EOSDIS
Technology Assessment Study

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Ames/GSFC EOSDIS Study

6/97-3/98

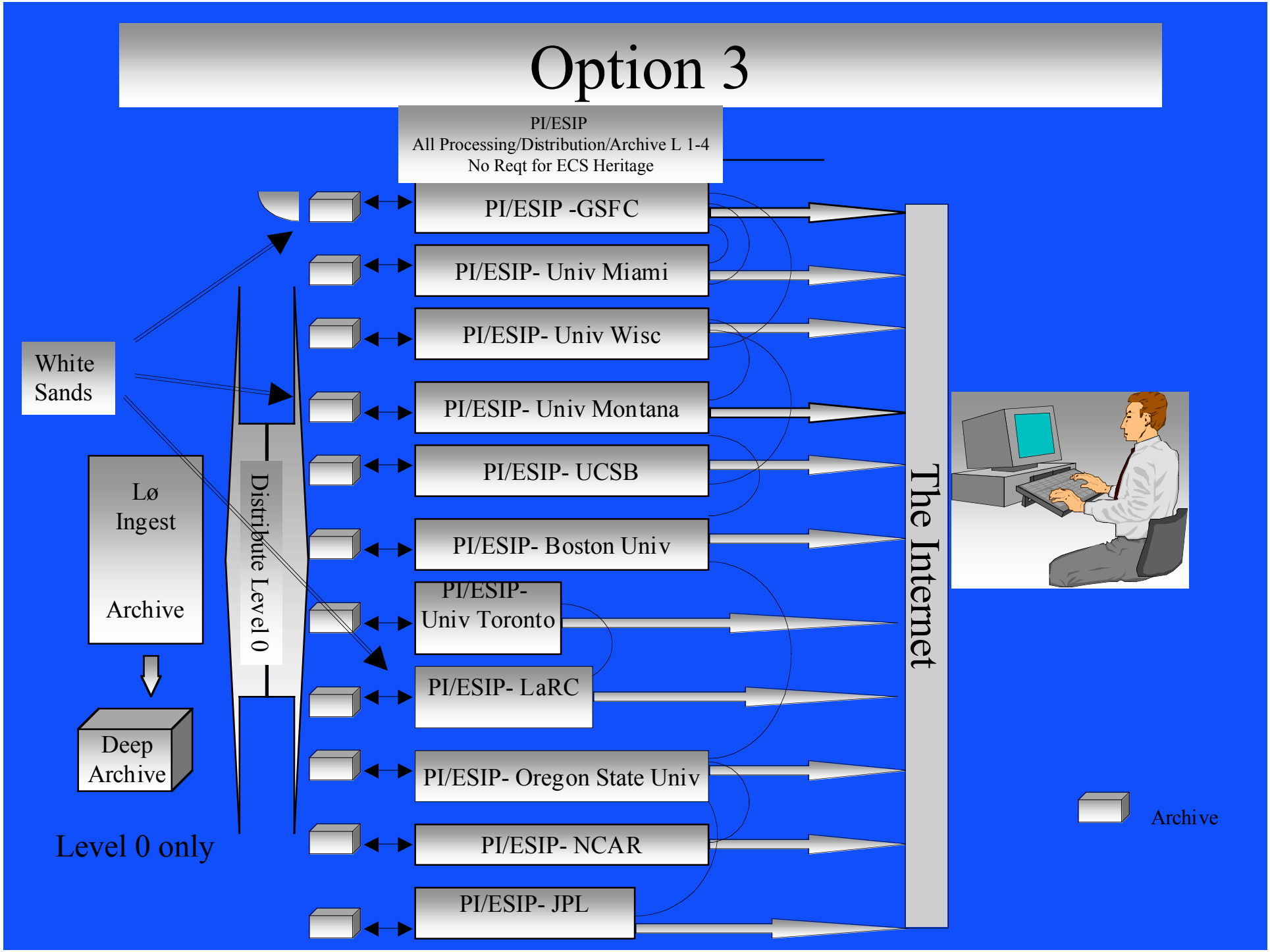
- System Study--End to end EOSDIS analysis including:
  - Technology Assessment
  - System Modeling
  - Requirements Analysis
  - Alternative Designs
  - S/W Design Analysis

- Requested by A. Diaz-POC -W.Brooks-G. McConnaughy, K. Moe(GSFC)

Team Members

• Study Objectives/Architectures	-Brooks
• Science Requirements	-Coughlan
• System Modeling	-Monahan
• ECS Software Analysis	-Reisman
• Technology Analysis Approach	-Lasinski
• Network WAN/LAN's	-Lisotta
• Processing	-Bergeron
• Storage Systems	-Poston
• Middleware/Distributed S/W	-Tweeten
• Databases	-Cox

