The 3rd BG/L Sytems Software and Applications Workshop

Large scale structural analysis using ADVC on Blue Gene

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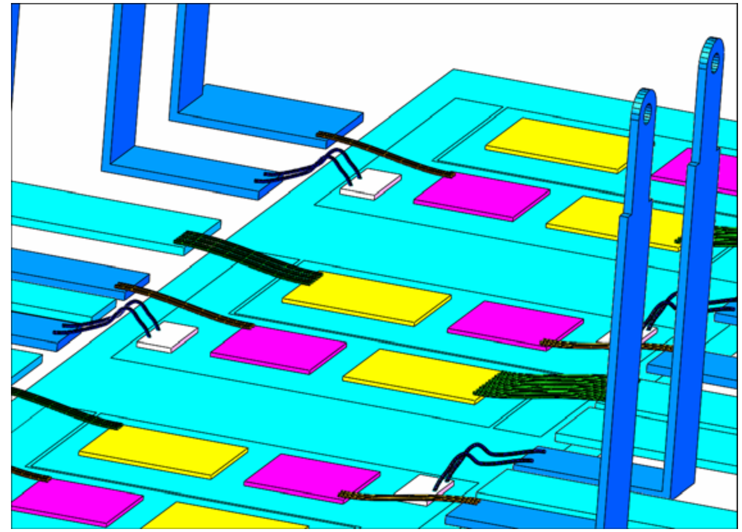
Hiroshi AKIBA
Allied Engineering Corporation

Background

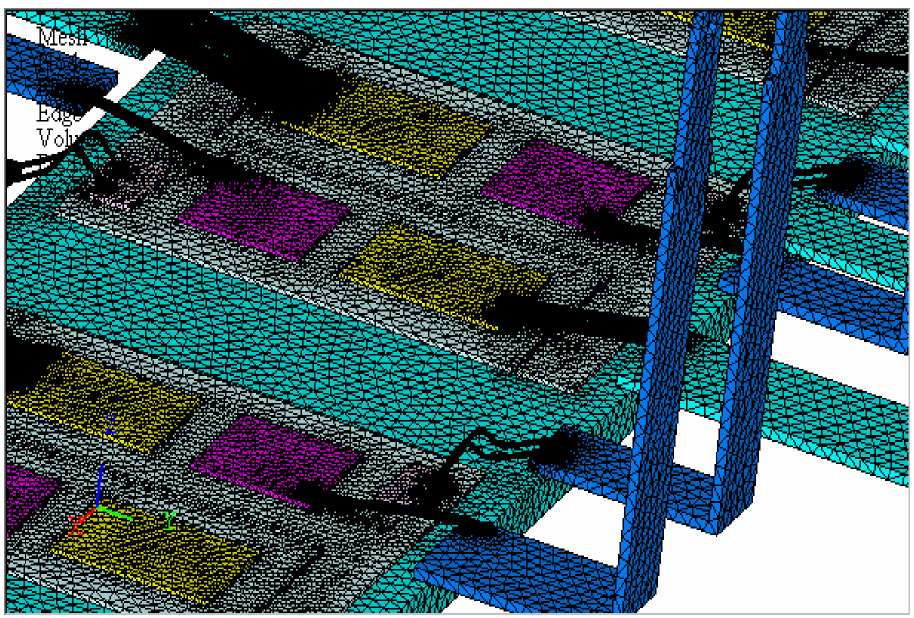
- Large scale analysis is needed in classical CAE field
- Existing CAE systems do not seem to show good performance on parallel computer systems
- We have developed a commercial parallel structural FEA code ADVC
- We are cooperating with NIWS Co. Ltd. and IBM Corporation as to BG/L
- BG/L is one of the best environment to make an evaluation of parallel performances of ADVC

