



GMRES Method on Lightweight GRID Systems

Haiwu HE

Guy BERGERE and Serge PETITON

LIFL ,USTL, INRIA Grand-Large Project,France

A decorative graphic consisting of overlapping yellow, red, and blue squares with a black crosshair.

Plan

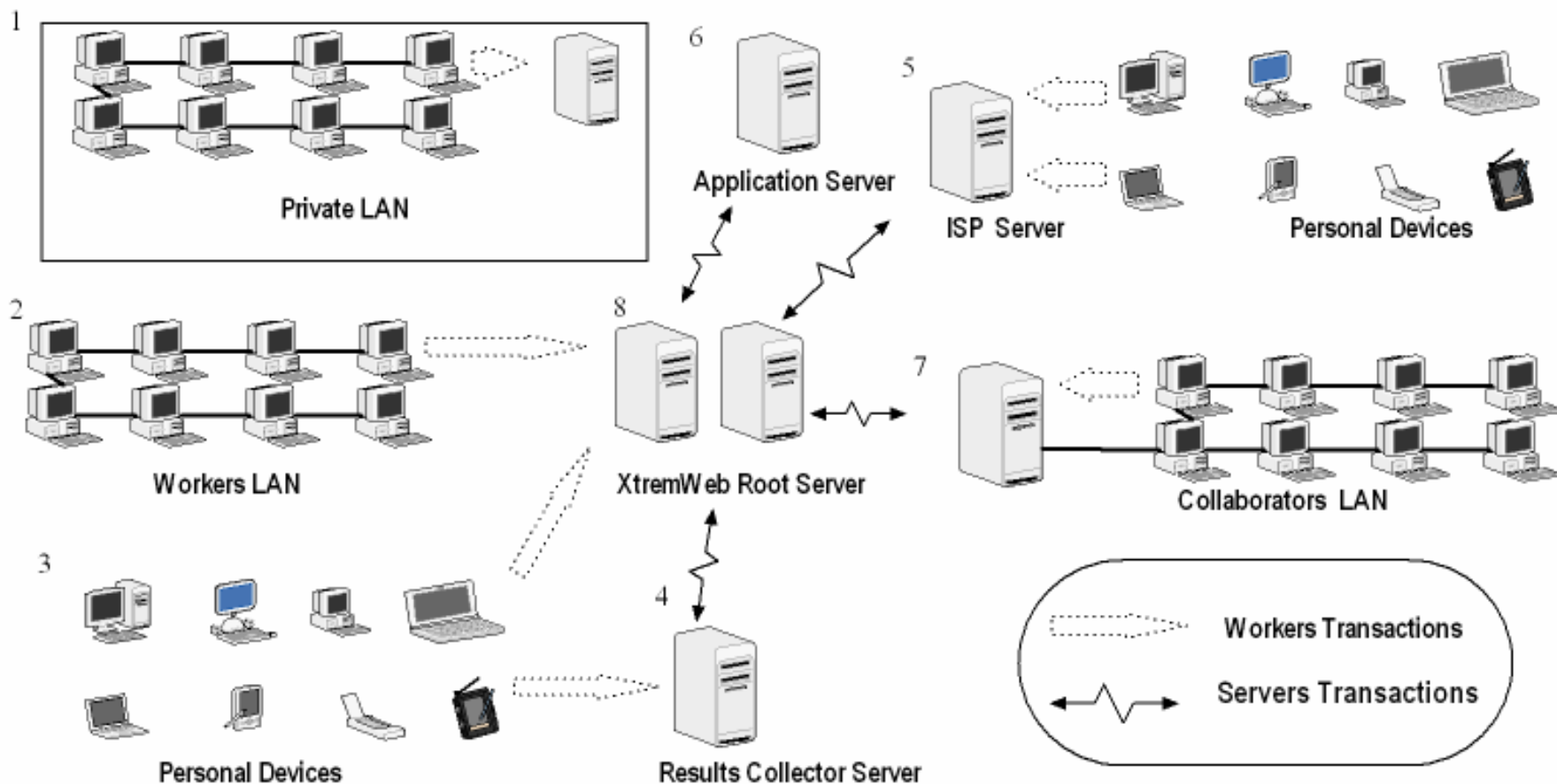
- Introduction
- XtremWeb GRID System
- GMRES(m) Algorithm Adapted To XtremWeb
- Numerical Results and Analysis
- Conclusion



