Symlink Races and how to deal with them

SambaXP 2022

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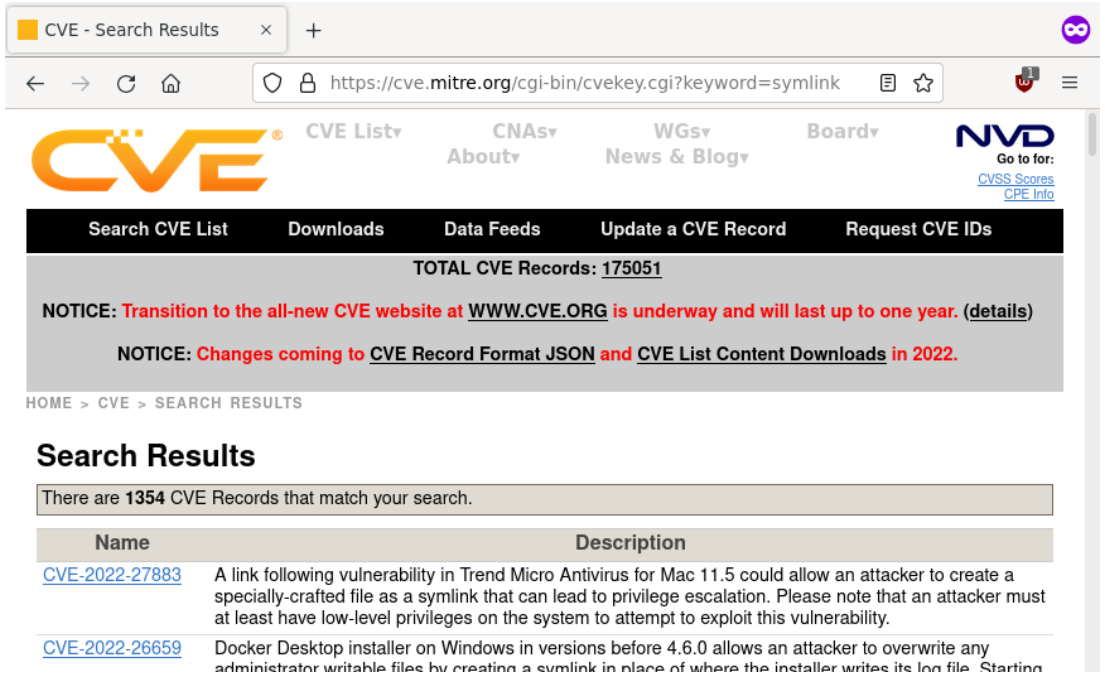
Symlink race – Why care?

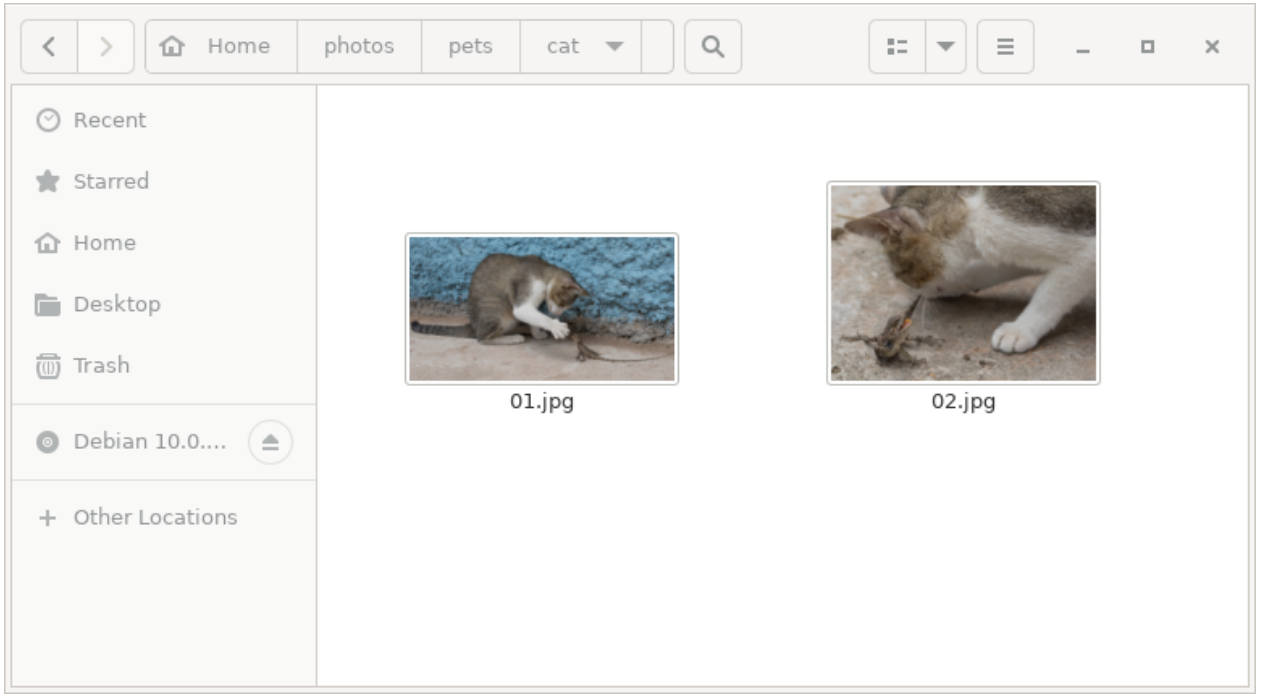
- Search for “symlink” in Common Vulnerabilities and Exposures:



