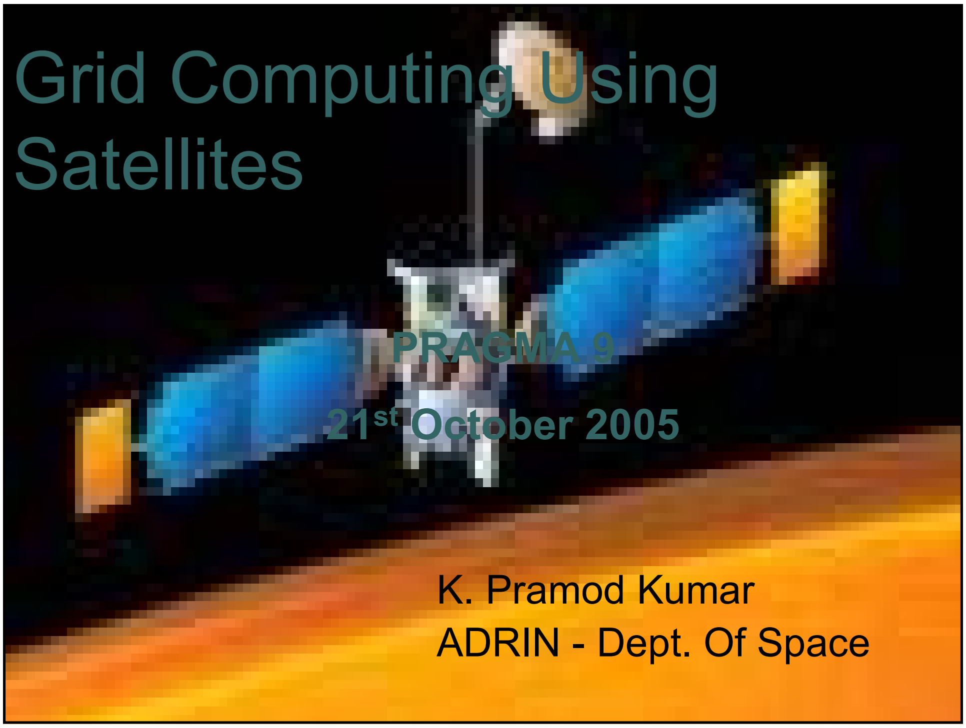

Grid Computing Using Satellites

PRAGMA 9

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PRESENTATION OUTLINE

- SATCOM – Basics, Topologies, Advantages, Limitations.
- SATCOM Issues for GRID
- ISRO’s Mission: INSAT, EDUSAT
- Globus GRID Architecture and Protocols
  - Resource Management
  - Data Access
- GRID Model using SATCOM
- FRM Scheduler
- GRID Applications and Model adopted
- SPL/MD Programming Model and Results
- Conclusion

SATCOM

- Communication satellites/Geo-stationary are placed in 36,000 Kms orbits
- SATCOMS have started about 40years ago with the launch of Syncom-1
- Fiber came still later and reaches only the lucky few.

Advantages of SATCOM

- Satellites are generally more reliable than terrestrial lines.
- Satellite offers instant coverage anywhere in the foot print of the satellite.
- Satellites cost effectiveness varies relative to terrestrial services
- They do not get dug up all it requires is clear sky
- Avoids local and national bottlenecks
- Offers a cost effective solution.
- Solves “last mile” problem
- Quick and simple to deploy.

Advantages of SATCOM contd.

- Satellite offer unifying technology solutions (Data, Voice, VC, Broadcast, Multicast etc..)
- Variety of topologies Star, Multi-Star & Mesh
- **Fiber cannot reach the majority of potential users in India.**
- Bandwidth can be easily expanded or new sites can be added.

SATCOMS developments

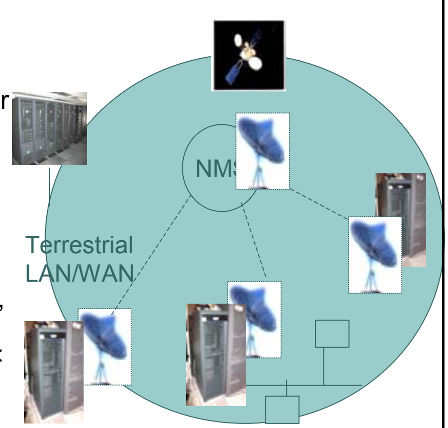
- VSATs are now cheaper to buy than what was in the past and operational costs have also fallen.
- Satellites now operate in both Ku and C-bands, which has made possible to use smaller antennas and transceivers for a given performance and data rate.
- This in turn offers savings on shipping and installations which make the start-up costs much more attractive.
- Modem technology (Turbo coding, 8PSK,16QAM etc) makes more efficient use of higher satellite power levels now available.

