Remote Procedure Calls

Implementing Remote Procedure Calls

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Lightweight Remote Procedure Call

Brian Bershad, Tom Anderson, Ed Lazowska, Hank Levy

Presented by Mark Reitblatt

Implementing Remote Procedure Calls

- ACM System Software Award
- Andrew Birrell
  - Xerox PARC, DEC, MSR (current)
- Bruce Jay Nelson
  - CMU PhD, Xerox PARC, Cisco

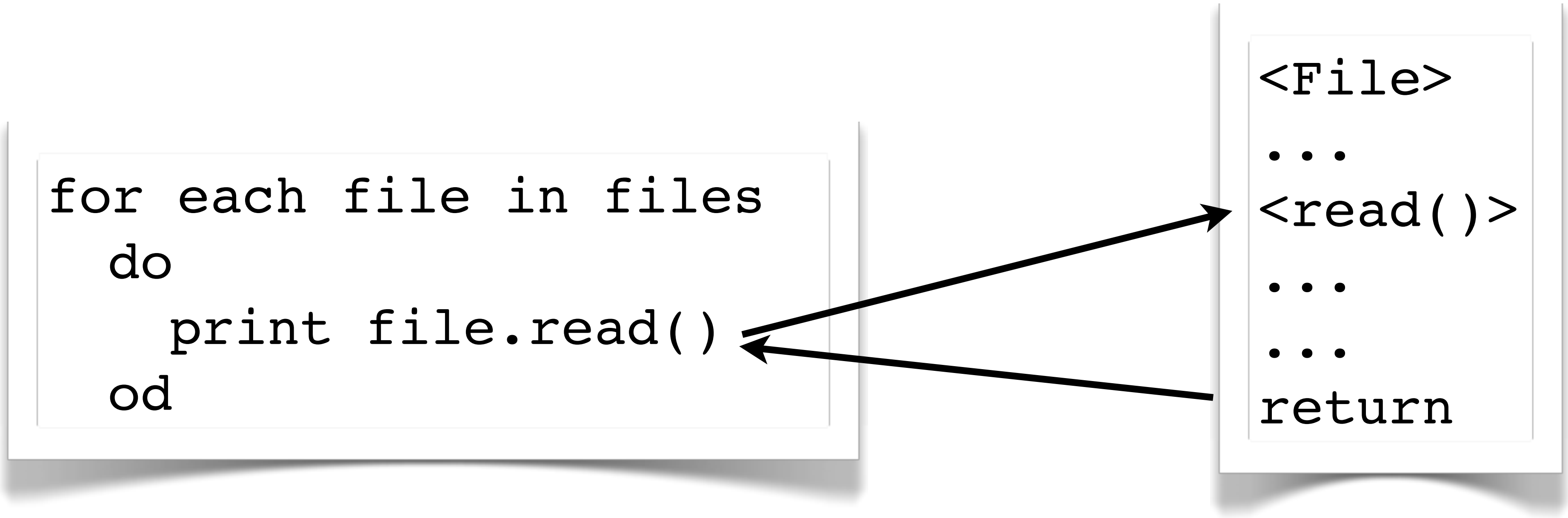
RPC

- How do we program distributed systems?
- What's the fundamental abstraction?
  - Message passing
  - Shared memory
  - Fork-Join

RPC Goals

- Clean, simple programming model
  - Transparent distribution
  - Late binding
    - Decide distribution at runtime
- Efficiency
- Generality

