Evolving Mach 3.0 to a Migrating Thread Model

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Terminology

Thread: A sequential flow of control.

RPC: A control transfer modeling a procedure call, that crosses the protection barrier between two processes.

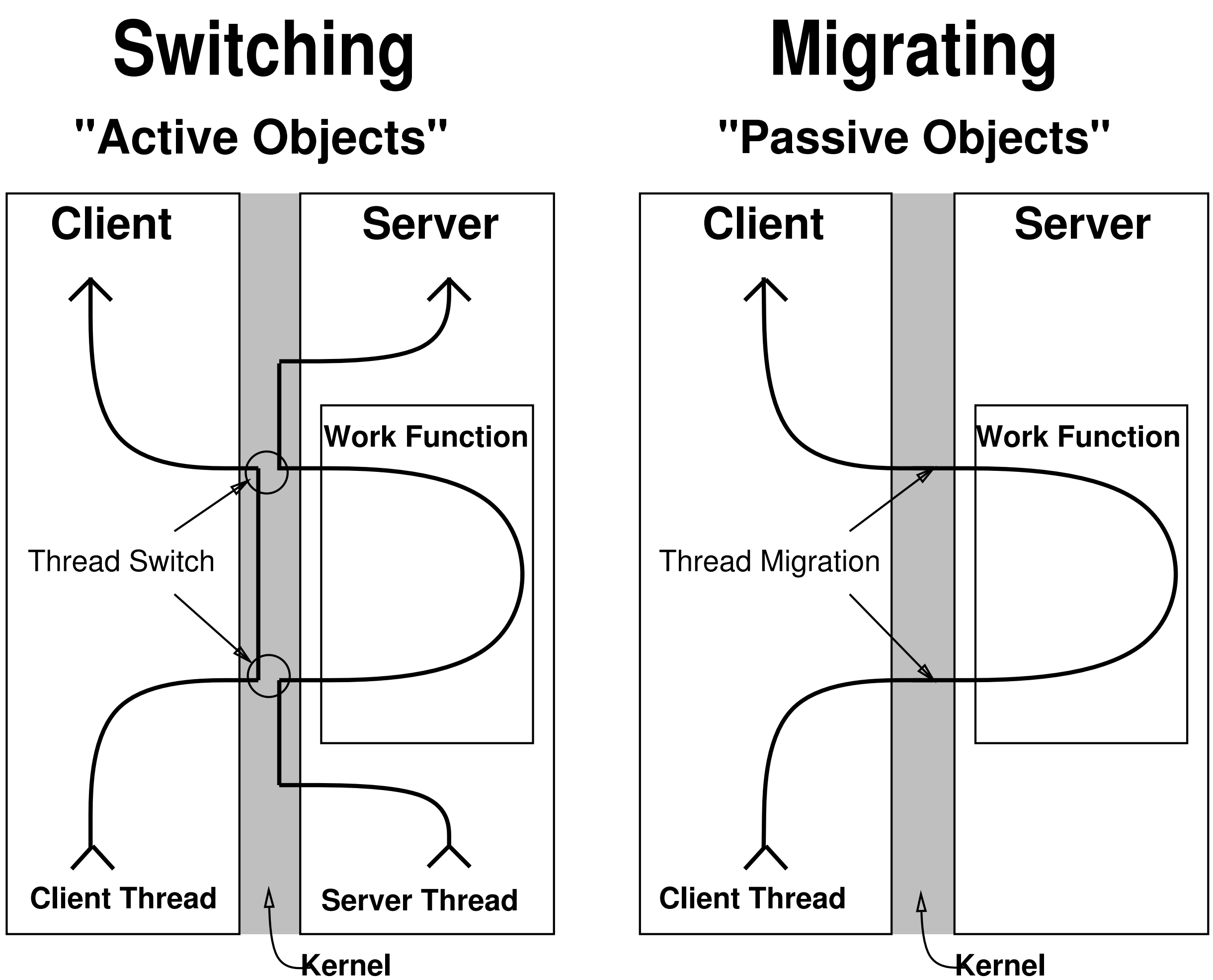
Static thread model: RPC is implemented by two separate threads, each confined to one process, passing messages.