Abbreviations

- SCPC-Single Channel Per Carrier
  (Equivalent to a terrestrial leased line)
- DAMA-Demand Assigned Multiple Access
  (On demand Leased Line)
- TDM-Time Division Multiplexed
  (several channels combined into a single transmission by allocating each a predefined time slot)
- TDMA-Time Division Multiple Access
  (Division of a channel into time slots which are then available on a continuous access basis to a large number of VSATs)
- FDMA-Frequency Division Multiple Access
  (Division of a channel into multiple frequency slots which are then available on a continuous access basis to a large number of VSATs)
- Outbound
  (Channel from the HUB to the remote VSAT)
- Inbound
  (Channel from the remote VSAT to the HUB)

Abbreviations contd.

- Single Hop: One VSAT to Central Terminal
- Double Hop: One VSAT to another via Central terminal
- HUB: Central large earth station in a star network
- Gateway Point: Point/Node which connects to other terrestrial network
- Master Control Station: Central Network site in a DAMA network which also may function as a gateway
- Antenna Sizes: 0.6m, 1.2m, 1.8m, 2.4m, 3.8m…
  - Hub based systems:Antenna sizes < 1m
  - Mesh Based Systems:>1.8m

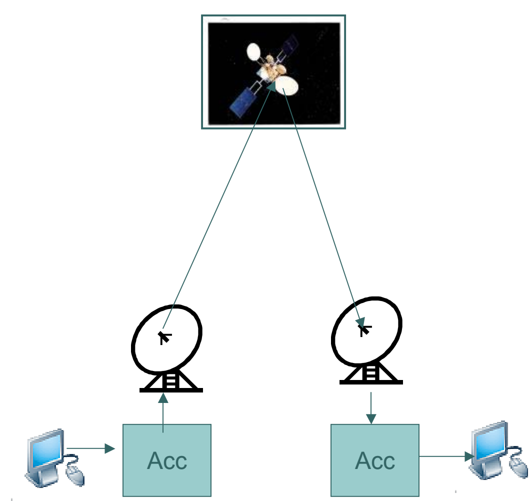


Limitations of SATCOMS

- High Latencies
  - Long RTT
  - False Time Out
- Low bandwidth and bandwidth asymmetry
  - 10:1 or more forward to return asymmetry
  - Return of acknowledgements degrade the performance
- Link Impairments due to rain, multi-path interferences
- Fixed number of Channels
- Uni-Directional i.e., UDP/IP
  - Provide TCP/IP wrappers which compromise on bandwidth
- Single Channel per node at any given point of time
- Requires very high level of Security

SATCOM Issues for GRID: Limitations revisited

- Latencies: Grid Protocols can be extended or tuned to accommodate high RTTs
- Low Bandwidth and bandwidth asymmetry: Link accelerators improve the performance but provide false acknowledgements when link is down
- Link Impairments: Increase the transmitting power



SATCOM Issues for GRID: Limitations revisited

- Uni-Direction and Limited Channels
- Grid Protocols are built over TCP/IP, where as SATCOMS are principally UDP based:
  Extensions to be done
- STAR Topology: GRID protocols assumed meshed topology, where as most of the SATCOMs are Pseudo Star
- Security: Signal is beamed down, highly susceptible for hacking / Jamming

SATCOMS for GRIDs

- Why Use SATCOM?
- Good Coverage
- Efficient Broadcast/Multi Cast
- Reliability
- Decent Bandwidth if managed well

