A User-Level Unix Server for the *SPIN* Operating System

David Dion

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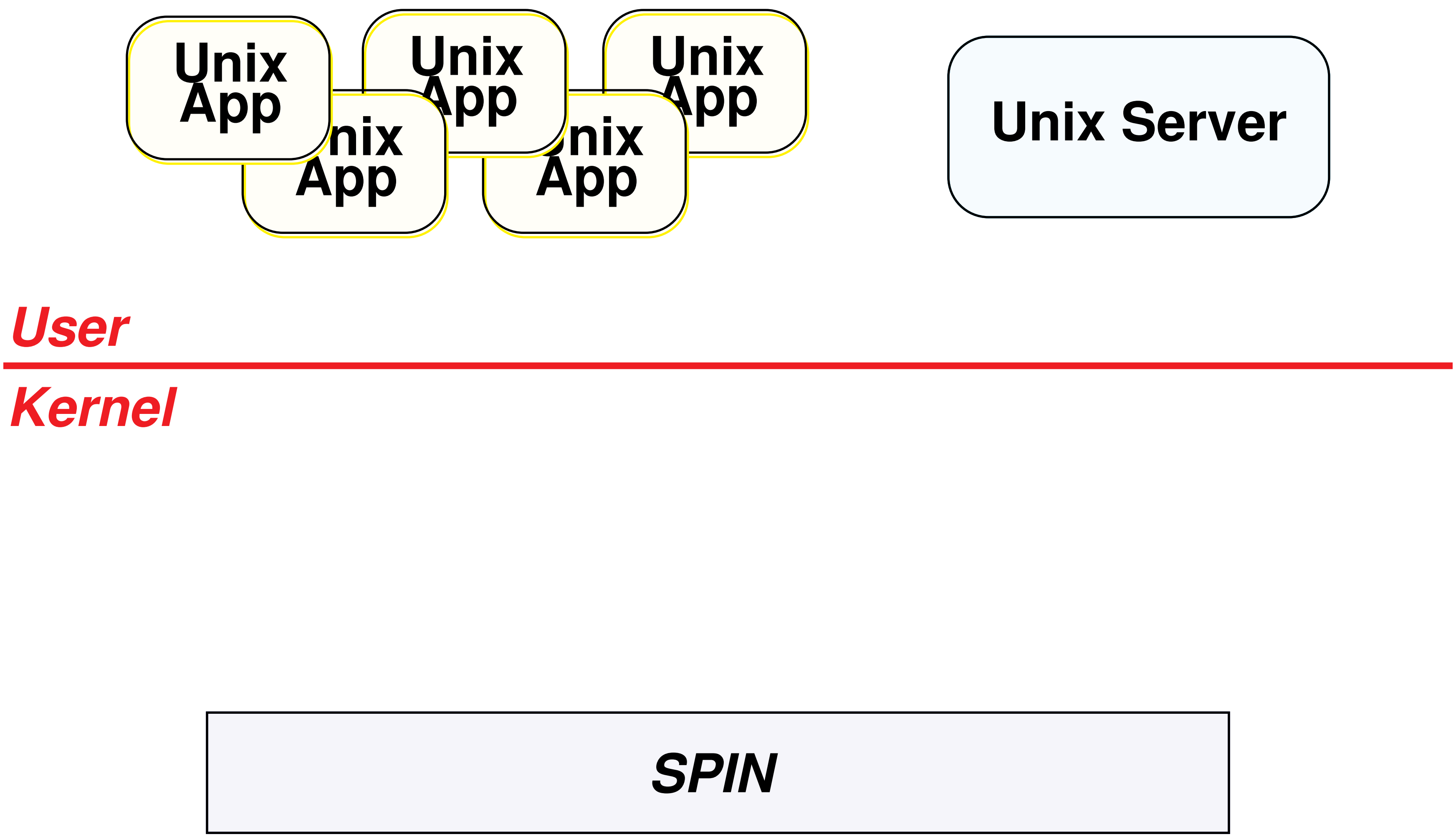
Objectives

