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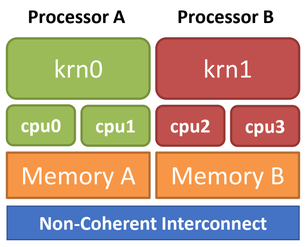
A Page Coherency Protocol for Popcorn Replicated-kernel Operating System

Marina Sadini, Antonio Barbalace, Binoy Ravindran, Francesco Quaglia*
Department of Electrical and Computer Engineering, Virginia Tech, Virginia, USA
{sadini, antoniob, binoy@vt.edu}
*Francesco Quaglia is with DIAG, Sapienza, University of Rome, Italy {quaglia@dis.uniroma1.it}

Future computing platforms are increasingly ISA-diverse and parallel

Scenario

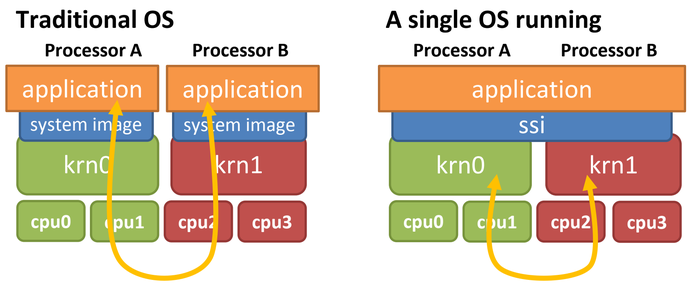
- Different interconnected processors (or machines)
- Each has its own (private) memory



Goals

- Illusion of a single OS running (like in SMP setups)
- Applications do not need to be rewritten/recompiled

- Explicit communication in the application (e.g. MPI)



- Kernels communicate instead of the application (i.e. DVSM)

Popcorn Linux

- A replicated-kernel OS
  - Similar in concept to a multikernel (i.e. Barrelfish) but ..
  - Based on Linux 3.2.14
- Open-source and freely available
- Can be used to simulate a Het. setup on Homogeneous hardware

Inter-Kernel Communication

- Communication take place by messages
- The messaging is built on top of a combination of shared memory buffering and IPI notification
- Mixture of interrupts and polling
- The multicast/broadcast is not scalable (no x2APIC)

Inter-Kernel Thread Migration

- When a thread migrates from kernel A to kernel B
- **If** other threads of that process reside on kernel B
  - **remote thread cloning**
- **Else if** it is the only thread of that process on kernel B
  - **remote thread creation**

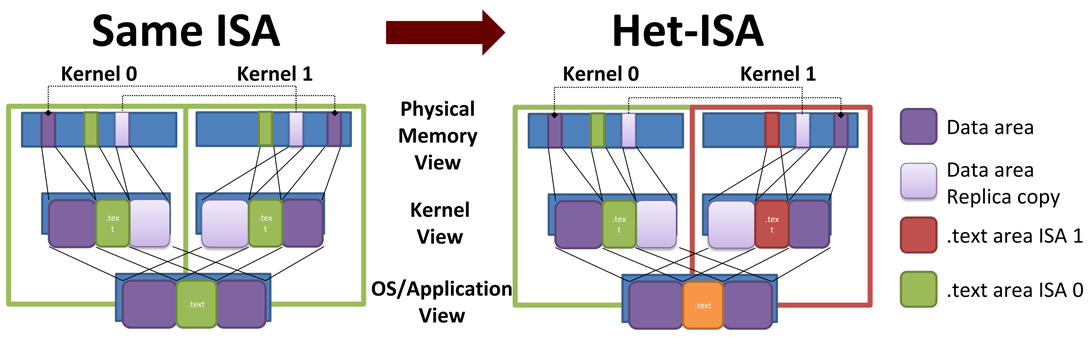
Inter-kernel Thread Migration, benefits:

+ Single System Image

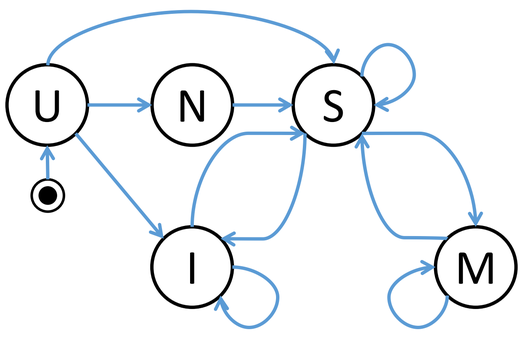
Load balancing, power saving, memory/device locality, performance, expanded memory space, greater device count, etc.

