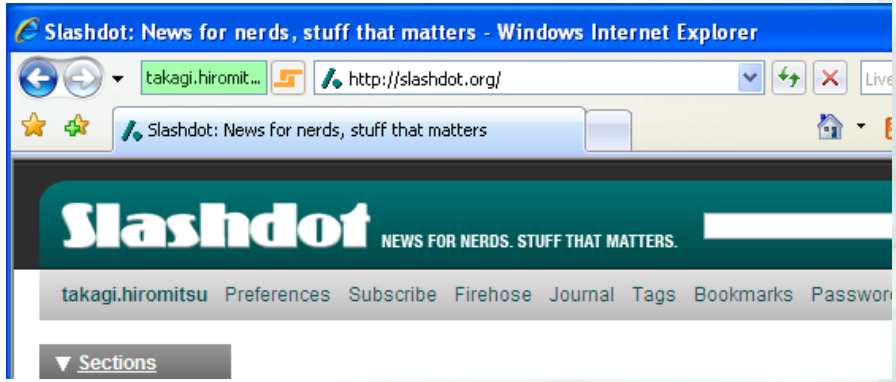
Content-Length: 15082

- Shared key can be reused for multiple requests
  - Nonce prevents replay
  - Number of reuse are limited by nonce counter limit

UI consideration

- Entry field must be protected from image-based forgeries
  - no popup dialog (↔ BASIC/DIGEST auth.)
  - e.g. use toolbar area (see above)
- Auth. status must be indicated
  - to prevent imitated auth. success





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Current status

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- Plugin for Apache server implemented
- Test Firefox extension implemented
  - Full implementation is about to start
- Internet-Draft in preparation

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Future Plans

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- Field test in a part of Yahoo! Japan
- Distribution of open-source modules
- Submitting Internet-Draft

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Related Work

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- EV-SSL … relies on central authorities
- Passpet … requires private key storage
- PwdHash
  - Similar hostname-based mangling
  - Weak against offline attacks

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Page Transition Examples

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Websites not supporting authentications

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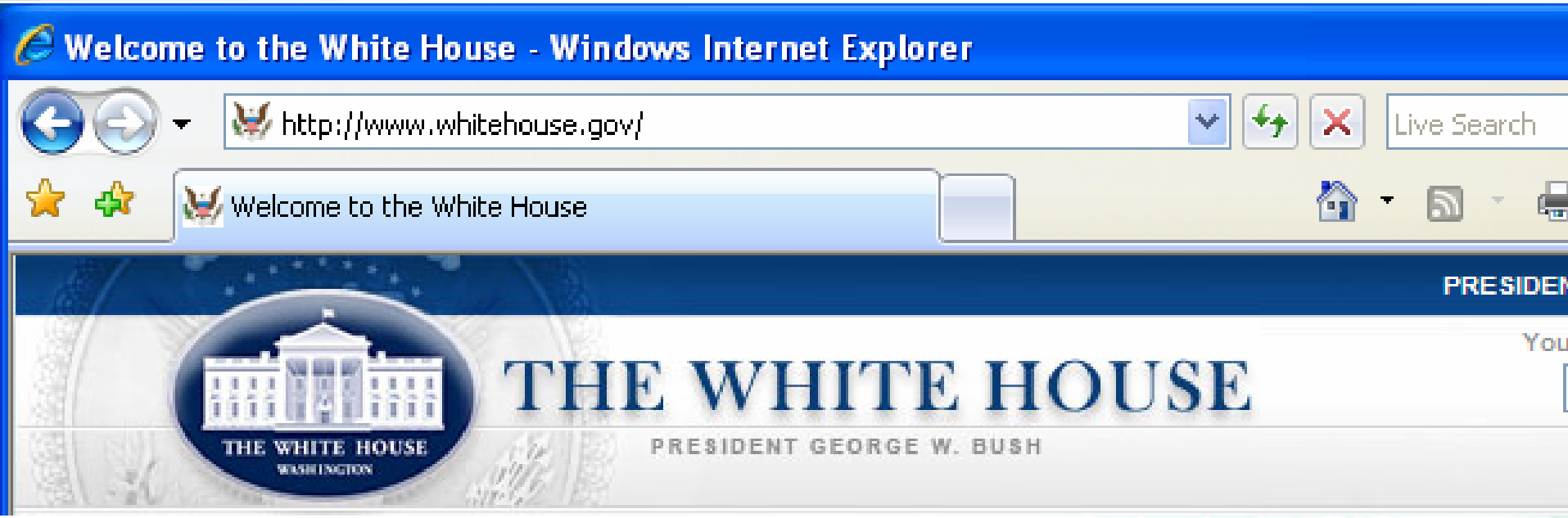
- Status: 200 OK
  - No login field displayed