- Ok, there’s something going on – but what??

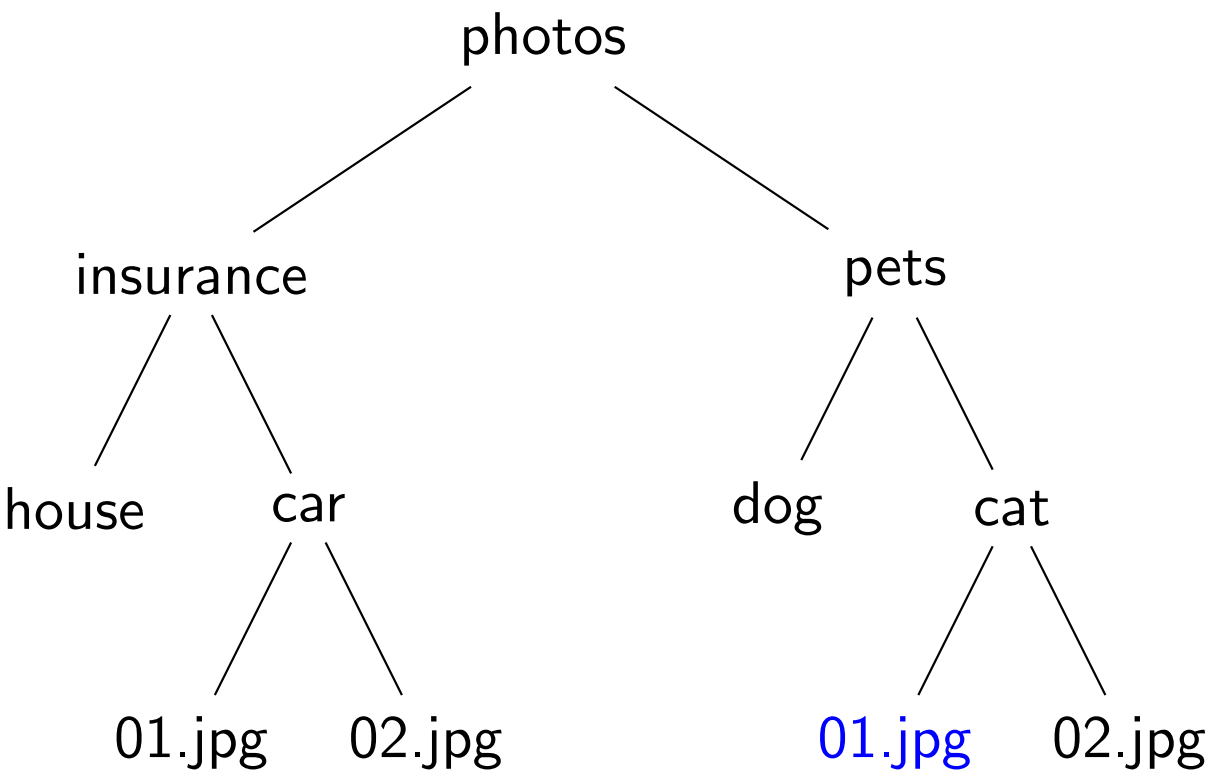
Publish cat photos to my blog

- Browse my directory hierarchy



- Copy file path /photos/pets/cat/01.jpg into Browser
- Press upload

My directory hierarchy



- Cute cat under /photos/pets/cat/01.jpg

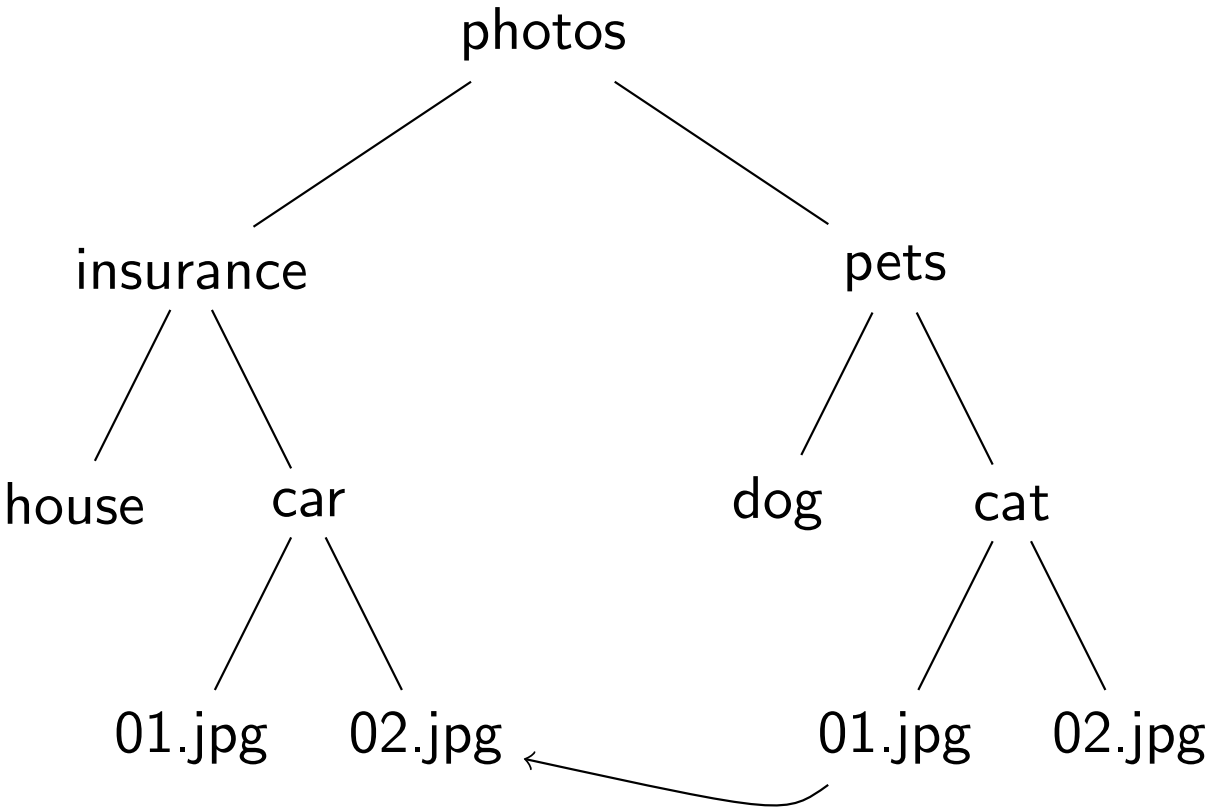
Cute cat

- /photos/pets/cat/01.jpg

Symlink Race

- Publish cat photo
  - Browse my directory hierarchy
  - Copy file path /photos/pets/cat/01.jpg into Browser
    - A few seconds for an ATTACK
  - Press upload
- The attacker replaces "01.jpg" with a symbolic link to the latest communication with my insurance
- ln -sf /photos/insurance/car/02.jpg /photos/pets/cat/01.jpg

My new directory hierarchy



What gets published?