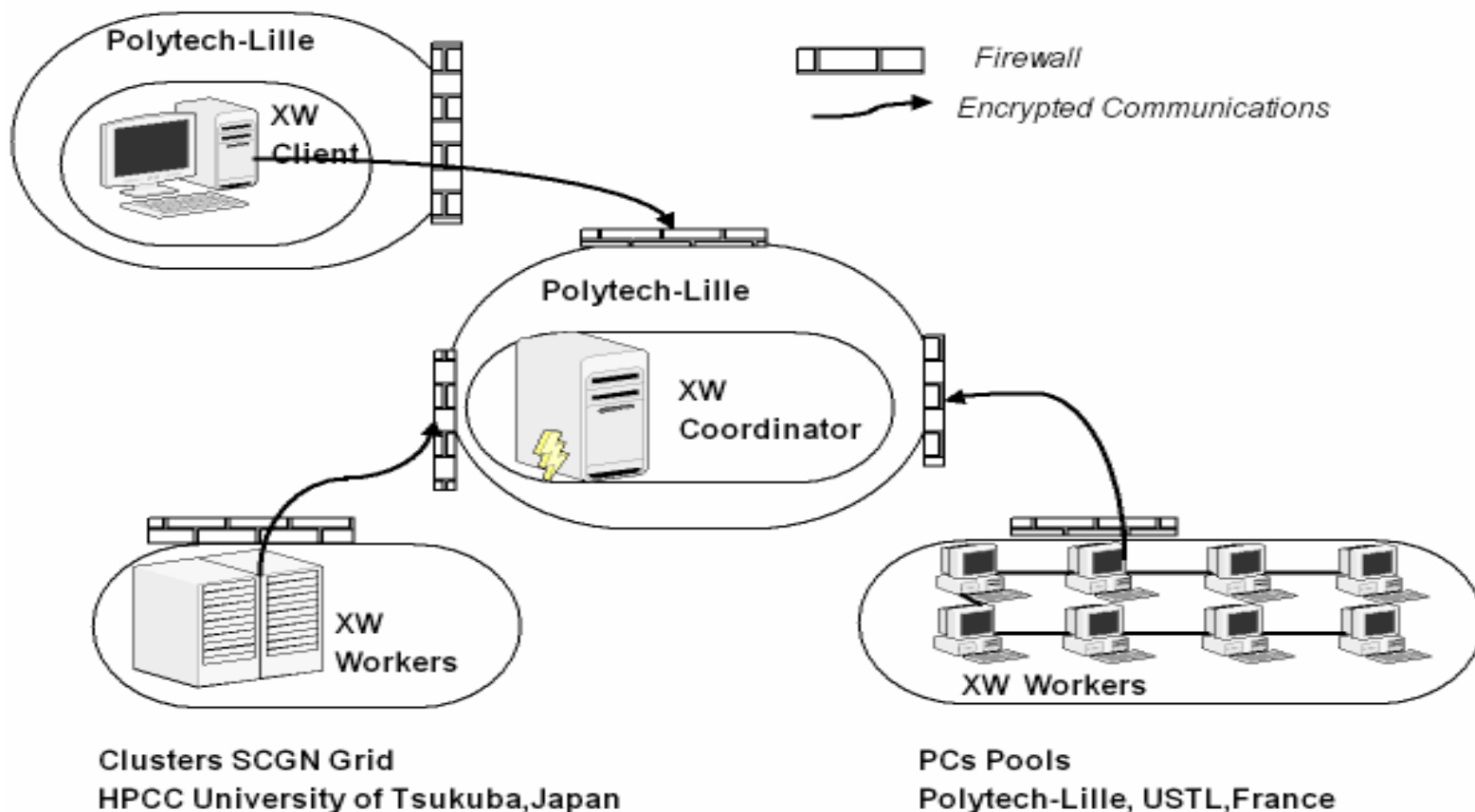
Introduction

- Global Computing System XtremWeb
 - Study execution models
 - Cycle stealing scheme
 - Multi-parameters applications
- LAM-MPI
 - MPI programming environment
 - MPI development system
 - A widely used MPI implementation
- GMRES(m) Method
 - A classic iterative method GMRES
 - GMRES(m) improved sparse matrices

XtremWeb Grid System 1



XtremWeb Grid System 2



GMRES(m) Method

1. Start: choose x_0 an initial guess of the solution,

m the dimension of Krylow subspaces, and ε the tolerance,

compute $r_0 = b - Ax_0$.

