Catamount Software Architecture with Dual Core Extensions

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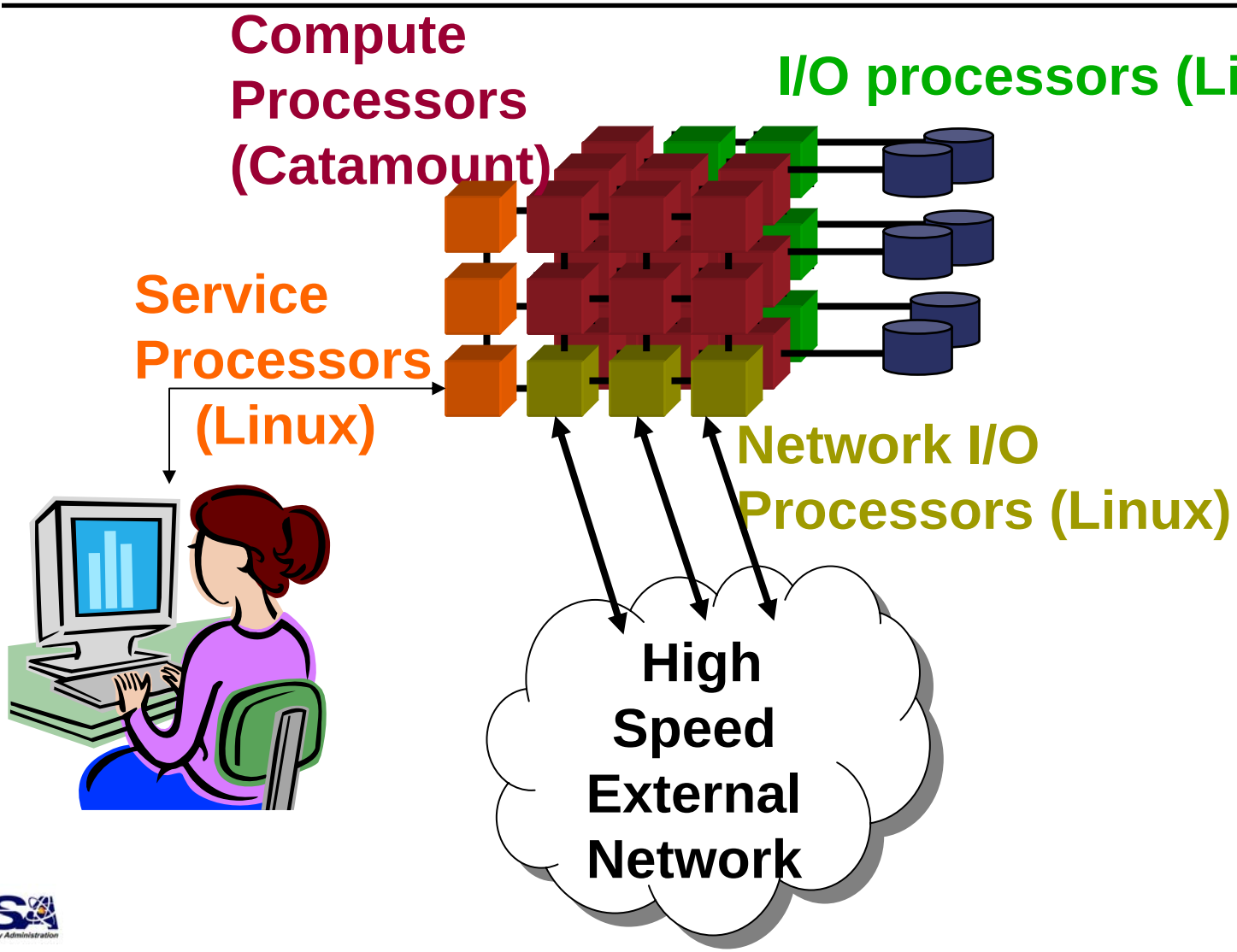
Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the United States Department of Energy's National Nuclear Security Administration under contract DE-AC04-94AL85000.

