Confinement
(Running Untrusted Programs)

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Untrusted Programs

Untrusted Application

- Entire Application untrusted
- Part of application untrusted
  - Modules or library untrusted

Possible Solutions

- Air Gapped Systems
- Virtual Machines
- Containers

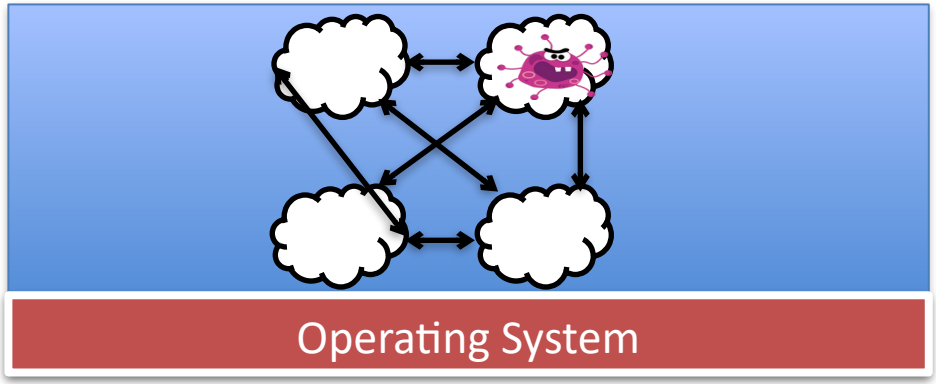
(all are coarse grained solutions)

Vulnerable Applications

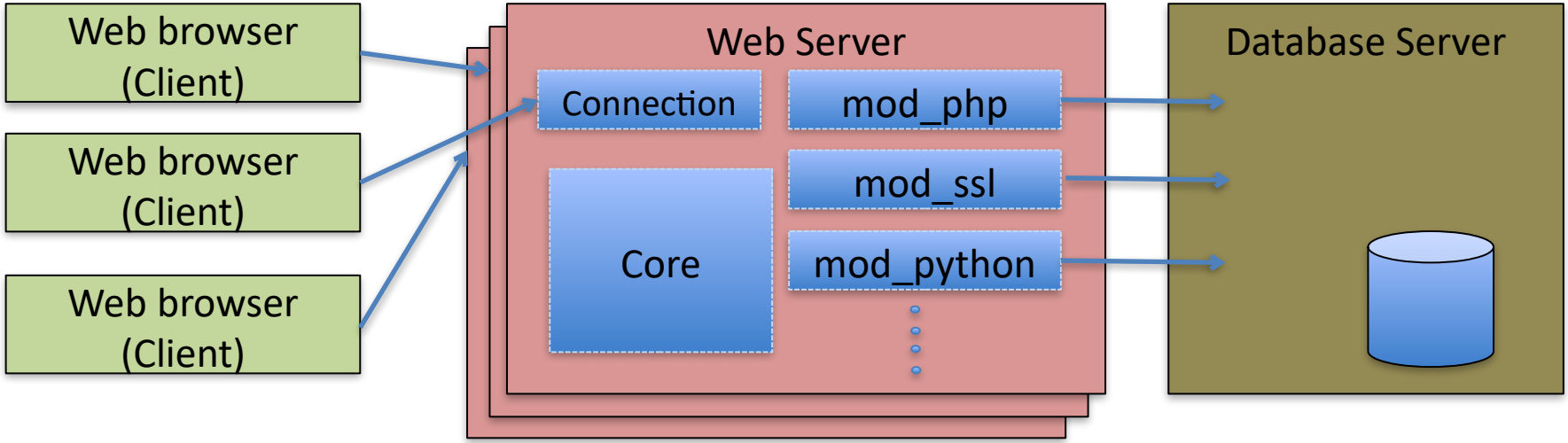
- A vulnerability in one application compromises the entire application

Confinement (using RPCs)

- Run each module as a different process (different address spaces)
  - Use RPCs to communicate between modules
  - Hardware ensures that one process does not affect another



