OSF Research Institute

Concurrent Remote Task Creation

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The First USENIX OSDI Symposium
Monterey, California
14-17 November 1994

Problem statement

- remote task address space creation is slow in Mach, it is common denominator for the support of:
  - new address space creation (*rexec* and *rspawn*)
  - parallel applications (*rspawn-multi*, *rfork-multi*)
  - process migration
- multiple task creation has increased performance, fault-tolerance and scalability requirements

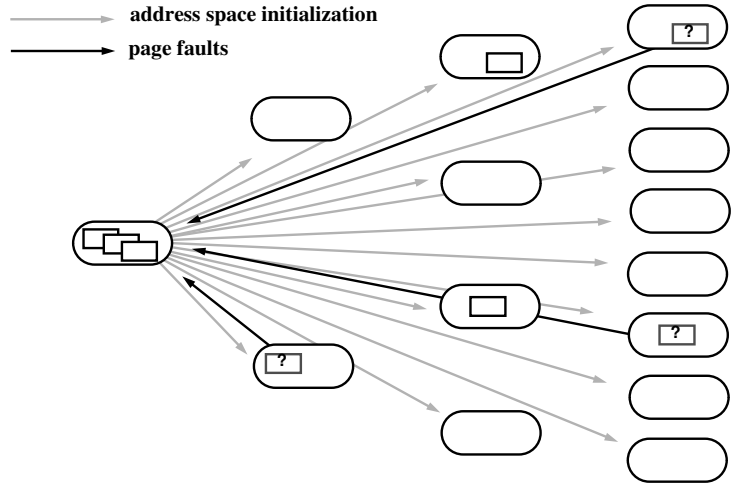
Sources of Problem

- network IPC, addressed by new DIPC
- distributed VM, will be partially addressed by new EMMI
- algorithm for remote task creation is unoptimized
- nonexistent support for multiple remote task creation

Do we really need optimized CRTC?

- creation/termination phase
- paging from all nodes (large address spaces)
- performing I/O initialization at one site

Internode Traffic for Centralized CRTC



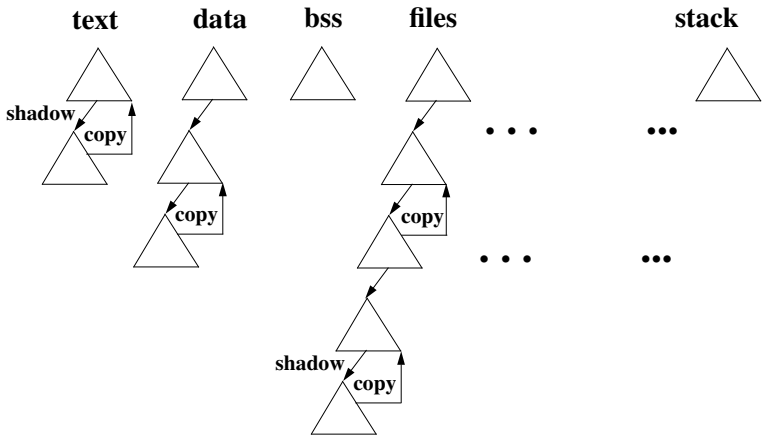
Presentation Outline

- overview of Mach VM (local and distributed)
- handling (avoiding) COW over network
- improvements to single remote task creation
- hierarchical remote task creation
- implementation, status, performance
- future work
- related work
- conclusion

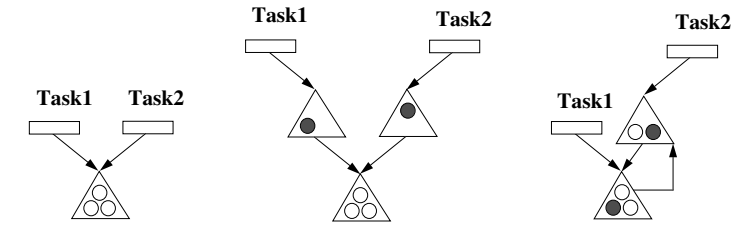
Mach VM

- built around VM object which is kernel cache for pages
- external memory manager
- VM copy optimizations, “Copy-On-Write” (COW)
- expanded to distributed, “Copy-On-Reference” (COR)