- /photos/pets/cat/01.jpg gets uploaded, but... oops

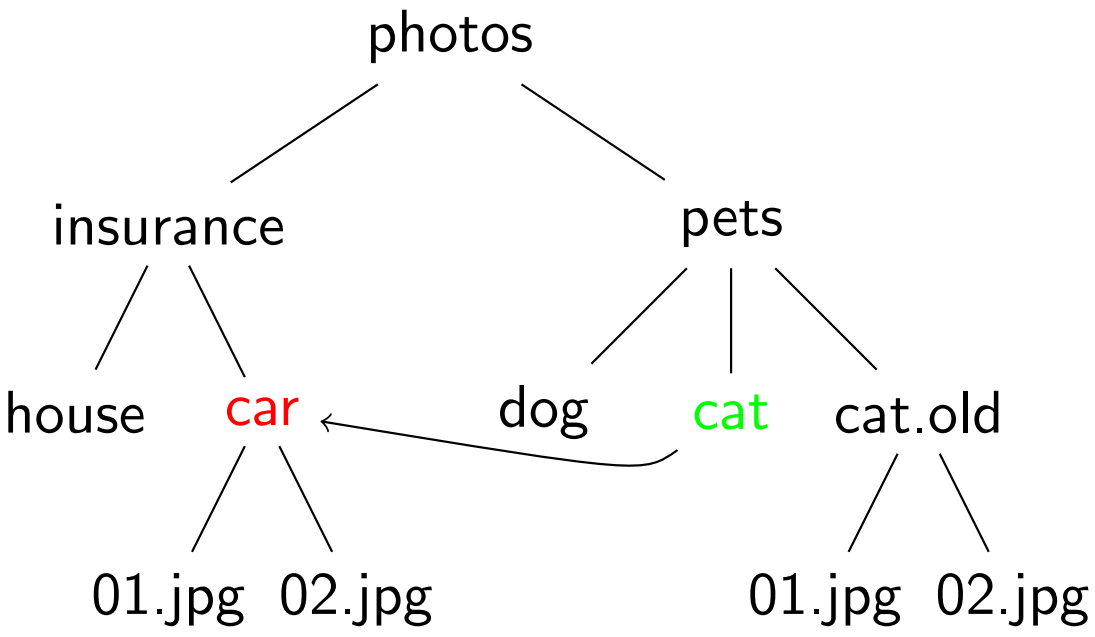
- This could have been your Passwords.DOCX

O_NOFOLLOW

- Posix/Linux can protect against this kind of attack
- Opening a file in Posix via C function open()
- Adding the flag O_NOFOLLOW to open() ensures "01.jpg" is not a symlink:
  - If the trailing component (i.e., basename) of pathname is a symbolic link, then the open fails, with the error ELOOP
- When using O_NOFOLLOW, the upload function will get an error
- However:
  - Symbolic links in earlier components of the pathname will still be followed.

My latest directory hierarchy

- Another attack

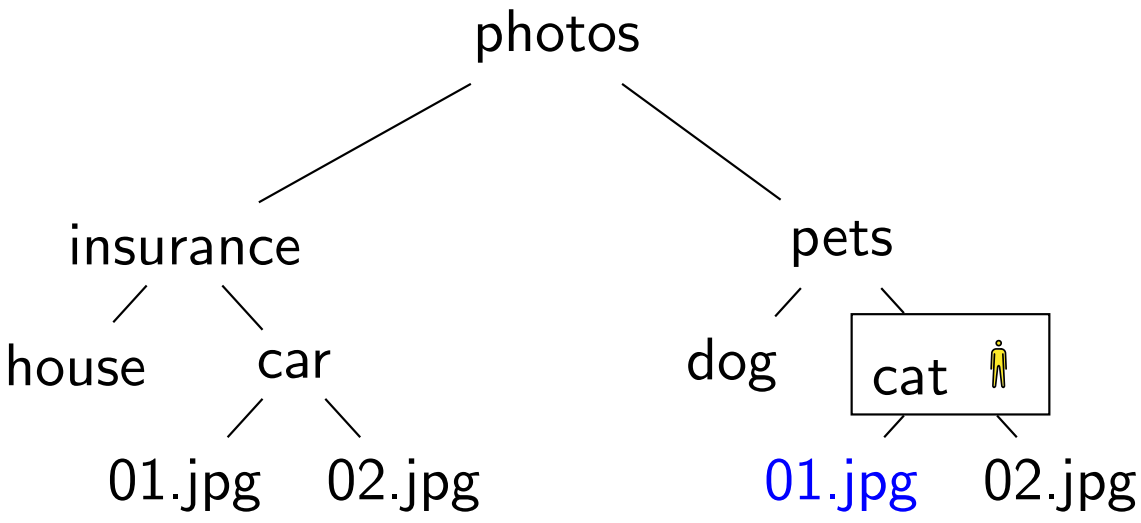


- /photos/pets/cat → /photos/insurance/car
- /photos/pets/cat/01.jpg → /photos/insurance/car/01.jpg