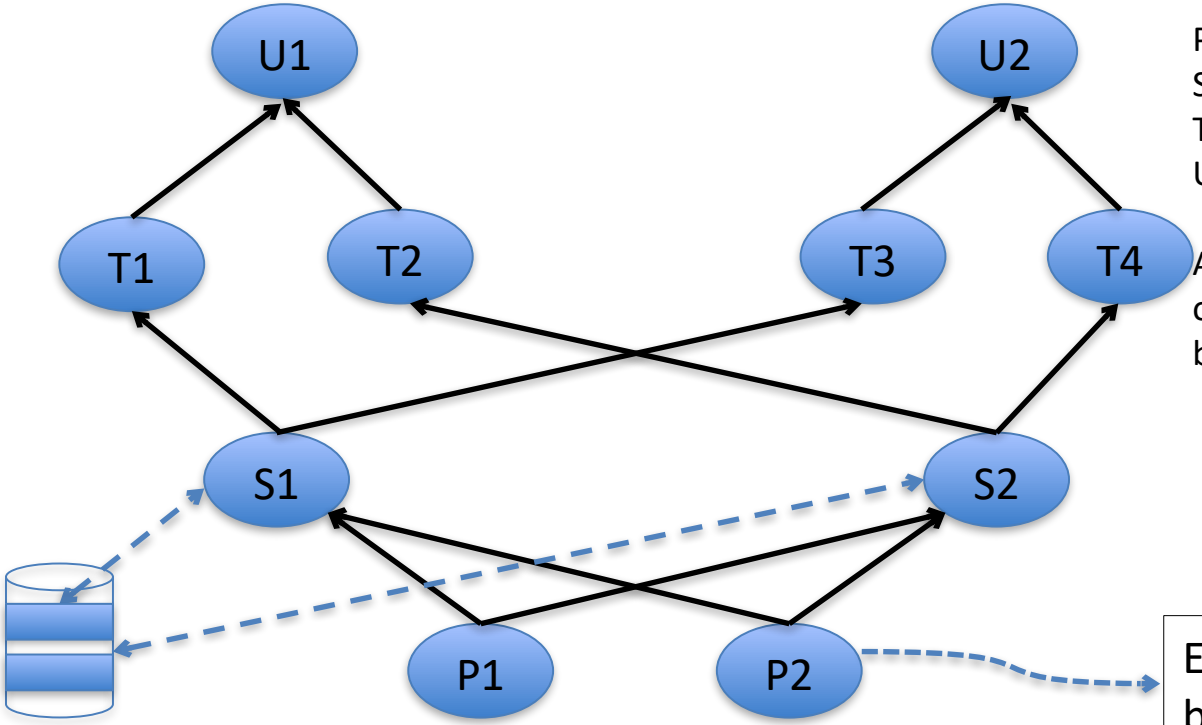
Typical Web Server



- single address space holds multiple web servers
- Every new client creates a new process
- HTTP interfaces restrict access to the database server
- Security achieved by coarse grained access control mechanisms in the data base server
- A vulnerability in any component can ripple through the entire system

https://www.usenix.org/event/usenix04/tech/general/full_papers/krohn/krohn.pdf

Apache Webserver (Dependency Graph)