Option 3


PI/ESIP
All Processing/Distribution/Archive L 1-4
No Reqt for ECS Heritage
PI/ESIP -GSFC
PI/ESIP- Univ Miami
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PI/ESIP- Univ Montana
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PI/ESIP- Boston Univ
PI/ESIP- Univ Toronto
PI/ESIP- LaRC
PI/ESIP- Oregon State Univ
PI/ESIP- NCAR
PI/ESIP- JPL
White Sands
Lø Ingest
Archive
Deep Archive
Distribute Level 0
Level 0 only
The Internet
Archive

Option 4

All Processing, Distribution and long term Archive L 1-4

ECS Heritage S/W

White Sands

Consolidated DAAC

SCF Support

Lø Ingest

GSFC Archive

Query Lø

The Internet

Deep Archive

Deep Archive

Other Data Archives

Level 0

Level 1-4

Sources of Assessment Information

- Direct Experience with research, development and operations of major information systems
  - supercomputers, networks, storage, workstations, s/w glue, viz., ...
- β-Tests for emerging products
  - SGI, STK, Bay Networks, Fore Sys., ...
- Prototype Research Grants&Contracts
  - RAID (UCB), PVM Performance (Emory), Global File Sys. (U. Minn.), Ultranet (Ultra), ...
- Experience derived from activity with Standards and Forums
  - ACM, IEEE, Byte, MPI Forum, DMIG, IETF/RFC, ATM Forum, ...
- Connections to major Silicon Valley companies

Assessment Content

- Technologies considered
- Definition of assessment criteria
- Assessment matrix, architecture independent
- Description of technologies
- Comments on 4 architecture options
- Assessment matrix, architecture specific
- Recommendations

Assessment Criteria

- **Maturity** - Stable and reliable, wide vendor support...
- **Scalability** - Scalability with respect to ...
- **Functionality** - Does it work as defined by the standards, applicability to the EOSDIS architectures
- **Cost** - Relative dollar cost to implement and maintain the technology as well as cost required for training
- **Additional criteria** as appropriate

Example Assessment Matrix

Architecture Independent	Shared ATM			Shared Frame Rly			Satellite LEOs			Network QoS/CoS			Reliable Multicast			Compress-ion			Dedicated Circuits		
Options 1-4 including user access	AM	PM	Chm	AM	PM	Chm	AM	PM	Chm	AM	PM	Chm	AM	PM	Chm	AM	PM	Chm	AM	PM	Chm
Maturity	🟡	🟢	🟢	🟢	🟢	🟢			🔴	🔴	🟡	🟢	🔴	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Scalability (up/down)	🟢	🟢	🟢	🟡	🟡	🟡			🔴	🟡	🟢	🟢	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Functionality	🟡	🟢	🟢	🟢	🟢	🟢			🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Cost	🟢	🟢	🟢	🟢	🟢	🟢			🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🔴	🔴	🔴
Interop (w/legacy & installed base)	🟡	🟢	🟢	🟢	🟢	🟢			🟢	🔴	🟡	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Performance (Capacity, reliability, delay)	🟢	🟢	🟢	🟢	🟢	🟢			🟢	🟡	🟢	🟢	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Market Trend	🟢	🟢	🟢	🟢	🟢	🟢			🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟢	🟡	🔴	🔴
Mature Standards	🟢	🟢	🟢	🟢	🟢	🟢			🔴	🔴	🟡	🟢	🔴	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Availability	🟡	🟡	🟢	🟢	🟢	🟢			🟢	🔴	🟢	🟢	🔴	🟡	🟢	🟢	🟢	🟢	🟢	🟢	🟢
Recomend	🟢	🟢	🟢	🟢	🟢	🟢			🔴	⇩	🟢	🟢	🔴	🟢	🟢	🟢	🟢	🟢	🟡	🟡	🟡

🟡 - IP QOS
🟢 - ATM QOS

Key: Blank = Not Applicable 🔴 = applicable but not ready, prototype/invest 🟡 = limited deployment 🟢 = fully deploy

Example Technology Recommendations

LAN Key Technology Issues

- LAN/WAN interconnect needs to be addressed
  - HiPPI-ATM w/Gigarouters may be an alternative
  - Unclear how to interconnect Fibre Channel to ATM
  - 1Gb/s Enet will more than likely be supported by ATM switch manufactures via MPOA in 1998-1999
- QoS/CoS support is an end-to-end requirement
  - HiPPI 800 does not have QoS support
  - HiPPI 6400 may and therefore might be required for Origin class machine interconnections to WAN if QoS is used
  - Fiber Channel has three classes of service which may be suitable, but prototyping is necessary to verify