Emulate Unix with binary compatibility

Reuse a large piece of existing code

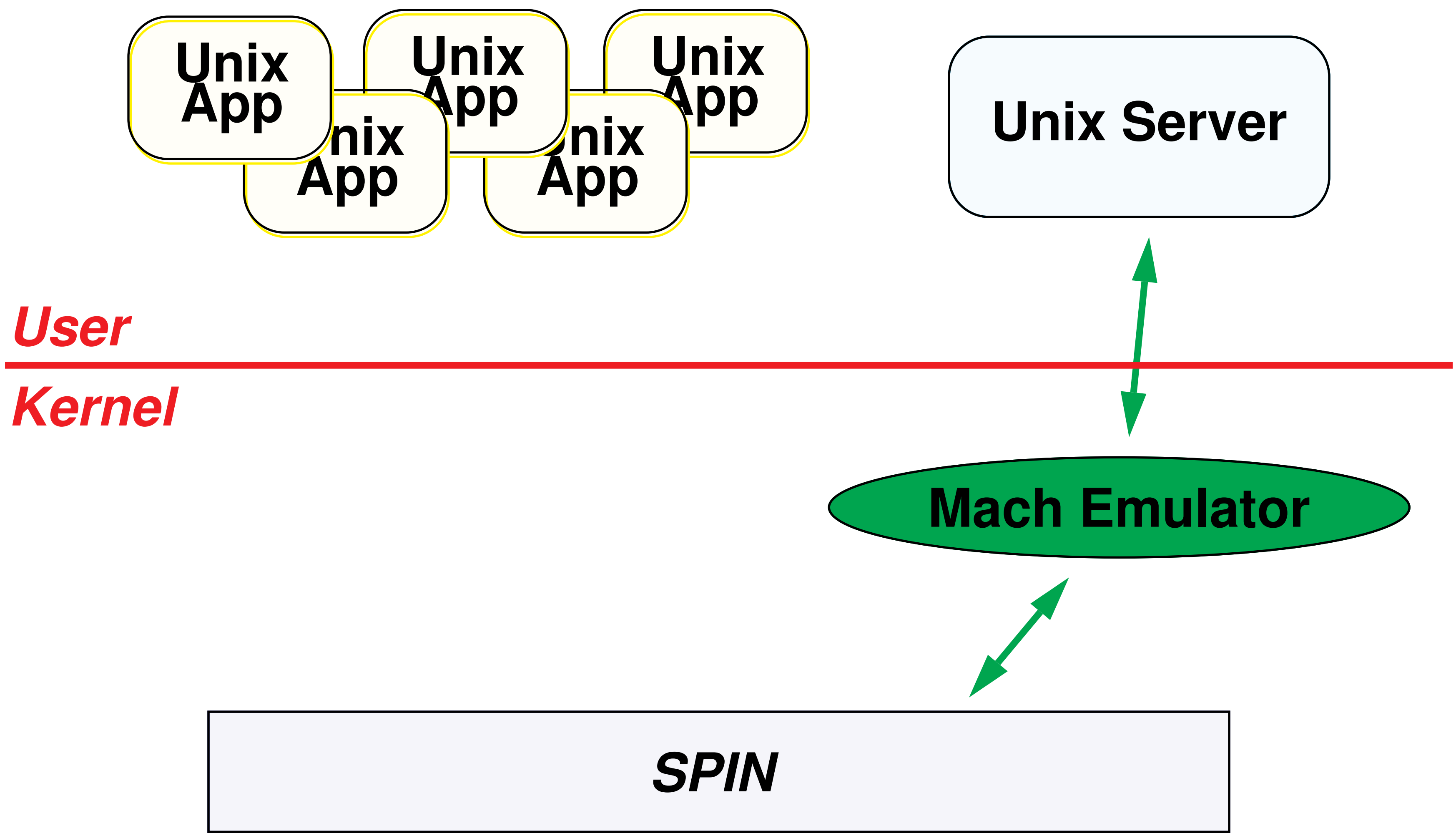
Run a large application on *SPIN*

Approach



Unix App
Unix App
Unix App
Unix App
Unix App
Unix Server
User
Kernel
SPIN

Approach


Unix App
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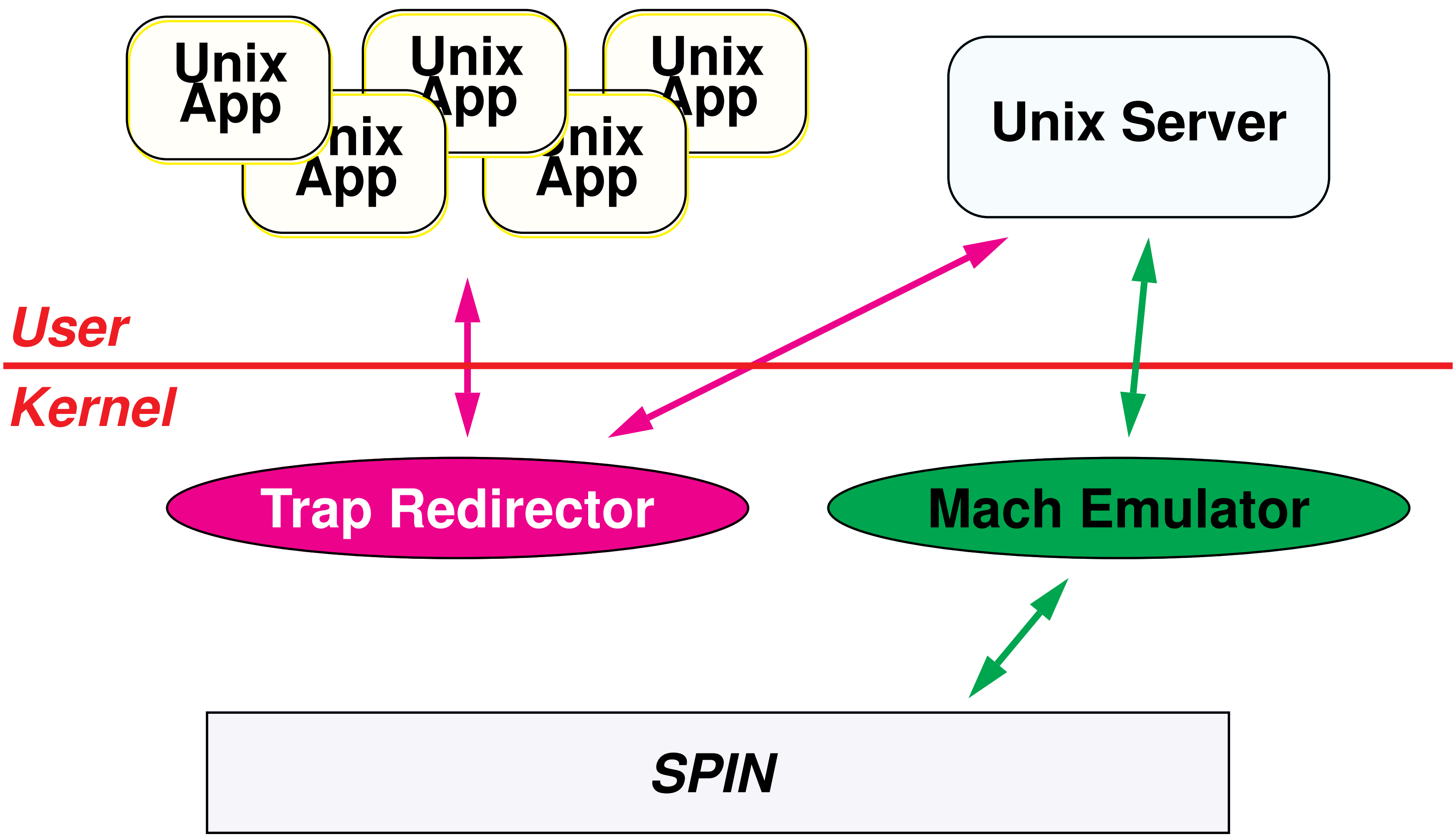
Mach Emulator
SPIN

Approach


Unix App
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Unix App
Unix Server
User
Kernel
Trap Redirector
Mach Emulator
SPIN

Unix Applications

Lots of popular programs

Well-known system interface

SPIN

Safety, extensibility, performance

Untrusted applications dynamically extend the kernel

SPIN Extensions

Bind *handlers* to *events*

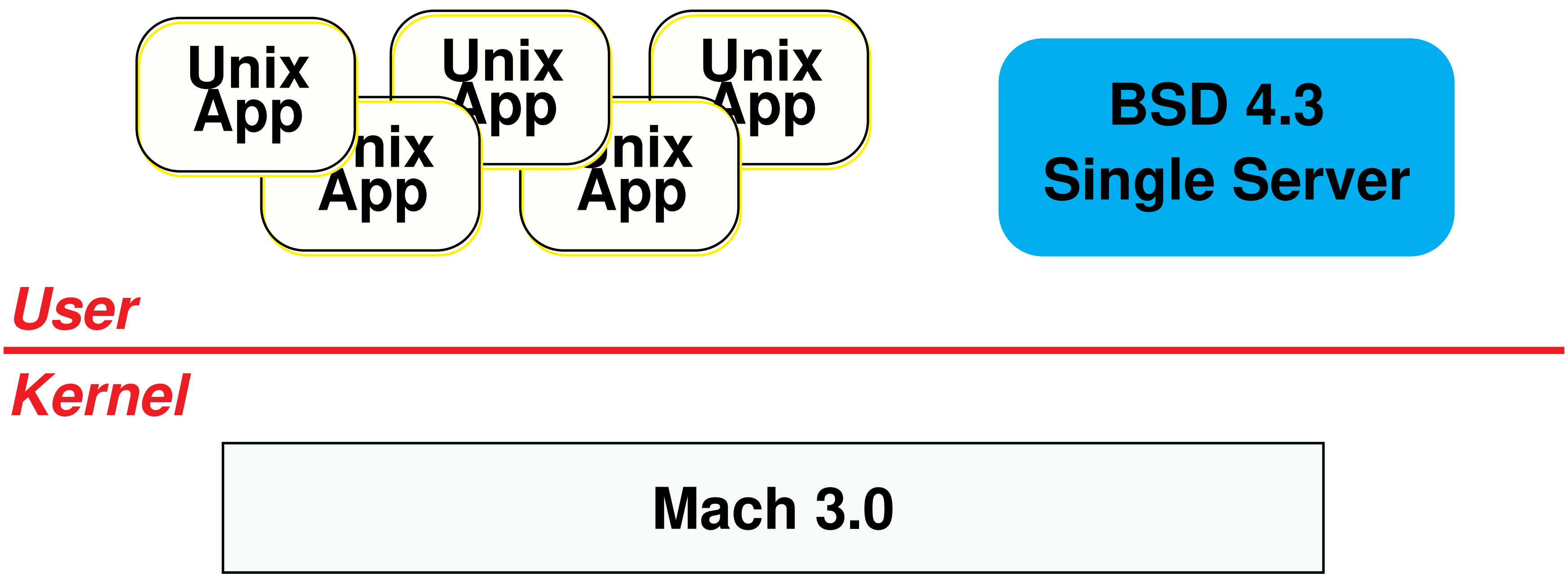
Event: change in system state

Handler: procedure that responds to an event

Example: system call is an event

Unix Server

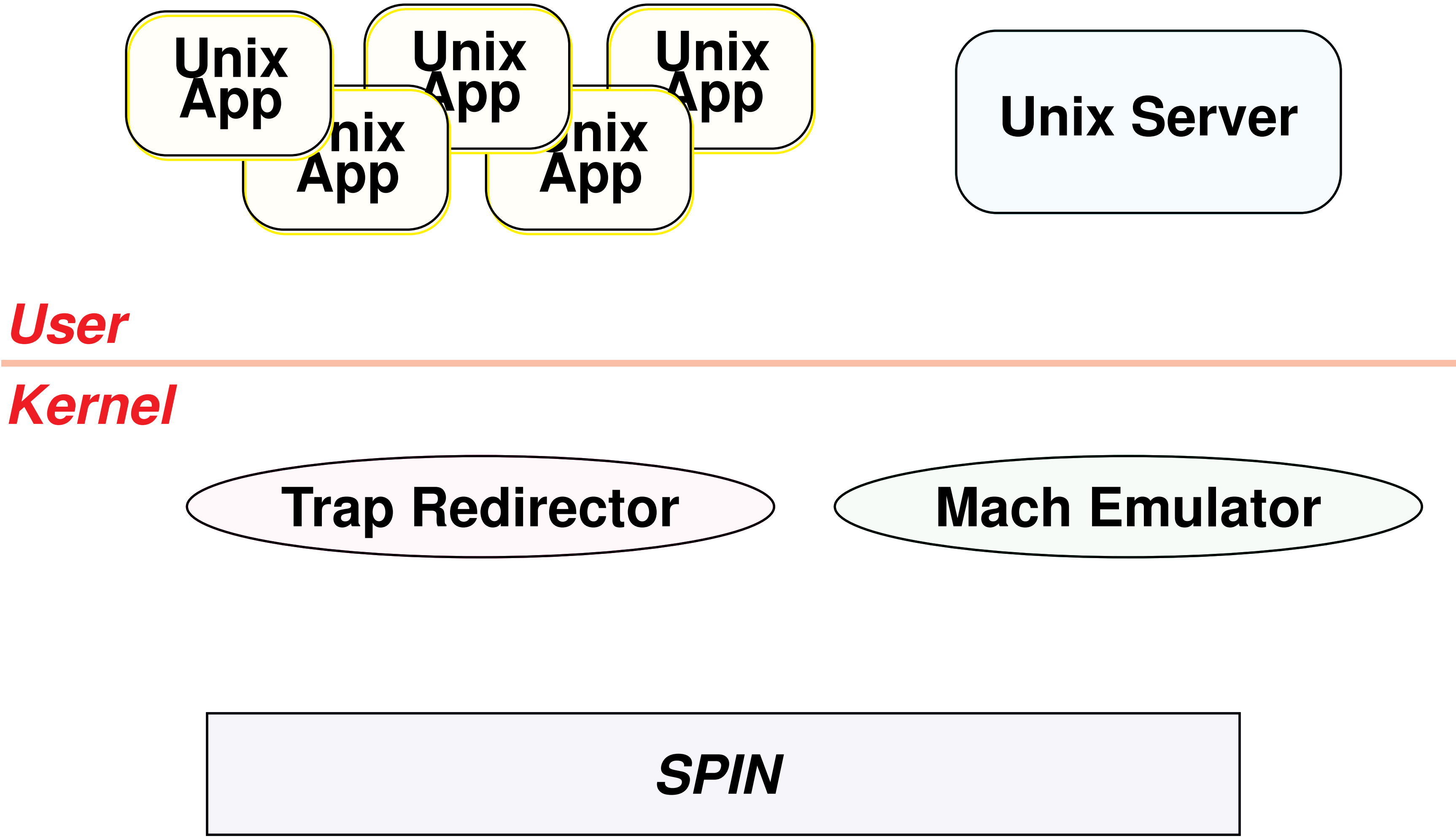
Once upon a time ...



