Administration

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Hydra: The Kernel of a Multiprocessor Operating System

Wulf, Cohen, Corwin, Jones,
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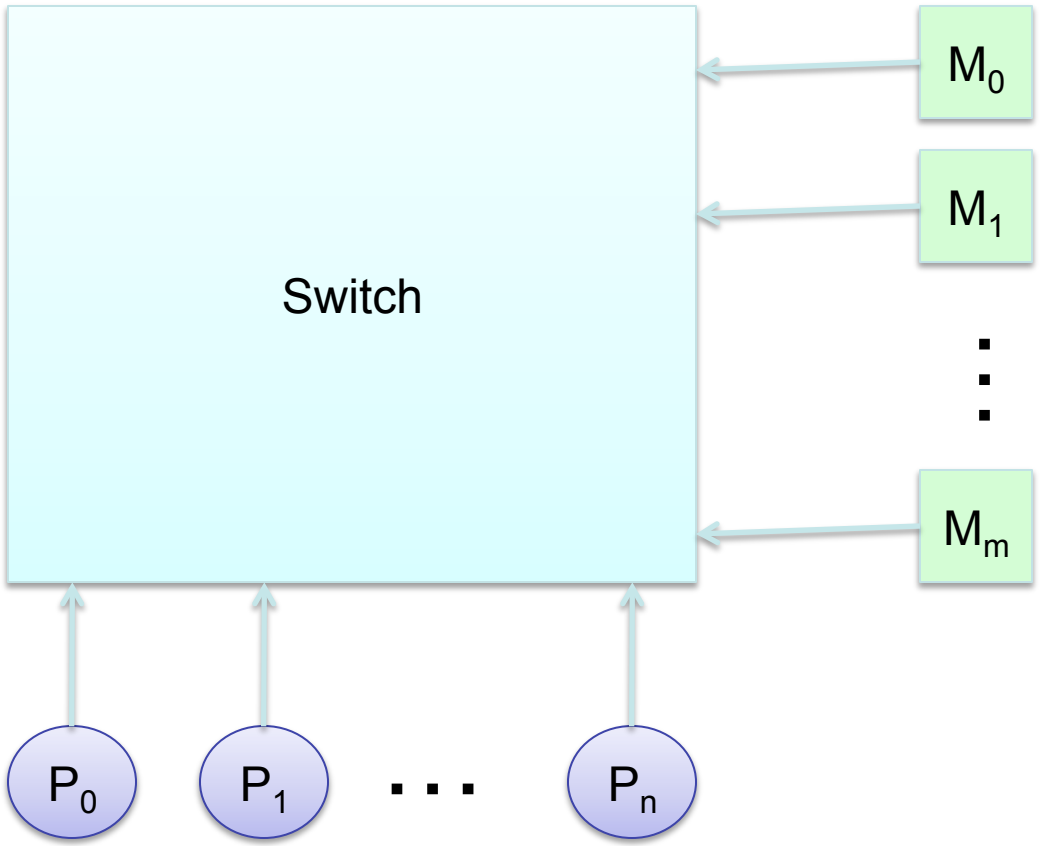
CMU

Presentation by: norm

Timeline

- In 1971 CMU decided to build a “multi-mini-processor”
  - This became C.mmp
- At the same time, work on the kernel of the OS began
  - HYDRA
- They also worked on language design, debugger design, IDEs, …

The hardware



C.mmp

- 16 processors
- 32 MB shared memory
- Each processor is a PDP-11
- Each processor has a memory controller to manage access to memory

Design philosophy

- A collection of facilities of universal applicability and absolute reliability
- … from which an arbitrary set of operating systems can be conveniently, flexibly, efficiently, and reliably constructed
- … the resulting operating systems able to co-exist simultaneously.

Considerations

- Multiprocessor environment
- Separation of mechanism and policy
- Integration of the design with the implementation methodology
- Rejection of strict hierarchy
- Protection
- Reliability

What is an Operating System?

- It defines an abstract (virtual) machine that is more convenient than the bare hardware
- It allocates hardware resources

The architecture

- Objects
- Types
- Procedures
- Local name space (LNS)
- Process
- Capability

Object

- Unique name
- Type part
- Representation
  - Capability part
  - Data part

Type

- An object whose type part is a distinguished object named TYPE
- TYPE itself is a type, by virtue of naming itself in its own type part

Procedure

- An object
- Data part
  - executable instructions
- Capability part
  - Caller independent
  - Caller dependent
    - Holes
    - Parameter positions
    - Templates

Local name space (LNS)

- The environment of an executing procedure
- Consists of
  - Caller-independent capabilities of the procedure
  - Caller-dependent capabilities
    - “Derived” from the parameters
    - Not the same as the parameters

Process

- A stack of LNS's
- Unit of asynchronous execution
- Creating lots of processes allows you to exploit the multi-processor nature of C.mmp

Capability

- Reference to an object
- Set of access rights
  - Kernel rights
  - Auxiliary rights
- It is impossible to forge a capability

Call and Return

- Call creates a new LNS
  - Caller-independent capabilities
  - Derived caller-dependent capabilities
  - Jump to the code
- Return destroys the current LNS, returning to the instruction following the CALL in the previous LNS

