Programming Semantics for Multiprogrammed Computations

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Overview

- Terminology
- Concepts
- Parallel Programming Semantics
- Protection
- Exceptional Conditions
- Protected Entry Points
- Names and Directories
- Conclusion

Introduction

- MCS - Multiprogrammed Computer System
- MCS Properties
  - Support for Multiple Users - Computation process are concurrent operation for more than one user.
  - Sharing of Resources
  - Demand for computing resources - vary by computation
  - Reference to Common Information (common sub-routines)
  - Should meet the changing requirements.

Terminology

- Word
  - Smallest unit of stored information
- Segment
  - Ordered set of words
  - References are done by a word name, w=[i,a]
- C-list
  - List of capabilities (Access List)
- Computations
  - Set of processes that are working harmoniously on the same problem.

Concepts

- Protection of Segments
  - Done by the use of segment capabilities using access indicators
- Access Indicators
  - X - executable as procedure
  - R - readable as data, non executable
  - XR - executable as procedure & readable as data
  - RW - readable and write able as data
  - XRW - exec as procedure, read and write as data

Concepts ...

- Ownership Indicators
  - O - owned
  - N - not owned
- Sphere of Protection
  - Defined by the list of capabilities
  - Capabilities would be frequently changed (add/delete) during execution of computation defining its sphere of protection.
- Principal
  - User of the MCS

Sphere of Protection

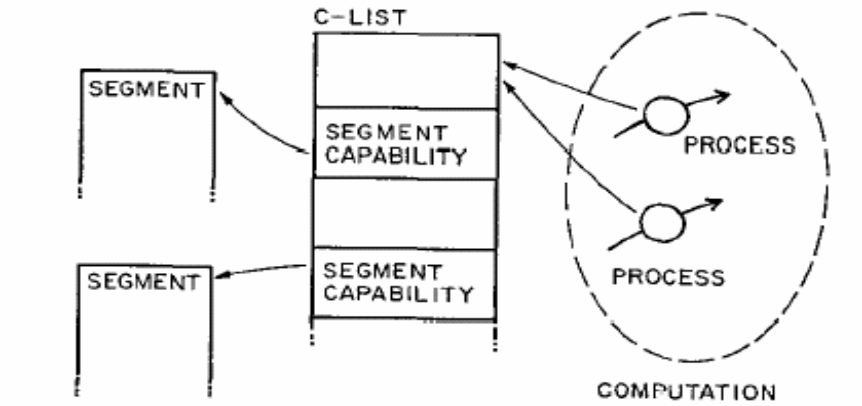


FIG. 1. A computation

Concepts ...

- Supervisor
  - HW and SW elements that implement basic computer system functions
  - all computations are performed around this
- Process List
  - Data structure within the Supervisor having entries of every process

Parallel Programming Semantics

- fork w
  - initializes a new process at instruction w
- quit
  - Remove a process. The state word is discarded
- join t, w
  - Conway's join instruction
  - If counter at word t becomes zero, word at w is executed

Parallel Programming Example

```
begin   real array A[1:n], B[1:n];
        Boolean w;  real S;  integer t;
        private integer i;
        t := n;
        for i := 1 step 1 until n do
          fork e;
        quit;
        e:          begin private real X;
        substance:    X := A[i] × B[i];
                      lock w;
                      S := S + X;
                      unlock w;
                      join t, r;
                      quit;
                    end;
        r:
end;
```

Parallel Programming Semantics ...