ISRO's Missions Indian Communication Satellite systems

- INSAT : TV broadcasting
- HealthSat : TELE MEDICINE
- EduSat : TELE EDUCATION

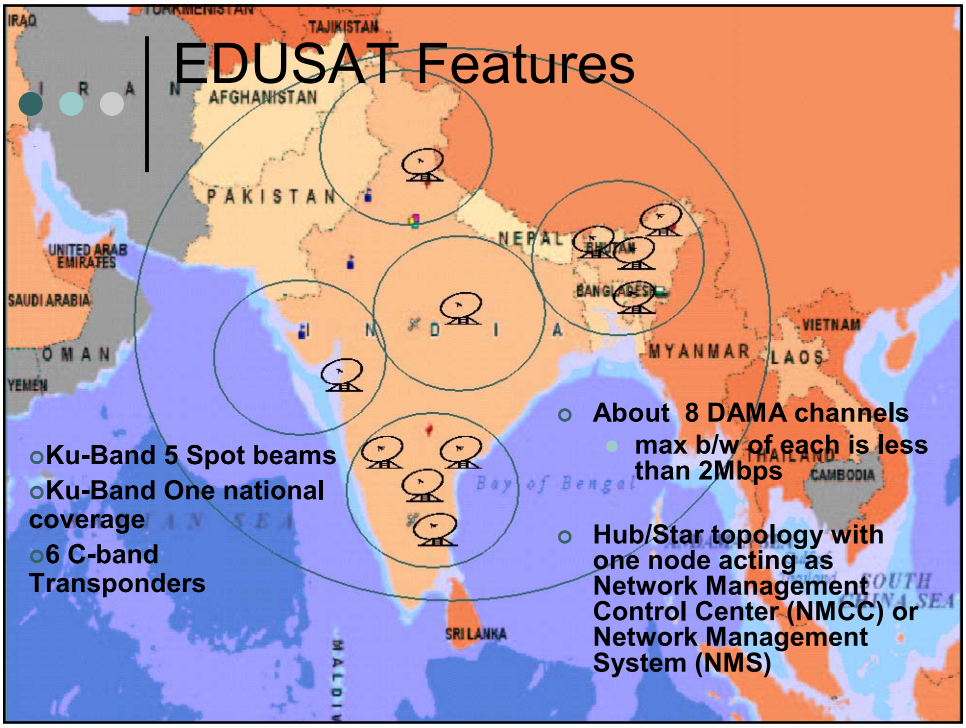
- EduSat/HealthSat although meant for Tele-education telemedicine they provides the Infrastructure required for GRID computing

- Virtual Labs can be created.

Network Topologies in SATCOM and capabilities

- Typical Transponder Capacity is 36MHz
  - @ 8PSK amounts Approx. 105 Mbps One way.
- Compromise between number of channels and bandwidth.
  - More Channels less bandwidth
- Generally Two type of Usage is possible
  - If requirement is more number of users and less cost
    - STAR(EDUSAT): Double Hop, TDMA, Low bandwidth, Large numbers, Minimum Cost
    - DAMA is preferred
  - If requirement is High bandwidth and limited users – Military apps
    - Mesh: Single Hop, FDMA, High Bandwidth, Limited users, Higher cost, complex NMS/NMCC
    - DAMA is preferred

EDUSAT Features



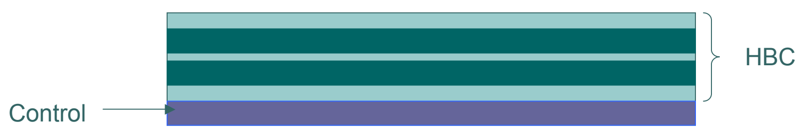
- Ku-Band 5 Spot beams
- Ku-Band One national coverage
- 6 C-band Transponders

- About 8 DAMA channels
  - max b/w of each is less than 2Mbps
- Hub/Star topology with one node acting as Network Management Control Center (NMCC) or Network Management System (NMS)

SAT System for High bandwidths

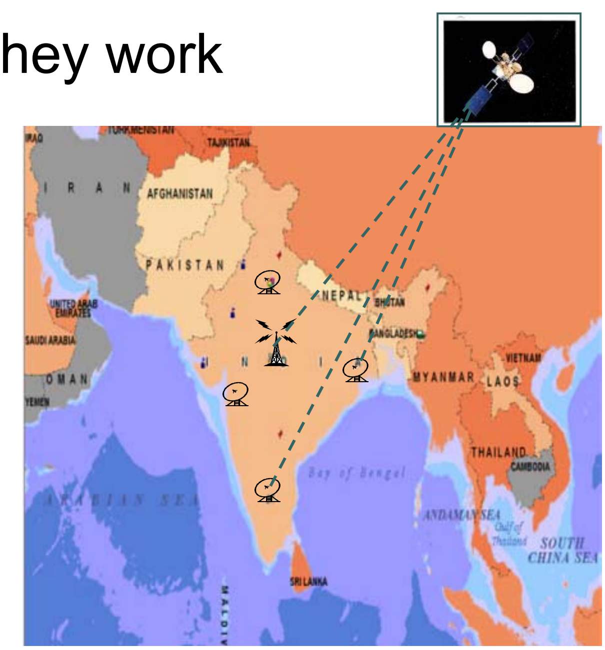
Military/High Bandwidth Usage

- Limited Users
- High bandwidth
- Role of NMS is critical
- One High Bandwidth channel (SCPC)
- One Control channel fully mesh
- Optional DAMA pool