Unix Server Evolution

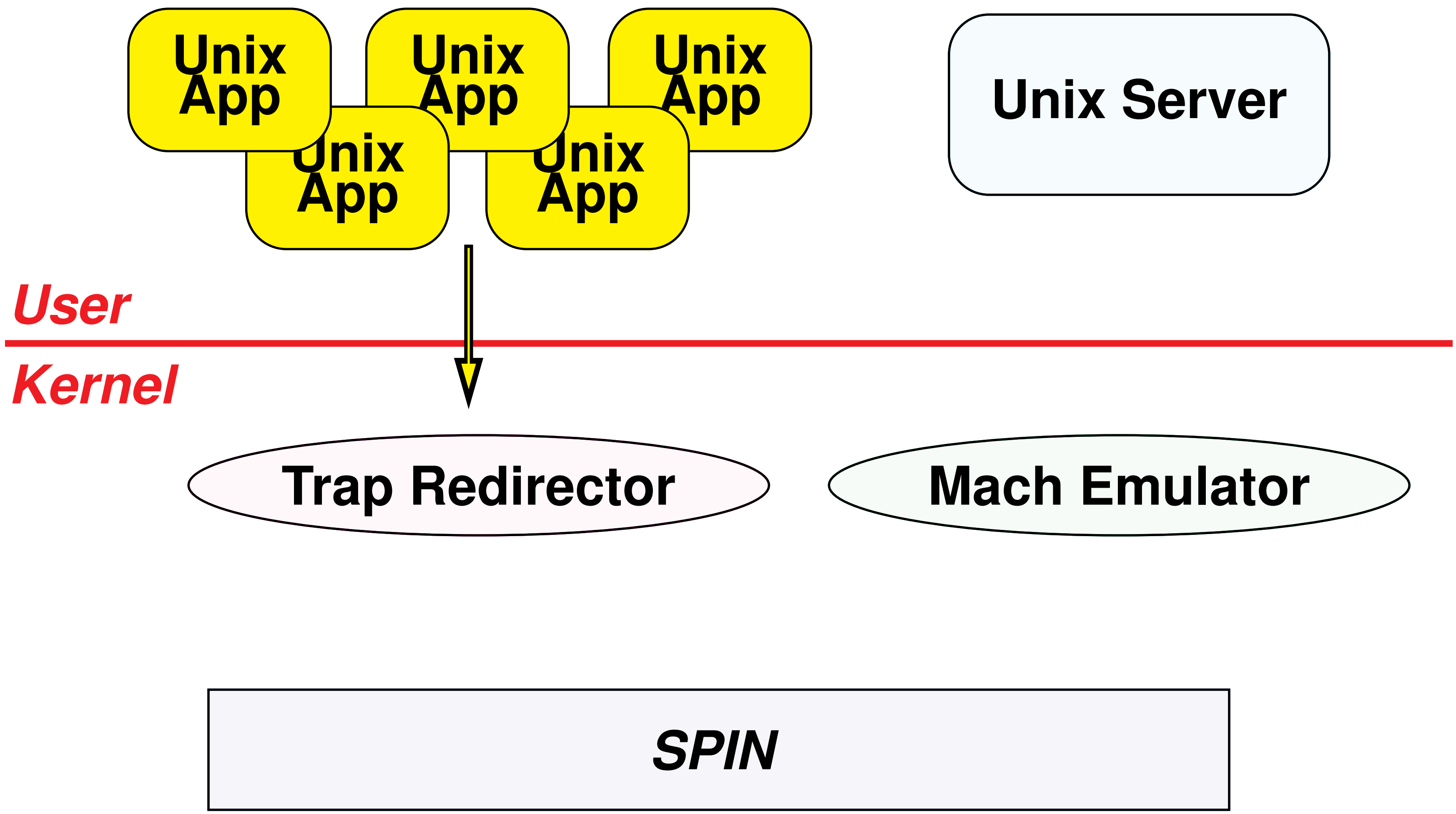
Life of a System Call

How does it fit together?



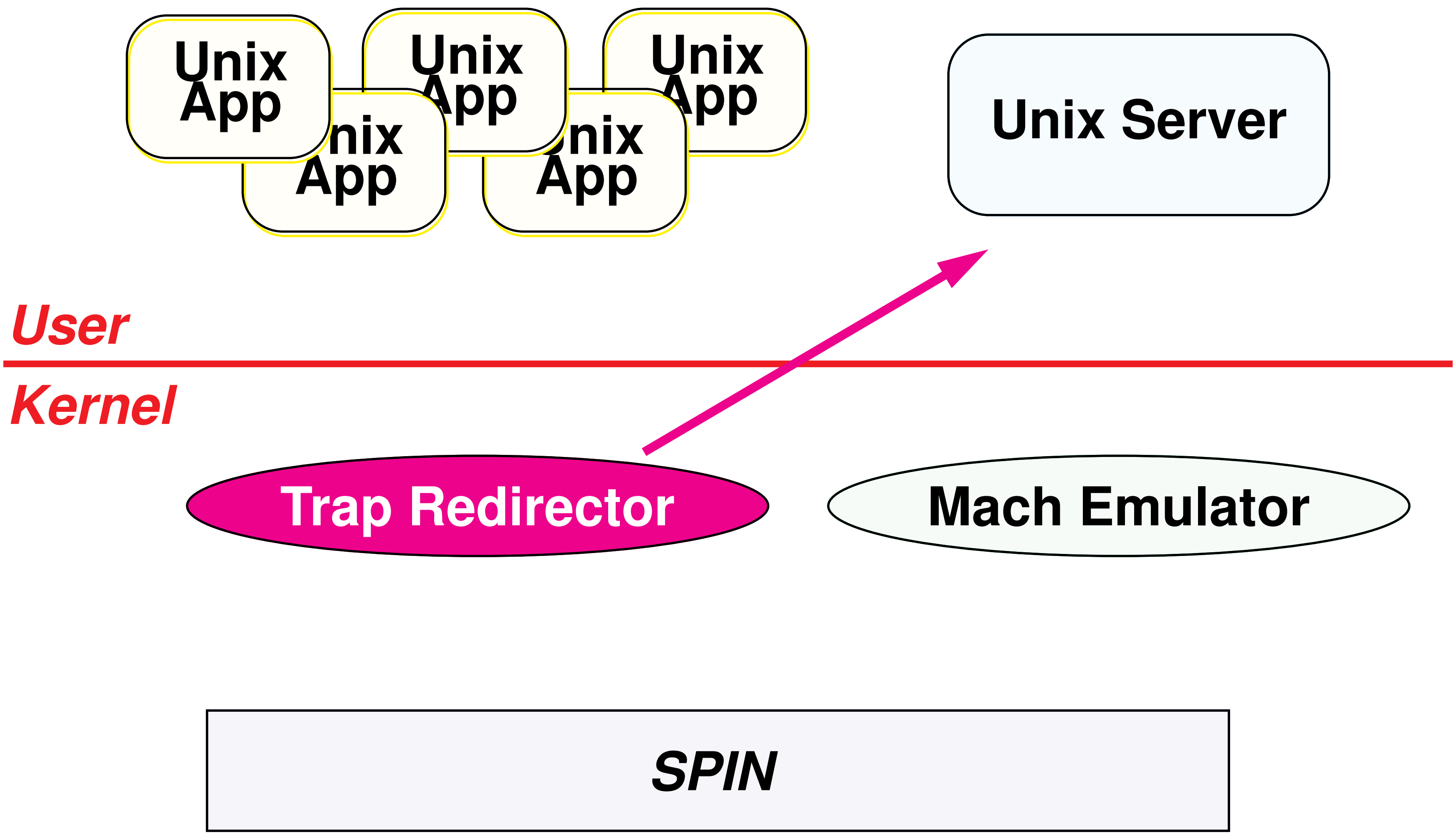
Life of a System Call

Invocation: read()