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Visiting Mutual-auth sites as guest

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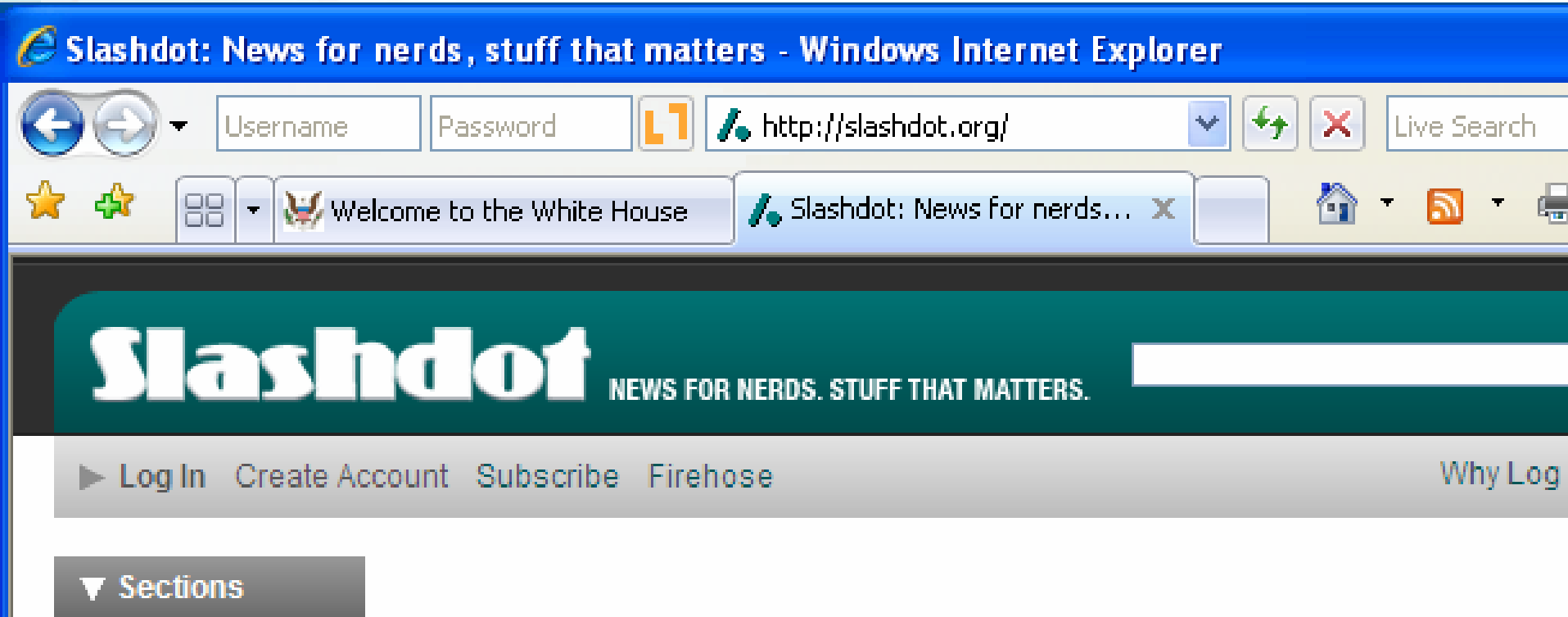
- Status: 200 OK
  - Optional-WWW-Authenticate: Mutual …
- ID/Password box appears



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Switching Tabs

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- Login field displayed/hidden, according to te status of each tab

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Login!