2. Apply Arnoldi process to $K_m(A, r_0)$.

3. Compute $y_m = \operatorname{argmin}_{y \in \mathbb{R}^m} \|\beta e_1 - \overline{H}_m y\|_2$ with QR

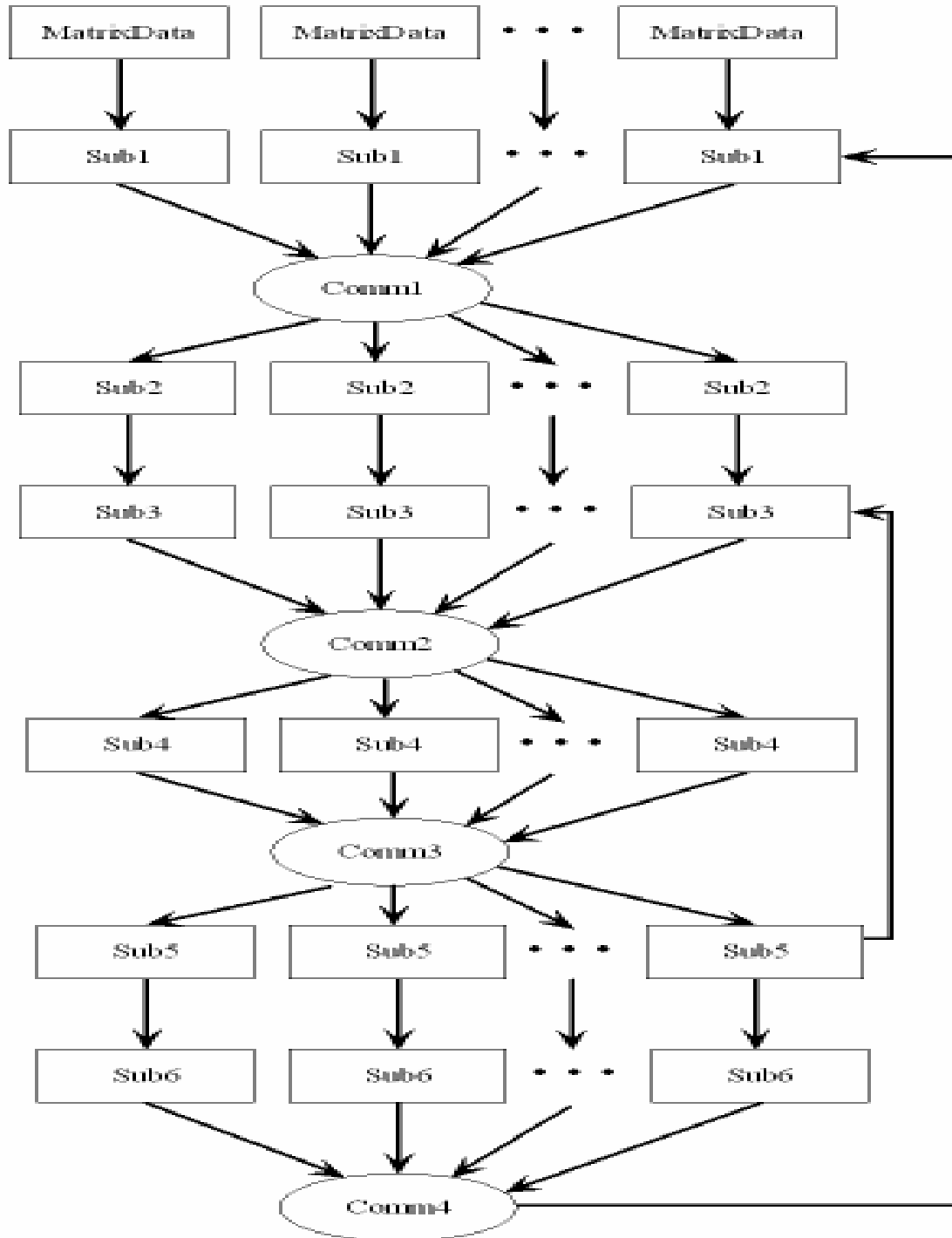
factorization, and set $x_m = x_0 + V_m y_m$.

$r_m = b - Ax_m$.

4. Restart: if $\|r_m\|_2 \leq \varepsilon$ stop

else set $x_0 = x_m, r = r_m$, and goto 2

and set $x_m = x_0 + V_m y_m, r_m = b - Ax_m$.