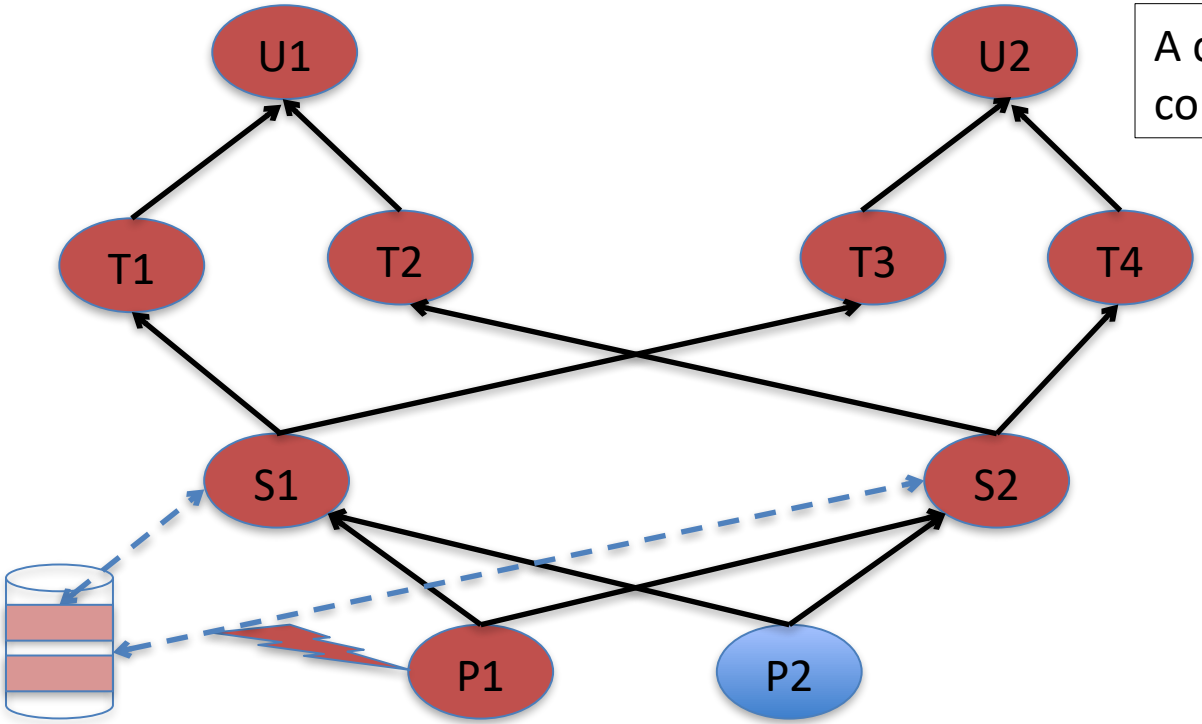


Px pool of processes
Sx services access private databases
Tx state data
Ux users

An edge from (a, b) implies b's dependence on a. If a gets compromised b also will be compromised.

Every child process created by Apache, Includes all services

A compromised process
(Apache Webserver)



A compromised child process will compromise all services

Known attacks on Web Servers

- A bug in one website can lead to an attack in another website
  example: Amazon holds credit card numbers. If it happens to share the same web server as other users this could lead to trouble.

- Some known attacks on Apache's webserver and its standard modules
  - Unintended data disclosure (2002)
    users get access to sensitive log information
  - Buffer overflows and remote code execution (2002)
  - Denial of service attacks (2003)
  - Due to scripting extensions to Apache

Principle of Least Privileges

Aspects of the system most vulnerable to attack are the least useful to attackers.

- Decompose system into subsystems
- Grant privileges in fine grained manner
- Minimal access given to subsystems to access system data and resources
- Narrow interfaces between subsystems that only allow necessary operations
- Assume exploit more likely to occur in subsystems closer to the user (eg. network interfaces)
- Security enforcement done outside the system (eg. by OS)

OKWS Webserver
(designed for least privileges)

each independent service runs in an independent process	Do not expose more code/services than required! Tradeoff security vs performance
Each service should run in a separate chroot jail	Allow access to only necessary files.
Each process should run as a different unprivileged user.	Prevent interfering with other processes
Narrow set of database access privileges	Prevent unrequired access to the DB service