Address Space of a Mach Task

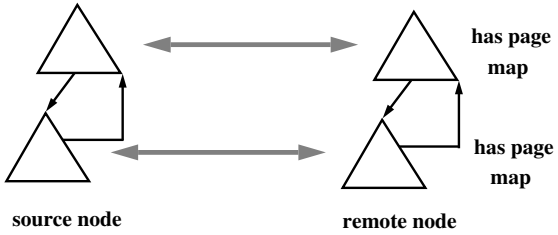


COW Optimization



(a) Read-only sharing (b) Symmetrical COW (c) Asymmetrical COW

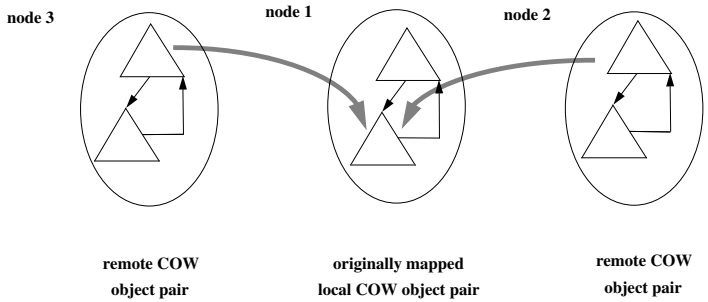
COR Optimization



Handling COW in CRTC

- prevent the case of pushing a page into a copy object over network
- prevent creation of new copy objects over network
- introduction of COR objects:
  - they are read-only, no need for coherence
  - do not page-out, pages brought from nodes higher in the tree hierarchy

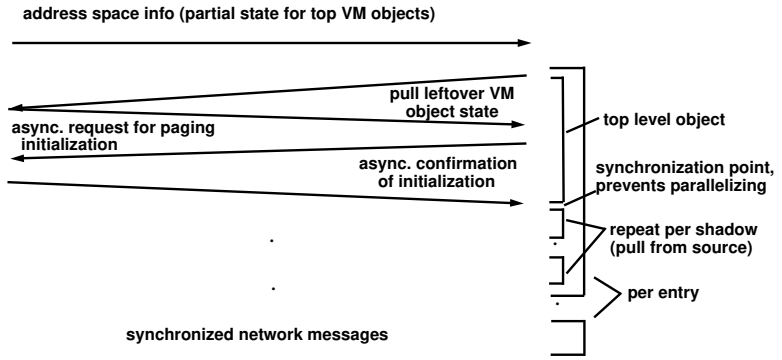
Avoiding Distributed COW



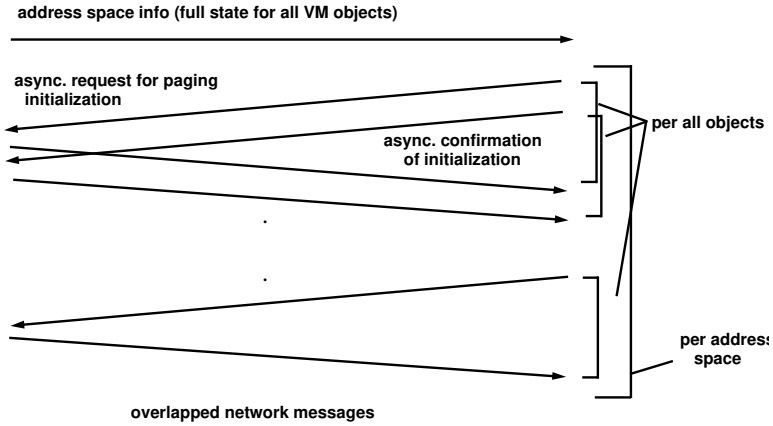
Improving Single Rem. Task Creation

- any delay is multiplied in concurrent case
- improvements consists of:
    - sending more state per each object eagerly
    - sending the whole shadow chain eagerly
    - eliminating all synchronization points
- hard to batch object initialization, so overlap them