- private x
  - x exists only for the executing process
- lock w
  - The lock bit is set to 1
- unlock w
  - The lock bit is set to 0
- The lock and unlock are used to denote a critical section

Input/Output

- Classes of Communication
  - Programmed I/O
    - This process waits until the data is transferred from I/O to memory and vice versa
    - Suited for small amount of data
  - DMA
    - The process is suspended until all the operations between the memory and the I/O device is completed
    - Suited for large data transfer
- Semantics
  - execute i/o function i

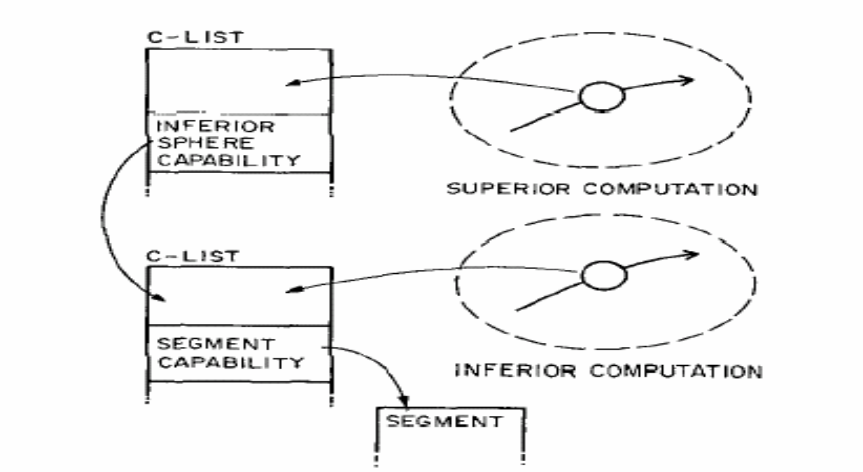
Parallelism

- Motivation
  - Freedom to allocate system resources with great efficiency
  - Express the frequently occurring operations of computations from the same code.

Protection

- Inferior Sphere of Protection
  - Process operating within another sphere of protection
- Semantic
  - i:= create sphere w
    - Create an inferior sphere
  - i:= grant X j,k
    - Grant permission to execute to j, k
  - start i,w
    - Start process in the inferior sphere

Creating an Inferior sphere



Exceptional Conditions

- Problems occurred in the inferior sphere
  - Fault
    - Hardware Malfunction or Memory parity error
  - Resource excess
    - allocation of resources exceeding the allotment
  - Addressing snag
    - Process generated a valid address, data not in memory.
  - Sphere Violation
    - Process refers to a capability not present in the C-list.

Exceptional Conditions ...

- Other exceptional Conditions- Inferior Sphere
  - Halt Instruction
    - Terminate this process and notify superior
  - Breakpoint Instruction
    - same as halt instruction
  - Undefined Instruction
    - execute an undefined operational code
  - Arithmetic contingencies
    - called for action by superior procedure

How is an exception handled?

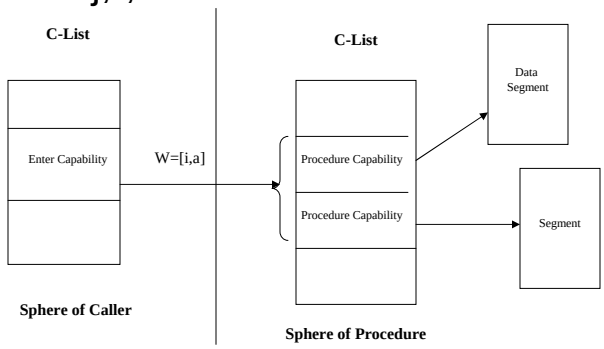
- A new process is created in the superior.
- Suspended process capability created to have access to the state word of inferior.
- Meta-Instructions used
  - fetch status i,w
  - set status i,w
  - continue I
  - stop k
  - examine i,j,w
  - ungrant i,j