What gets published?

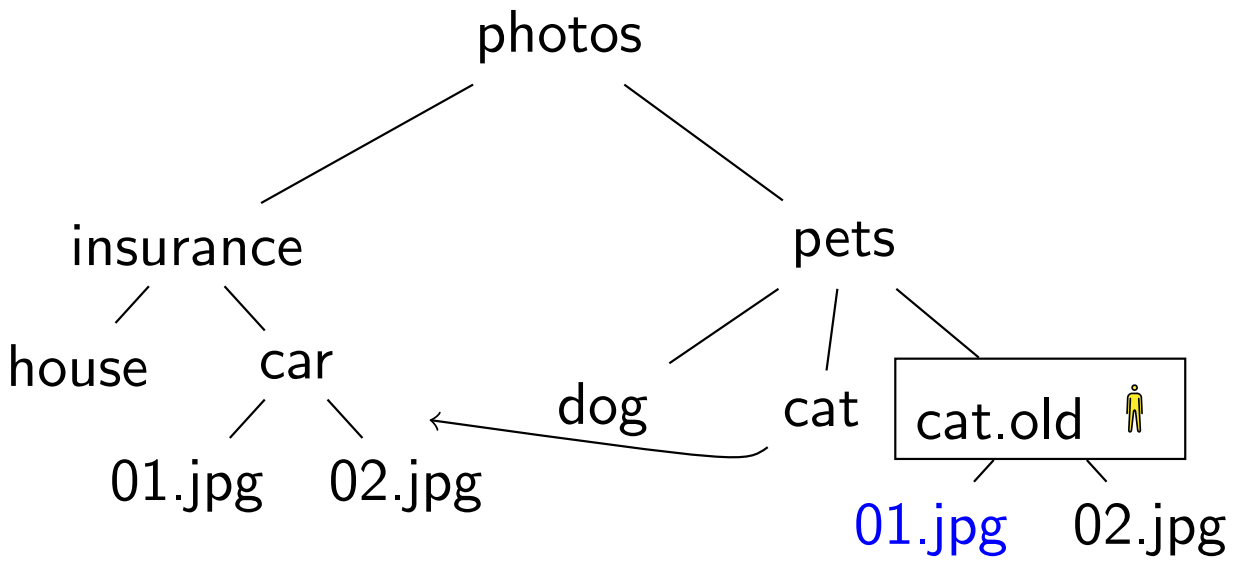
- /photos/pets/cat/01.jpg gets uploaded, but... ouch!