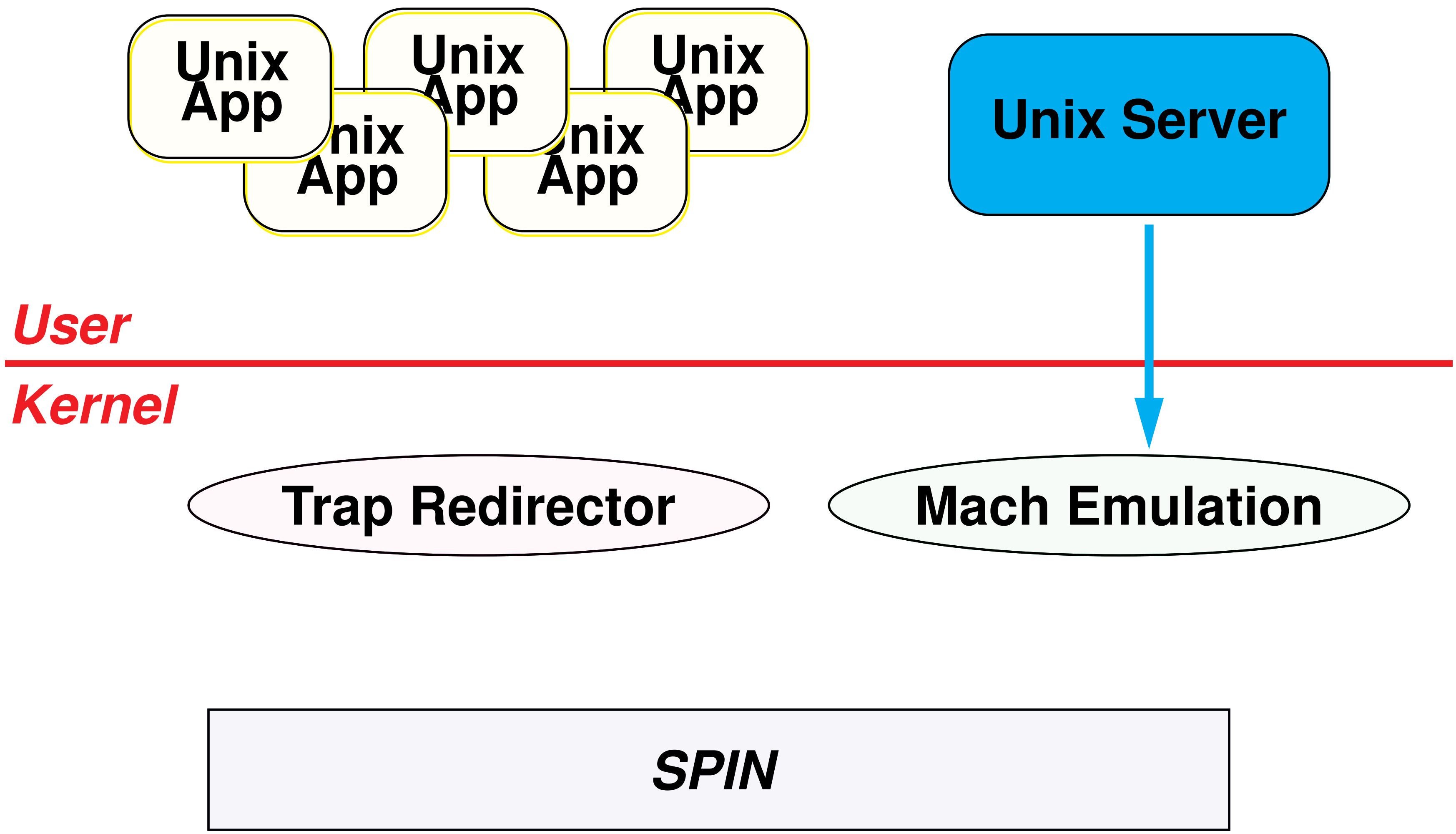
Life of a System Call

Intercept and hand-off to server



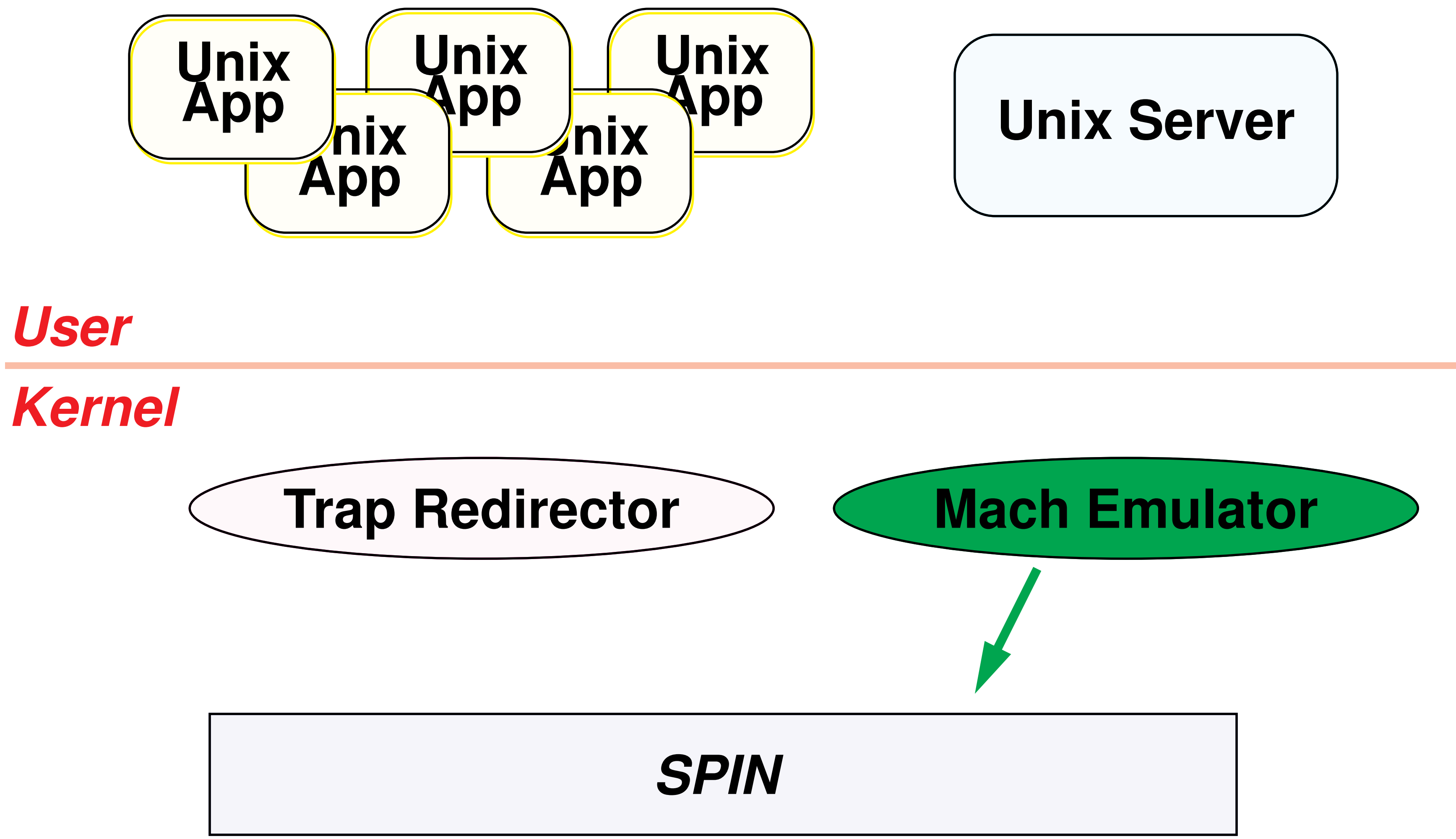
Life of a System Call

Invoke kernel services: device_read()