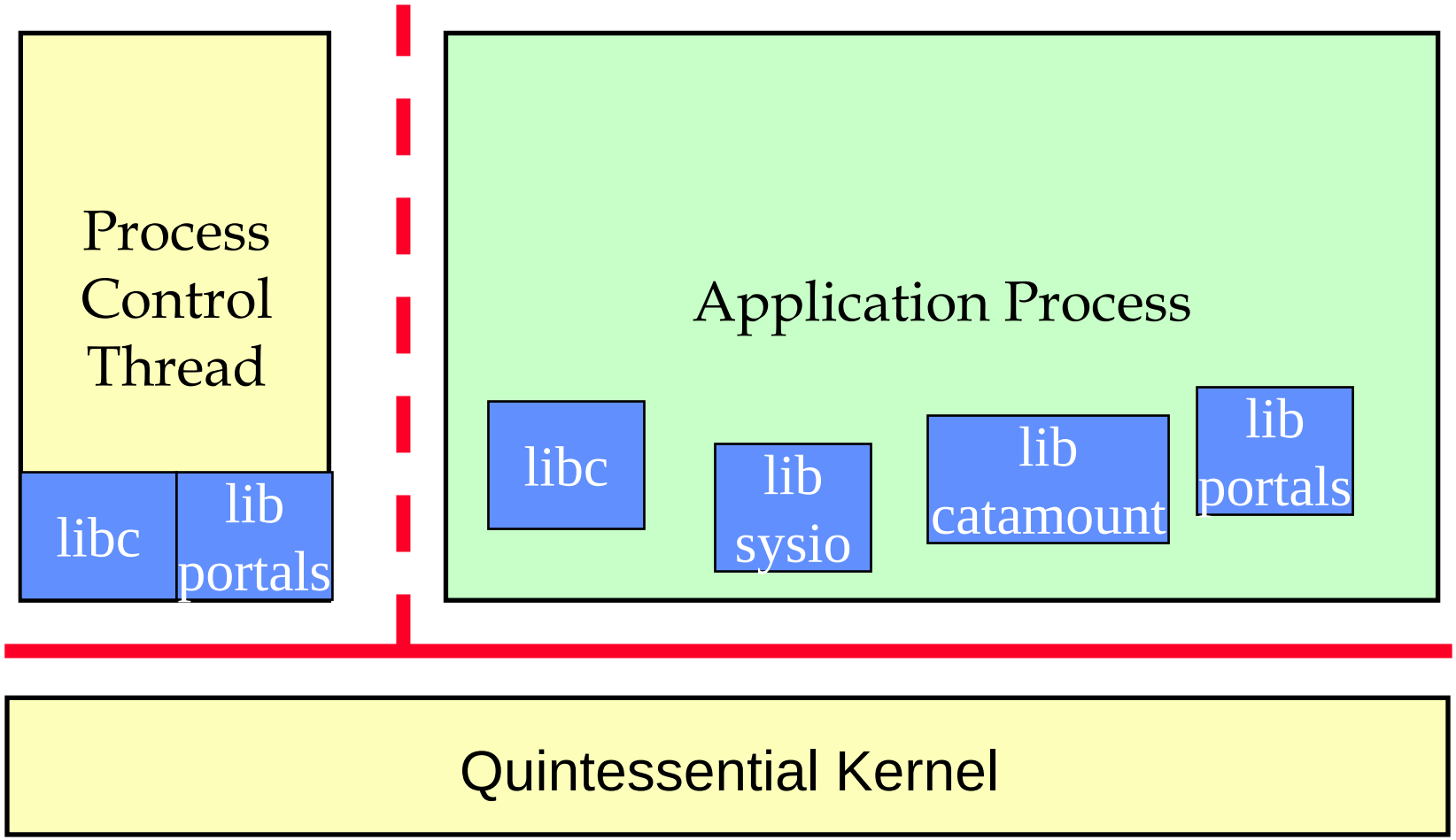
SUNMOS, PUMA, Cougar, Catamount Design Goals

- Targeted at massively parallel environments comprised of thousands of processors with distributed memory and a tightly coupled network.
- Provide *necessary* support for scalable, performance-oriented scientific applications
- Offer a suitable development environment for parallel applications and libraries.
- Emphasize efficiency over functionality.
- Maximize the amount of resources (e.g. CPU, memory, and network bandwidth) allocated to the application.
- Seek to minimize time to completion for the application.