Procedures

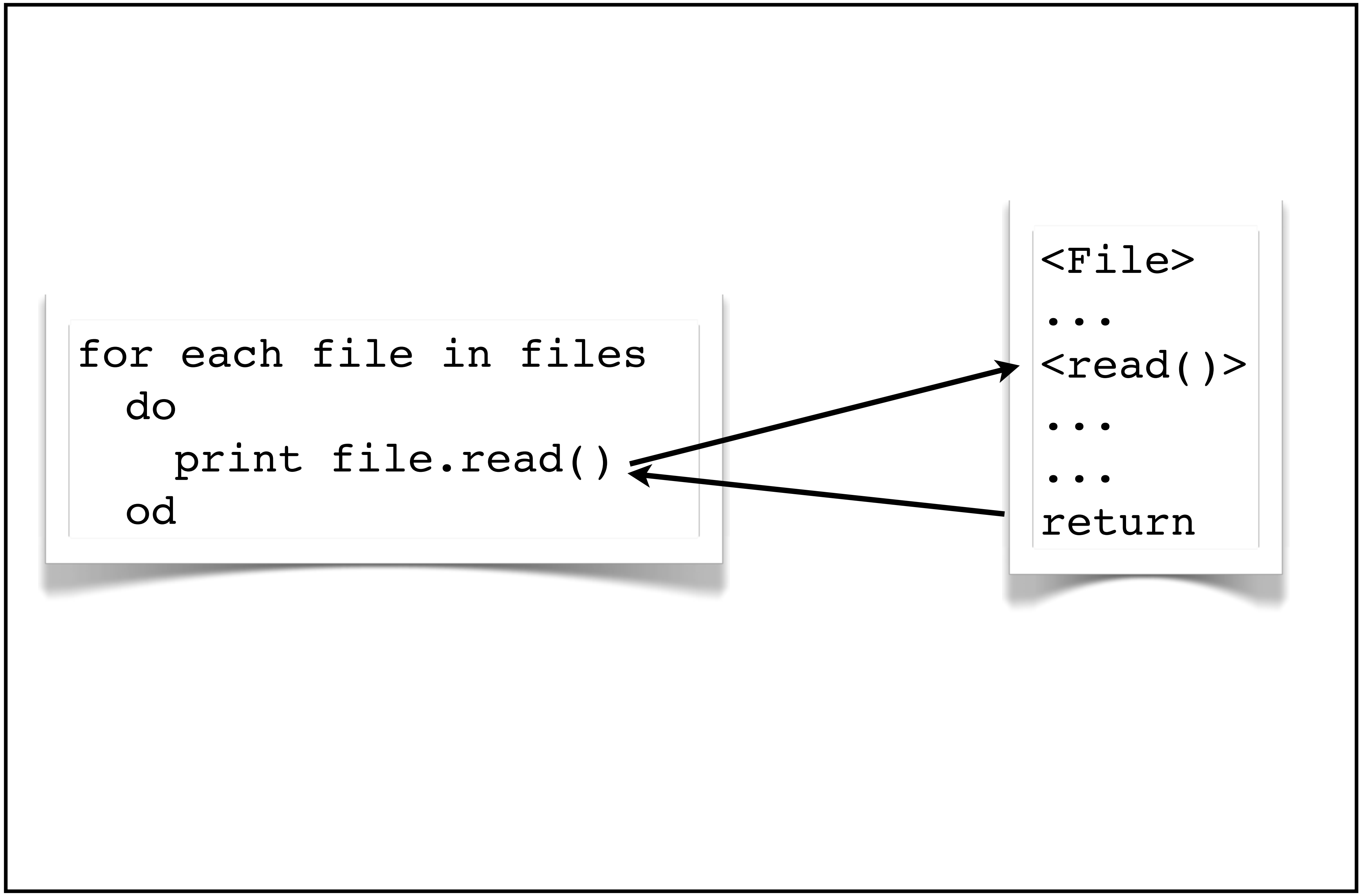


```
for each file in files
  do
    print file.read()
  od
```

```
<File>
...
<read()>
...
...
return
```

