Related approaches

Other recent kernelised systems:

- Spring
- SPIN
- Exokernel
- Vino

Spring

- Developed around 1992/3 at Sun Microsystems [Hamilton, Nelson et al.]
- "Object-oriented" OS
- "microkernel" (providing tasks and threads) and "VM manager"
- other components run as user-level servers which can be replaced dynamically (late binding)
- IPC is based on "doors" (segregated capabilities)
  - door designates an entrypoint into an address space together with an (integer) reference to a particular object to use
  - invokation of a door passes a door for controlled return

  Some of this seems to find its way into Solaris

SPIN

- Developed mid '90s at University of Washington, Seattle [Bershad et al.]
- implemented in Modula-3
- "extensible kernel": components can be added by loading them into the kernel at run-time (called *grafting*)
- secure through use of *type-safe language* and *sandboxing*
- replaces overhead of kernel calls by (hopefully small) overhead of software range checks
- supports OSF/1 API

Exokernel

- Developed mid '90s at MIT [Kaashoek et al.]
- idea is to multiplex hardware and leave control to higher levels
- basic mechanism is *protected control transfer* (PCT): similar to hardware interrupt, parameterless cross-address-space call
- PCT is faster than L4 IPC (but not a lot)
- run OS at application level, sharing address-space with apps
- lets application level decide on speed-security tradeoff
- not shown better performance than L4 (yet)

Vino

- Developed mid-late '90s at Harward [Seltzer et al.]
- grafting
- uses transaction mechanism to recover from misbehaved extensions
- typical overheads are order of $100\mu s$

[1] Graham Hamilton and Panos Kougiouris. The Spring nucleus: A microkernel for objects. Technical Report 93-14, Sun Microsystems Labs, April 1993.

[2] Brian N. Bershad, Stefan Savage, Przemysław Pardyak, Emin Gün Sirer, Marc E. Fiuczynski, David Becker, Craig Chambers, and Susan Eggers. Extensibility, safety and performance in the SPIN operating system. In *Proc. 15th ACM Symp. OS Princip.*, pages 267–284, Copper Mountain, CO, USA, December 1995. ACM.

[3] Dawson R. Engler, M. Frans Kaashoek, and James O'Toole, Jr. Exokernel: An operating system architecture for application-level resource management. In *Proc. 15th ACM Symp. OS Princip.*, pages 251–266, Copper Mountain Resort, Co, USA, December 1995. ACM.

[4] M.I. Seltzer, Y. Endo, C. Small, and K.A. Smith. Dealing with disaster: Surviving misbehaved kernel extensions. In *Proc. 2nd Symp. Operating Syst. Design and Implementation*, pages 213–228, November 1996.