Initialization

Read/Generator data of Matrix

GMRES Iteration Cycle :

Calculation of residual vector locally

Reconstruction of whole residual vector
Test of convergence

Normalization

Cycle of GMRES (m) :

Filling the column j of H locally

Reconstruction of whole H_j

Calculation of local $V(:,j+1)$

Reconstruction of whole vector $V(:,j+1)$

Normalization

End of Cycle GMRES(m)

Least Square
Calculation of local result

End of GMRES iteration Cycle

Numeric Results and Analysis

XtremWeb Network Configuration

Local configuration in Lille (128 PCs)		
Number	CPU	Memory
28	Pentium III (Katmai), 450MHz	128MB
28	Intel Celeron, 2.2GHz	512MB
23	Intel Celeron, 2.4GHz	512MB
15	AMD Duron, 750MHz	256MB
14	Celeron (Coppermine), 600MHz	128MB
8	Intel Celeron, 2GHz	512MB
8	Intel Celeron, 1.4GHz	256MB
4	Pentium 4, 2.4GHz	512MB
WAN configuration in Tsukuba (3 Clusters)		
Number of Node	CPUs of node	Memory per node
15	Dual P4 Xeon 3065MHz	1GB
10	Dual Athon 1533MHz	882MB
8	Quad P3 450MHz	2GB

Numeric Results and Analysis

Variety of Gird platform

DA20000 WITH 15 WORKERS on LAN

(N=20000,NZ=20000*20000 Lille, with Generator,4 executions)

Computing Time (CPU Time)	24.87s	21.96s	22.78s	6.93s
Computing Time (Coordinator)	4390.64s	1958.84s	2624.44s	591.02s
Communication Time	1029.46s	1028.54s	1027.02s	1024.62s
Total Time	5420.10s	2987.38s	3651.46s	1615.64s

Numeric Results and Analysis

Importance of matrix storage

MatrixVP1E05 WITH 10 WORKERS ON WAN (Tsukuba)
 (M(GMRES)=30, Iterations=5, 3730 Jobs)

	With Data File	With Generator
CPU Time	2.71s	2.89s
Computing Time (Coordinator)	33223s	26252s
Communication Time	61947s	55482s
Total Time	95170s	81734s

Numeric Results and Analysis

Difference of Network

DA10000 of XtremWeb of LAN Lille (N=10000, NNZ=10000*10000, M(GMRES)=8,Iterations=3,Generator)

	nW=5	nW=10	nW=20	nW=25
Jobs	400	800	1600	2000
CPU Time	4.88s	2.51s	1.39s	1.10s
Total Time	894.10s	863.71s	1394.23s	1696.73s

DA10000 of XtremWeb of WAN Tsukuba (N=10000, NNZ=10000*10000, M(GMRES)=8,Iterations=3,Generator)

	nW=5	nW=10	nW=20	nW=25
Jobs	400	800	1600	2000
CPU Time	2.59s	1.31s	0.76s	0.61s
Total Time	1793.47s	1059.51s	1581.55s	1760.57s

Numeric Results and Analysis

Test of Matrix ADD200 on XtremWeb

Convergence Result of Matrix ADD200 on WAN

(Tsukuba, Data File)

	nW=4	nW=10	nW=20	nW=30
Jobs	6124	15310	30620	45930
CPU Time	1.71s	1.28s	1.10s	1.01s
Computing Time (Coordinator)	25115s	20017s	21613s	27607s
Communication Time	13402s	15018s	26351s	37827s
Total Time	38517s	35035s	47964s	65434s

Numeric Results and Analysis

Test of VP100000 on XtremWeb

Convergence Result of VP100000 with 10 workers on WAN
(Tsukuba, Data File)

	M=10	M=15	M=20	M=30
Iterations	15	9	7	5
Jobs	4630	4330	3790	3730
Computing Time (Coordinator)	33185s	29027s	30340s	33223s
Communication Time	53960s	49404s	54265s	61947s
Total Time	87145s	78431s	84605s	95170s

Numeric Results and Analysis

Test of DA10000 on XtremWeb & LAM-MPI

DA10000 of XtremWeb of LAN Lille (N=10000, NNZ=10000*10000, M(GMRES)=8,Iterations=3,Generator)

	nW=5	nW=10	nW=20	nW=25
Jobs	400	800	1600	2000
CPU Time	4.88s	2.51s	1.39s	1.10s
Total Time	894.10s	863.71s	1394.23s	1696.73s

DA10000 of LAM-MPI of LAN Lille (N=10000, NNZ=10000*10000, M(GMRES)=8,Iterations=3,Generator)

	nP=5	nP=10	nP=20	nP=25	nP=40
CPU Time	8.94s	2.88s	1.95s	1.25s	0.67s
Communication Time	6.09s	4.73s	4.45s	3.84s	12.25s
Total Time	15.03s	7.61s	6.40s	5.09s	12.92s

Conclusion

- XtremWeb
 - Large-scale, good fault tolerance, low cost
 - Scheduling to improve, central management=bottleneck
- LAM-MPI
 - Good performance, inexpensive
 - Fault tolerance weak

A decorative graphic in the top-left corner consisting of overlapping yellow, red, and blue squares with a black crosshair.

Thank you!

Merci!