How they work

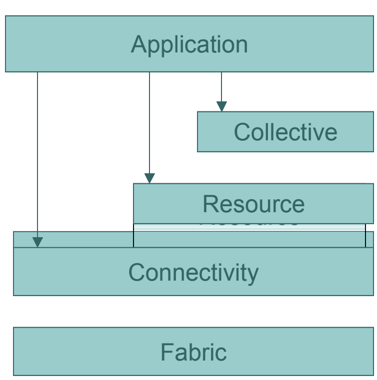
- User Request for a channel
- NMS schedules and allocates channel partial or complete (DAMA pool)
- Activation of Carrier or B/W allocation
- Deactivation of carrier



Link as a resource

- If NMS has DAMA pool then allocation of b/w becomes a KNAPSACK problem
- You cannot allocate as and when the requirement comes up.
- Pool the requests and schedule the channel(s)

Globus Grid Architecture



Information services

Apart from compute/storage Link also
Becomes a resource

Security : Grid Security Infrastructure
Channel Allocation/de-allocation
Link Accelerators: XTP, UDT

Grid Protocols

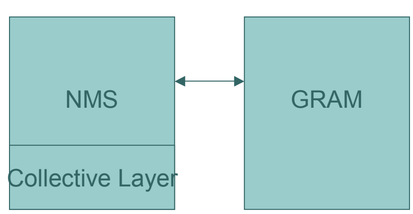
- Connectivity Layer: Security and communication
  - No change in the GSI design suggested
  - Link accelerators, NMS interactions for b/w allocation and de-allocation required. This may be pushed to resource layer also
  - TCP/IP Protocols may be extended to UDP, XTP,UDT may be extended to

- Resource Layer: Link also to be considered as a resource
  - Resource Management: Link aware management is required
  - Data Transfer: Since only one channel is provided GridFTP requires changes

- Collective Layer: Brokers, Replica catalogues
  - Brokers also require changes

Resource Management

- If High speed channel or places where only satcom is proposed to be used then
  - GRAM, GRIP and NMS have to be integrated.



- In hybrid networks the GRID architecture holds good but local schedulers should model the link resources also

Scheduler : Key concerns

- Dynamic State of the cluster:
  - No a-priori knowledge about the incoming/outgoing tasks/nodes.
- Heterogeneous resources:
  - Heterogeneous environment thus varying processing capability.
- Job/Task characteristics cannot be predicted
  - Each Job may be different from others, Some are ‘int’ operation oriented, some are ‘float’ and like wise.
- Dependency: Each job is scheduled independently, this may cause problems to next job in the queue. This may lead to chaining/cascade effect.
- Sometimes scheduling one or two jobs on sub-optimal resource may increase the overall throughput.
- Similarly stopping a job in between and starting afresh on another node would be beneficial

Above discussed issues result in a requirement of scheduling complete group of jobs on hand together in total.

FRM Scheduler*

- Why Fuzzy Logic for RM
  - A job requirement (Resource requestor Ad) may/may not meet all the resource requirements available on a given node (Resource Provides Ad)
  - Hence Model these resources as fuzzy functions
  - The extent to which a job can be executed on a node