Migrating thread model: RPC is implemented by one thread temporarily crossing the protection barrier and “doing its own work” in the server’s code.

Thread Models in RPC

RPC is *supposed* to model a procedure call.

So, what's all the gunk on the left?!



Research Overview

Questions: Is the migrating thread model a good idea? Does it make much difference?

Project: Design and implement a version of Mach based on migrating threads; compare the two versions.

Result: Migrating threads are better in speed, code simplicity, and functionality; do not sacrifice protection or backward compatibility.

Primary Issues

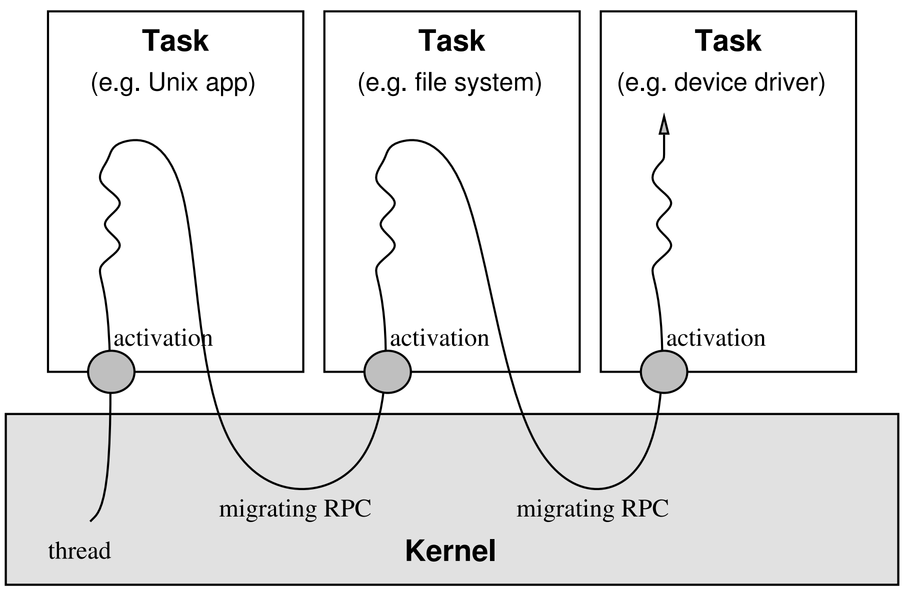
- What is the execution environment of a client thread in a server?
- How can clients and servers be protected from each other?
- How can good controllability be provided?

Key Design Element:
Split Up the Thread

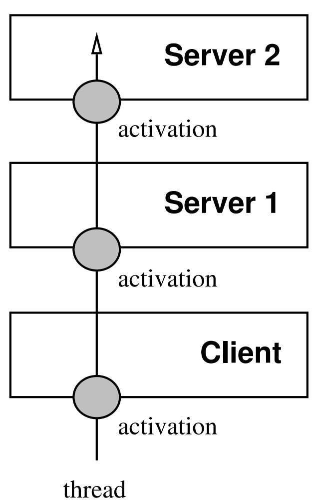
- "Thread" (migrating part)
  - Logical flow of control
  - Schedulable entity
    (priority, policy, time quantum)
  - Resource accounting statistics

- "Activation" (static part)
  - Execution context
    (PC, registers, stack)
  - Exported point of control
    (Mach "control port")