https://www.usenix.org/event/usenix04/tech/general/full_papers/krohn/krohn.pdf

Achieving Confinement

Through Unix Tools

- **chroot:** define the file system a process can see

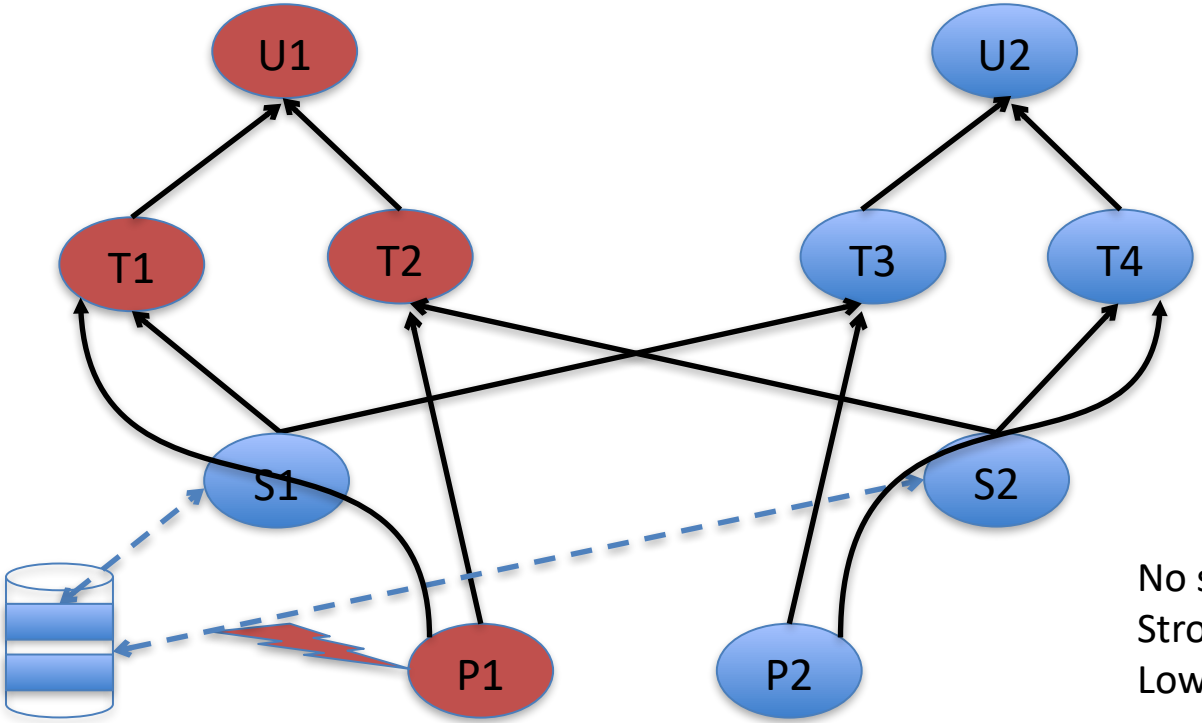
  if system is compromised, the attacker has limited access to the files. Therefore, cannot get further privileges

- **setuid:** set the uid of a process to confine what it can do

  if system runs as privileged user and is compromised, the attacker can manipulate other system processes, bind to system ports, trace system calls, etc.

- **Passing file descriptors:** a privileged parent process can open a file and pass the descriptor to an unprivileged child
  (don't have to raise the privilege of a child, to permit it to access a specific high privileged file)