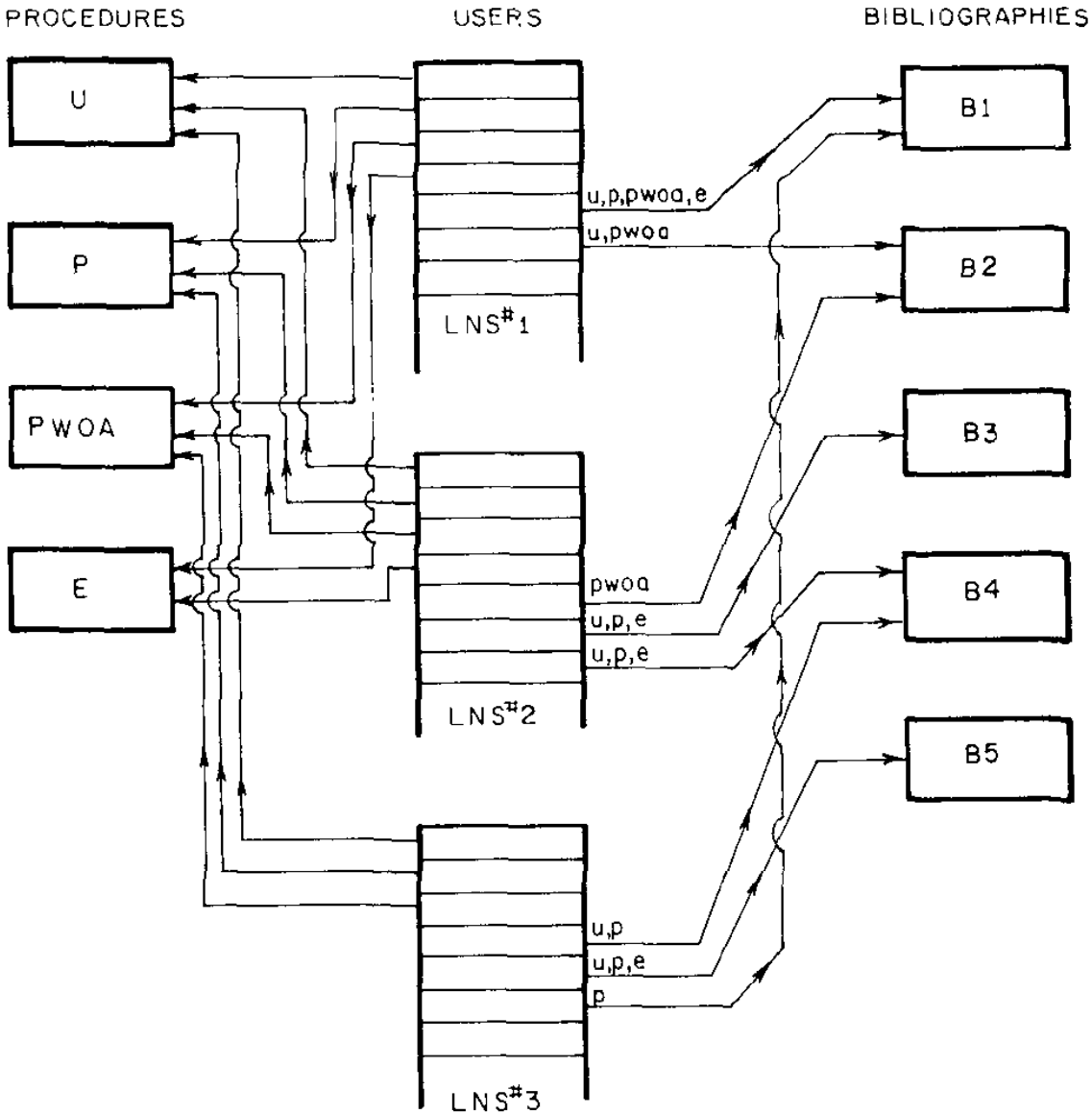
Parameter passing

- A procedure template contains:
  - A type attribute – the required type of the parameter
    - There is a wildcard ANY type attribute
  - Access rights
    - Check field
      - Rights required of the parameter
    - Regular field
      - Rights included in the capability in the new LNS

Paths

- The “walk” primitive returns a capability in the capability list of a target object
- Your capability for the target object must include the “walk” right

Bibliography example



Considerations - review

- Multiprocessor environment
- Separation of mechanism and policy
- Integration of the design with the implementation methodology
- Rejection of strict hierarchy
- Protection
- Reliability

Discussion

- Is there a similarity between HYDRA and today's micro-kernel operating systems?

Discussion

- Who cares about an operating system meant for a collection of 16 PDP-11? How does that hardware compare to today's?

Discussion

- In the old days, why do all the operating systems (Hydra, Multics) choose a heavy-weight protection scheme?
- Why doesn't Linux choose to use a heavy-weight protection scheme?
- Are there any contemporary O/Ses that use a heavy-weight protection scheme?

Discussion

- Can type mismatches (part of the parameter checking process) be detected at compile time?

Discussion

- Capabilities in a procedure in Hydra need not be stored in the local capability, but can be (using walk) in the capabilities of an object that is referenced in the current capability.
- Does that mean that for every access to an object, the kernel walks the entire list of capabilities until it finds the match to the object type?

Discussion

- “This implies that a callee may have greater freedom to operate on an object than the caller.”
- Will this allow security breaches if an object amplifies its rights to a global object by way of another object it calls?

Discussion

- Why does the separation of mechanism and policy seem so important?
- What is an example where this separation gains you something?

Discussion

- What rights do you need to create a template within a procedure that amplifies the rights in a given parameter capability?

Discussion

- HYDRA rejects the notion of ownership, Multics embraces it (the owner has absolute rights to a segment it creates).
- Which is better?
- For what situations is one to be preferred over another?
- What happens (in HYDRA) if you accidentally lose critical rights to a critical object?