Parallel Processing in NX NASTRAN

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Topics of presentation

- Introduction – What is Parallel processing
- DMP Parallel Processing
- Running DMP Solutions
- DMP Examples

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Topic

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Why use parallel processing

- Increasing Model Complexity
- Increasing Model Size
- Increase in the number of analysis jobs being run
- Decrease in the time allocated to analysis

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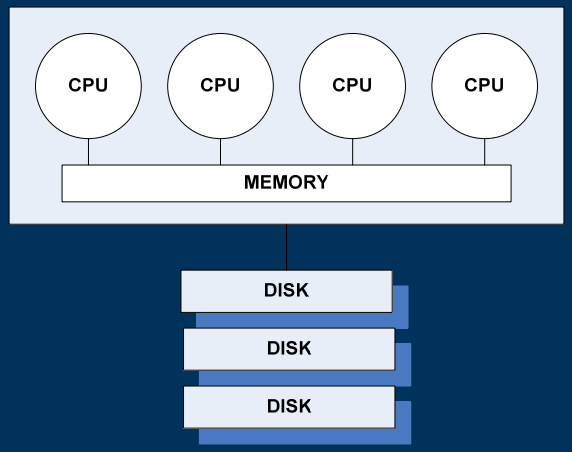
Machine Architectures

- Shared Memory Parallel (SMP) Machines
- Multiple Processors share
  - Common memory pool
  - Common I/O Pool



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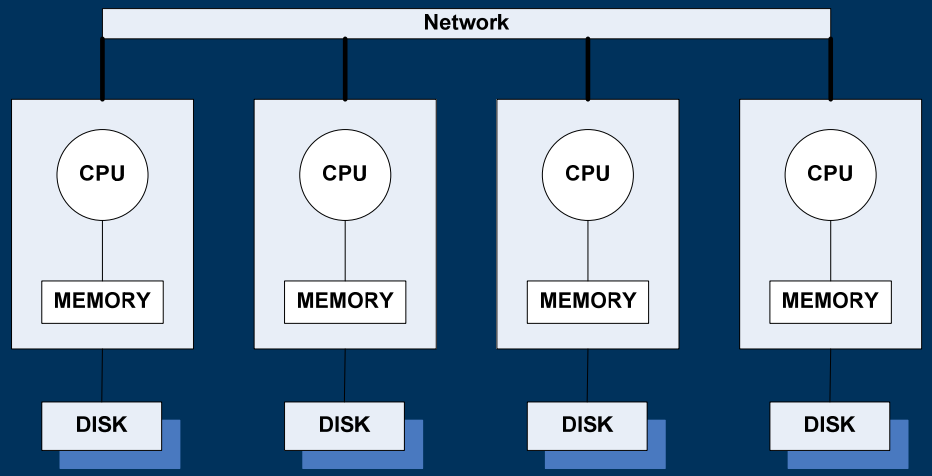
Machine Architectures

- Distributed Memory Parallel (DMP)
  - multiple machines with one or more processor communicating over a network
  - multiprocessors with multiple I/O channels
  - each processor has
    - its own memory
    - its own disk



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Difference between DMP and SMP

- Hardware environment
  - High performance workstation clusters vs.
  - Shared memory multi-processor workstations
- Parallelism level
  - High: Partitioning in physical domains vs.
  - Low: Subdivide matrix and vector operations
- Software mechanism
  - Message Passing Interface vs.
  - Threads, fork-join system calls

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Distributed technology advantage

- Reason to Subdivide Very Large Problems

	Undivided	Subdivided
Problem Size	N	$n = N / k$
Operation Cost	$N^3 = k^3 n^3$	kn^3
Advantage	k^3 >	k

- Distribution technologies
  - Frequency domain decomposition
  - Geometric domain decomposition

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Frequency domain decomposition

- Concept

- Technology foundation
  - Subdivide wide frequency domain into (not equal) segments containing close to equal number of eigenvalues
  - Modal and response computations in the frequency segments are independent from each other
- Practical considerations
  - A prior load balancing (user given subdivision)
  - Gathering of segment results into master processor(s)

