# Name Collision Vulnerabilities

# DNS Service Discovery - Zero Configuration

***Zeroconf, what is it?***

Created in 1999 by the group IETF (Internet Engineering Task Force), the Zero Configuration Networking (Zeroconf) is a methodology and a special set of technologies that enable the configuration of a network and discovery of services in a simple way that an average user will not notice.

- Dynamic Host Configuration Protocol (DHCP)
- Find and list services (printers, servers, etc.)

# DNS Service Discovery - Zero Configuration

Computer will automatically search for services on the network

DNS-SD works well with the MDNS but also works with the classic DNS

Messages for service discovery are of the same format queries

The queries are of type SRV, PTR, A and TXT

- SRV: Contains name, service port, and host name
- PTR: Is a pointer, stores the service type and service name
- A: Stores the IP address of the service
- TXT: It is used for additional service information

# DNS Service Discovery - Example

A computer wants to know the printers that are on the LAN:

- PTR DNS query:
  - _ipp._tcp.local PTR
- Response:
  - sales._ipp._tcp.nTLD
  - marketing._ipp._tcp.nTLD
  - legal._ipp._tcp.nTLD

Components of Service Name:

- User-Visible Name: **SecondFloorQA**._ipp._tcp.nTLD
- Service Type & Service Protocol: SecondFloorQA**._ipp._tcp**.nTLD
- Domain: SecondFloorQA._ipp._tcp.**nTLD**

# DNS Service Discovery - Example

- Trying to connect SecondFloorQA printer: SecondFloorQA._ipp._tcp.nTLD will issue the subsequent DNS lookups:
    - SecondFloorQA._ipp._tcp.nTLD SRV
        - => 0 0 30000 myprinter.nTLD
    - SecondFloorQA._ipp._tcp.nTLD TXT
        - => pdl=application/postscript (name/value pairs)
    - myprinter.nTLD A
        - => myprinter.nTLD A 13.2.4.6

# Client-side Name Collision Vulnerabilities

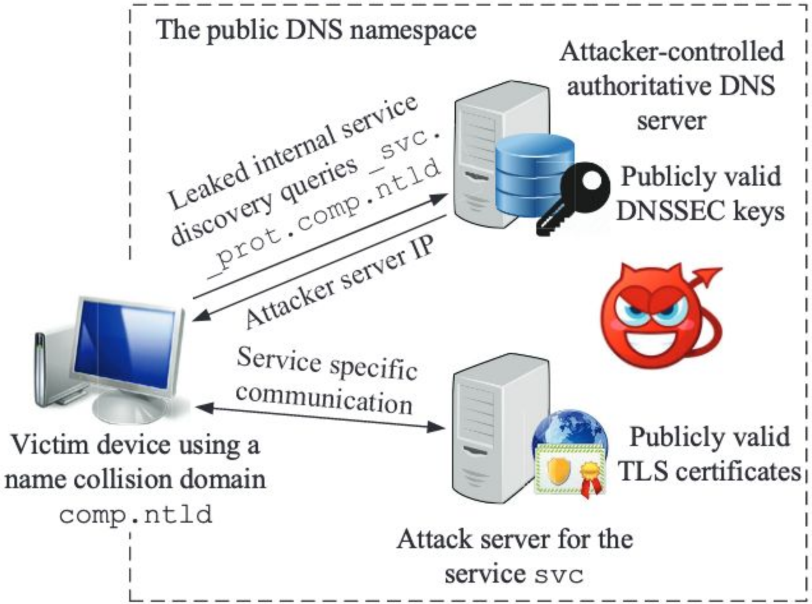
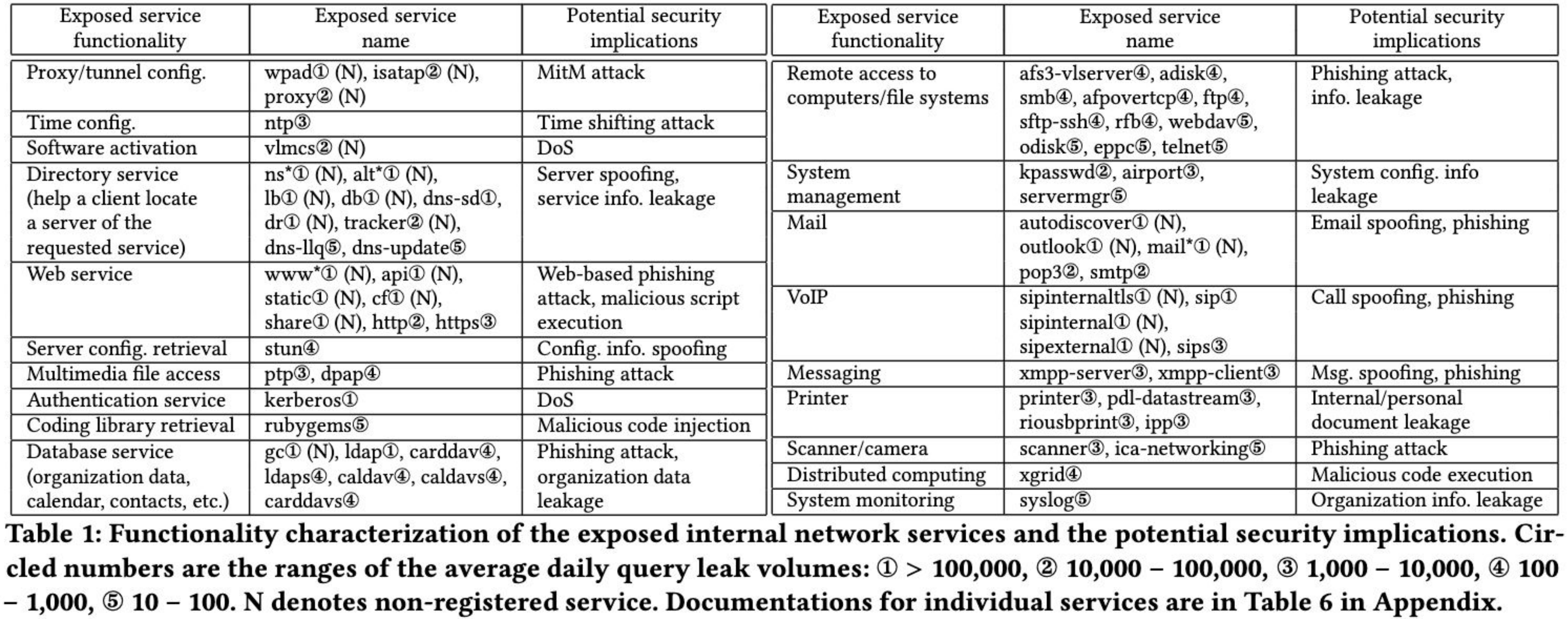