	N1	N2	N3	N4
J1	0.7	0.8	0.2	0.5
J2	0.4	0.9	0.8	0.7
J3	0.5	0.6	0.5	0.4

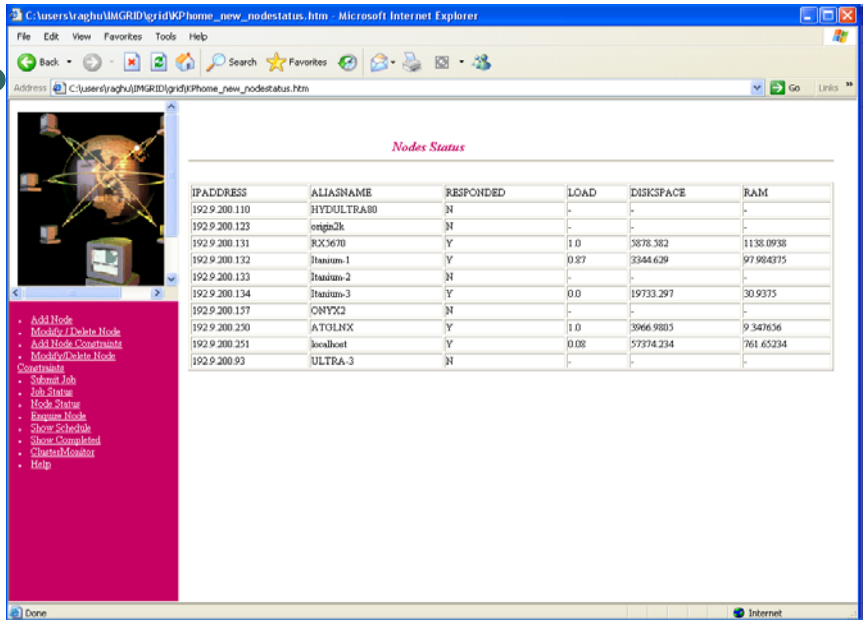
* Work Appeared in CCGRID-2004

GRID Model using SATCOM suggested for IP Applications being discussed

- **64 Itanium-2 CPUs**
- **High Bandwidth mode usage of SATCOM**
- **DAMA preferred**
- **Link Accelerators**
- **XTP instead of TCP/IP**
- **FRM SCHEDULER ay NMS**

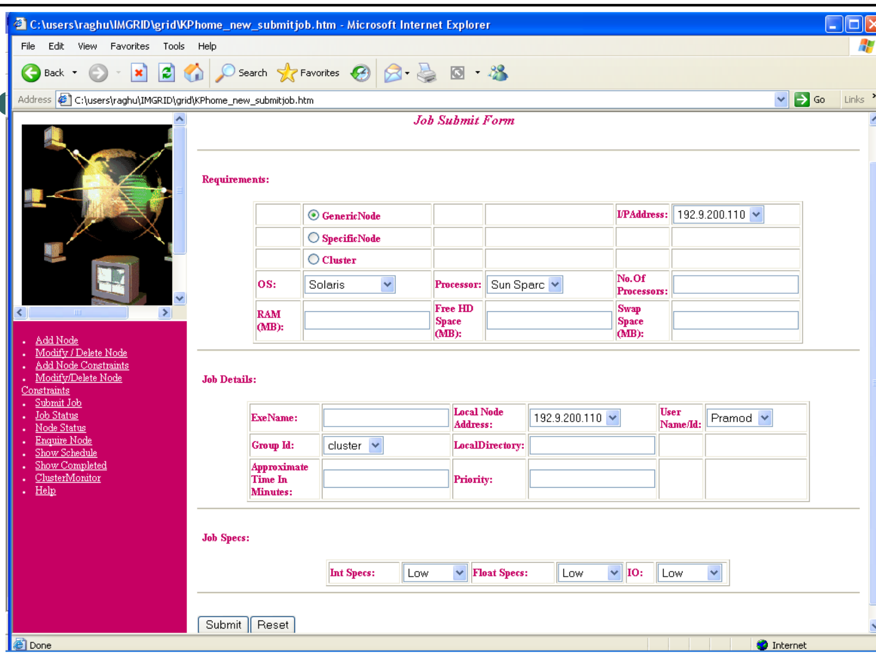
FRM Scheduler

- Collect the dynamic state of each node and sends it to NMS (MDS)
- Collect the Requirements/Results of the user applications
- Make the schedule using FRM scheduler
- Communicate to NMS
- NMS allocates bulk channels
- Get the channels or bandwidth allocated
- Send Job and data or Results

