MinorFS & AppArmor

Taming mutable state for filesystem access.

MinorFS & AppArmor

- Shared mutable state
- Emakers
- AppArmor
- FUSE
- MinorFs
- Bringing things together.

A powerful program

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- Read your confidential files.
- Mail them to the competition.
- Delete or compromise your files.
- Initiate a networking tunnel allowing your competitor into your corporate network.

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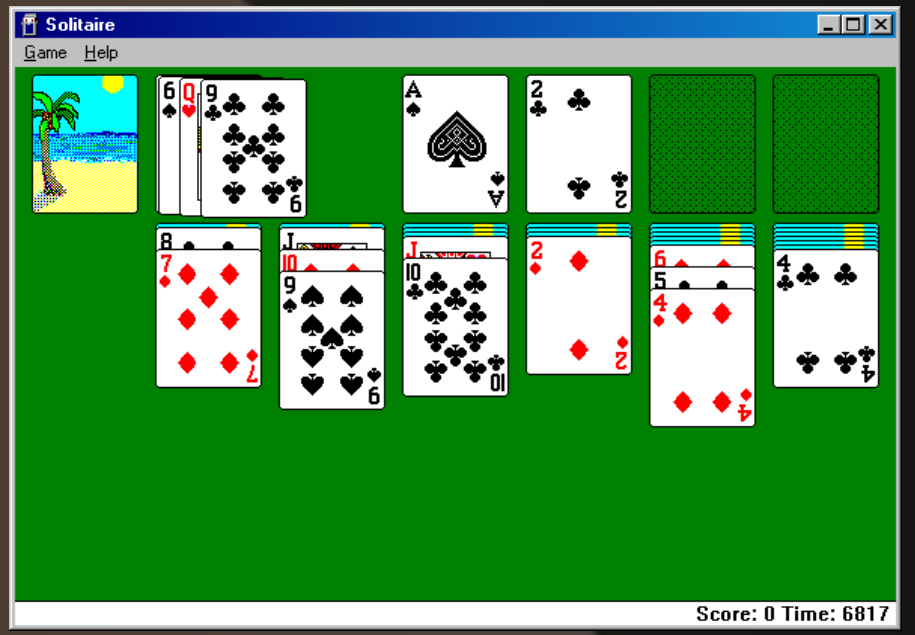
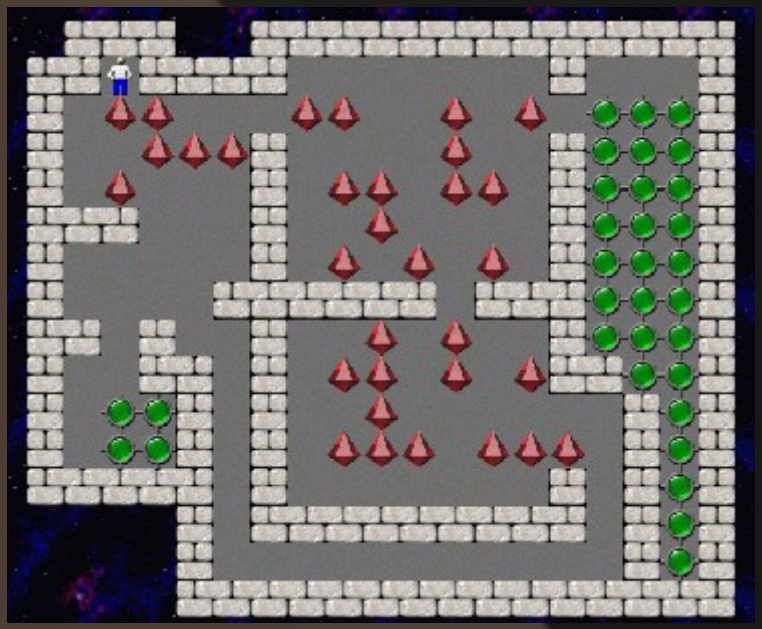