The public DNS namespace
Attacker-controlled authoritative DNS server
Publicly valid DNSSEC keys
Leaked internal service discovery queries _svc._prot.comp.ntld
Attacker server IP
Service specific communication
Victim device using a name collision domain comp.ntld
Publicly valid TLS certificates
Attack server for the service svc

**Figure 1: The generalized name collision attack threat model.**

- Client-side Name Collision Vulnerability in the New gTLD Era:A Systematic Study, Chen et al. 2017
- Systematic study of the robustness of internal network services under name collision attacks
- Perform a measure study and uncover a wide spectrum of services affected by the name collision problem
- Out of the 48 identified exposed services, we find that nearly all (45) of them expose vulnerabilities in popular clients.
- Construct exploits and find a set of new name collision attacks with severe security implications including MitM attacks, internal or personal document leakage, malicious code injection, and credential theft.

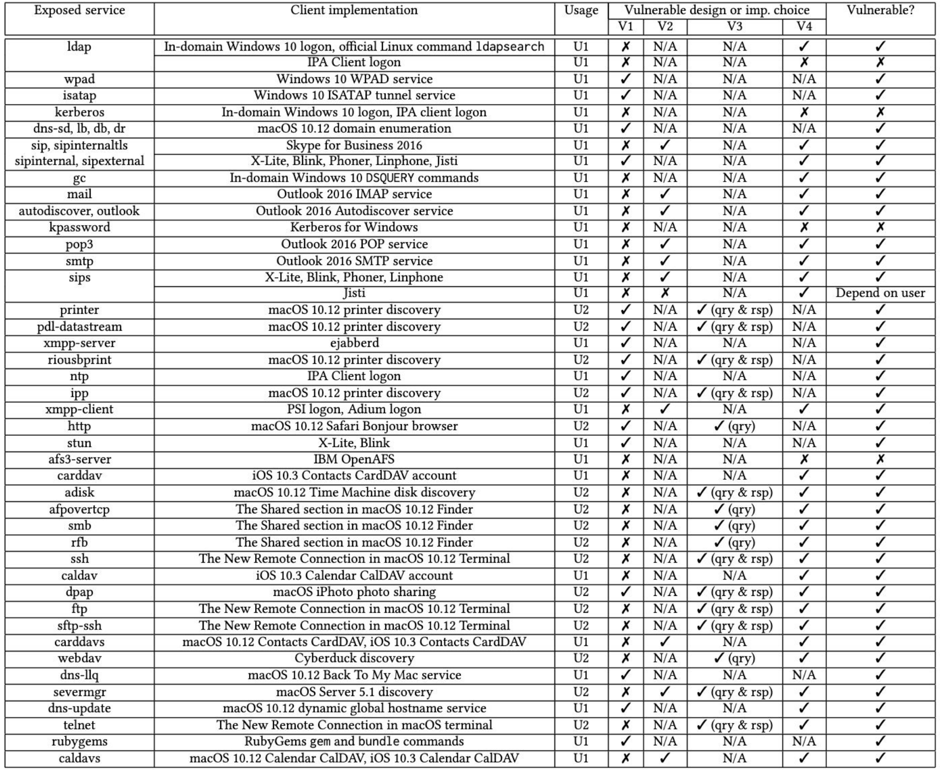
# Name Collision Vulnerabilities



| Exposed service functionality | Exposed service name | Potential security implications |
|---|---|---|
| Proxy/tunnel config. | wpad① (N), isatap② (N), proxy② (N) | MitM attack |
| Time config. | ntp③ | Time shifting attack |
| Software activation | vlmcs② (N) | DoS |
| Directory service (help a client locate a server of the requested service) | ns*① (N), alt*① (N), lb① (N), db① (N), dns-sd①, dr① (N), tracker② (N), dns-llq⑤, dns-update⑤ | Server spoofing, service info. leakage |
| Web service | www*① (N), api① (N), static① (N), cf① (N), share① (N), http②, https③ | Web-based phishing attack, malicious script execution |
| Server config. retrieval | stun④ | Config. info. spoofing |
| Multimedia file access | ptp③, dpap④ | Phishing attack |
| Authentication service | kerberos① | DoS |
| Coding library retrieval | rubygems⑤ | Malicious code injection |
| Database service (organization data, calendar, contacts, etc.) | gc① (N), ldap①, carddav④, ldaps④, caldav④, caldavs④, carddavs④ | Phishing attack, organization data leakage |
| Remote access to computers/file systems | afs3-vlserver④, adisk④, smb④, afpovertcp④, ftp④, sftp-ssh④, rfb④, webdav⑤, odisk⑤, eppc⑤, telnet⑤ | Phishing attack, info. leakage |
| System management | kpasswd②, airport③, servermgr⑤ | System config. info leakage |
| Mail | autodiscover① (N), outlook① (N), mail*① (N), pop3②, smtp② | Email spoofing, phishing |
| VoIP | sipinternaltls① (N), sip① sipinternal① (N), sipexternal① (N), sips③ | Call spoofing, phishing |
| Messaging | xmpp-server③, xmpp-client③ | Msg. spoofing, phishing |
| Printer | printer③, pdl-datastream③, riousbprint③, ipp③ | Internal/personal document leakage |
| Scanner/camera | scanner③, ica-networking⑤ | Phishing attack |
| Distributed computing | xgrid④ | Malicious code execution |
| System monitoring | syslog⑤ | Organization info. leakage |

**Table 1: Functionality characterization of the exposed internal network services and the potential security implications. Circled numbers are the ranges of the average daily query leak volumes: ① > 100,000, ② 10,000 – 100,000, ③ 1,000 – 10,000, ④ 100 – 1,000, ⑤ 10 – 100. N denotes non-registered service. Documentations for individual services are in Table 6 in Appendix.**

