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AEROSPACE TECHNOLOGY DIRECTORATE

STRUCTURES DIVISION
Structural Dynamics Branch

NASA
Lewis Research Center

COMPUTATIONAL STRUCTURAL METHODS AT NASA LEWIS

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COMPUTATIONAL STRUCTURAL METHODS

SOME HISTORY:

Custom Architecture Parallel Processing System - CAPPS
Simulation of wind turbine dynamics & controls.

Real Time Multi - Processor System - RTMPS
Simulation of engine systems control dynamics.

Computational Structural Methods Activity - initiated 2 years ago - to complement on-going computational structural analysis methods development.

The Structural Dynamics Branch at Lewis conducts research in propulsion and power systems, and in mechanical systems applications. We have four major areas of work which are:

- Aeroelasticity
  - Classical (computational)
  - Computational (time domain)
  - Experimental
  - Applications (Turboprop, turbofan, turbopump, and advanced core technology)
- Vibration Control
  - Active methods
  - Passive methods
  - Forcing functions
  - Applications (Electromagnetic dampers, magnetic bearings, cryo turbomachinery)
- Dynamic Systems
  - Micro-gravity robotics systems
  - Parameter identification
  - Applications (Space lab, SP100 Engine, NASP seals, tethered satellites)
- Computational Methods
  - Algorithms for modern computing
  - Engineering data analysis
  - Parallel architecture computers
  - Applications (Parallel FE methods, transputer lab, transients analysis)

Our computational methods activity relates to other branch and lab programs. It is based on current needs, past activities, and is coordinated with activities in the fluid mechanics division and the computer services division.

COMPUTATIONAL STRUCTURAL METHODS

PROGRAM OBJECTIVE:

EXPLOIT MODERN COMPUTER HARDWARE & SOFTWARE TO FUNDAMENTALLY IMPROVE THE USE OF COMPUTERS FOR SOLVING STRUCTURAL PROBLEMS.

WORK ELEMENTS:

ALGORITHMS FOR MODERN COMPUTING

ENGINEERING DATA ANALYSIS

PARALLEL ARCHITECTURE COMPUTERS

APPLICATION STUDIES

The goal of our work is to exploit modern computing architectures. It is a new activity for Lewis. Our initial work has been directed to more fundamental concerns dealing with how we might formulate new algorithms to take advantage of parallel computing and how these new computers might be applied to data-taking and analysis. Our longer-term goal is to make new methods part of design and analysis practice with the engine simulator activity also underway at Lewis.

COMPUTATIONAL STRUCTURAL METHODS

KEY THRUSTS:

INNOVATIVE METHODS
High performance potential
Applications which require parallel computing
Applications which greatly benefit from parallel computing

METHODS FOR ADAPTING EXISTING CODES
FORTRAN conversion
Finite Element Modeling

REQUISITE SOFTWARE TOOLS
Code analysis
Architecture Evaluation
Architecture Synthesis

We have placed strong emphasis on new innovative approaches which we feel will offer significant performance advantages in future structures codes. Along with this activity we have started to identify methods which may be employed to successfully re-utilize the large stock of existing codes that we currently use, because of the tremendous investment that the agency has in these codes. Finally, it became apparent that some effort was also required in developing and updating software tools to analyze the performance potential of alternative methods on alternative architecture processors.

COMPUTATIONAL STRUCTURAL METHODS

APPROACH:

FOCUS ON FUNDAMENTALS - LEADING TO APPLICATIONS

FORM LAB-WIDE CSM RESEARCH TEAM

REPRESENTATIVE PROBLEM CASE STUDY

INSTALL RE-CONFIGURABLE ARCHITECTURE TRANSPUTER

ESTABLISH USER COMMUNITY

"EVENTUALLY" - PURCHASE COMMERCIAL SYSTEM

Our approach starts with fundamentals. There are many interested parties at Lewis who have come together to form a lab-wide team. We currently have representatives from Structures, Computational Fluid Mechanics, ICOMP, and Computer Services Division. By pooling our resources and studying representative problems we hope to develop some common understanding which will lead to a user community at Lewis. We will be attempting to pool resources to procure a commercial parallel processing computer to complement the research architecture processors currently on hand (the transputer and the hypercluster architectures).