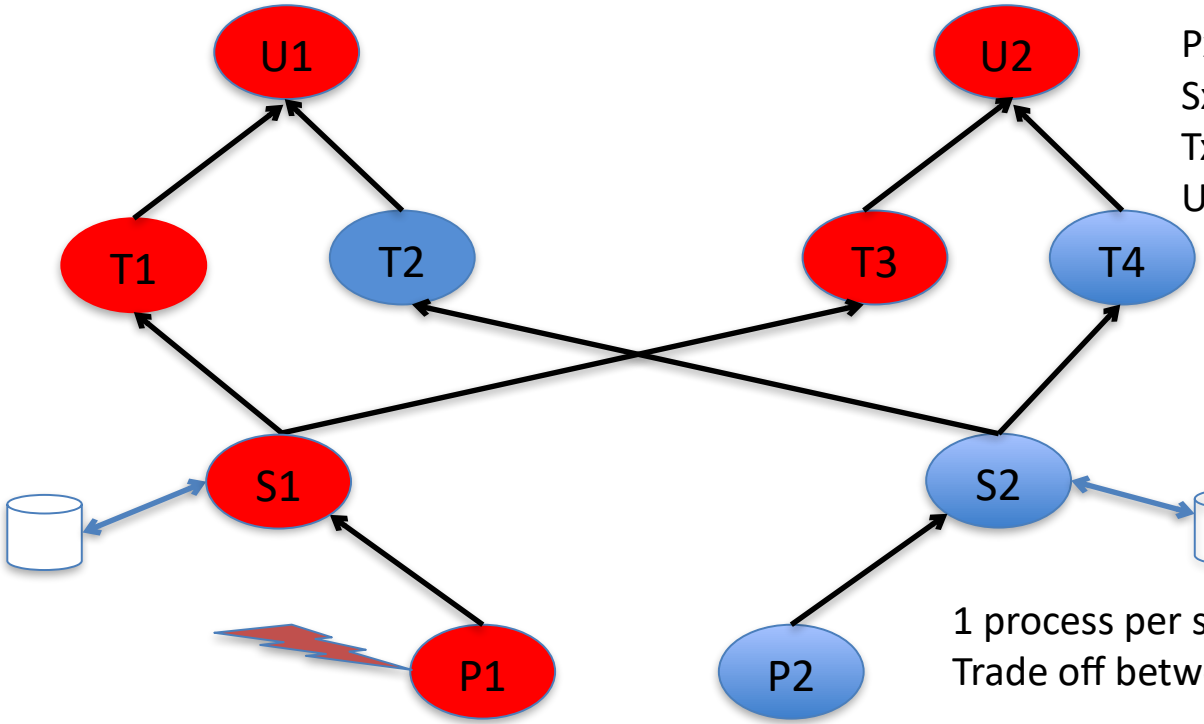
Strict Confinement



If a user process is compromised, then data corresponding to that process is compromised

No sharing of services or processes;
Strong confinement;
Low performance due to too many processes
(1 process per user)

OKWS



Px pool of processes
Sx services access private databases
Tx state data
Ux users

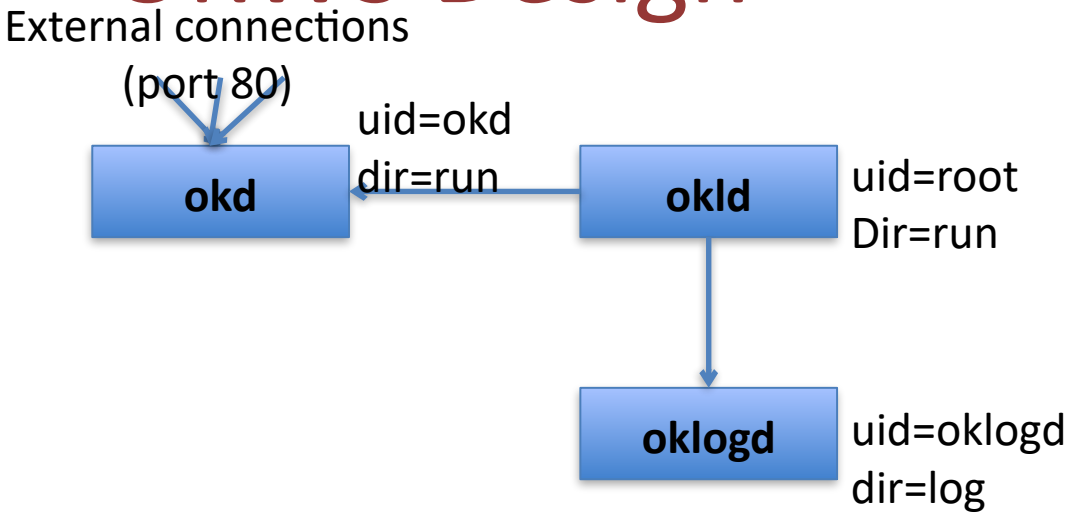
1 process per service
Trade off between security and performance

OKWS Design

uid=root
dir=run

runs as superuser; bootstrapping; chroot directory is run monitors processes; relaunches them if they crash