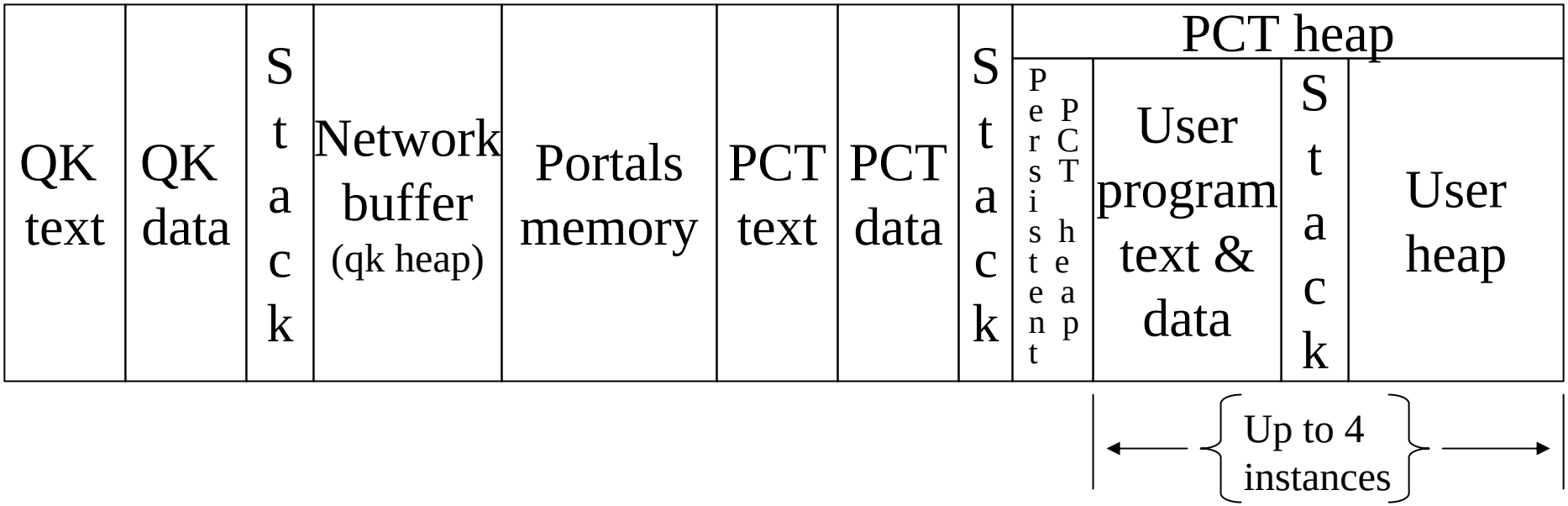
Catamount is designed for an MPP environment with functional partitions



Catamount General Structure



Catamount Physical Memory layout



Note: not to scale

Quintessential Kernel (QK)

- Policy enforcer
- Initializes hardware
- Handles interrupts and exceptions
- Maintains hardware virtual addressing
- No virtual memory support
- Static size
- Non-blocking
- Few, well-defined entry points

Process Control Thread (PCT)

- Runs in user space
- More privileged than user applications
- Policy maker
  - Process loading (with yod)
  - Process scheduling
  - Virtual address space management
  - Fault handling
  - Signals

YOD runs in the service partition

- **Functions**
  - **Controls the logarithmic launch of a parallel job**
  - **Proxies standard I/O, plus other I/O, if necessary**
  - **Manages the parallel job throughout its run**
- **Yod is an evolution of the xnc (eXecute Network Computer) program used to launch jobs on the nCube: (x+1)(n+1)(c+1) = yod**
- **yod [-Account project task] [-D option] [-help] [{ -size | -sz | -np }{ n | all }] [-stack size] [-tlimit secs] [-list processor-list] [-strace] [-target { catamount | linux }] [-share] [-heap size] [-Priority priority] [-Version] progname [progargs] | -F loadfile**