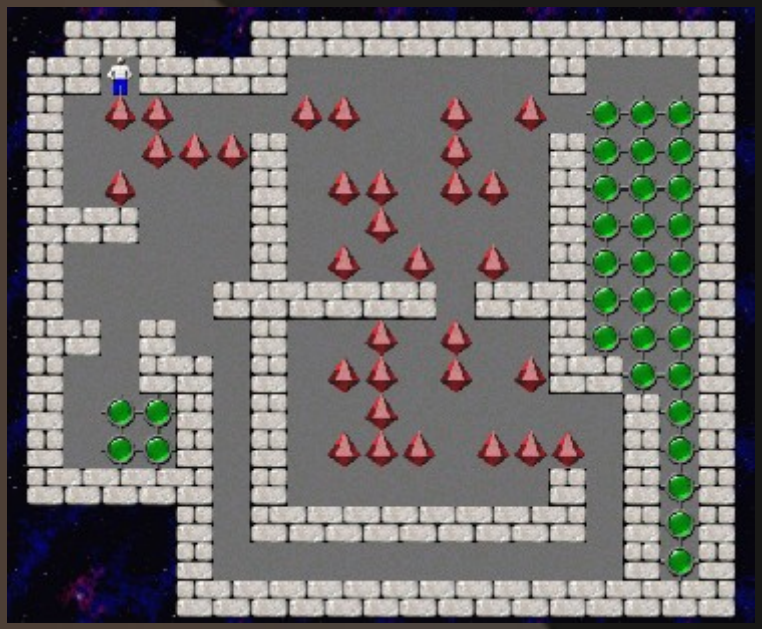
A powerful program

- Read your confidential files.
- Mail them to the competition.
- Delete or compromise your files.
- Initiate a networking tunnel allowing your competitor into your corporate network.
- Not (just) MS !!



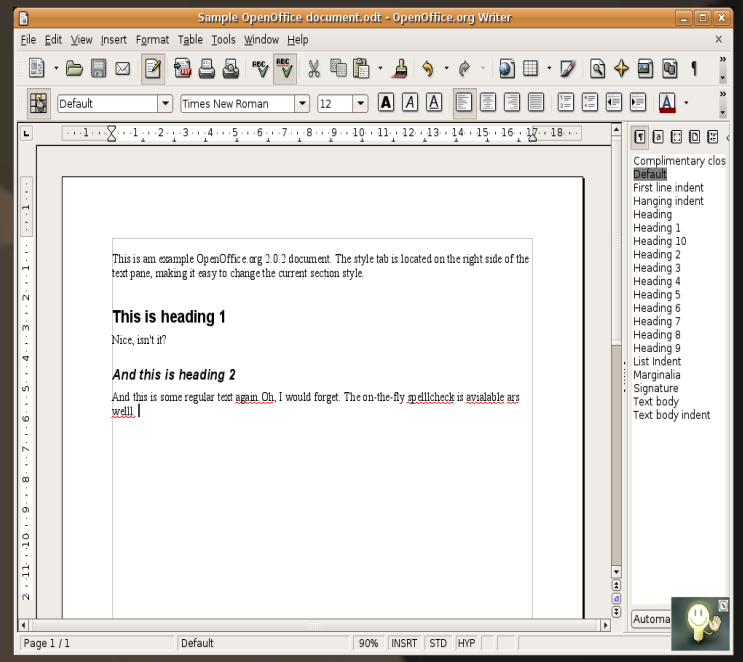
Who/what do we trust?

- Do we trust Sokoban with all this power?
- How many people would have been able to trojanize Sokoban?
- How about firefox?
- Exploitable bugs?
- More programs?
- Lines of code ?



Two sides of the coin

- Sokoban has the power to read your secrets.
- Openoffice Writer does NOT have the power to protect your secrets.
- Your programs could use some privacy.



mutable state

public

vs

private

Global mutable state & filesystems

- $TEMP
- $HOME
- Other (obscure?) places

Problems with global mutable state

- Can potentially be modified from anywhere
- Any subsystem may rely on it.
- Potential for creating mutual dependencies
- Makes composite systems hard to analyze or review.
- Makes composite systems hard to test.
- Violates the principle of least authority.