# Name Collision Vulnerabilities



| Exposed service | Client implementation | Usage | Vulnerable design or imp. choice | | | | Vulnerable? |
|---|---|---|---|---|---|---|---|
| | | | V1 | V2 | V3 | V4 | |
| ldap | In-domain Windows 10 logon, official Linux command `ldapsearch` | U1 | ✗ | N/A | N/A | ✓ | ✓ |
| | IPA Client logon | U1 | ✗ | N/A | N/A | ✗ | ✗ |
| wpad | Windows 10 WPAD service | U1 | ✓ | N/A | N/A | N/A | ✓ |
| isatap | Windows 10 ISATAP tunnel service | U1 | ✓ | N/A | N/A | N/A | ✓ |
| kerberos | In-domain Windows 10 logon, IPA client logon | U1 | ✗ | N/A | N/A | ✗ | ✗ |
| dns-sd, lb, db, dr | macOS 10.12 domain enumeration | U1 | ✓ | N/A | N/A | N/A | ✓ |
| sip, sipinternaltls<br>sipinternal, sipexternal | Skype for Business 2016 | U1 | ✗ | ✓ | N/A | ✓ | ✓ |
| | X-Lite, Blink, Phoner, Linphone, Jisti | U1 | ✓ | N/A | N/A | ✓ | ✓ |
| gc | In-domain Windows 10 `DSQUERY` commands | U1 | ✗ | N/A | N/A | ✓ | ✓ |
| mail | Outlook 2016 IMAP service | U1 | ✗ | ✓ | N/A | ✓ | ✓ |
| autodiscover, outlook | Outlook 2016 Autodiscover service | U1 | ✗ | ✓ | N/A | ✓ | ✓ |
| kpassword | Kerberos for Windows | U1 | ✗ | N/A | N/A | ✗ | ✗ |
| pop3 | Outlook 2016 POP service | U1 | ✗ | ✓ | N/A | ✓ | ✓ |
| smtp | Outlook 2016 SMTP service | U1 | ✗ | ✓ | N/A | ✓ | ✓ |
| sips | X-Lite, Blink, Phoner, Linphone | U1 | ✗ | ✓ | N/A | ✓ | ✓ |
| | Jisti | U1 | ✗ | ✗ | N/A | ✓ | Depend on user |
| printer | macOS 10.12 printer discovery | U2 | ✓ | N/A | ✓ (qry & rsp) | N/A | ✓ |
| pdl-datastream | macOS 10.12 printer discovery | U2 | ✓ | N/A | ✓ (qry & rsp) | N/A | ✓ |
| xmpp-server | ejabberd | U1 | ✓ | N/A | N/A | N/A | ✓ |
| riousbprint | macOS 10.12 printer discovery | U2 | ✓ | N/A | ✓ (qry & rsp) | N/A | ✓ |
| ntp | IPA Client logon | U1 | ✓ | N/A | N/A | N/A | ✓ |
| ipp | macOS 10.12 printer discovery | U2 | ✓ | N/A | ✓ (qry & rsp) | N/A | ✓ |
| xmpp-client | PSI logon, Adium logon | U1 | ✗ | ✓ | N/A | ✓ | ✓ |
| http | macOS 10.12 Safari Bonjour browser | U2 | ✓ | N/A | ✓ (qry) | N/A | ✓ |
| stun | X-Lite, Blink | U1 | ✓ | N/A | N/A | N/A | ✓ |
| afs3-server | IBM OpenAFS | U1 | ✗ | N/A | N/A | ✗ | ✗ |
| carddav | iOS 10.3 Contacts CardDAV account | U1 | ✗ | N/A | N/A | ✓ | ✓ |
| adisk | macOS 10.12 Time Machine disk discovery | U2 | ✗ | N/A | ✓ (qry & rsp) | ✓ | ✓ |
| afpovertcp | The Shared section in macOS 10.12 Finder | U2 | ✗ | N/A | ✓ (qry) | ✓ | ✓ |
| smb | The Shared section in macOS 10.12 Finder | U2 | ✗ | N/A | ✓ (qry) | ✓ | ✓ |
| rfb | The Shared section in macOS 10.12 Finder | U2 | ✗ | N/A | ✓ (qry) | ✓ | ✓ |
| ssh | The New Remote Connection in macOS 10.12 Terminal | U2 | ✗ | N/A | ✓ (qry & rsp) | ✓ | ✓ |
| caldav | iOS 10.3 Calendar CalDAV account | U1 | ✗ | N/A | N/A | ✓ | ✓ |
| dpap | macOS iPhoto photo sharing | U2 | ✓ | N/A | ✓ (qry & rsp) | ✓ | ✓ |
| ftp | The New Remote Connection in macOS 10.12 Terminal | U2 | ✗ | N/A | ✓ (qry & rsp) | ✓ | ✓ |
| sftp-ssh | The New Remote Connection in macOS 10.12 Terminal | U2 | ✗ | N/A | ✓ (qry & rsp) | ✓ | ✓ |
| carddavs | macOS 10.12 Contacts CardDAV, iOS 10.3 Contacts CardDAV | U1 | ✗ | ✓ | N/A | ✓ | ✓ |
| webdav | Cyberduck discovery | U2 | ✗ | N/A | ✓ (qry) | ✓ | ✓ |
| dns-llq | macOS 10.12 Back To My Mac service | U1 | ✓ | N/A | N/A | N/A | ✓ |
| severmgr | macOS Server 5.1 discovery | U2 | ✗ | ✓ | ✓ (qry & rsp) | ✓ | ✓ |
| dns-update | macOS 10.12 dynamic global hostname service | U1 | ✓ | N/A | N/A | ✓ | ✓ |
| telnet | The New Remote Connection in macOS terminal | U2 | ✗ | N/A | ✓ (qry & rsp) | ✓ | ✓ |
| rubygems | RubyGems `gem` and `bundle` commands | U1 | ✓ | N/A | N/A | N/A | ✓ |
| caldavs | macOS 10.12 Calendar CalDAV, iOS 10.3 Calendar CalDAV | U1 | ✗ | ✓ | N/A | ✓ | ✓ |