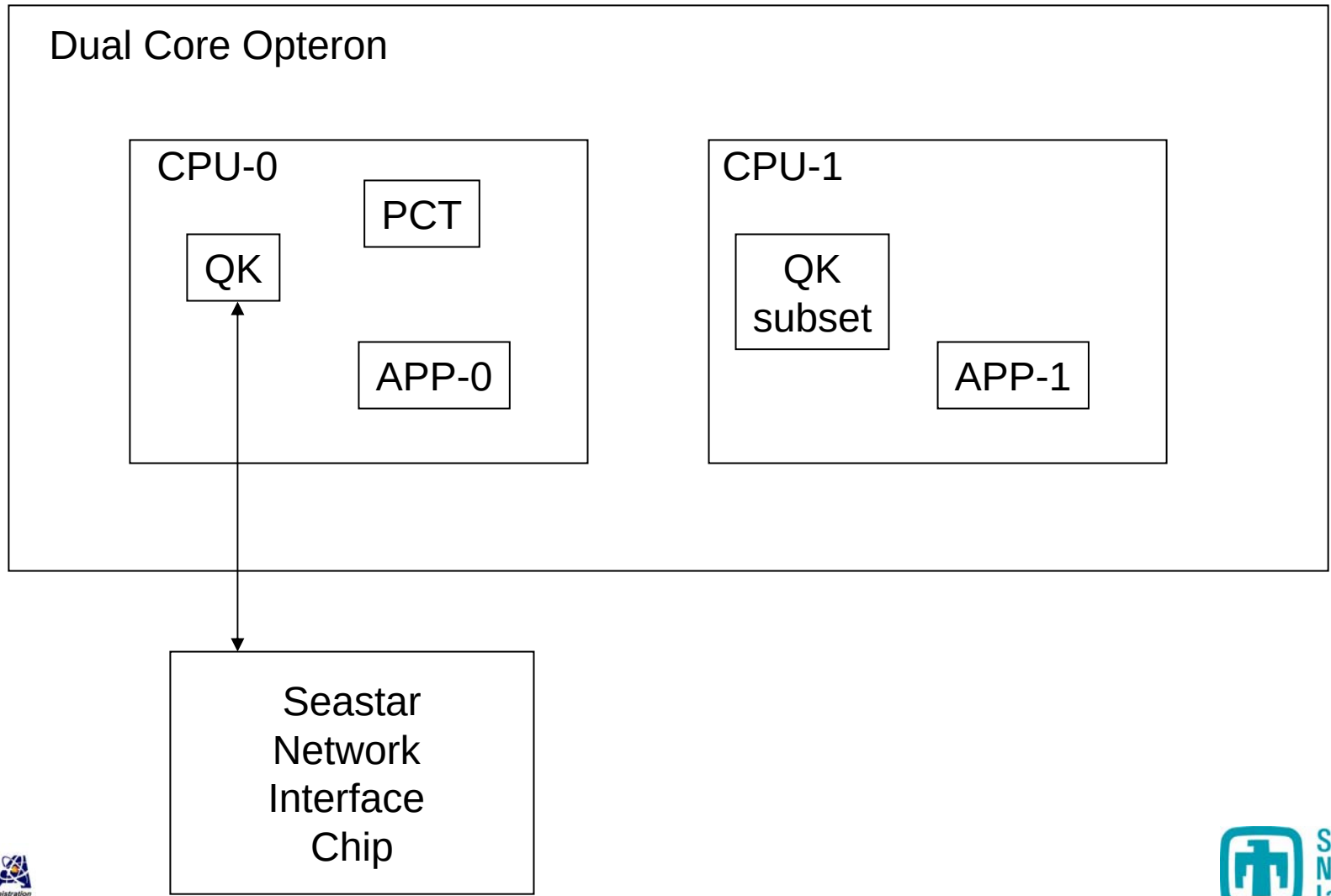
Dual Core Support for Catamount

- Motivation for Virtual Node (VN) on Catamount
  - Virtual Node Mode was a very successful late additional to Cougar on ASCI Red
  - Doubles the number of available nodes
  - Significantly increases compute power for many applications
- AMD has a dual-core Opteron that simply plugs into an XT3 node

Catamount Dual Core Design

- Follow Cougar and ASCI Red
- Application perspective
  - Twice as many nodes
  - Half the memory
- System perspective
  - One copy of QK
  - One PCT
  - Network access done by CPU-0 QK only
  - Network requests from CPU-1 are proxied to CPU-0
- Network perspective
  - One Node Identifier
  - Two process Indices