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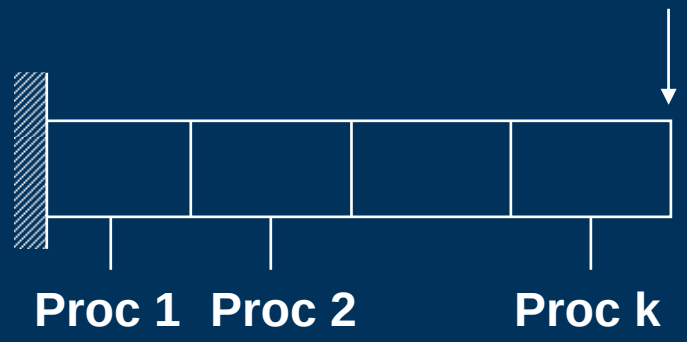
Geometry domain decomposition

- Concept



- Technology foundation
  - Subdivide large geometry domain into limited number of partitions containing close to equal number of grids and elements
  - Linear solution and eigenvalue computations in the geometry partitions dependent on each other
- Practical considerations
  - Minimize the size of the boundary between partitions
  - Communication of partition results through master processor

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Supported Solutions for DMP

- Supported Solution sequences
  - SOL 101 Linear static
  - SOL 103 Normal modes
  - SOL 108 Direct frequency response
  - SOL 111 Modal frequency response
  - SOL 112 Modal transient response
  - SOL 200 Design optimization

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Calculation Methods

- Calculation Methods supported
  - Geometric Domain Static Analysis (GDSTAT)
    - Linear Statics – Sol 101
  - Frequency Domain Normal Modes Analysis (FDMODES)
    - Normal Modes – Sol 103
    - Frequency response – Sol 108,111
    - Design Optimization – Sol 200
  - Geometric Domain Normal Modes Analysis (GDMODES)
    - Normal Modes – Sol 103
    - Frequency response – Sol 108,111
    - Design Optimization – Sol 200
  - Hierarchic Domain Normal Modes Analysis (HDMODES)
    - Normal Modes – Sol 103
    - Frequency response – Sol 108,111
    - Design Optimization – Sol 200

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DMP hardware environments

Computer	Architecture	Processor	OS level
IBM	AIX	Power 3+	AIX 5.1+
HP	HP-RISC	PA-RISC	HP-UX 11.00
Intel	LINUX 64 HP-UX	Itanium 2	RHEL 2.1+ HP-UX 11.22
SGI	ALTIX MIPS	ALTIX MIPS	LINUX IA-64 IRIX 6.5.7
INTEL	Linux-64	x86-64	Suse 9.0
INTEL	Linux-32	X86-32	RHEL 2.1+
AMD	Linux-64	Opteron	Suse 9.0

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Frequency domain parallel solutions

- Serial pre-solution processing

  (create and process global matrices on all processors)

- Execute solution process by distributing response locations or eigenvalue spectrum (dynamically on availability basis)

- Serial result data recovery

  (gathering of response solution vectors)

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Geometric domain parallel solutions

- Model subdivision prior to solution steps
  - (create local sub-matrices and boundary information) in SEQP
  - (process local sub-matrices)
- Execute solution process via distributed algorithm
  - (distributed decomposition and FBS)
- Enable parallel result data recovery
  - (produces segments of solution vectors)

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Distributed memory normal modes

- Frequency domain parallel - fdmodes
  - Wide frequency range of interest
  - 10,000 eigenvectors
- Geometry domain parallel - gdmodes
  - Very large matrices
  - 10,000,000 DOF
- Hierarchic domain parallel - hdmp
  - Simultaneous execution of the two principles