Shared mutable state, can we fix it?

Shared mutable state, can we fix it?

Didn't they fix this already ??

Shared mutable state & programing

- Global variables
- Static member variables (OO)
- Singletons (OO)

Solutions from OO programming

- Basic OO: Encapsulation/Data hiding.
  - Private member variables.
  - Static member variables (the lesser evil)
  - Singletons (the hidden lesser evil)
- Dependency injection.
  - Avoid the lesser evils for testability purposes.
- Object capabilities.
  - Avoid the lesser evils for least authority purposes.

POLA example: emakers

- E-Language
  - Memory safe programming language
  - Asynchronous language running on JVM.
  - Code in the *main* program code runs with the program's full authority.
  - Subsystems implemented as emaker run with dynamic least authority.
  - Fewer *powerful code* lines.

POLA example: emakers

- Subsystems implemented as **emaker** only have authority:
  - That was handed to it at construction time.
  - To objects created by the subsystem itself.
  - That is passed to it explicitly.

Shared mutable state, can we fix it?

Lets use these principles to fix access control for the File system.

Basic principles

- **Avoid implicitly shared mutable state.**
- **Instead use decomposition, attenuation and EXPLICIT delegation.**
- Use the OO paradigm at all abstraction levels.
- Minimize knowledge, minimize authority.
- **Minimize the size of the trusted code base.**

Avoid implicitly shared mutable state

- 3 ways to gain access to resources:
  - Parenthood
  - Initial conditions.
  - Passed (delegated) explicitly.

Shared mutable state, can we fix it?

First the foundation.

Initial conditions: AppArmor

- Path based access control for Suse & Ubuntu.
- Allows profiles to be created for applications.
  - Authority handed to process at construction time.
  - A strict profile makes a program into a coarse-grained static equivalent of the emaker.
  - For POLA-based file system access we need to make this equivalence dynamic.
- AppArmor takes away ambient authority to data, now let's replace that with private data and explicit designation.

FUSE

- File systems as user space
- Library and kernel module
- Allows a user space program to expose a file system abstraction to the system.

Shared mutable state, can we fix it?

Now for the carrying walls

MinorFs: parenthood and delegation

- MinorCapFS:
  - Unguessable tokens for directory access
  - Toplevel mountpoint appears empty.
    - /mnt/minorfs/cap is an empty directory.
    - /mnt/minorfs/cap/1a12bd48fa710276432a986865876fcd4587873d discloses a directory tree.
- MinorViewFS
  - Delegation of private directories to processes.
    - /mnt/minorfs/priv/tmp delegates private storage to non persistent processes.
    - /mnt/minorfs/priv/home delegates private storage to pseudo persistent processes.

MinorFS and $TMP usage

- /mnt/minorfs/priv/tmp is a symbolic link.
- For each process id the link points at a different private storage dir.
- When a process dies, MinorViewFS deletes its private storage dir.
- Processes can safely store private data in temporary files.
- Good alternative for /tmp/ usage without the problems of global or static mutable state.

Pseudo persistent processes

- Non persistent processes don't survive reboots.
- Often their functionality **does or should**.
- Part of (or all) the program state can be serialized to disk.
- Persistent **global or static mutable storage** is used to allow restoring state after reboot.
- Using the program identity and a slot system, we can define pseudo persistent processes.

Pseudo persistent processes

- Pseudo Persistent Process Unique ID's (PPPID):
  - The path of the executable.
  - The invocation chain with all parent processes up to init.
  - All loaded libraries in the invocation chain.
  - Often the command line.
  - Often specific environment variables.
  - A slot, identifying the n-th process invoked in this way.
- If after a reboot a process claims a PPPID, we shall adress it as the same pseudo persistent process as the one holding the PPPID before reboot.

MinorFS and $HOME

- /mnt/minorfs/priv/home is a symbolic link.
- For each PPPID the link points at a different private storage dir.
- When a process dies, MinorViewFS retains the storage for the next incarnation.
- Processes can safely store persistent private data, including its own serialization.
- Good alternative for $HOME usage without the problems of global or static mutable state.