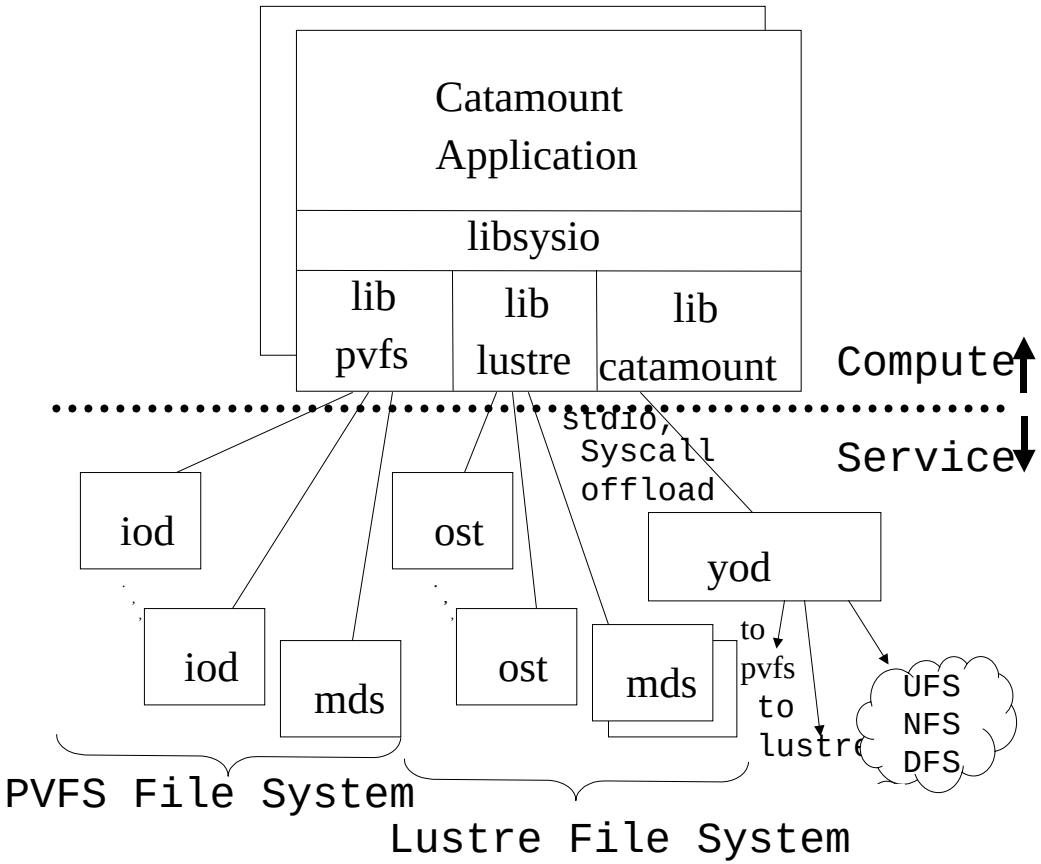
Dual Core CPU Responsibility Assignments



Catamount's libc is pruned version of glibc

- No threads support
- No off-node communication other than via Portals, such as pipes, sockets, rpc's or Internet Protocols
- No dynamic process creation; for example: no exec(), fork(), popen(), or system()
- No dynamic loading of executable code
- Limited signals support
- No /proc or ptrace
- No mmap. A skeleton function is supplied, but returns –1.
- No profil()
- Limited ioctl
- No getpwd family of calls
- No functions requirement any form of db (e.g. ndb). For example, there is no support for the uid, gid family of queries that based on the ndb.
- No terminal control
- No functions that require UNIX-style daemons
- Custom catamount malloc is used by default

Libsysio routes I/O calls to the appropriate file system handler



Libcatamount

- RPC mechanism to communicate with yod for stdio and system call offload
- Custom malloc tuned for large allocations
- Pre-main initialization
- Interface routines for PCT and QK services

Libportals

- Message passing API
- Separate software package
- Required by Catamount
- http://www.sourceforge.net/packages/sandiaportals

Multi-Partition Job Support is new with Catamount

- Support for parallel applications that span Catamount and Linux
  - Yod using load file option (-F)
  - Requires a PCT to run on Linux
  - Requires different executables
  - Creates one MPI_COMM_WORLD

Future Plans

- Studying whether catamount is viable for four-core support
- Utilize a portals protocol offload engine in the Network Interface Chip (NIC)