L4 Microkernel

See final slide for sources

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L4 Advantages

- Recursive construction of memory spaces
  - Allows construction of memory managers in userspace that just use memory mapping
  - Kernel provides map, grant, and flush
- Blazing fast IPC
  - Passes short messages in registers
  - Avoids copying large messages and thus avoids TLB flushes and cache misses
  - Lazy scheduling of thread queues improves small message IPC around 25%

L4 Performance

OS	Microseconds	Instructions
Mach	115	1150
L4	5	50
Exokernel	1.4	30
SPIN	102	1100

(Exokernel runs on MIPS R2000, which operates more efficiently than the x86 for L4, and has a tagged TLB. It also does not provide a portable API.)

L4 Conceptual Contributions

- The author of the L4 paper, Jochen Liedtke, showed that microkernels do not inherently:
  - Exhibit slow IPC
  - Impose significant processor overhead
- Instead, he showed that particular implementations are to blame:
  - Mach was causing lots of cache misses because it's fat, making it look like microkernels have high overhead

Microkernel Non-portability

- Liedtke argues that microkernels should be non-portable, but present a uniform API:
  - Abstract microkernels require additional hardware abstraction layer
  - Can't take advantage of specific performance-enhancing hardware features
  - Can't protect against peculiar hardware performance pitfalls

L4 Subprojects

http://www.dakotacountyswcd.org/treetype.htm

- L3 – Predecessor to L4
- FIASCO – C++ implementation of L4, poor performer in comparison to “Pip” series
- L4Ka – Most active L4 project, maintains Lemon and Lime Pip series, plus Hazelnut
  - Pips: assembly language (a pip is a small citrus seed)
  - Hazelnut/Pistachio: C++/assembly (bigger than pips)
    - Only 10% slower, but doesn't support tagged TLB

L4Ka Specifics

- Used in “client” systems:
  - SawMill: multi-server operating systems
  - Mungi: single address space OS
- Supports multi-processor realtime system
- Automatically saves “hibernation” information as system is running
  - Crashes are recovered by simply rebooting
- Minimal support for security

L4Ka Target Platforms

- Desktops
- Pervasive computers
- “Deep” computers
  - Clusters, supercomputers
- New 64-bit machines
  - IA-64, Power4
  - X86-64 not really new

References

- Microkernel overviews:http://www.cs.cornell.edu/Info/People/ulfar/ukernel/ukernel.html#current-l4
- L4 microkernel family:http://os.inf.tu-dresden.de/L4/
- On microkernel construction: http://borneo.gmd.de/~liedtke/L4/sosp95.ps