- Simple
- Well understood
- Easy-to-use
- Common

Distributed Application



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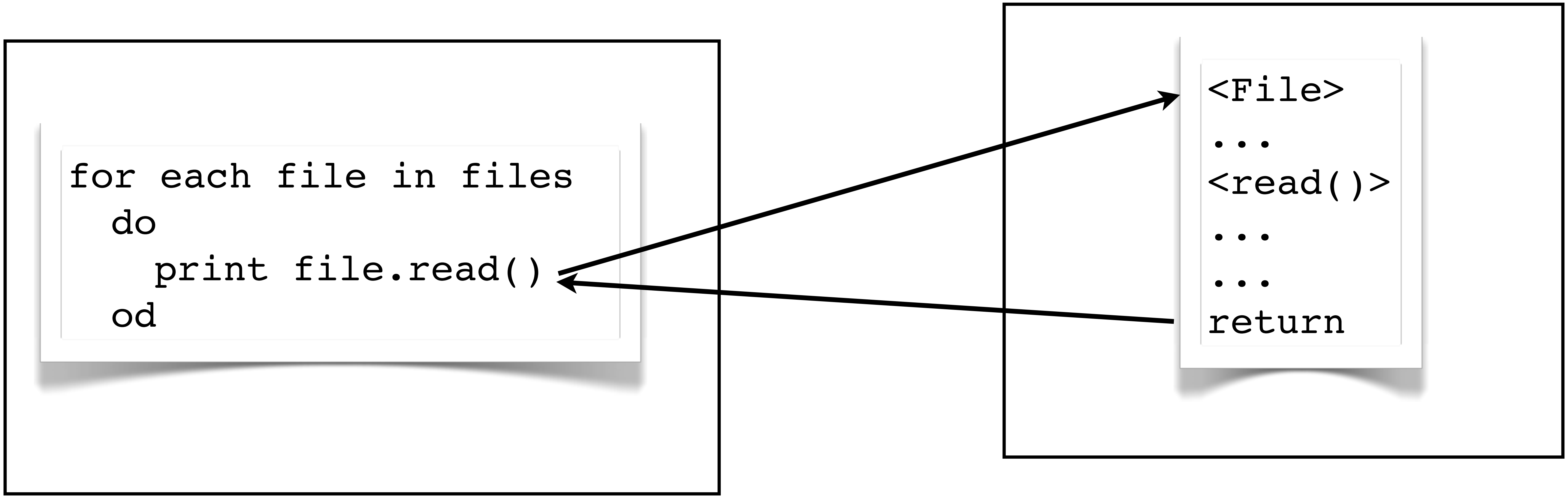
Distributed Application



```
for each file in files
  do
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  od
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```
<File>
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<read()>
...
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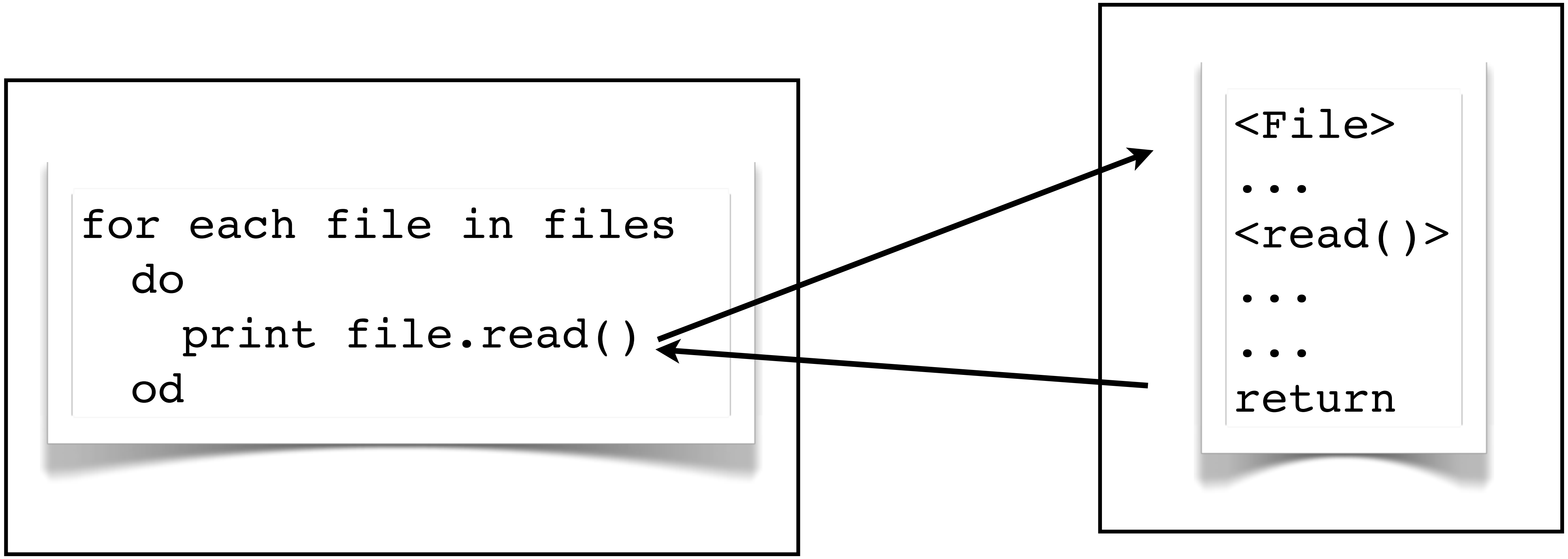
return
```