Unoptimized Address Space Transfer



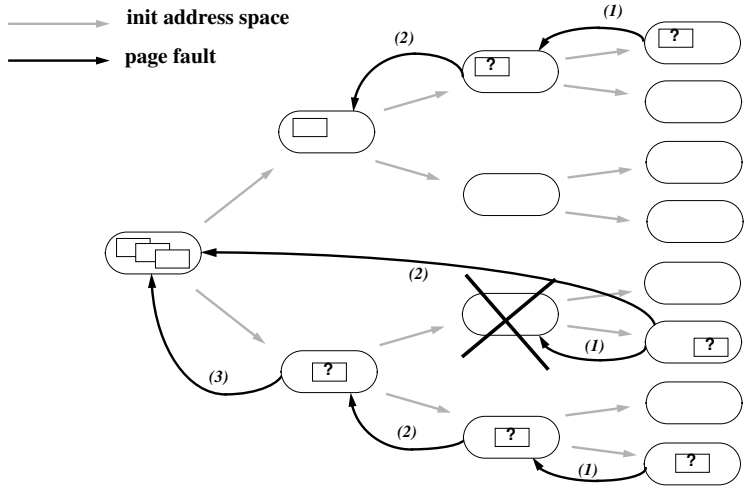
Optimized Address Space Transfer



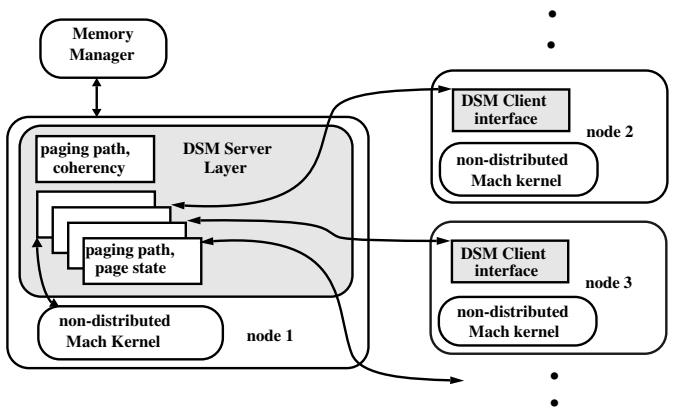
Hierarchical Remote Task Creation

- performance
- scalability
- hooks for fault-tolerance

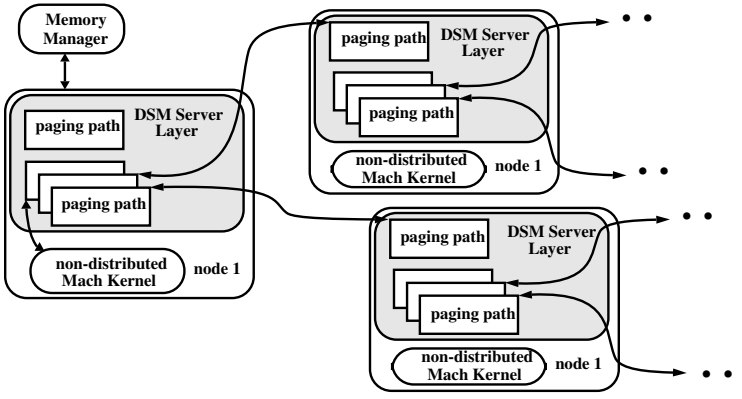
Hierarchical XMM



Centralized VM



Hierarchical VM



Implementation

- developed on a cluster of PCs connected through ethernet
- measurements performed on a 64-node Intel Paragon computer
- software base is OSF/1 AD 1.0 and Mach nmk17.2
- result of one-man effort during this year (11 months)