COMPUTATIONAL STRUCTURAL METHODS

RESOURCES:

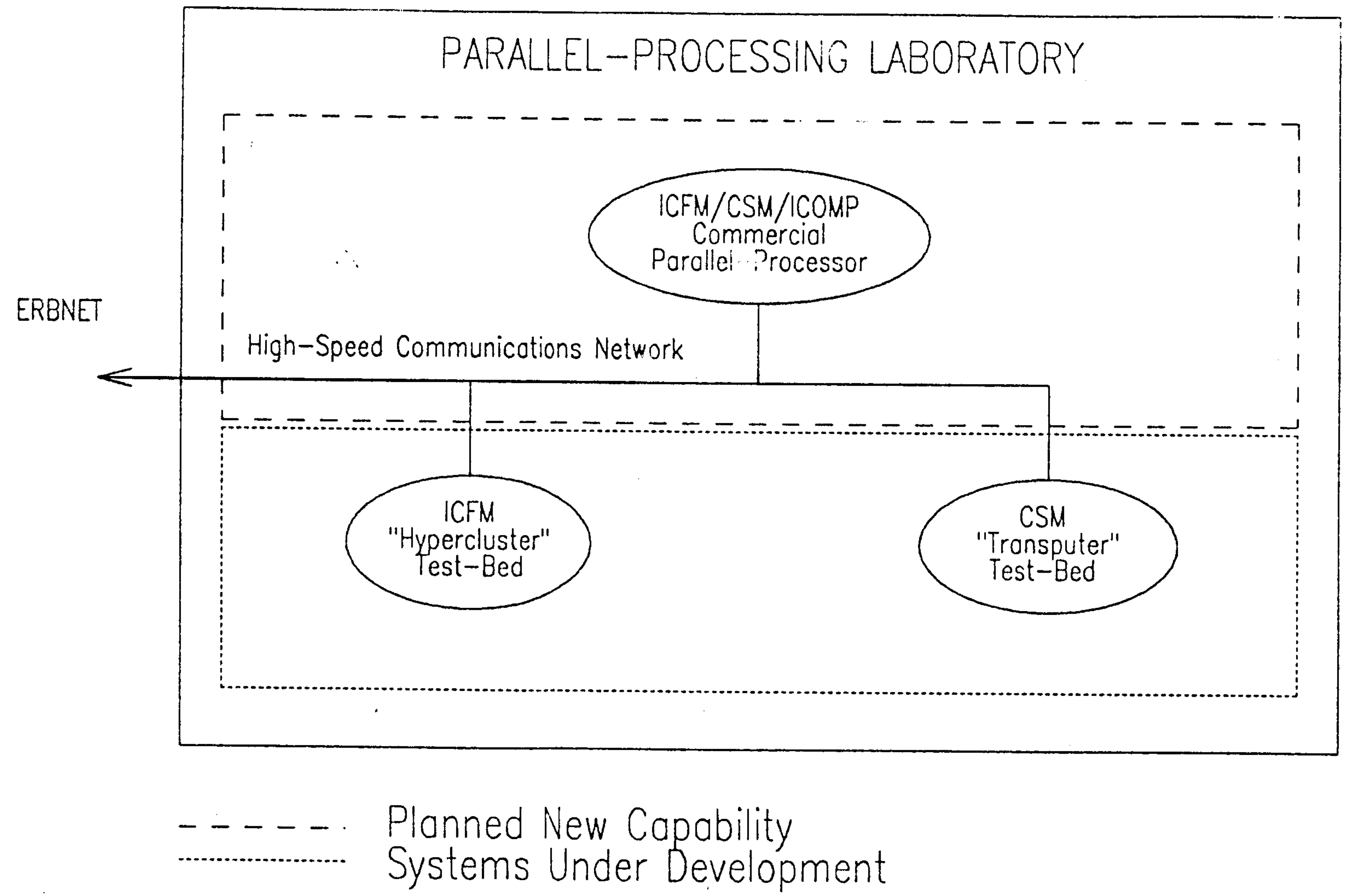
IN-HOUSE CSD, ICFM, ICOMP & CSM TEAM

67 PROCESSOR TRANPUSTER ARRAY TEST BED

NETWORKING RESOURCES: ERBNET, NASNET

OTHERS COMPUTERS: HYPERCLUSTER, XMP, CRAY II

PROPOSED COMMERCIAL SYSTEM


PARALLEL-PROCESSING LABORATORY
ICFM/CSM/ICOMP
Commercial
Parallel Processor
High-Speed Communications Network
ERBNET
ICFM
"Hypercluster"
Test-Bed
CSM
"Transputer"
Test-Bed
Planned New Capability
Systems Under Development

TECHNICAL FOCUS AREA - *Computational Structural Methods*

FY87 ACCOMPLISHMENTS

- 67 processor TRANSPUTER test bed system installed.
- 'PARAPHRASE' code for FORTRAN data flow analysis & optimization was installed. Both fine grain and coarse grain data flow analysis completed for the transient blade loss dynamics code.
- Critical blade loss dynamics routines run on the XMP & hypercluster. Coded for the TRANSPUTER test bed.
- Initial multi-gridding structural analyses demonstrated on the IBM 3033.
- Preconditioned conjugate gradient integration algorithms shown to be distributable over limited number of parallel processors (TRANSPUTERS).
- 2D Finite element analyses demonstrated significant speed up on TRANSPUTERS.
- 2D graphics primitives for structural modeling/animation on TRANSPUTER.
- A general model of parallel processors (as seen by structures codes) using both deterministic and statistical factors formulated for algorithm assessment.
- Space station power systems control strategies were simulated on the CAPPS.

TECHNICAL FOCUS AREA - *Computational Structural Methods*

FY88 PLANS