Just distribute the procedure to another machine

Distributed Application



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  do
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  od
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```
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...
<read()>
...
...
return
```

But there's no cross-machine "`jmp`"

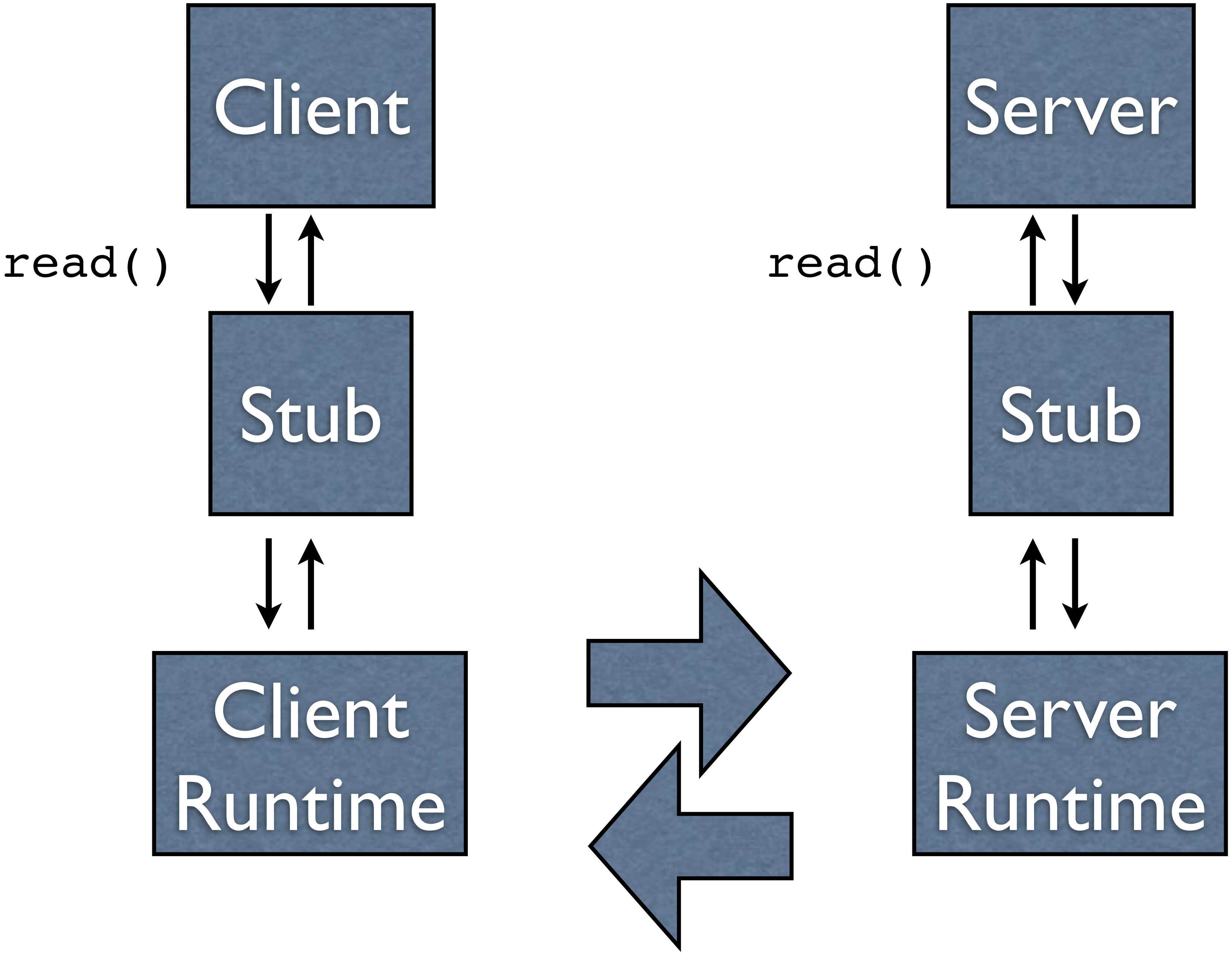
Need to deal with the network now

RPC

- Mechanism exposes stub procedure entry point
- Stub transforms call into packets
- RPC Runtime finds server, sends call
- Reverse process on server

