kAFS

Overview

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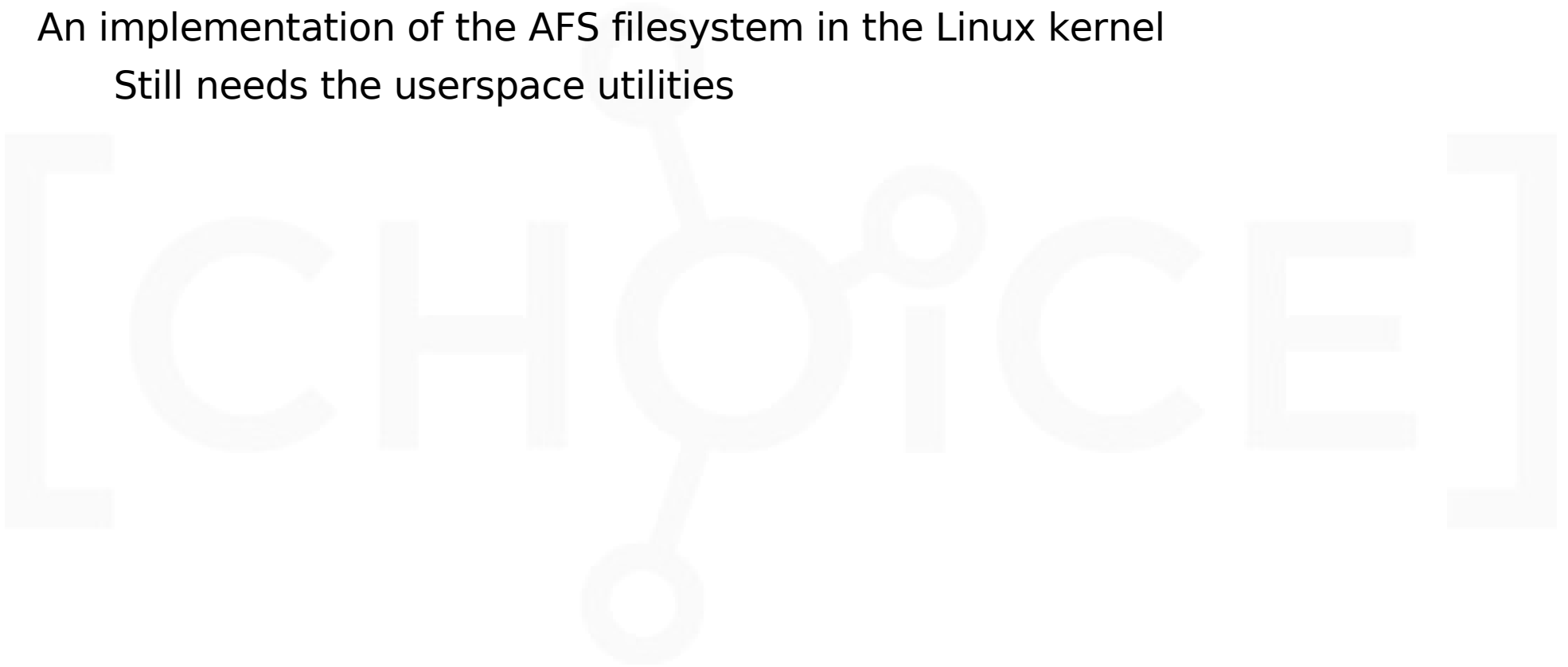
What is it?

An implementation of the AFS filesystem in the Linux kernel

- Still needs the userspace utilities



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Who?

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GSoC contributions

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Why write kAFS?

Red Hat needed an AFS solution for a customer

OpenAFS cannot be included in the Linux kernel

- IPL vs GPL
- Runs on everything: #ifdef hell

Disliked Arla's architecture

- Had a potential fundamental deadlock flaw at the time
- Userspace transport: potential OOM problems

Possible to write our own

- Wrote kAFS initially as a prototype
- Can take advantage of Linux kernel-only integration

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Why write kAFS?

Most of all:

- It's a challenge!
- It's *fun*!