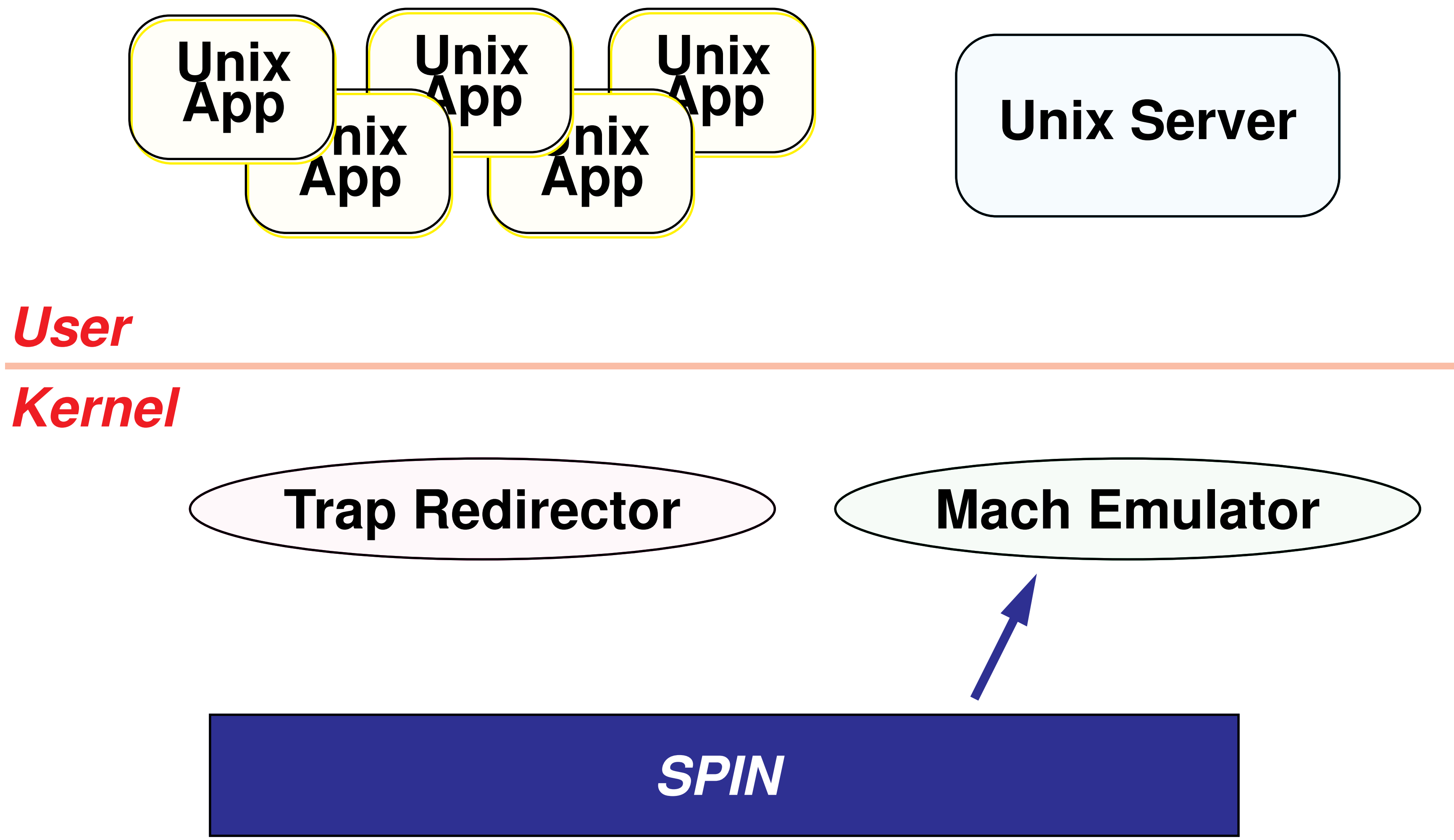
Life of a System Call

Invoke SPIN services: DiskDevice.Read()