Shared mutable state, can we fix it?

Lets go multi-storey

Persistent processes

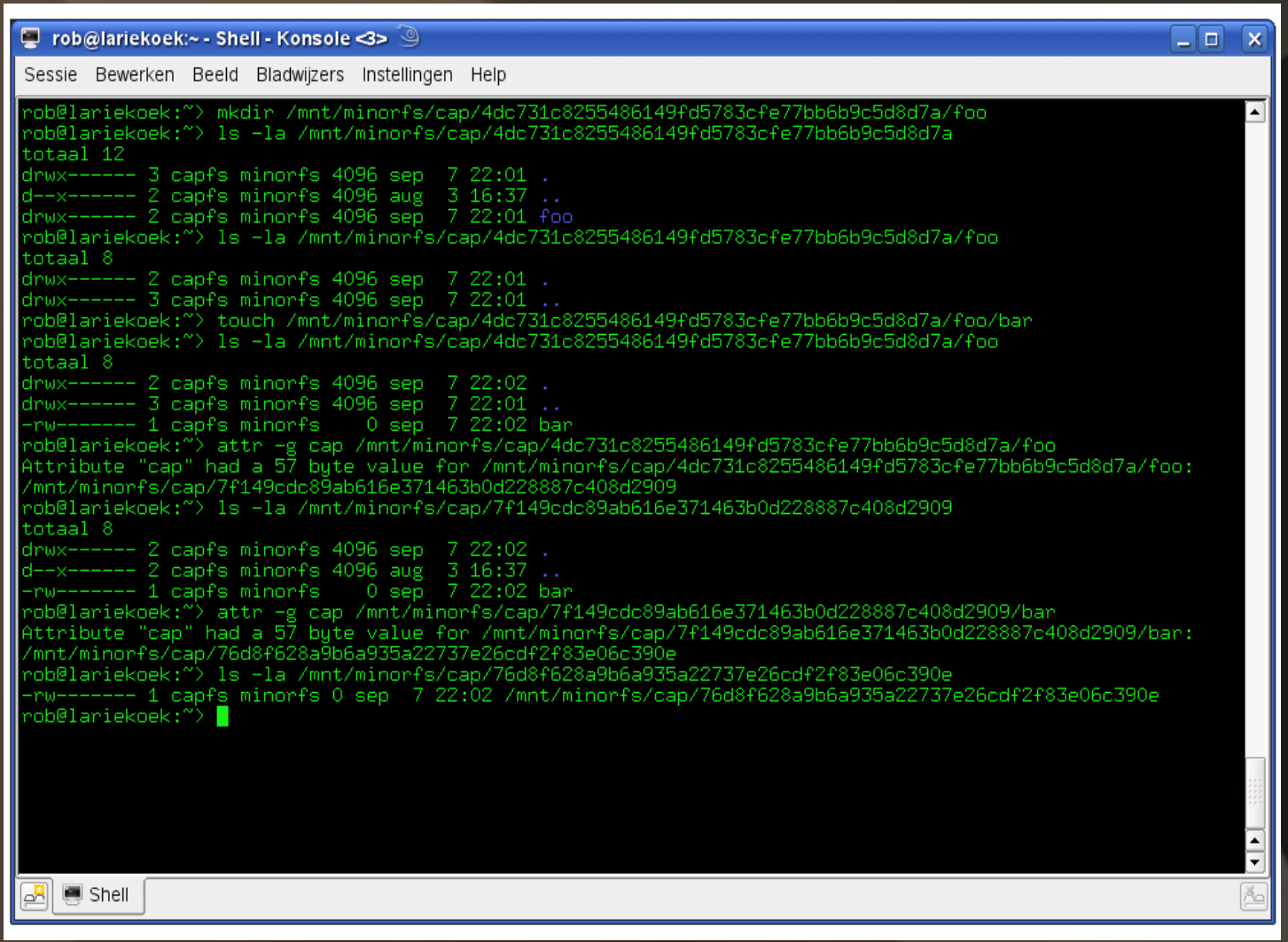
- AppArmor takes away excess authority.
- MinorFS delegates private storage to pseudo persistent processes.
- The E-Language allows a so called VAT to be made persistent by coupling to on-disk storage.
- Combining these 3 allows for the creation of persistent processes without using global or static mutable state.
- Combining these 3 uses the same abstractions at multiple granularities.