Address Space Page Replication and Coherency to deploy thread migration

- Replicated page table per kernel (same application)
- Replicated page content on each kernel
- Page level protocol to guarantee a coherent memory view to the app.



New Page Coherency Protocol



- We started from the MSI coherency protocol extending it with *Unmapped* and *NotReplicated* states
- Linux pages are not present at initialization (*Unmapped*)
- On-demand pages become present and access any of the other states (N, M, S, I)

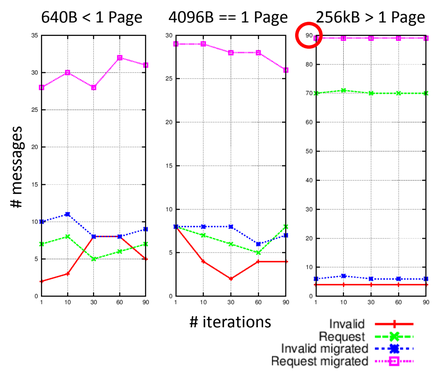
Why a new protocol?

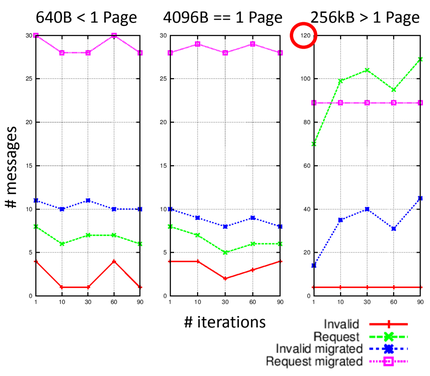
- A distributed algorithm with voting (i.e. no centralized approach)
- Less constraints on the hardware (e.g. no global clock)
- Designed for heterogeneous platforms

Protocol's Initial Evaluation

R,R Workload

- Increasing the number of iterations does not change the number of page requests
- All pages are locally copied during the first iteration
- No more requests are generated in the successive iterations



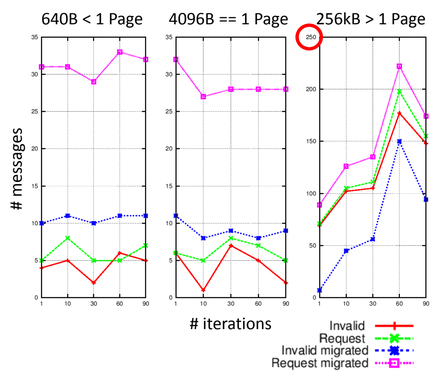


R,W Workload

- The number of messages required to update the reader increased
- All the other messages are kept around the same value
- The communication overhead only slightly increases (<20% total)

W,W Workload

- Increasing the number of iterations does change the number of messages
- Both replicas are concurrently updating the array invalidating the content of the pages
- Requests are generated during each iteration



Conclusions

We designed, implemented and tested a new page coherency protocol in Popcorn Linux.

The design properties are satisfied and the implementation is effective. The voting scheme is a promising solution.

New software components have been added to Popcorn sources (and Linux) to support thread migration (i.e. SIGFORK).

www.popcornlinux.org

ACKNOWLEDGMENTS
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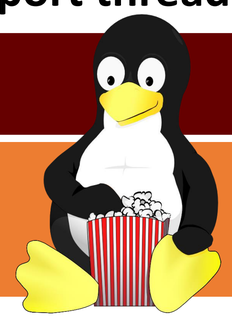

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