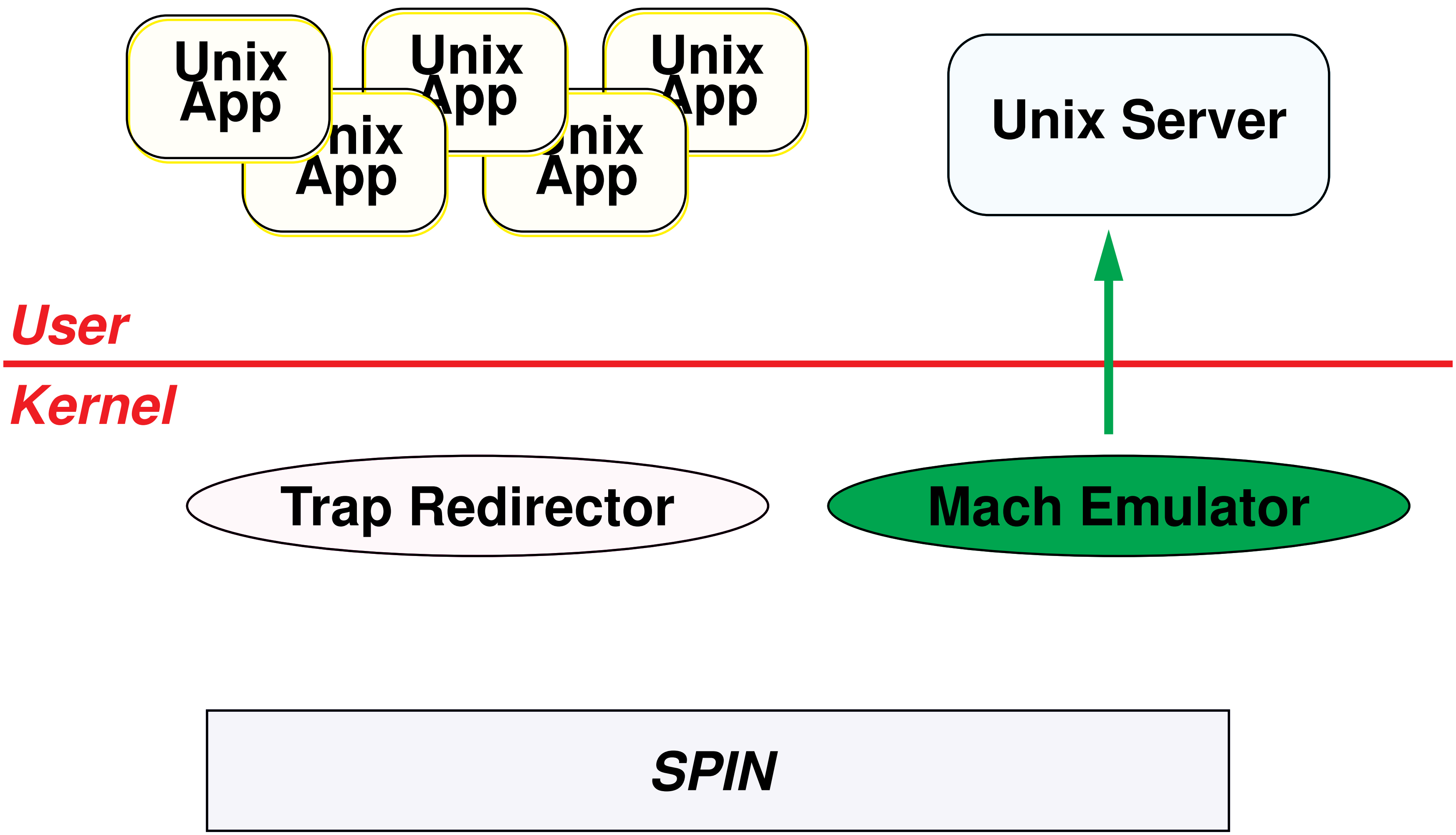
Life of a System Call

Get data from disk and give it to emulator



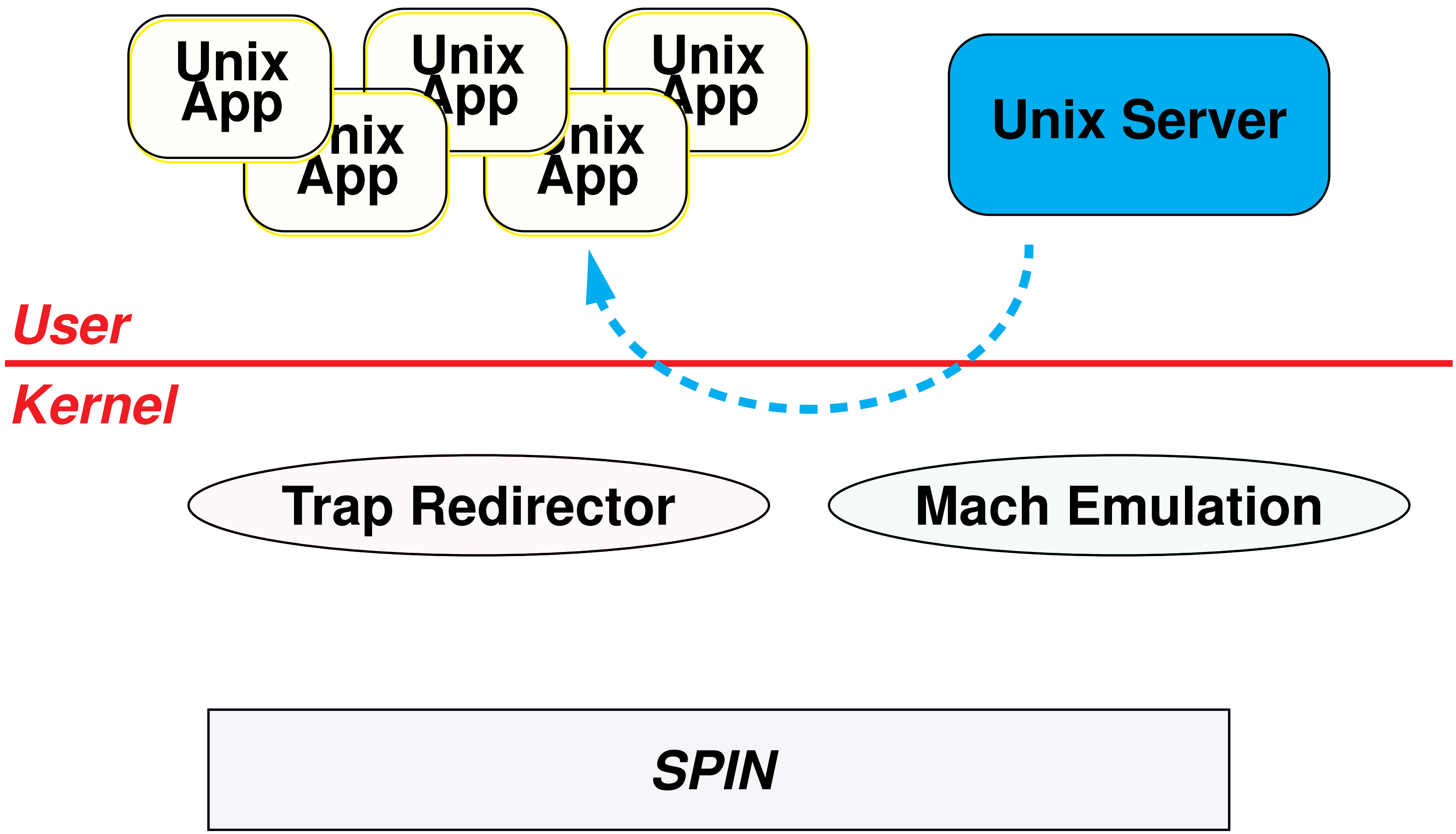
Life of a System Call

Copy data to server



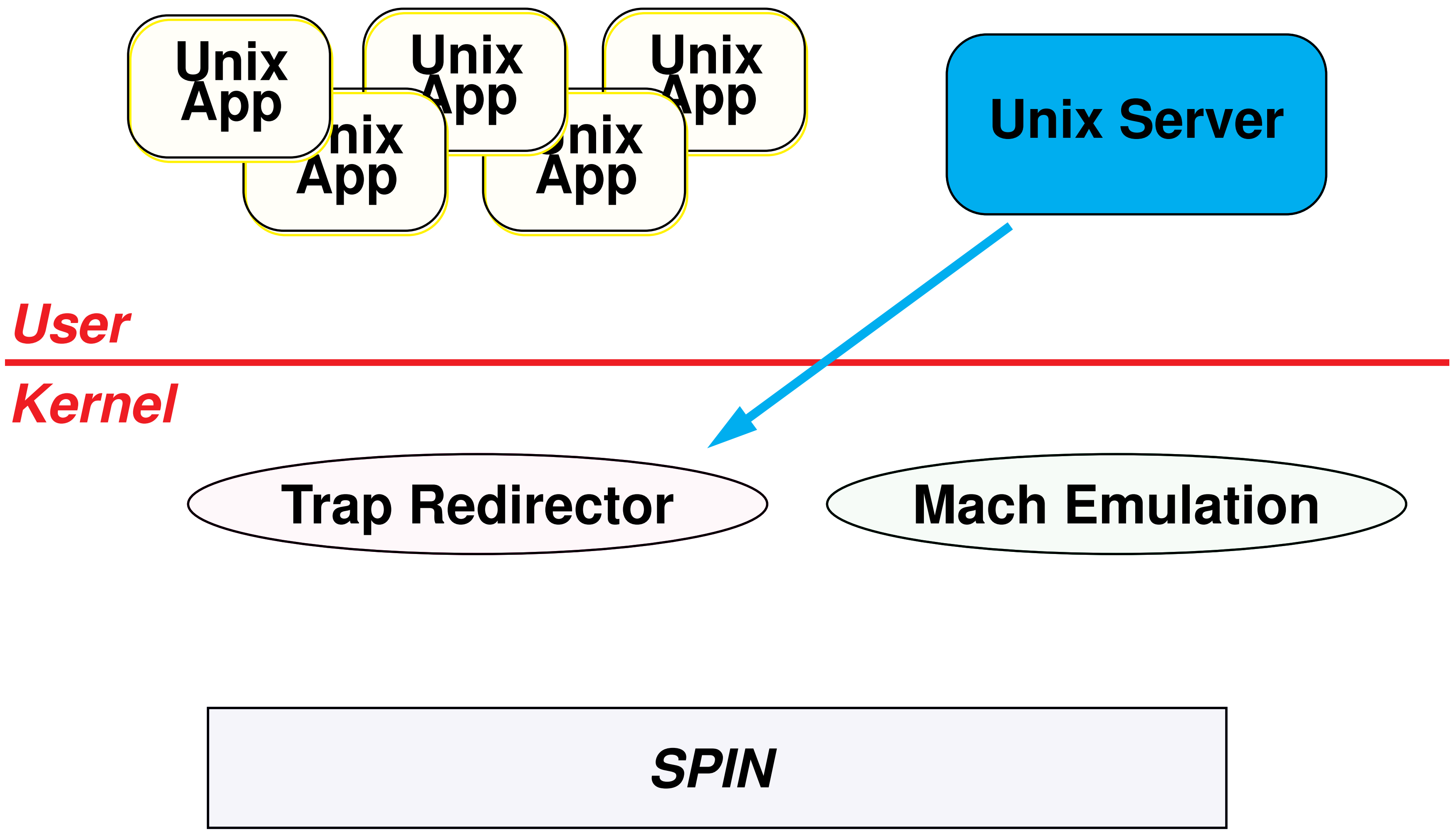
Life of a System Call

Copy data to application



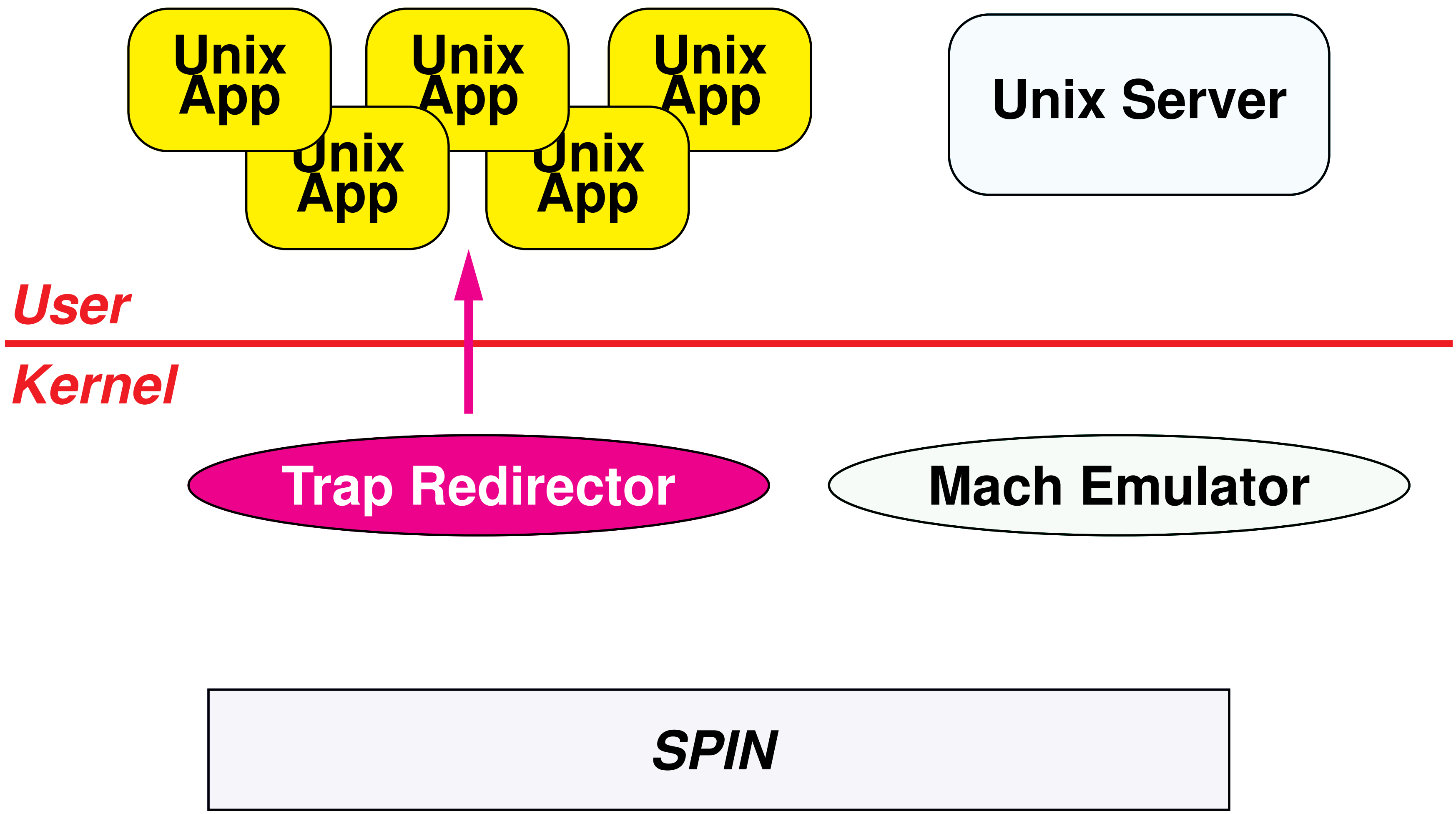
Life of a System Call

Return to Trap Redirector

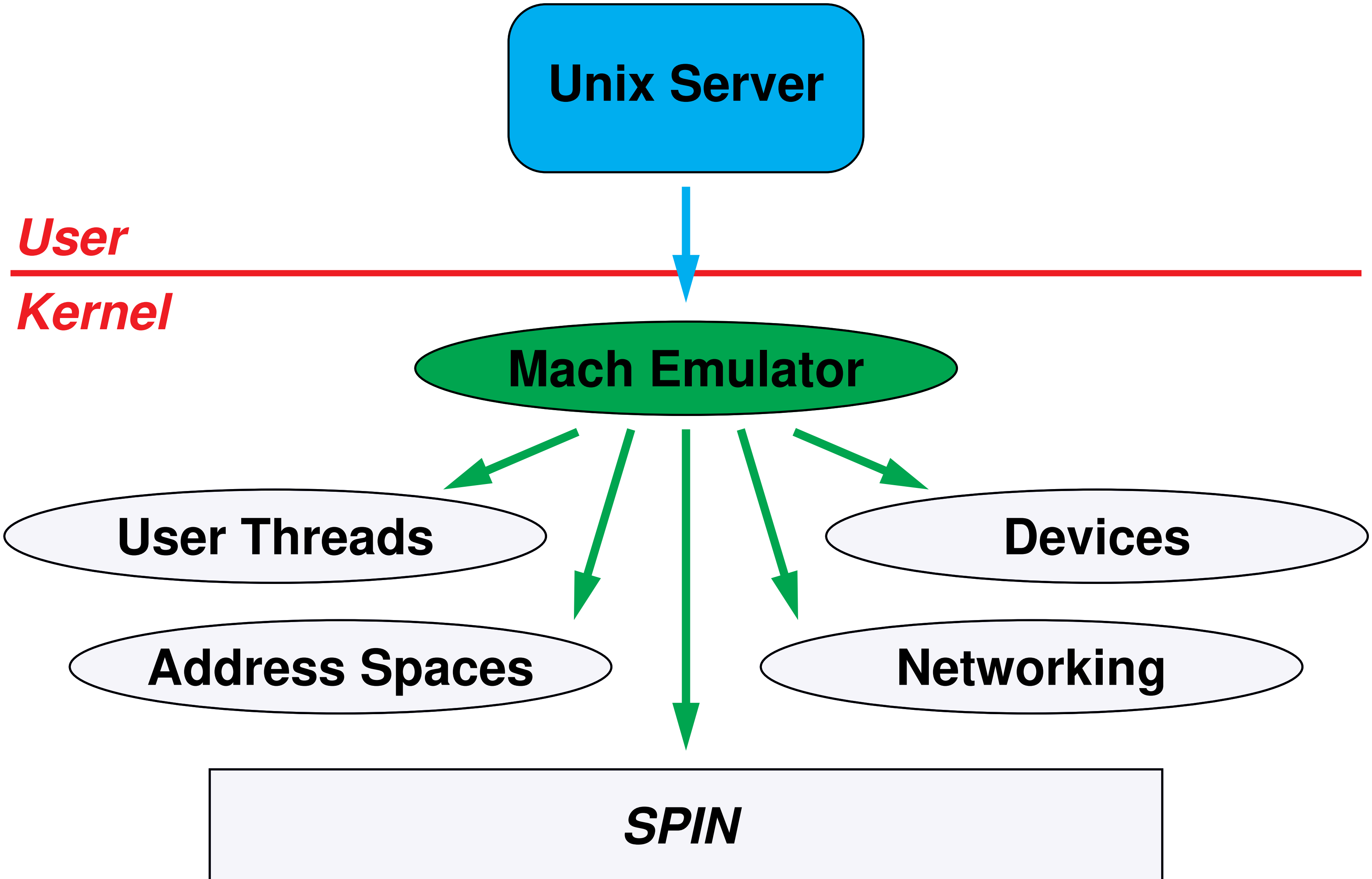


Life of a System Call

Return to application