Global versus private, example:

- Shared $HOME
- Shared $TMP
- 20 *'trusted'* programs
- Use memory unsafe languages for all programs
- 50.000 of lines of *'trusted'* code per application.
- 1.000.0000 lines of *trusted* code.

- Private $HOME
- Private $TMP
- 2 *'trusted'* programs.
- Use capability secure languages for trusted programs.
- 1000 lines of *'trusted'* code per trusted application.
- 2.000 lines of *trusted* code.

DEMO


rob@lariekoek:~ - Shell - Konsole <3>
Sessie Bewerken Beeld Bladwijzers Instellingen Help
rob@lariekoek:~> mkdir /mnt/minorfs/cap/4dc731c8255486149fd5783cfe77bb6b9c5d8d7a/foo
rob@lariekoek:~> ls -la /mnt/minorfs/cap/4dc731c8255486149fd5783cfe77bb6b9c5d8d7a
totaal 12
drwx------ 3 capfs minorfs 4096 sep 7 22:01 .
d--x------ 2 capfs minorfs 4096 aug 3 16:37 ..
drwx------ 2 capfs minorfs 4096 sep 7 22:01 foo
rob@lariekoek:~> ls -la /mnt/minorfs/cap/4dc731c8255486149fd5783cfe77bb6b9c5d8d7a/foo
totaal 8
drwx------ 2 capfs minorfs 4096 sep 7 22:01 .
drwx------ 3 capfs minorfs 4096 sep 7 22:01 ..
rob@lariekoek:~> touch /mnt/minorfs/cap/4dc731c8255486149fd5783cfe77bb6b9c5d8d7a/foo/bar
rob@lariekoek:~> ls -la /mnt/minorfs/cap/4dc731c8255486149fd5783cfe77bb6b9c5d8d7a/foo
totaal 8
drwx------ 2 capfs minorfs 4096 sep 7 22:02 .
drwx------ 3 capfs minorfs 4096 sep 7 22:01 ..