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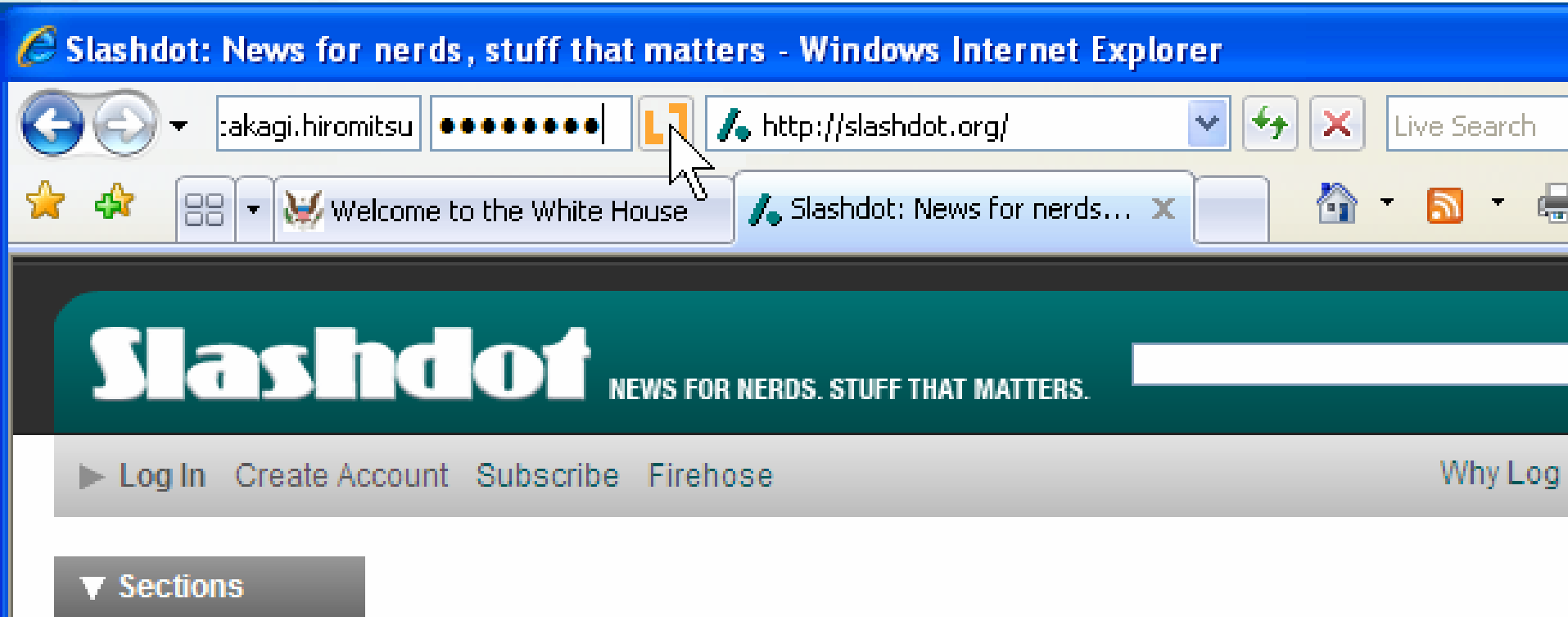
- Enter ID/password, click the button…