**Table 2: Vulnerability analysis results for the collected client implementations of the exposed services.**

**Vulnerable design or implementation choice:**

- **V1**. Lack of server authentication by default.
- **V2**. Accept a publicly-valid but previously-unseen TLS certificate by default.
- **V3**. Mix local-link and unicast DNS domain discovery.
- **V4**. No enforcement of server authentication in PSK-based authentication.

# Web Proxy Auto Discovery (WPAD)

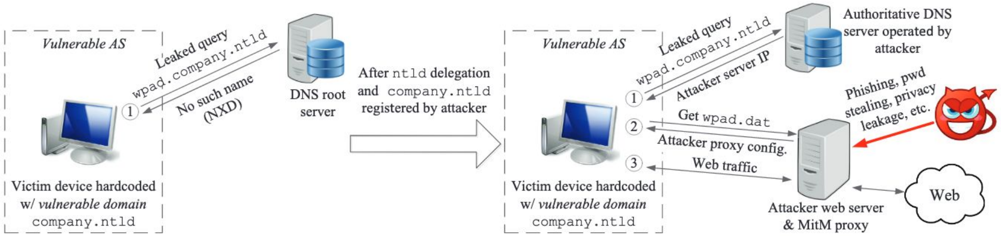
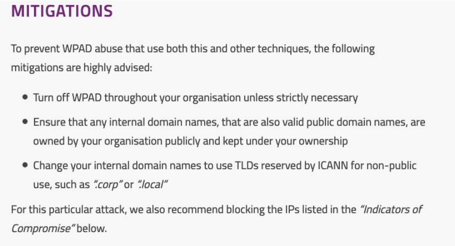

Vulnerable AS
Leaked query
wpad.company.ntld
① 
No such name
(NXD)
DNS root server
Victim device hardcoded w/ *vulnerable domain* company.ntld
After ntld delegation and company.ntld registered by attacker
Vulnerable AS
Leaked query
wpad.company.ntld
Attacker server IP
Authoritative DNS server operated by attacker
Phishing, pwd stealing, privacy leakage, etc.
① 
② Get wpad.dat
Attacker proxy config.
③ Web traffic
Victim device hardcoded w/ *vulnerable domain* company.ntld
Attacker web server & MitM proxy
Web

Fig. 1: Illustration of the WPAD name collision attack. If an internal namespace TLD is delegated as a new gTLD, internal namespace WPAD query leaks can be easily exploited using MitM attack from anywhere on the Internet.

WPAD is a scheme used by operating systems to automatically configure web (i.e. HTTP and HTTPS) proxy settings.

The auto-discovery mechanism of WPAD will attempt to find a *"wpad.dat"* configuration file on the current network. It will first attempt to retrieve a web URL to the file through DHCP. If not provided by DHCP, it will subsequently attempt to download it from the internal domain over HTTP. The following is the order of URLs it will attempt to download the file from:

1. *http://wpad.department.branch.domain.tld/wpad.dat*
2. *http://wpad.branch.domain.tld/wpad.dat*
3. *http://wpad.domain.tld/wpad.dat*
4. *http://wpad.tld/wpad.dat*



**MITIGATIONS**

To prevent WPAD abuse that use both this and other techniques, the following mitigations are highly advised:

- Turn off WPAD throughout your organisation unless strictly necessary
- Ensure that any internal domain names, that are also valid public domain names, are owned by your organisation publicly and kept under your ownership
- Change your internal domain names to use TLDs reserved by ICANN for non-public use, such as *".corp"* or *".local"*

For this particular attack, we also recommend blocking the IPs listed in the *"Indicators of Compromise"* below.