OKWS Design



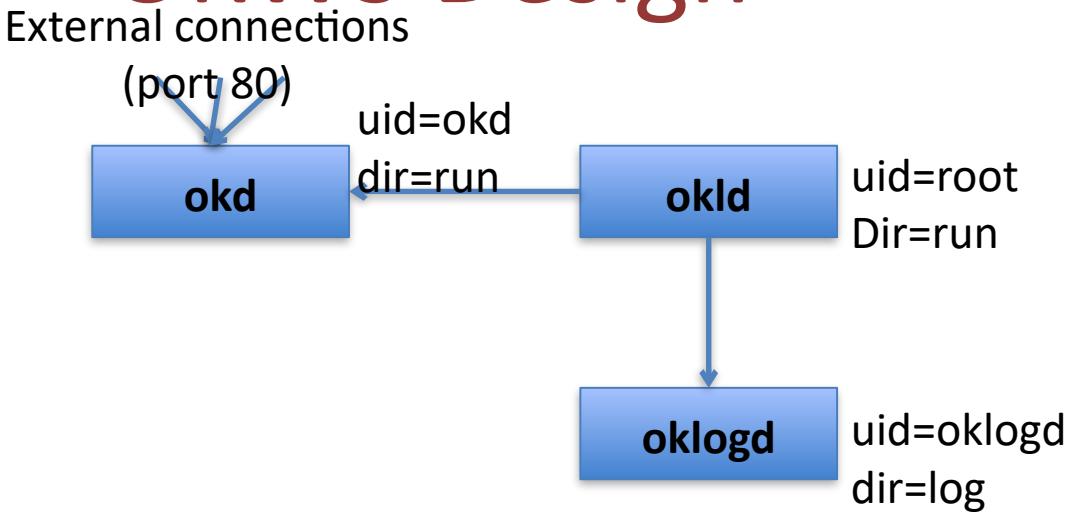
Launch okd (demux daemon) to route traffice to appropriate service ;

If request is valid, forwards the request to the appropriate service

If request is invalid, send HTTP 404 error to the remote client

If request is broken, send HTTP 500 error to the remote client

OKWS Design

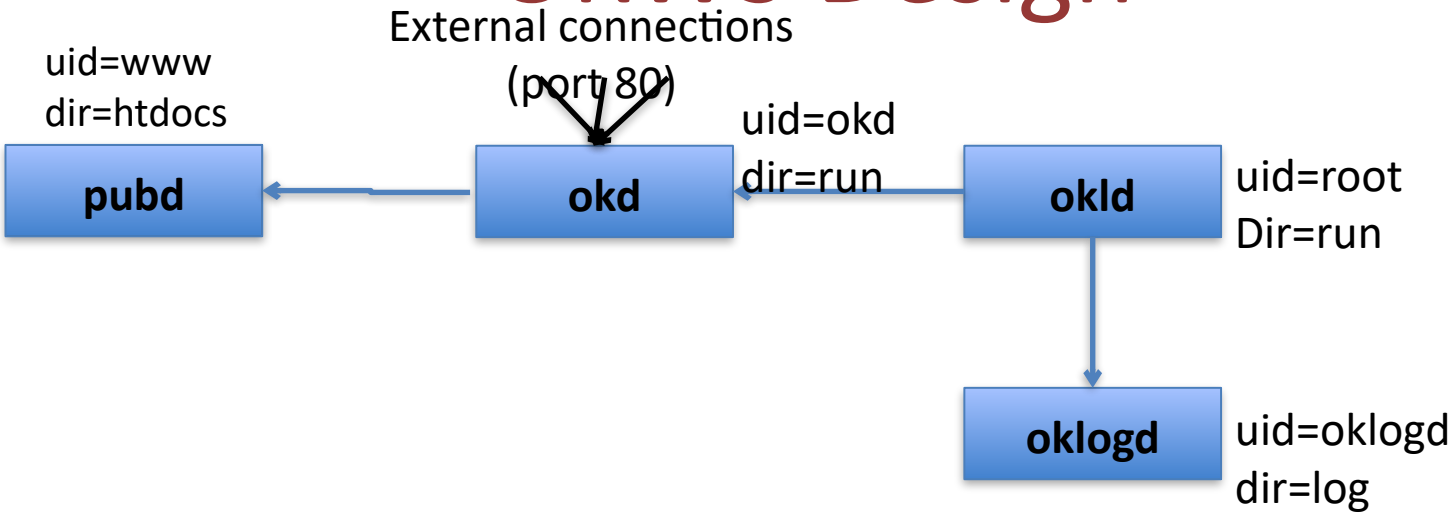


oklogd daemon to write log entries to disk

chroot into their own runtime jail (within a jail, each process has just enough access privileges to read shared libraries on startup, dump core files if crash)