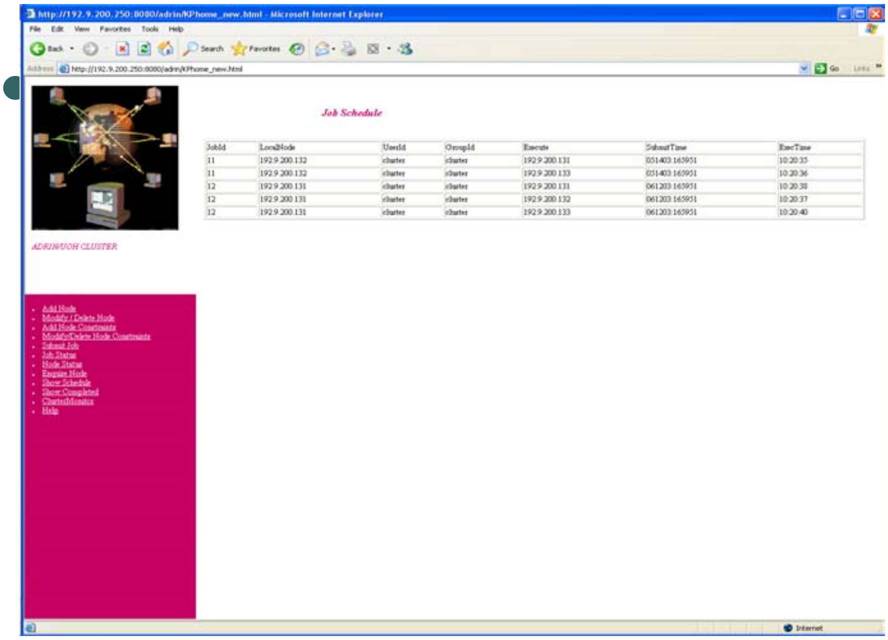


IPADDRESS	ALIASNAME	RESPONDED	LOAD	DISKSPACE	RAM
192.9.200.110	HYDULTRA80	N	-	-	-
192.9.200.123	origin2k	N	-	-	-
192.9.200.131	RX5670	Y	1.0	5878.582	1138.0938
192.9.200.132	Itanium-1	Y	0.87	3344.629	97.984375
192.9.200.133	Itanium-2	N	-	-	-
192.9.200.134	Itanium-3	Y	0.0	19733.297	30.9375
192.9.200.157	ONYX2	N	-	-	-
192.9.200.250	ATGLNX	Y	1.0	3966.9805	9.347656
192.9.200.251	localhost	Y	0.08	57374.234	761.65234
192.9.200.93	ULTRA-3	N	-	-	-

Nodes Status in the cluster



Submitting a job



Scheduled Jobs in the cluster

Applications

- Satellite Data Processing Applications
  - Image Processing: Improving radiometry (visual quality)
  - Rectification/Registration: Improving geometric accuracy
  - Automatic Target Recognition systems
  - …
- Data Volumes
  - Previous generation : 10 to 5m resolution and one/two satellite systems
  - Present : < 1m res, more than 10 satellite systems
  - Volume of data to be analyzed has grown phenomenally from < 1GB to more than 100GB per day

Grid Applications and Model adopted

APPLICATIONS

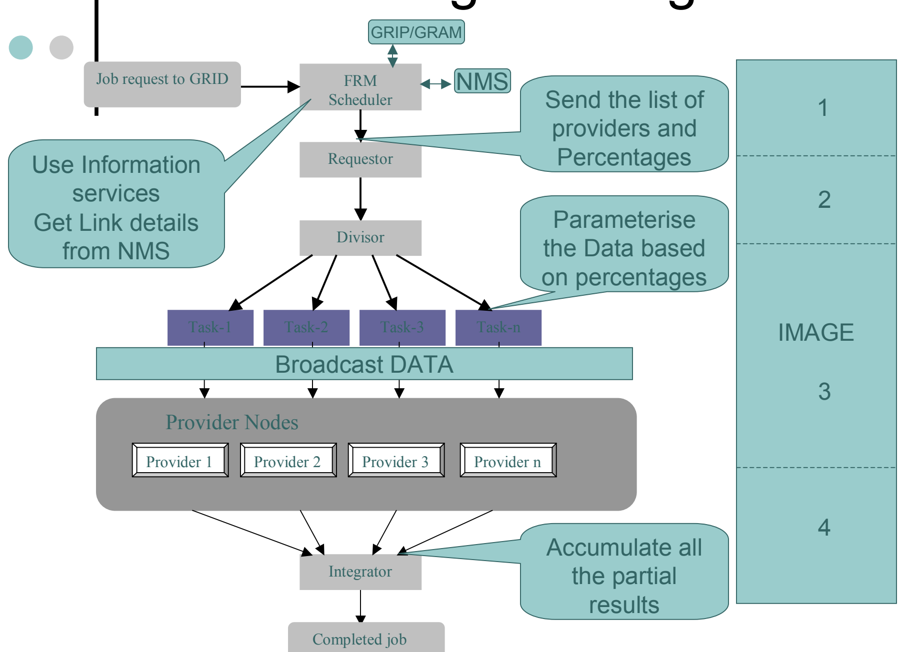
- Image Enhancements
- Image Matching/DEM
- Automatic Feature Extraction
- Image Quality determination
- Knowledge Based System : Tele Medicine

All the applications are Data Parallelizable

MODEL

- SPL/MD: Single Program Large to Multiple Data Model

SPL/MD Programming Model



SPL/MD contd …

- SPL/MD is better than Parametric model if the volumes of data is large
- High Throughput Model used to achieve High performance
- SATCOM can be effective/optimal compared to terrestrial for SPL/MD and SPMD

Image Enhancements

- **Speckle Reduction based on MAP reconstruction and optimization by Simulated Annealing**

Timelines on a single node machine with sequential Processing

- For 200 iterations on 1MB file takes 219 minutes on a single processor machine
- For complete scene (60MB) takes more than 180 hours i.e., 6-7 days.