```
for each file in files
  do
    print file.read()
  od
```

```
<File>
...
<read()>
...
...
return
```



Client

read()

Stub

Client Runtime

Server

read()

Stub

Server Runtime

Stubs

- Intercept procedure call
- Serialize arguments
- Automatically generated
  - Advantage of high-level language

Runtime

- Handles transmission to/from server
- Shared across different stubs
- End-to-end principle?

Simple?

- Remote calls aren't local calls
  - Pass-by-reference?
  - Network related exceptions
  - Out-of-memory exception?
  - Call-backs?

Binding

- How to match signatures to instances
  - Signature: FileAccess.Alpine
  - Instance: Ebbets.Alpine
- Where is the instance?
  - Ebbets.Alpine -> 3#22#
- Is this still transparent?

Lightweight Remote Procedure Call

- Brian Bershad
  - UW PhD, CMU Prof, SPIN, returned to UW
- Tom Anderson
  - UW PhD, Berkeley Prof, returned to UW
- Ed Lazowska
  - UW Prof
- Hank Levy
  - UW Prof

LRPC

- Enter µ-kernels:
  - Split into separate address spaces (protection domains)
  - RPC common interface
    - “Remote” across domains on single machine
    - Deals with disjoint address spaces

LRPC (Cont.)

- Cross-domain RPC expensive
  - Forces functionality into single domains for performance
  - Defeats purpose of μ-kernel

Make the common case fast

- Cross-domain RPC
  - 100-30x more common
  - Tends to be simple
    - Few, small parameters

Why is the common case slow

- Stub overhead
- Message buffer overhead
  - Double buffer
- Message transfer
- Context switch

LRPC Solution

- Essentially a bunch of hacks that "work"
  - Remap argument stack into server domain
  - Client provides thread for execution
  - Domain caching
  - Single arg copying into A stack

Performance

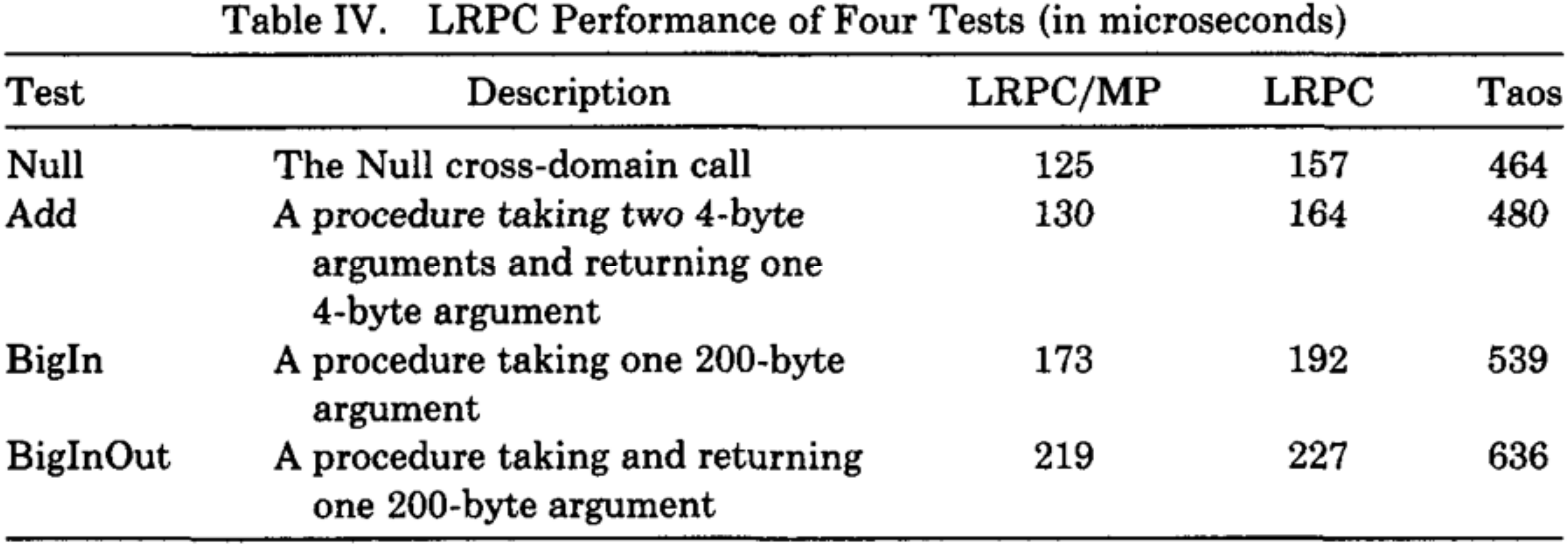


Table IV. LRPC Performance of Four Tests (in microseconds)

Test	Description	LRPC/MP	LRPC	Taos
Null	The Null cross-domain call	125	157	464
Add	A procedure taking two 4-byte arguments and returning one 4-byte argument	130	164	480
BigIn	A procedure taking one 200-byte argument	173	192	539
BigInOut	A procedure taking and returning one 200-byte argument	219	227	636

Performance Cont.

Fig. 2. Call throughput on a multiprocessor.