Threads and Activations



Threads and Activations

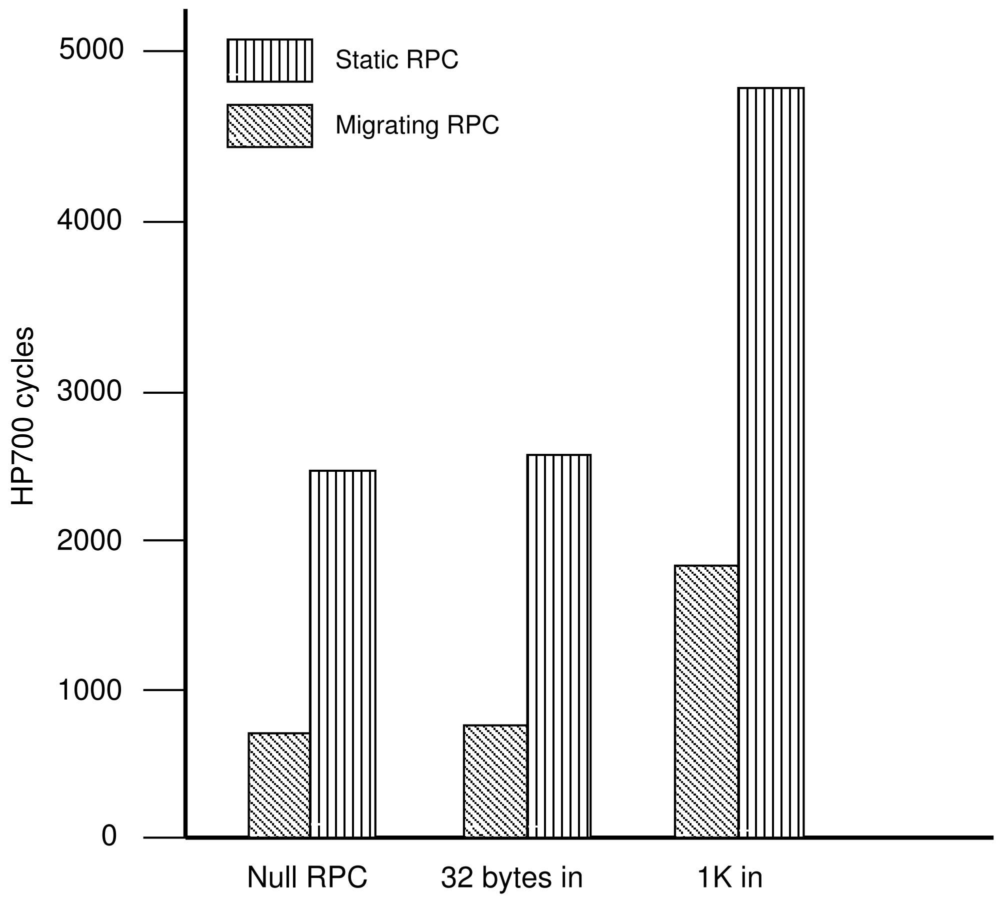


And the winner is...

Migrating threads provide better:

- Performance
- Simplicity of kernel code
- Functionality

Performance Comparison



Why is it faster?

- Upcall semantics on server side
- Kernel-visible RPC (no "reply ports")
- No scheduler involvement

Simpler

RPC paths:
Approx 2000 lines of code
replaced by 400.

Control mechanisms:
Approx 3000 lines of code
replaced by 1700.

Macrobenchmark Results

- “make” of `gas`: 2% faster
- link of HP-UX linker: 14% faster

Note: without additional leverage of migrating RPC yet.

What made the RPC path simpler?

Answer: the same things that made it faster!

- Reversed call semantics on server side:
  146 instructions down to 33

- Kernel-visible RPC:
  206 instructions down to 12

- No scheduler involvement:
  408 instructions down to 30

More Functional

- Inherited thread attributes:
  - Priority (real-time)
  - Resource limits and accounting
- RPC call chain provides client-server communication channel

Related Work

- Amoeba: exports RPC to user
- Alpha: real time, remote migration
- LRPC on Taos
- Spring: confronted Unix issues
- "Passive Object" Systems:
  Emerald, Clouds, Psyche

LRPC Comparison

- LRPC addressed data transfer also
- We attempted to isolate control transfer
- We examined simplicity
- We fully addressed controllability issues (Taos has weak protection semantics)

Issues/Future Work

- Leverage to further optimize Mach RPC
- Use improved functionality to simplify servers
- Leverage for real-time support
- Extend to cross-node RPC
- Show another OS can be evolved

Conclusions

- A migrating thread model is faster, simpler, and more powerful.

- Exported RPC abstraction a prerequsite; synchronous invocation beats async.

- Existing systems can be adapted without sacrificing backward compatibility.

Why We Don't Use Spring's Terminology

- High-level concept of "thread"
  fits the migrating entity better

- Encourages us to think in the new model

- Precedent: Alpha, LRPC

- Momentum