Change into /photos/pets/cat



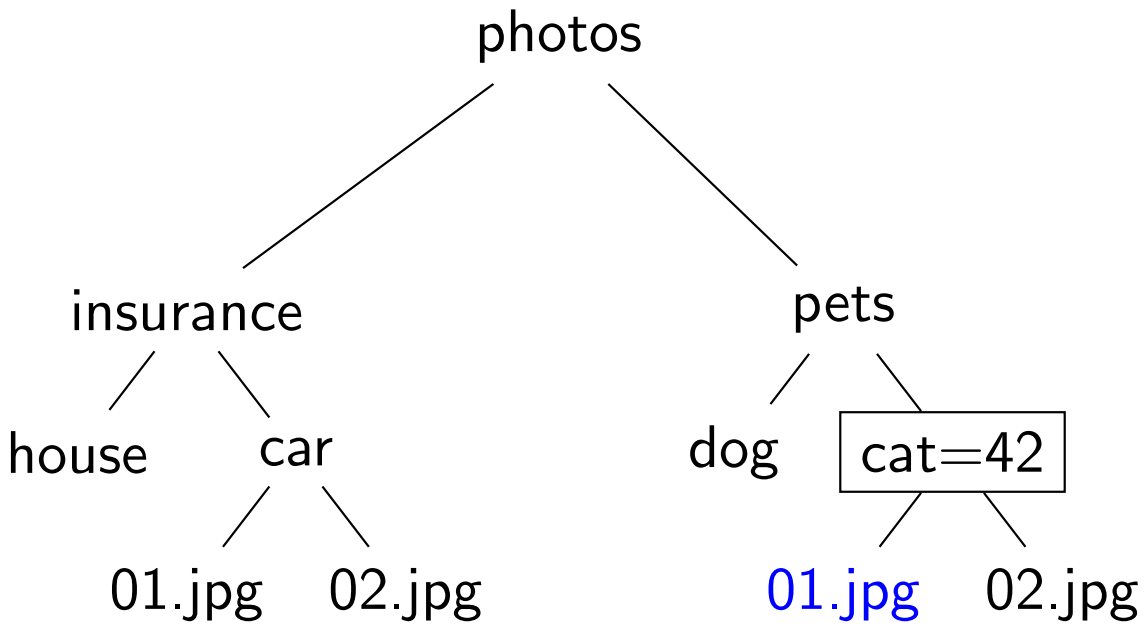
- Four expensive steps
  - chdir /photos/pets/cat
  - check I am really in /photos/pets/cat
  - open("01.jpg", O_NOFOLLOW)
  - chdir /

Attack mitigated



- Attacker moves me to cat.old
- open("01.jpg", O_NOFOLLOW) references the correct file
- Opening files becomes expensive due to the four steps

Openat-Call



- Four expensive steps done just once
- Hold and cache reference to /photos/pets/cat (=42)
- Cheap openat(42, "01.jpg", O_NOFOLLOW)

Symlink races from 30,000ft

- Paths in Posix are prone to input validation problems
- Symlink races are a Time-Of-Check Time-Of-Use (TOCTOU) problem
- Sanitizing paths is possible, but tedious
  $\Rightarrow$ Nobody does it
- Current status in Samba with 4.16:
  - Many places in Samba chose the chdir/check/open/chdir way
  - Work is ongoing to pass directory handles (the "42") everywhere
- Work ongoing in Linux to make sanitizing easier:
  - openat2(RESOLVE_NO_SYMLINKS)
  - Mount option disallowing symlinks?

Samba 4.16

- OEMs complain to SerNet that Samba 4.15 is slower than 4.12
  - Benchmarks like specsfs swbuild do a lot of stat-opens
  - Just ask for file metadata like timestamps or filesize
- Number of syscalls is a problem:
- strace -p <smbd-pid> of smbclient -c "open a/b/c/d/e/f/g/x.txt":
  - v4-12-strace: 30 lines
  - v4-16-strace: 55 lines
  - v4-17-strace: 43 lines
- v4-17 removes one parent_pathref() from create_file_unixpath()
  - filename_convert_dirfsp() provides the directory fsp now

Deleting a directory

- Three steps
  1. Open file with DELETE access permissions
     - Check parent access for DELETE_CHILD
  2. Set DELETE_ON_CLOSE disposition
     - Check for empty directory
  3. Close
     - parent_pathref() to prepare for unlinkat()
- In every step there is one or more non_widelink_open()

Next steps

- Replace filename_convert() with filename_convert_dirfsp()
- Pass dirfsp through as many callers as possible
- Alternative: Store dirfsp on every fsp
  - Required for file deletion
  - dirfsp is rather heavy-weight (344 bytes for files_struct alone)
- Eliminate calls openat_pathref_fsp
  - synthetic_pathref(), parent_pathref() etc
- Create a conn→root_fsp to avoid calls to chdir()

How to speed up filename_convert()?

- test_chdir: Do what we do today
  - Get current working directory
  - Verify full pathname with realpath()
  - chdir() into target directory
  - Verify "." inside current working directory
  - open("filename", O_NOFOLLOW);
  - chdir back
- test_openat:
  - next = openat(dirfd, "single component", O_PATH);
  - close(dirfd);
  - dirfd = next;
  - This is the path to proper SMB2 server-side symlink handling
- test_openat2: Just use RESOLVE_NO_SYMLINKS

Thanks for your attention

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