- Demonstrate structural multi-gridding analyses on the TRANSPUTER array.
- Formulate parallel algorithms for real-time (LQR) rotor response control, and develop real-time rotor response simulation codes on the TRANSPUTER test bed.
- Demonstrate a general architecture assessment model for structures codes.
- Demonstrate binary-tree sub-domain decomposition frontal method eigen-solver codes.
- Demonstrate a TRANSPUTER library of 'GKS-style' graphics primitives for animation.
- Formulate TRANSPUTER 3D FE analyses with out-of-core solution strategies.
- Formulate 2D FE re-meshing code to optimally re-distribute and balance the computing load to an array of TRANSPUTERS.
- Assess processing array limits for preconditioned conjugate gradient integration.
- Compute the aerodynamic coefficients across the surface of an ATP blade in parallel.
- Use 'PARAPHRASE' to optimally convert existing FORTRAN codes to OCCAM.

COMPUTATIONAL STRUCTURAL METHODS

SUMMARY OF CURRENT & PLANNED ACTIVITIES

	NOVEL METHODS	EXISTING CODE USE	PAR. TOOLS/ DEMO's
ALGORITHMS	- *Structural Multi-gridding* - *Finite Time Dynamics FE*	- *FORTRAN to OCCAM Conversion*	- *Real Time Adaptive Rotor Control*
DATA ANALYSIS	- *Digital Comb Filter*		- *'EASY-FLO' Course Grain data Flow*
PARALLEL COMPUTING	- *Pre-cond Conj-Grad Integration* - *Sub-Domain Eigen-solver methods*	- *PARAPHRASE Evaluation* - *ATP Blade Aero Coefficients*	- *TRANSPUTER primitives* - *Architecture Modeling* - *Architecture Synthesis*
APPLICATIONS		- *Blade Transient Architecture Assessment*	- *TRANSPUTER Graphics Engine* - *2D FE model re-meshing* - *TRANSPUTER FE Work-station*