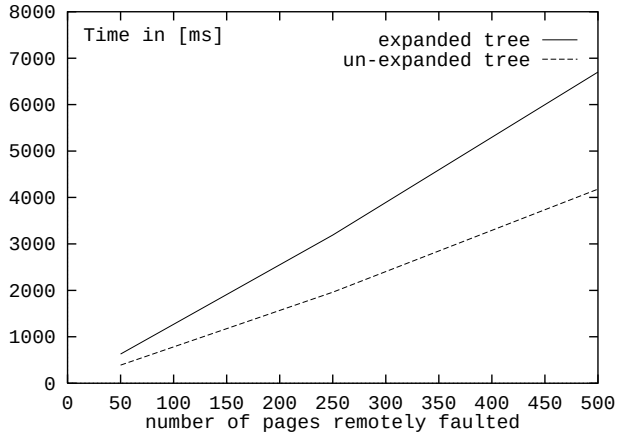
Status

- reliable creation of remote tasks and tree hierarchies;
- testing of hierarchical paging performed on PCs, in progress on Paragon
- profiling of distributed and local VM activity (COW/COR)
- work in progress on merging COW and COR objects

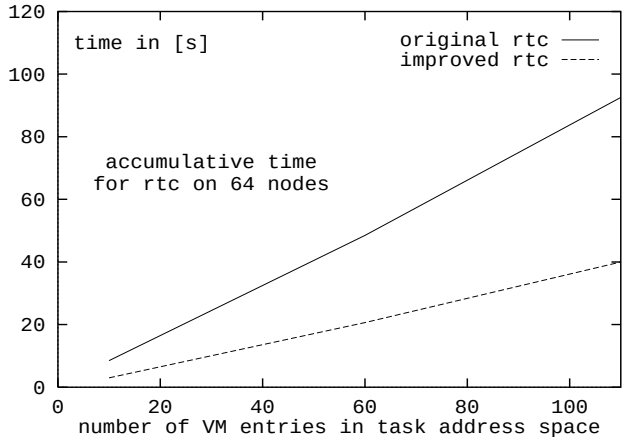
Performance, single RTC case

- 30% performance improvement for eager copy of XMM objects
- 14% performance improvement for eager copy of one additional shadow in the chain
- the rest is due to the overlap of object initialization
- pushing of 64 copy objects on 64 nodes as a consequence of touching a page on the root node takes **1 sec**!

Distributed COW



RTC v. Number of VM Entries



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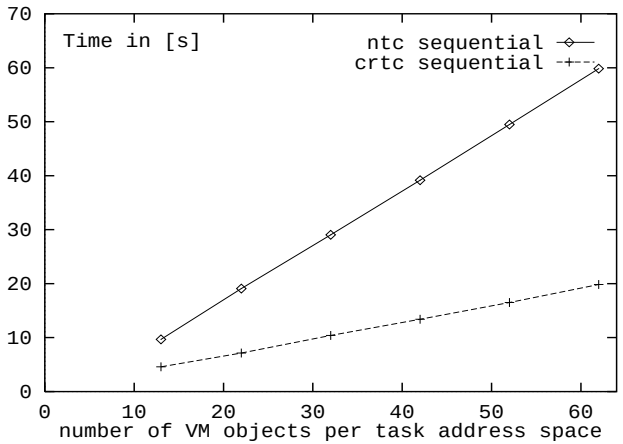
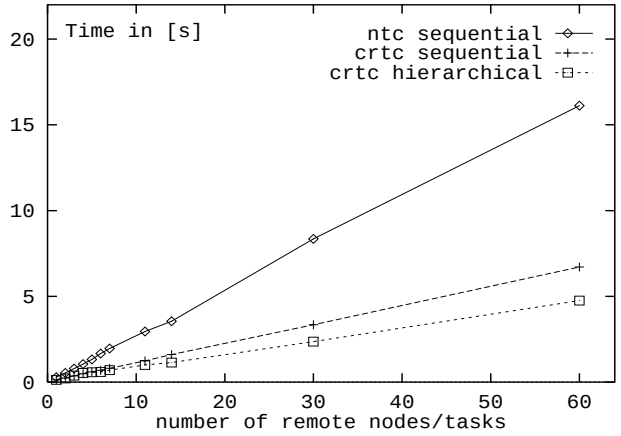


Hierarchical Creation



Future Work

- experiments with wider trees, currently size is 2 which leads to tree depth of *e.g.* 5 for 64 nodes, 9 for 1024;
- repeat experiments with new DIPC
- generalize work on relationship between COW and COR
- heuristic optimizations on shadow chain transfer:
  - lazy evaluate shadow chains
  - perform local COW obligations eagerly
- make experiments with real-world applications

Related Work

- Zayas, COR for process migration on Accent
- Barrera's original work
- Douglis, process migration on Sprite
- distributed shared memory (Kai Li, etc.)