LAN Technology Summary

Architecture Independent	HiPPI			HiPPI 6400			Gb/s Ethernet			Ethernet/ Fast Enet			Fibre Channel			Mryinet			ATM			FDDI		
Options 1-4 including user access	AM	PM	Chm	AM	PM	Chm	AM	PM	Chm	AM	PM	Chm	AM	PM	Chm	AM	PM	Chm	AM	PM	Chm	AM	PM	Chm
Maturity	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Scalability (up/down)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Functionality	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Cost	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Interop (w/legacy & installed base)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Performance (Capacity, reliability, delay)	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Market Trend	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Mature Standards	●	●	●		●	●	●	●	●	●	●	●	●	●	●				●	●	●	●	●	●
Availability	●	●	●		●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Recomend	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Key: Blank = Not Applicable • = applicable but not ready, prototype/invest • = limited deployment • = fully deploy

LAN Recommendations

- AM Era Recommendations
  - Consider using HiPPI, and Fiber Channel for high-speed interconnect of Origin-scale processors and mass storage
  - Consider direct ATM interconnection to the WAN, or the use of gigarouters to interconnect LAN HiPPI to WAN ATM
  - Use FDDI and Fast Ethernet (switched and unswitched) as general connectivity technologies
  - Consider use of ATM's QoS end-to-end between computers/servers involved in large file transfers
- AM Era Investment Opportunities
  - 1Gb/s Ethernet, HiPPI 6400, ATM at OC-12 and beyond, ATM/IP QoS and Reliable Multicast prototypes
  - ATM MPOA prototyping
- PM and Chem Era Recommendations
  - Consider HiPPI 6400, 1Gb/s Enet and ATM at OC-12 for high-speed and LAN/WAN interconnections
  - Deployment of QoS and reliable multicast within the LAN where appropriate

HPC Technology Assessment

Issues by Era

- The major issue occurs in the AM Era due to the high processing rate requirements of MODIS-43
- If this issue is resolved, EOS can solve its computing requirements by appropriate purchases of RISC SMP technology

SYSTEM MODELING

RESULTS OF FIRST SIMULATIONS

- CONSTRAINT: using Option 1, maximized utilization of processors with minimum number of processors necessary to produce NPP in 1 day
- Assigned number of processors to each process based on above constraint
- Result: minimum number of processors = 89
  (see next slide for locations)

OPTION 1 (CURRENT)

of Processes: 6
# of Processors: 37
Ave. Utilization:0.90

T-3: 4.5 MB/s

# of Processes: 11
# of Processors: 54
Ave. Utilization:0.34

GSFC

EDC

OPTION 2 (SCF)

of Processes: 17
# of Processors: 89
Ave. Utilization:0.54

GSFC-SCF

OPTION 3 (QA)

T-3: 4.5 MB/s

T-1: 0.1544 MB/s

# of Processes: 6
# of Processors: 37
Ave. Utilization:0.90

# of Processes: 7
# of Processors: 48
Ave. Utilization:0.36

# of Processes: 4
# of Processors: 4
Ave. Utilization:0.01

GSFC

BOSTON UNIVERSITY

UNIV. OF MONTANA

HPC Technology Assessment

EOS Algorithm MODIS-02

- Goal: produce spectral radiance and reflectance
- Operates on 36 spectral bands
- Processing consists of applying 4 correction factors to convert measured Digital Number to radiance
- Algorithm involves weighted contributions from nearest-neighbor pixels
- MODIS-02 requires 1299 MFLOPS

EOS Algorithm MODIS-09

- Goal: Provide BRDF and albedo for 7 spectral bands
- Reflectance is treated as the weighted sum of a series of semi-empirical kernels
- Minimizing RMSE leads to a linear system whose solution for all pixels produces weighting coefficients
- Climate superpixels involves nearest neighbors
- MODIS-09 requires 2395 MFLOPS

HPC Technology Assessment

Recommendations/Future Work

- All codes should provide a measured floating-point operation count based on a representative sample problem(s).
- The most demanding codes should be arranged into a standalone suite for vendor testing.
- More detailed workload data should be used to update the processing configurations and costs.
- Intrinsa PREfix tool should evaluate all EOS algorithms.

Automated Software Engineering

- Two Meetings have resulted in Agreement on Collaboration using formal methods for software validation.
- Formal methods are mathematically based notations with which one can ...specify systems before they are programmed together with algorithms for proving programs correct with respect to such specifications.

- Developed a tool called the "Java PathFinder", which basically allows one to specify properties about a Java program and then prove that the Java program satisfies these properties. This area is closely related to testing, but uses more advanced techniques for exploring ALL! possible states of a program rather than SOME as in testing.

- The collaboration follows two tracks:

  - General application of formal methods to software development. Here we want to support them in choosing and using formal methods in their daily work.

  - Specific application of the "Java PathFinder" to one of the their Java applications: the SAFE protocol, a prototype file communication system for satellites allowing these to be accessed over the internet.
  - The protocol will be tested in a prototype "satellite" sailing on a ship in the black sea during the solar eclipse in august 1999. The purpose being to observe the eclipse.

background