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Login…

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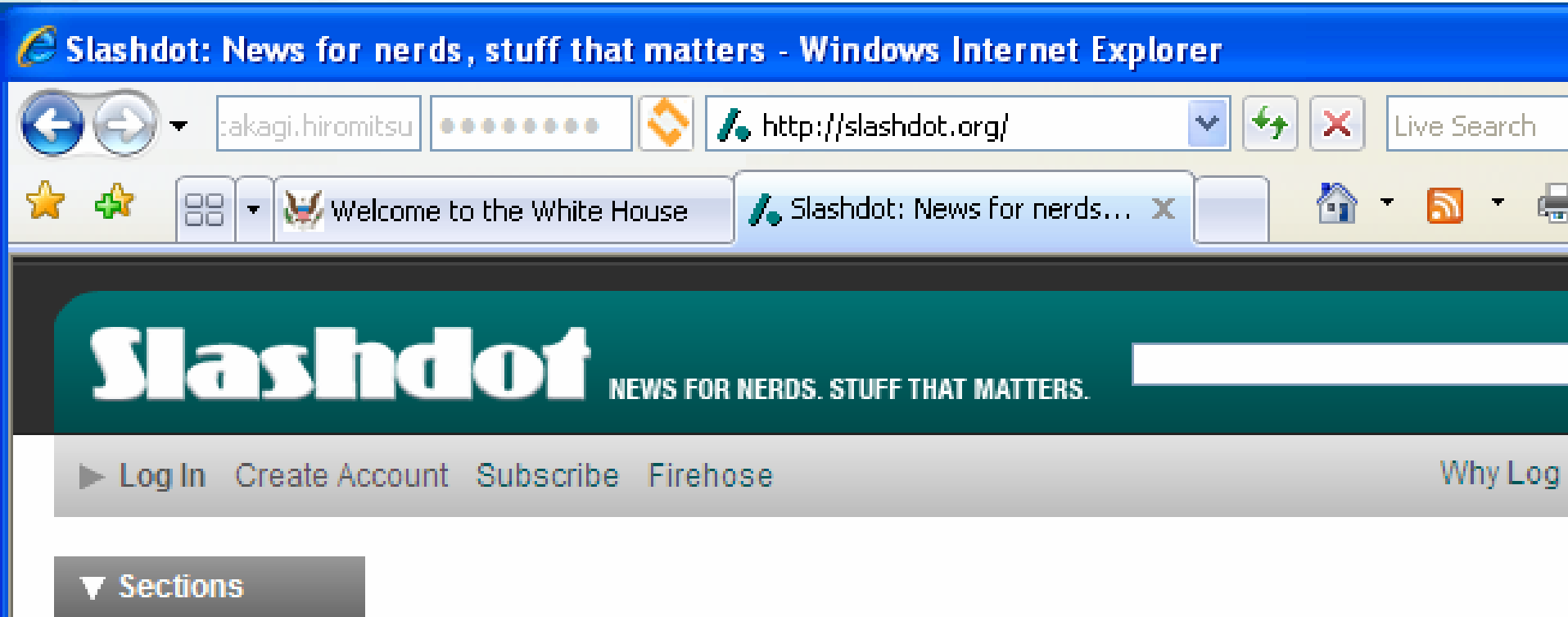
- Waiting for authentication response



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Logged in

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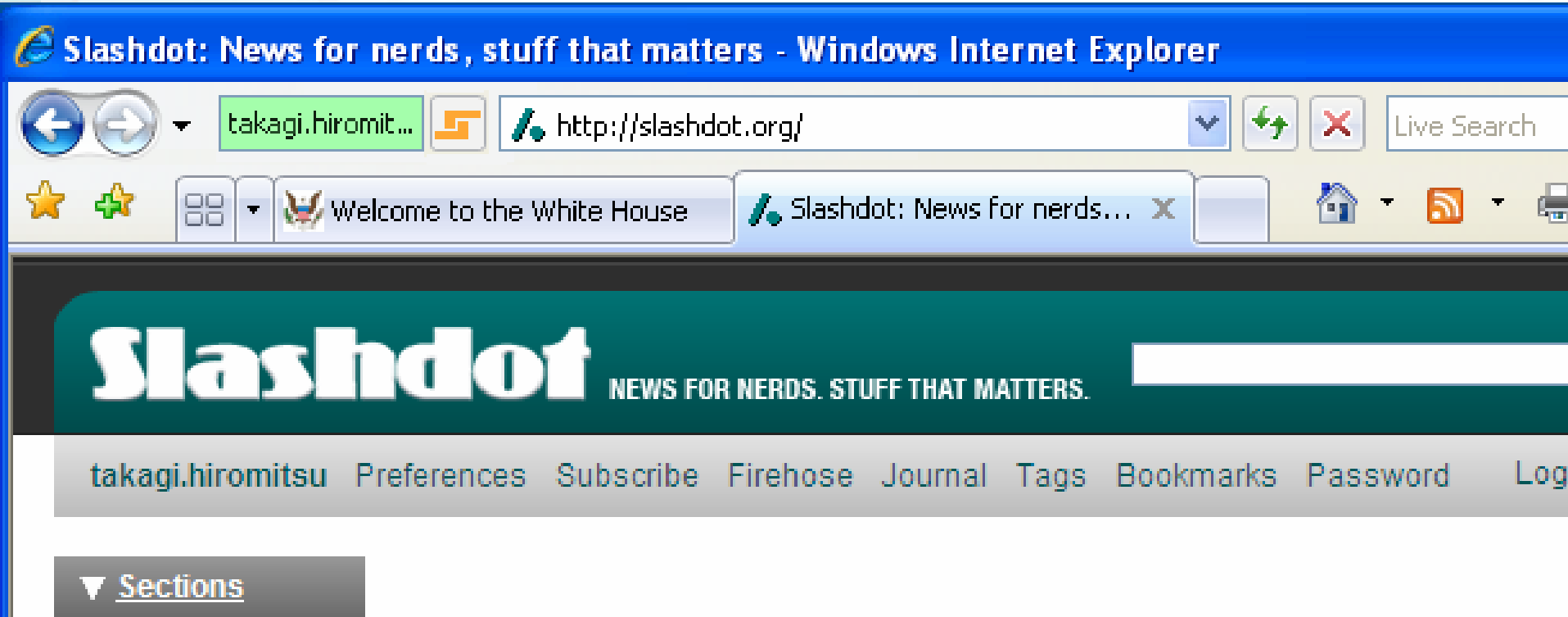
- Status: 200 OK
  - Authentication-info: Mutual ……
- ID indicated with green background