Emulating Mach



Mach VM and Tasks

Mach VM/Task interface richer than *SPIN*

Address Space interface

Keep track of lots of data

Construct new services

Aggressive copying for correctness

Result: it works, but it’s not pretty

Performance

The user-level server model is inherently slow.

System call latency

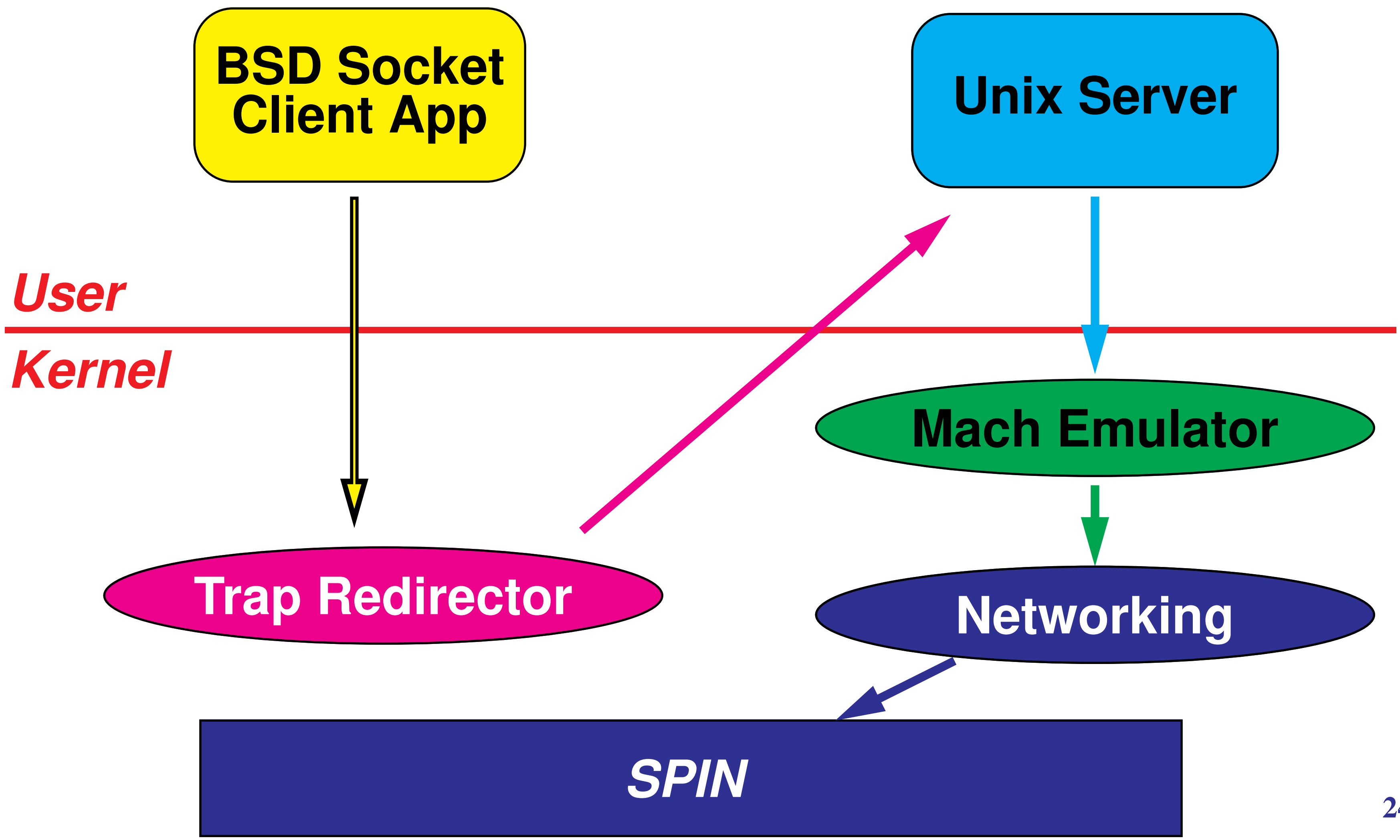
Operation	Digital Unix	*SPIN* + Unix Server
getpid()	2 μsec	597 μsec
read() 1KB	24 μsec	643 μsec