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Goals of kAFS

Write a complete kernel filesystem that can drop-in replace OpenAFS's kernel module

Able to use OpenAFS userspace tools

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The ultimate goal

Fedora/RHEL integration

Install by default

Set up at system installation

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kAFS Architecture

kAFS comprises a number of components within the kernel:

- Keys/keyring management
- The AF_RXRPC socket family
- FS-Cache local cache
- An AFS filesystem driver

All within the kernel: no userspace component

Keys

Data required by kernel services for secure operation:

- Identities
- Authorisation tokens
- Encryption keys

May be used by userspace too

Keys: Keyrings

Keyrings are special keys that hold other keys

Contents can be added and deleted

Processes have special keyrings that can be inherited and shared

- *Session keyring*
  - Set up by PAM upon login
  - Inherited across *fork()*

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Keys: Use

Allow kernel filesystems and drivers to look up and cache keys

Allow user programs to propose and look up keys

add_key(), *request_key()* and *keyctl()* system calls

pam_keyinit module

keyctl program

Keys: After login

After logging in, I see:

```
[dhowells@andromeda ~]$ cat /proc/keys
17517315 I--Q--     1 perm 1f3f0000  4043    -1 keyring   _uid_ses.4043: 1/4
1bac056e I--Q--     5 perm 1f3f0000  4043  4043 keyring   _ses: 1/4
2ea802a8 I--Q--     3 perm 1f3f0000  4043    -1 keyring   _uid.4043: empty


[dhowells@andromeda ~]$ keyctl show
Session Keyring
       -3 --alswrv   4043  4043  keyring: _ses
782762664 --alswrv   4043    -1   \_ keyring: _uid.4043
```

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AF_RXRPC

socket() interface family:

```
fd = socket(AF_RXRPC, SOCK_DGRAM, PF_INET);
```

Can be used from the kernel or from userspace

Does RxRPC remote procedure call transport in the kernel

- Uses *recvmsg()* and *sendmsg()*

Secure

- Uses keys to pass security tokens
- Can do authenticated and encrypted transfer
- Uses *setsockopt()* to set parameters

Can be a client or a server

- *connect()*, *bind()* and *listen()* are available

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AF_RXRPC

RxRPC connections are shared between callers with same:

- Source, Destination, Direction, Service ID and key

New connections are created automatically to expand call slots

UDP port belongs to AF_RXRPC and so can be shared

Userspace and kernel can share

AF_RXRPC state

AF_RXRPC state can be viewed through /proc:

```
[root@andromeda ~]# cat /proc/net/rxrpc_calls
Proto Local        Remote           SvID ConnID   CallID   End Use State    Abort    UserID
UDP   0.0.0.0:7001 90.155.74.22:7000    1 00000008 00000002 Clt   1 Complete 00000000 ffff880002c31058
UDP   0.0.0.0:7001 90.155.74.22:7000    1 00000008 00000003 Clt   1 Complete 00000000 ffff880002c31058
UDP   0.0.0.0:7001 90.155.74.22:7000    1 00000008 00000004 Clt   1 Complete 00000000 ffff880002c31058
UDP   0.0.0.0:7001 90.155.74.22:7000    1 00000008 00000005 Clt   1 Complete 00000000 ffff880002c31058
UDP   0.0.0.0:7001 90.155.74.22:7000    1 00000008 00000006 Clt   1 Complete 00000000 ffff880002c31058
UDP   0.0.0.0:7001 90.155.74.22:7000    1 00000008 00000007 Clt   1 Complete 00000000 ffff880002c31058


[root@andromeda ~]# cat /proc/net/rxrpc_conns
Proto Local        Remote           SvID ConnID   Calls    End Use State    Key      Serial   ISerial
UDP   0.0.0.0:7001 90.155.74.22:7003   34 00000008 00000001 Clt   0 Client   2bed31d2 00000003 00000002
UDP   0.0.0.0:7001 90.155.74.22:7000    1 00000008 00000007 Clt   6 Client   2bed31d2 00000011 00000009
UDP   0.0.0.0:7001 90.155.74.22:7000    1 284bd9a0 00000000 Svc   0 SvUnsec  00000000 00000001 00000007
```

klog

My test klog adds a key for AF_RXRPC to the session keyring:

```
[dhowells@andromeda ~]$ klog
[dhowells@andromeda ~]$ cat /proc/keys
17517315 I--Q--     1 perm 1f3f0000  4043    -1 keyring   _uid_ses.4043: 1/4
19755aa7 I--Q--     1   1d 39390000  4043  4043 rxrpc     afs@CAMBRIDGE.REDHAT.COM
1bac056e I--Q--     5 perm 1f3f0000  4043  4043 keyring   _ses: 2/4
2ea802a8 I--Q--     3 perm 1f3f0000  4043    -1 keyring   _uid.4043: empty


[dhowells@andromeda ~]$ keyctl show
Session Keyring
       -3 --alswrv   4043  4043  keyring: _ses
782762664 --alswrv   4043    -1   \_ keyring: _uid.4043
427121319 --als--v   4043  4043   \_ rxrpc: afs@CAMBRIDGE.REDHAT.COM
```