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Switching Tabs

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- Login status display changes still according to the status of each tab

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Logout

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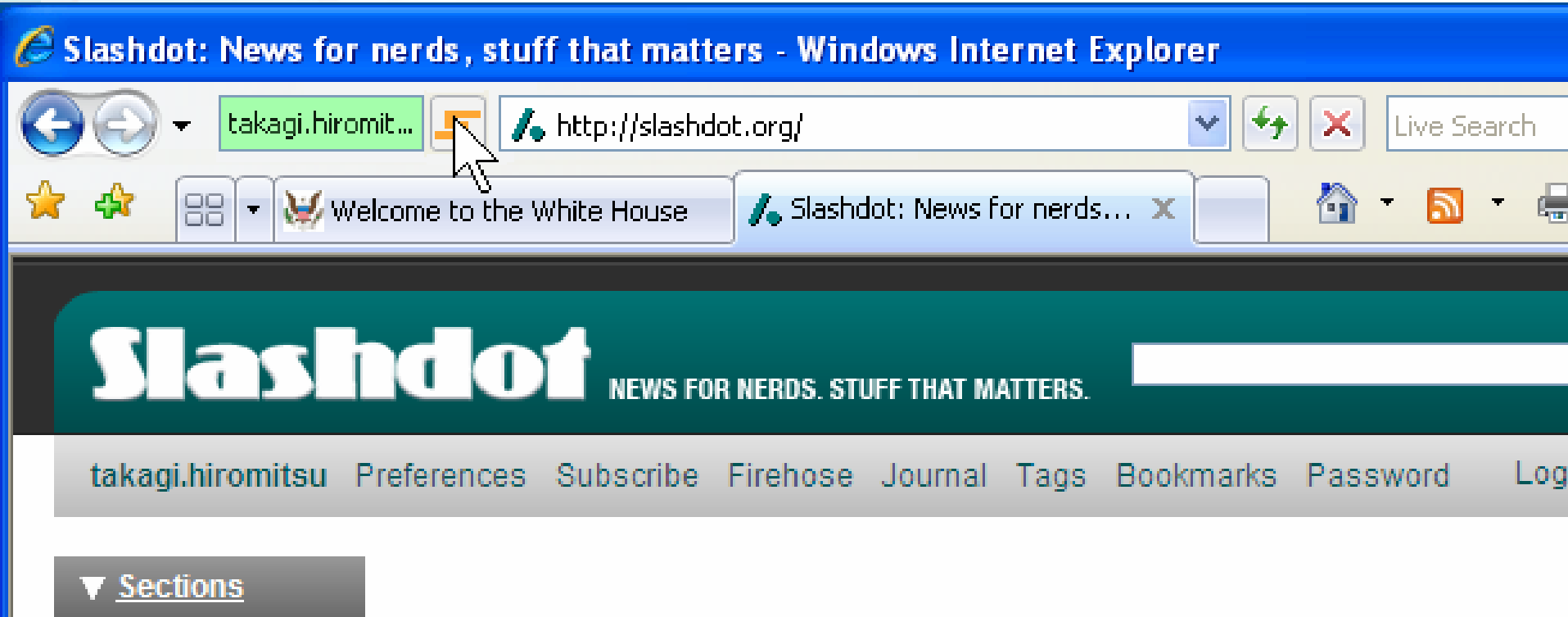
- Click button to logout



Logout

- Status: 200 OK
  - Optional-WWW-Authenticate: Mutual …
- Contents reloaded, back to the guest state