Application performance

Operation	Digital Unix	*SPIN* + Unix Server
ls -l (cold)	246 msec	2043 msec
ls -l (warm)	159 msec	530 msec

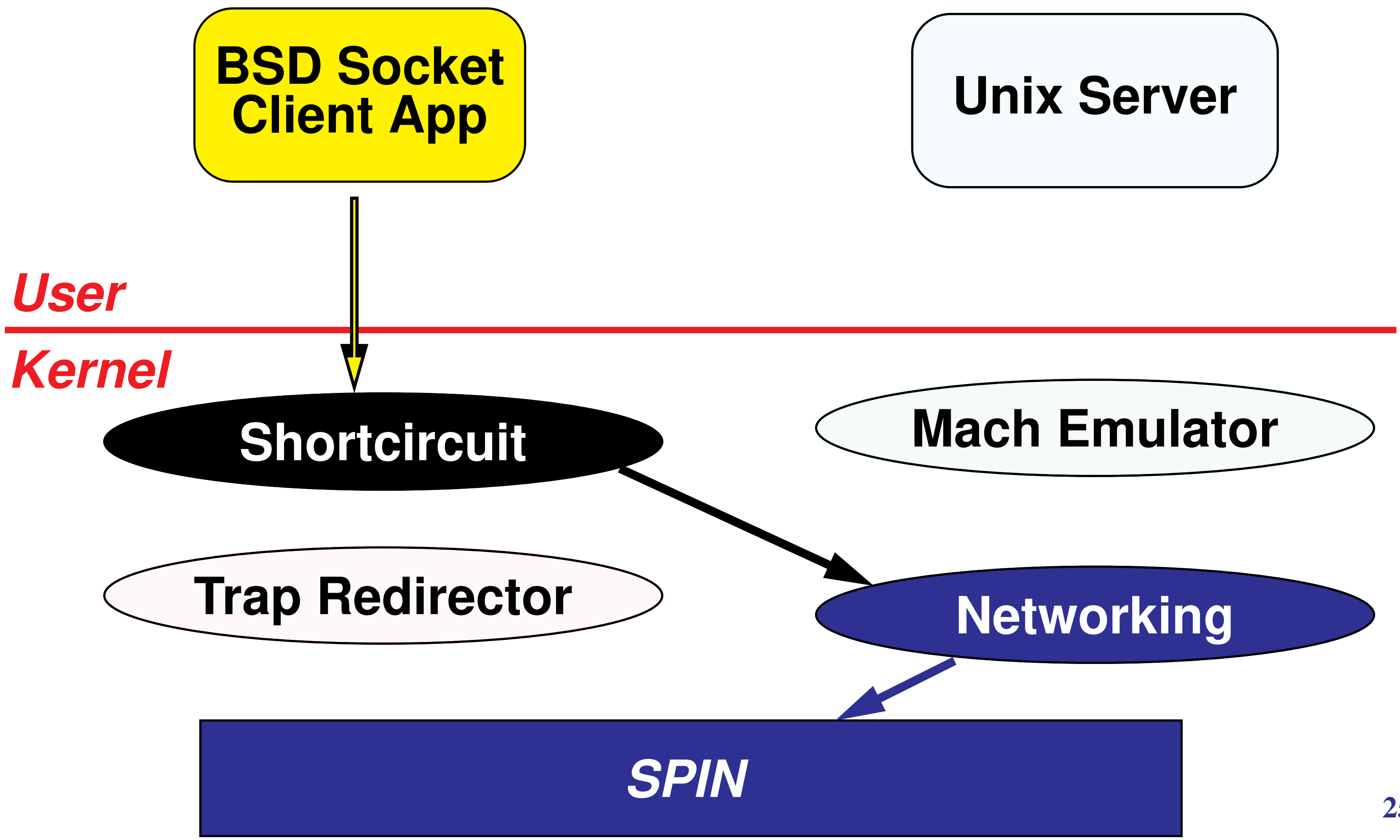
Improving Performance

Server path for UDP packet send



Shortcircuit

Shortcircuit path for UDP packet send



Shortcircuit Performance

Comparable to Digital Unix

Operation	**DEC Unix**	***SPIN* + UX**	***SPIN* + UX w/short**
UDP round trip	620 μsec	3.8 msec	660 μsec

Current Status

System boots, runs simple programs

Mach Emulator:

- **~50 system calls emulated**
- **~2500 lines of Modula-3 code**

Trap Redirector:

- **Completely implemented**
- **~500 lines of Modula-3 code**

Conclusion

Lessons learned

Emulation easy with *SPIN* extensions

Strategy for emulation: identify critical services first

Future Work

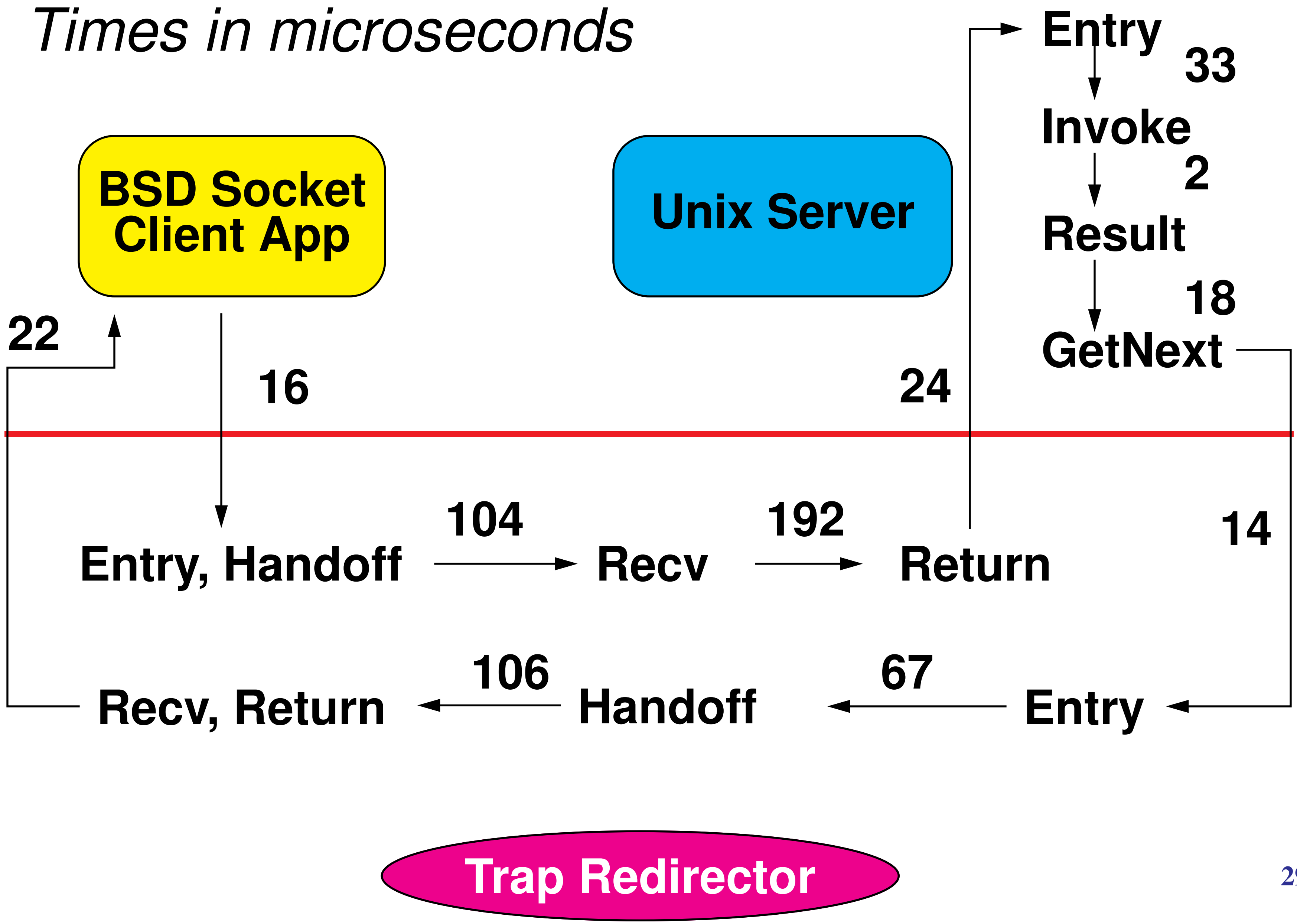
Integrate new Mach VM/Task support

Tune emulation to improve performance

Invoke shortcircuit for other applications

Trap Redirection

Times in microseconds



Mach + Unix Server

Operation	DEC Unix	Mach + UX	*SPIN* + UX
getpid()	5 µsec	1383 msec	1108 µsec
read() 1KB	44 µsec	1533 µsec	1207 µsec
ls -l (cold)	246 msec	8360 msec	2043 msec
ls -l (warm)	159 msec	7672 msec	530 msec