Conclusions

- performance is improved over the earlier versions
- scalability is improved
- there are hooks for introducing fault-tolerance
- underlying network IPC mechanism plays crucial role in performance

Availability

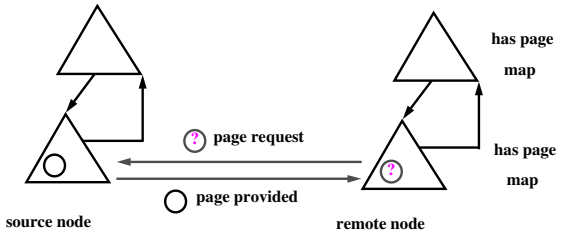
- this work will hopefully propagate to standard OSF Mach tree, and potentially become freely available
- presentation can be accessed through anonymous ftp at:

  riftp.osf.org: pub/task_migration/osdi.pres.ps

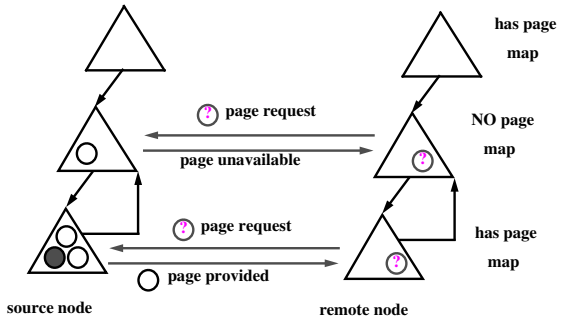
- the work is also described in a related paper submitted to another event; it is available on per request basis
- for more info, please contact us at:

  [dejan,dlb,sjs]@osf.org

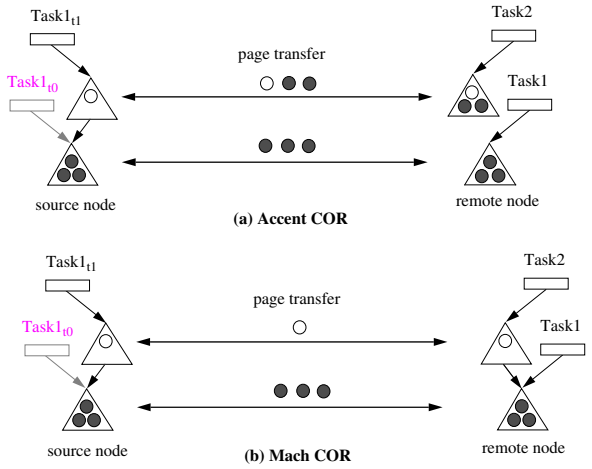
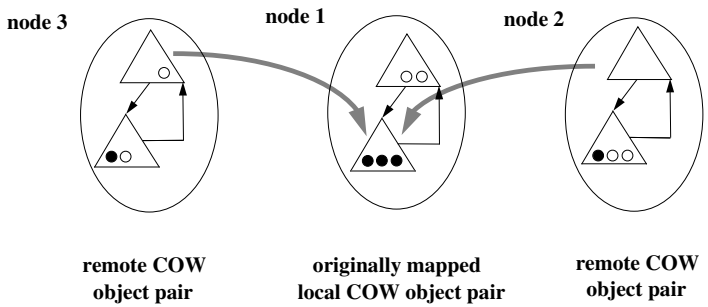
COR Optimization



COW Intrusion in Distributed Case



Accent v. Mach COR



Avoiding Distributed COW