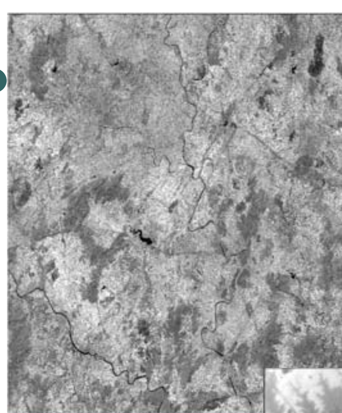
Results

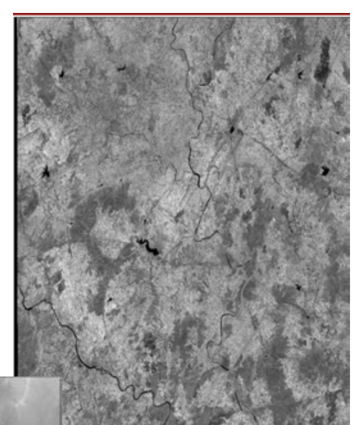
No of CPUs /Iterations	5 Time (MIN.)	100 Time (MIN.)	200 Time (MIN.)
1	4.11	102.08	**206.80**
2	2.06	51.28	103.67
3	1.36	35.66	69.55
4	1.03	25.76	52.20
5	0.83	20.61	41.46
6	0.73	17.28	35.70
7	0.58	14.78	29.65
8	0.51	13.00	**26.23**

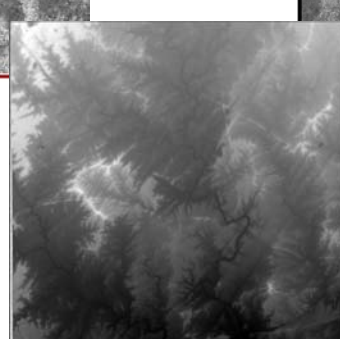
- If we use proposed GRID it would reduce to less than 4 hours

IMAGE MATCHING

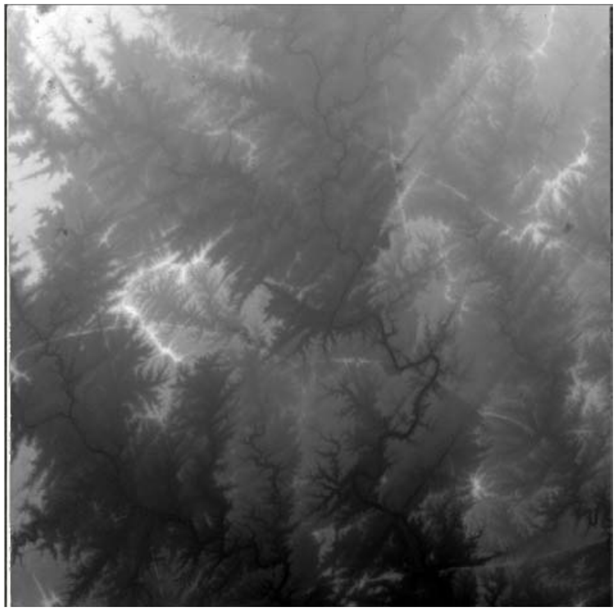
- Construction of Digital Elevation Model
- Generating Precision Maps
- Best Maps nation wide are 1:25000 i.e., 10m contour intervals
- With new generation satellites (CARTOSAT-1, 2.5m stereo) better DEMs can be constructed, 1:10000 with 5m contour intervals
- Matching Process is computationally expensive
  - Previous generation machines 15000 point/min
  - Present generation m/cs with optimizations more than 5000 points/sec i.e., **$3X10^5$ Points/min**







High Quality DEMs Can be constructed



Change Detection

Results
Scene size of 12000X12000 pixels

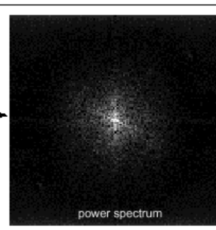
- Single Itanium-2 processor takes 6010 secs
- On a 4 node GRID it takes 1766 secs

- For a complete scene 12KX200K pixels more than a day (28 hours)
- With the GRID it would take less than an hour.