Protected Entry Points

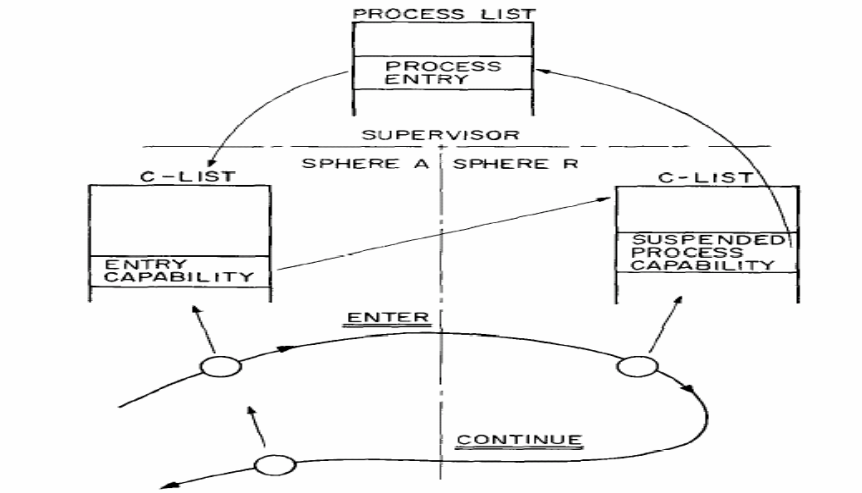
- Procedures need to be shared .
  - Protection of local objects.
- Protected Entry Points
  - Modification or change in C-list must accompany transfer of control to a procedure.
  - Restrictive use of a procedure.
  - Process calling a restrictive procedure requires an additional entry in the C-list, called as the “entry” capability.
  - Created by the owner

Meta-Instructions Used

- h=Create entry w,n
- enter j,r,k



Entry and Exit from a procedure



Naming

- Identify the objects
- Sharing of Retained Objects
  - Sharing procedures and data segments
- Desiderata for Names
  - Names of objects should be unambiguous
  - Name of an object can never be changed
    - As this impacts all the objects that embedded this name
    - Retained objects are directly referred.

Directory

- Directory
  - Set of items, each being an association between a name component and a capability
  - One root directory for every principal.
  - Directory capability for the root directory.

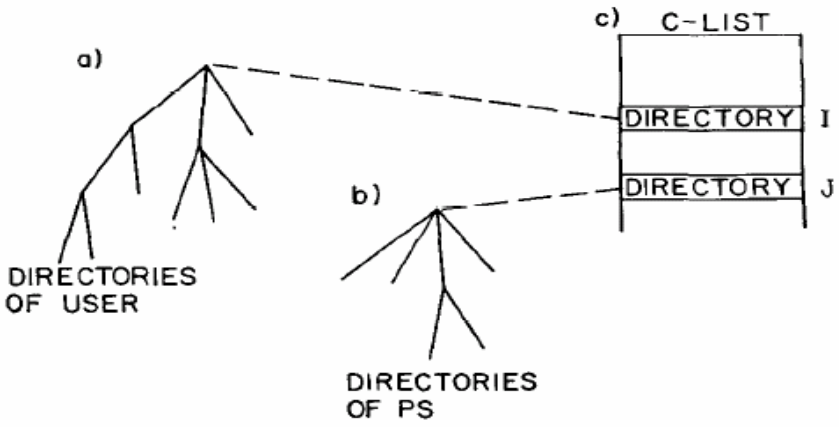
Directory Meta-Instructions

- J=acquire{accessindicator}I,<namecmpt>
  - Search directory for namecmpt and enters the capability to the C-List
- release I
  - remove the object capability from the C-List
- delete I
  - Delete the object

Directory Meta-Instructions

- Remove I,<namecmpnt>
  - Remove the objectname from directory.
- I=create segment{access list}
  - Creates a new segment and adds the capability to the C-List of the creating computation.
- I=create directory
- place{P,F}I,<cmpntname>,j
  - Associate name with the object.
- I=link <principal name>
  - Capability to access the principal's directory

Linking directories



Conclusion

- Semantics defined with meta-instructions for parallel programming in multi programming systems.
- Semantics relate to parallel processing, protection, sharing, debugging

References

- Programming Semantics for Multiprogrammed Computations
  - Jack B Dennis & Earl C. Van Horn - March 1966
- Fano, R.M. The MAC system: The computer utility approach
  - IEEE spectrum2 - Jan 1965

Thank You