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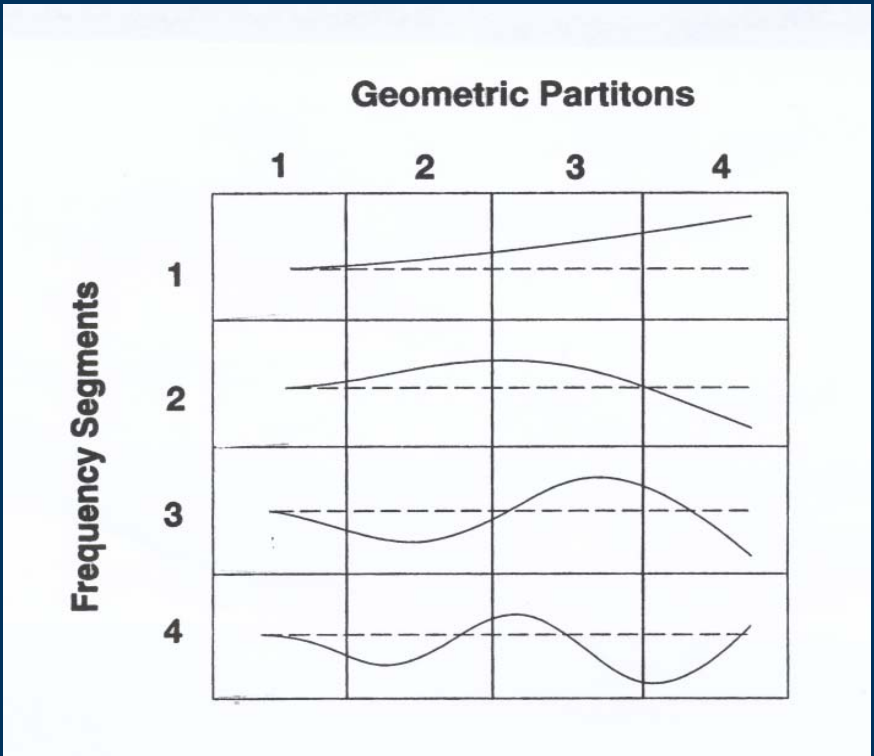
Hierarchic domain decomposition

- Geometry domain decomposition - partitions
- Frequency domain decomposition - segments



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Hierarchic computational strategy

- Computing geometry partitions in frequency segments

Hierarchy	Segment 1	…	Segment j	…	Segment s
Partition 1	Φ_1^1, Λ_1				Φ_s^1, Λ_s
…					
Partition i			Φ_j^i, Λ_j		
…					
Partition p	Φ_1^p, Λ_1				Φ_s^p, Λ_s

- Number of processors = s*p

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DMP specific submittal keywords

- NASTRAN
  - dmp=n, number of CPUs
  - hosts=list, available hosts
  - slaveout = yes/no, slave output concatenated to master or not
  - mergeresults = yes/no, output results are collected or left distributed

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DMP specific submittal keywords

- fsegs = f – Specifies the number of frequency segments for an HDMODES or FDMODES analysis
  - should equal the number of nodes in the clusters
- gdoms = g – Specifies the number of geometry domains for an HDMODES analysis
  - should equal the number of processors per cluster
- The product of fsegs X gdoms = number of processes

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DMP recommended keywords

- NASTRAN
  - sdir= pathname, local scratch database storage
  - dbs = pathname, local permanent database storage
  - mem=size, local memory size in words or bytes, K or M
  - scratch=yes, delete local database files at end of run

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Command Line example

- nxnastran example dmp=p / hosts=node1:node2:noden / sdir=/scr1:/scr2:/scrn dbs=/dbs1:/dbs2:/dbsn / mem=xxxK, scratch=yes
  - scr1 and dbs1 correspond to node1,
  - scr2 and dbs2 correspond to node2, etc.

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Command Line examples

- Geometric Domain Static (GDSTAT)
  - nxnastran example dmp=p
- Geometric Domain Normal Modes (GDMODES)
  - nxnastran example dmp=p

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Command Line examples

- Frequency Domain Normal Modes Analysis (FDMODES)
  - nxnastran example dmp=p fsegs=p
- Hierarchic Domain Normal Modes (HDMODES)
  - nxnastran example fsegs=f gdoms=g

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DMP Application Examples

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Other references

- NX NASTARN Installation and Operations Guide
  - NX NASTRAN Documentation

- NX NASTRAN Parallel Processing Guide
  - Available from UGS Website
    - http://support.ugs.com/docs/nastran/v41/

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Thank you for coming.

Any questions?

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