-rw------- 1 capfs minorfs 0 sep 7 22:02 bar
rob@lariekoek:~> attr -g cap /mnt/minorfs/cap/4dc731c8255486149fd5783cfe77bb6b9c5d8d7a/foo
Attribute "cap" had a 57 byte value for /mnt/minorfs/cap/4dc731c8255486149fd5783cfe77bb6b9c5d8d7a/foo:
/mnt/minorfs/cap/7f149cdc89ab616e371463b0d228887c408d2909
rob@lariekoek:~> ls -la /mnt/minorfs/cap/7f149cdc89ab616e371463b0d228887c408d2909
totaal 8
drwx------ 2 capfs minorfs 4096 sep 7 22:02 .
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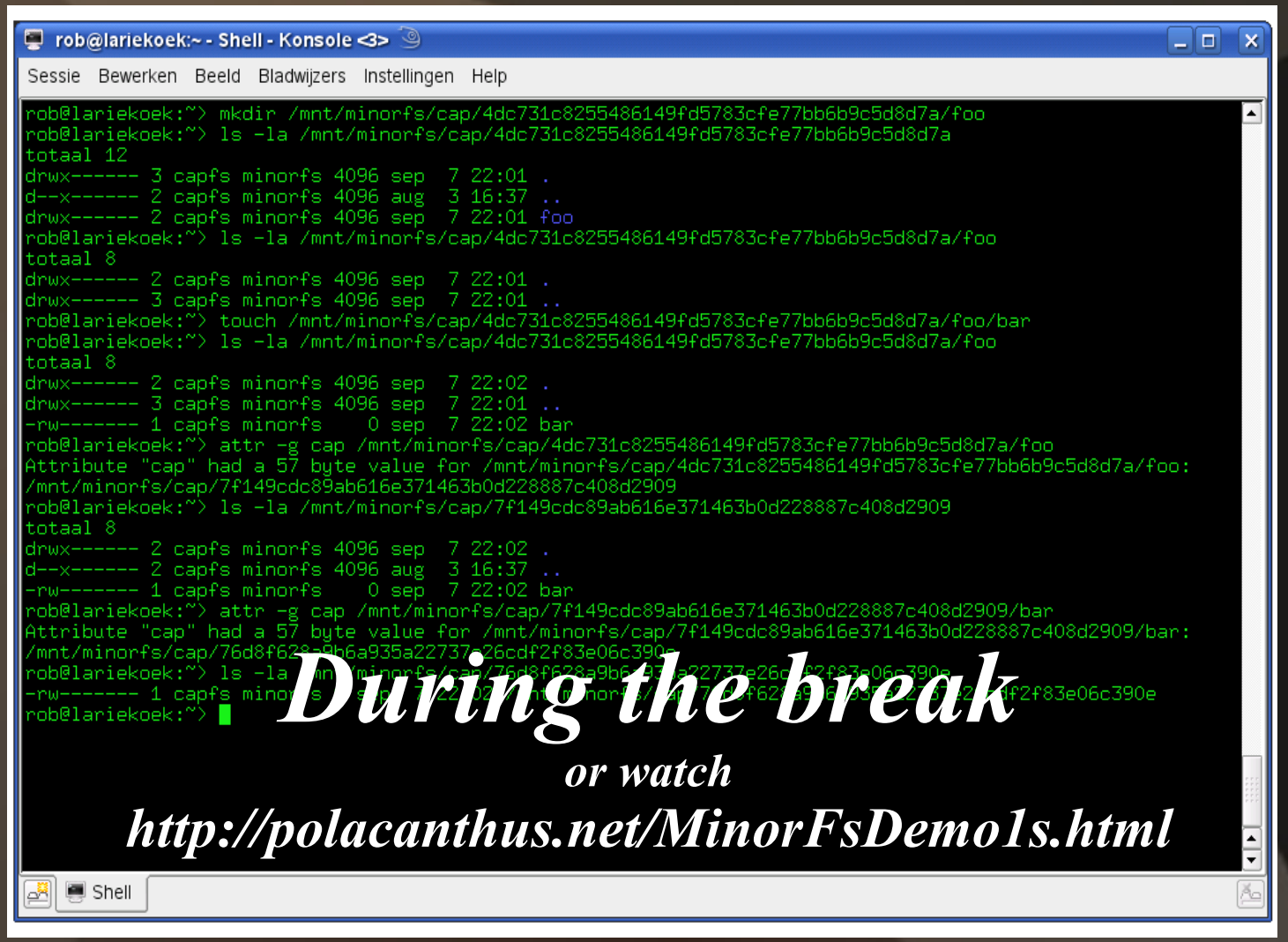
-rw------- 1 capfs minorfs 0 sep 7 22:02 bar
rob@lariekoek:~> attr -g cap /mnt/minorfs/cap/7f149cdc89ab616e371463b0d228887c408d2909/bar
Attribute "cap" had a 57 byte value for /mnt/minorfs/cap/7f149cdc89ab616e371463b0d228887c408d2909/bar:
/mnt/minorfs/cap/76d8f628a9b6a935a22737e26cdf2f83e06c390e
rob@lariekoek:~> ls -la /mnt/minorfs/cap/76d8f628a9b6a935a22737e26cdf2f83e06c390e
-rw------- 1 capfs minorfs 0 sep 7 22:02 /mnt/minorfs/cap/76d8f628a9b6a935a22737e26cdf2f83e06c390e
rob@lariekoek:~>
Shell

DEMO



During the break

or watch

http://polacanthus.net/MinorFsDemo1s.html

Resources

- The E-Language
  - http://www.erights.org/
- AppArmor
  - http://en.opensuse.org/AppArmor
- FUSE
  - http://fuse.sourceforge.net/
- MinorFS
  - http://minorfs.polacanthus.net/
  - http://www.linuxjournal.com/article/10199