Each service runs as an unprivileged user

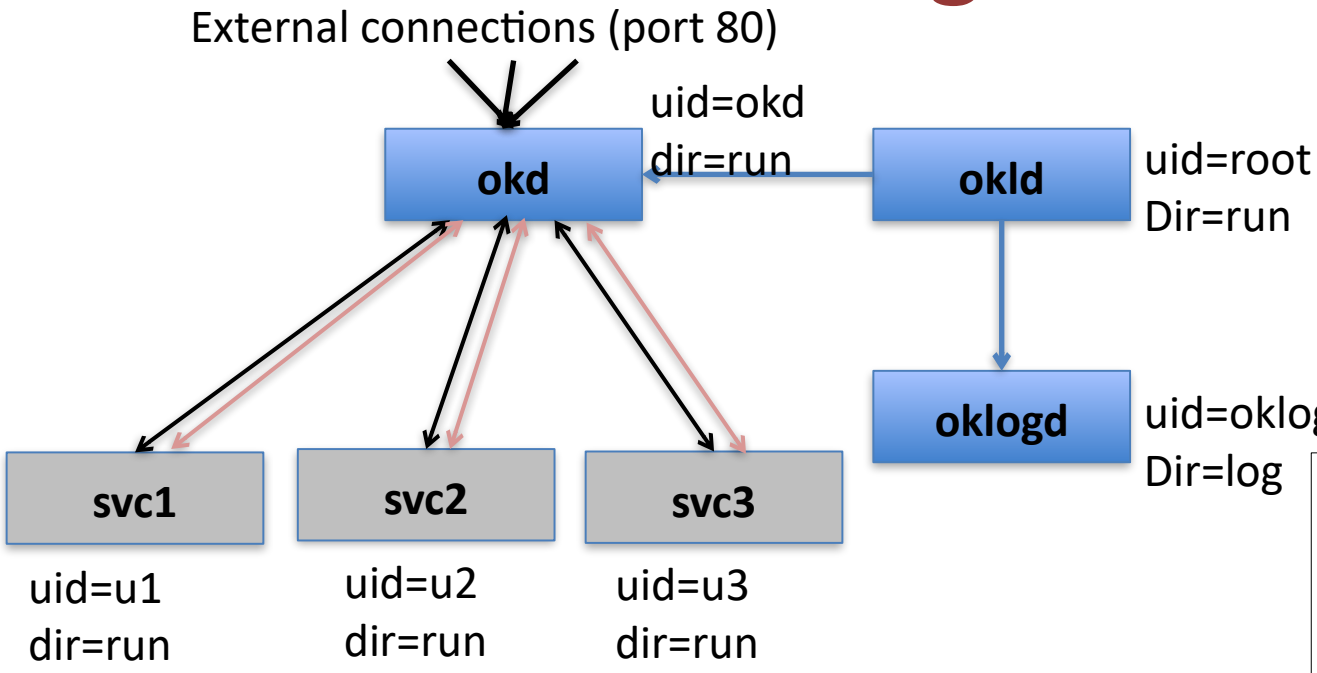
OKWS Design



pubd: provides minimal access to local configuration files, html files

Read only access to the files

OKWS Design




```
Request 2 sockets
fork()
if (child process){
    setuid()
    chroot()
    exec()
}
```

okld launch services; each service in its chroot with its own uid

Services owned by root with permissions 0410 (can only be executed by user)

okld catches SIGCHILD and restarts services if they crash

Logging

- Each service uses the same logging file
  - They use the oklogd to write into the file via RPCs
  - oklogd runs in its own chroot jail
    - Any compromised service will not be able to modify / read the log
    - A compromised service may be able to write arbitrary messages to the log (noise)