This is then picked up by AF_RXRPC based on the name of the key

The kAFS filesystem, by using AF_RXRPC, makes use of this key too

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FS-Cache

Local disk cache for network filesystems

Persistent across reboots

Designed for AFS, but also usable by NFS and others

Transparent to user

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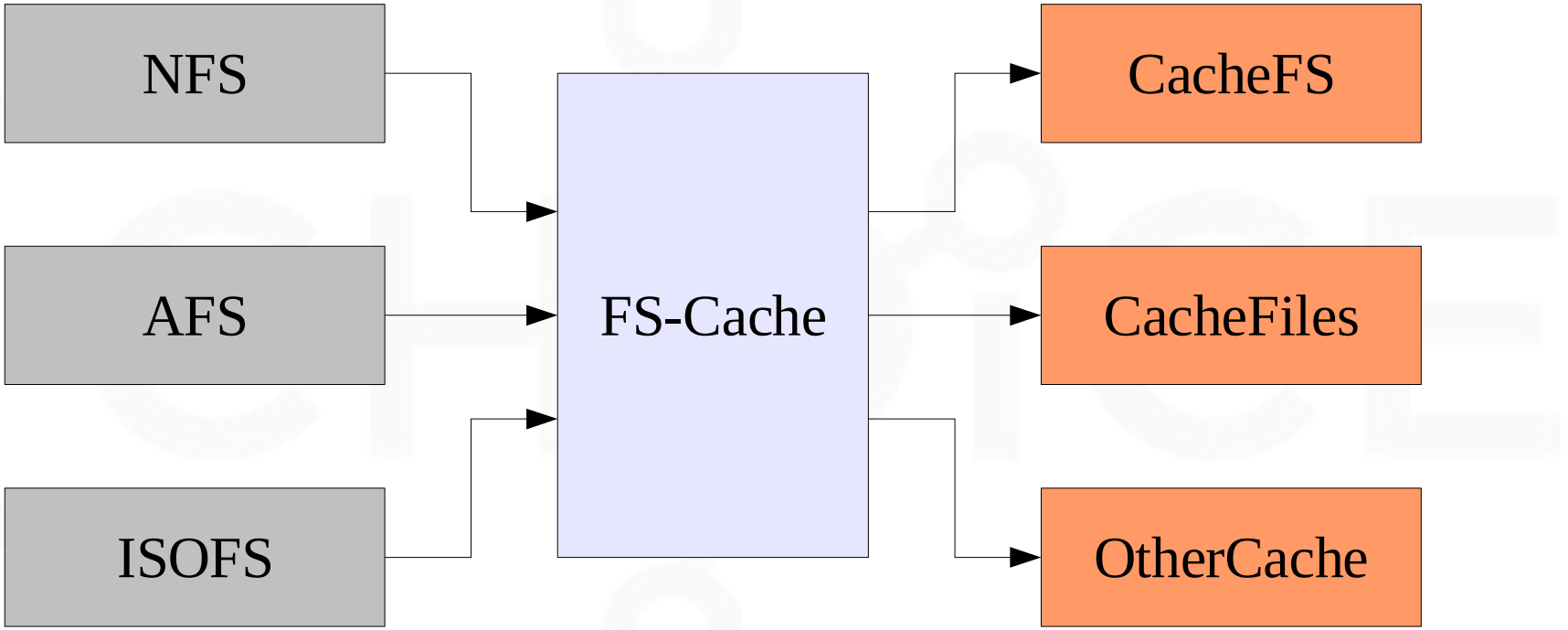
FS-Cache



AFS filesystem

Supports:

- Reading and writing
- File locking
- Security
- Automounting of mount points
- Local caching
- Failover

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AFS filesystem

Does not yet support (or in progress):

- *pioctl()*
- *ioctl()*
- *inotify(), dnotify()*
- AFS userspace tools
- In-DNS AFSDB VL server records
- Tuning
- Disconnected operations

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PAGs

- kAFS does not currently support PAGs
  - Keys go in the session keyring
- Standardise PAG support for OpenAFS and kAFS
  - Should go in main Linux kernel
- Represent each PAG as a keyring
  - Keyring name is PAG ID
  - Should not modify supplementary GID list
- Common OpenAFS/kAFS keys
  - Go in PAG keyring

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OpenAFS and kAFS coexistence

Would like for OpenAFS and kAFS to be able to coexist on a machine

Ought to be trivial:

- Give them separate local Cache Manager ports
- Give them different mountpoints
- Shared keys

However...

- Pathless *pioctl()* calls are a pain

Future Technologies

Support for future technologies needs considering:

- IPv6
- Non-UDP socket types
- Newer versions of AFS protocol
- Weirder security types

AFS filesystem

Set up by:

```
insmod kafs.ko rootcell=cambridge.redhat.com:192.168.1.1
```

Mounted by:

```
mount -t afs \#root.afs. /afs
```