National Image Interpretability Rating Scales (NIIRS)

- **IQM Approach:**
  Obtain Quality from Image Power Spectrum

→



→

1) Normalize PS
brightness
image size
2) Weight PS
Vision Filter
Noise Filter
Directional Scale
3) Sum Power

→

Image Quality Measure

$$\mathbf{IQM} = \frac{1}{M^2}\sum_{\theta}\sum_{\rho} S(\theta_i)\ W(\rho)\ A^2(T\rho)\ P(\rho,\theta)$$

M^2 = digital image size in pixels
$S(\theta_i)$ = directional image scale parameter
$W(\rho)$ = modified Wiener noise filter
$A^2(T\rho)$ = MTF of human visual system (T=constant)
$P(\rho,\theta)$ = brightness normalized image power spectrum
ρ,θ = spatial frequency in polar coordinates

Examples Criterion per NIIRS Level

NIIRS	Interpretability
0	Interpretability of the imagery is precluded by obscuration or very poor resolution
1	Detect a medium size port facility
2	Detect large buildings.
3	Detect trains or strings of rolling stock on railroad tracks.
4	Identify individual tracks, rail pairs, control towers, switching points in rail yards.
5	Identify individual railcars by type.
6	Identify automobiles as sedans or station wagons.
7	Identify individual rail ties.
8	Identify windshield wipers on vehicles.
9	Detect individual spikes in railroad ties.

National Image Interpretability Rating Scales (NIIRS)

SPOT Image

Predicted Visual Quality – 1.7

IRS-1D Image

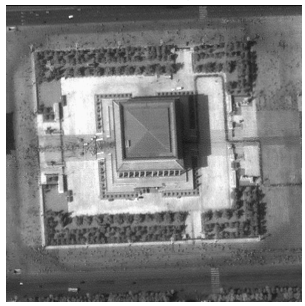
Predicted Visual Quality – 2.5

National Image Interpretability Rating Scales (NIIRS)

IKONOS Image

Predicted Visual Quality – 5.5

IKONOS Image

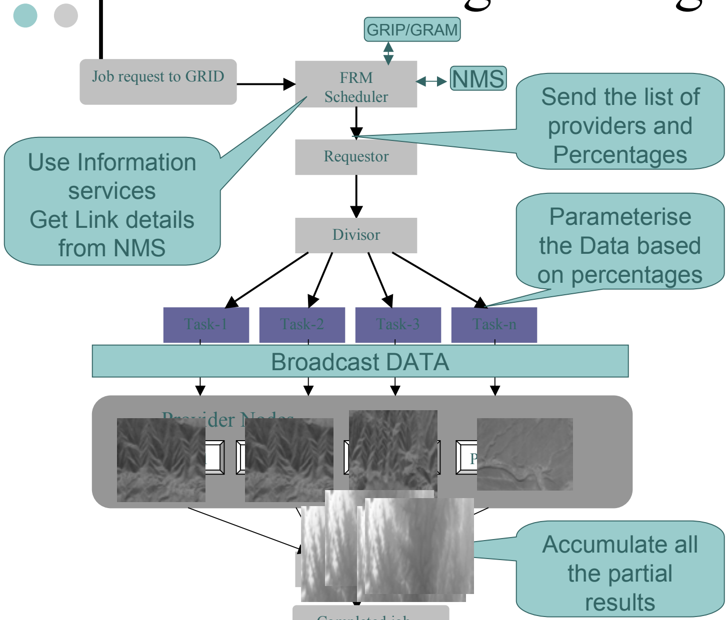


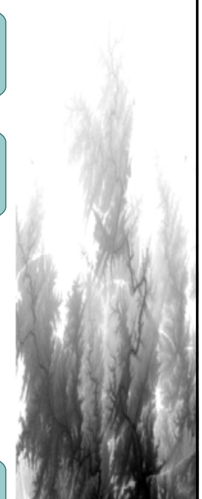
Predicted Visual Quality – 5.9

Aerial Image

Predicted Visual Quality – 7.2

SPL/MD Programming Model





SPL/MD Issues is confined to

- Design of Divisor
- Design of Integrator

- Unlike recoding the entire app in parallel model.

Conclusion

- SATCOMs have wider reach and hence can connect many resources, thus can form a bigger Grid
- Lot of research opportunities exist in this field
  - Protocol level
  - Resource Management Level
  - Security Level
- Today all the applications are data intensive and hence demand large bandwidth
- If Link is optimally utilized and, NMS and Resource Management Layer of GRID can seamlessly talk then Applications can benefit
- SPL/MD seams a promising model for data centric applications, especially for SATCOMs considering the broadcast and multicast features of SATCOM

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Thank You

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