Real products need detailed analysis

Wire bondings of real product

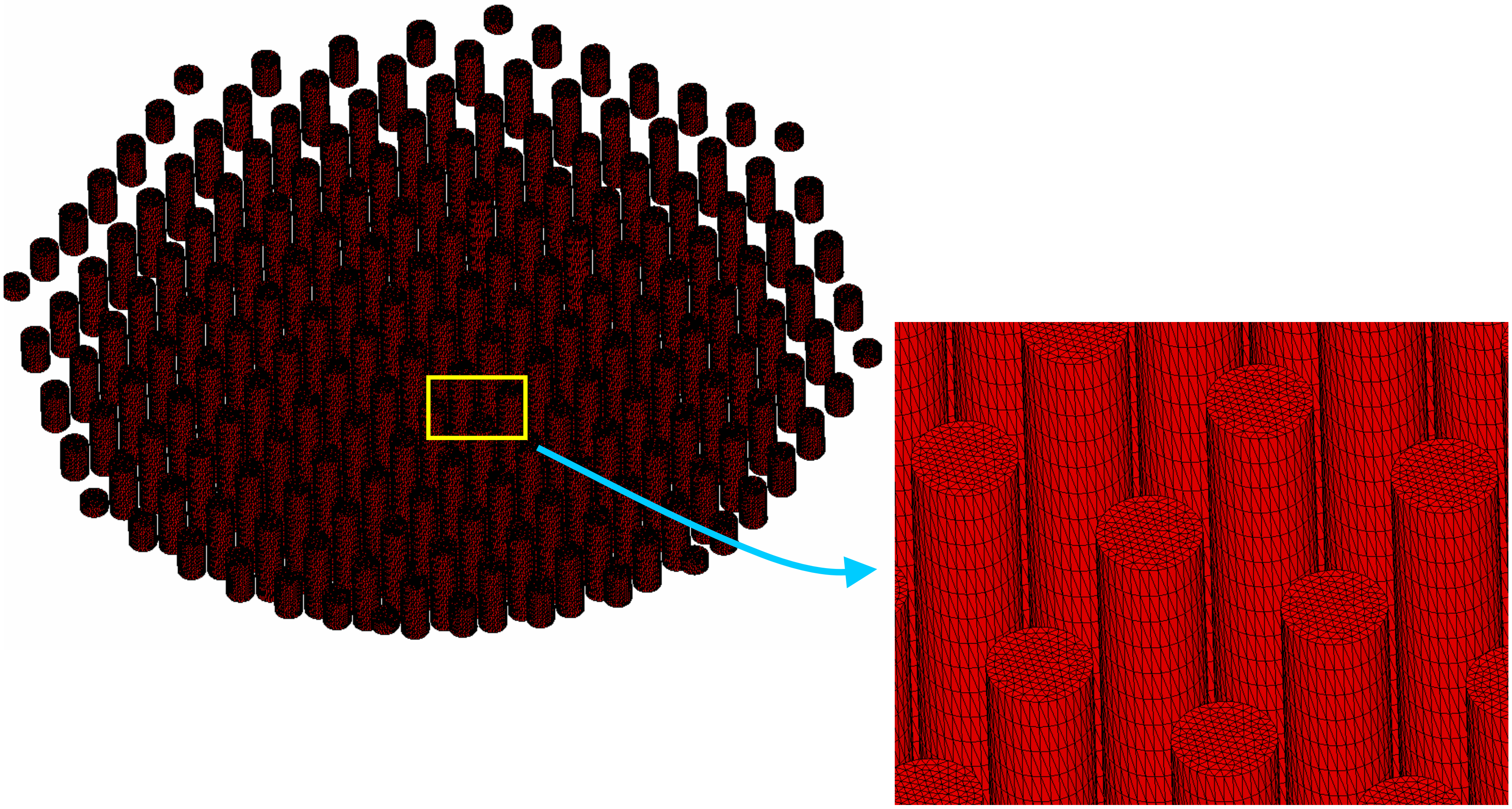


CAD



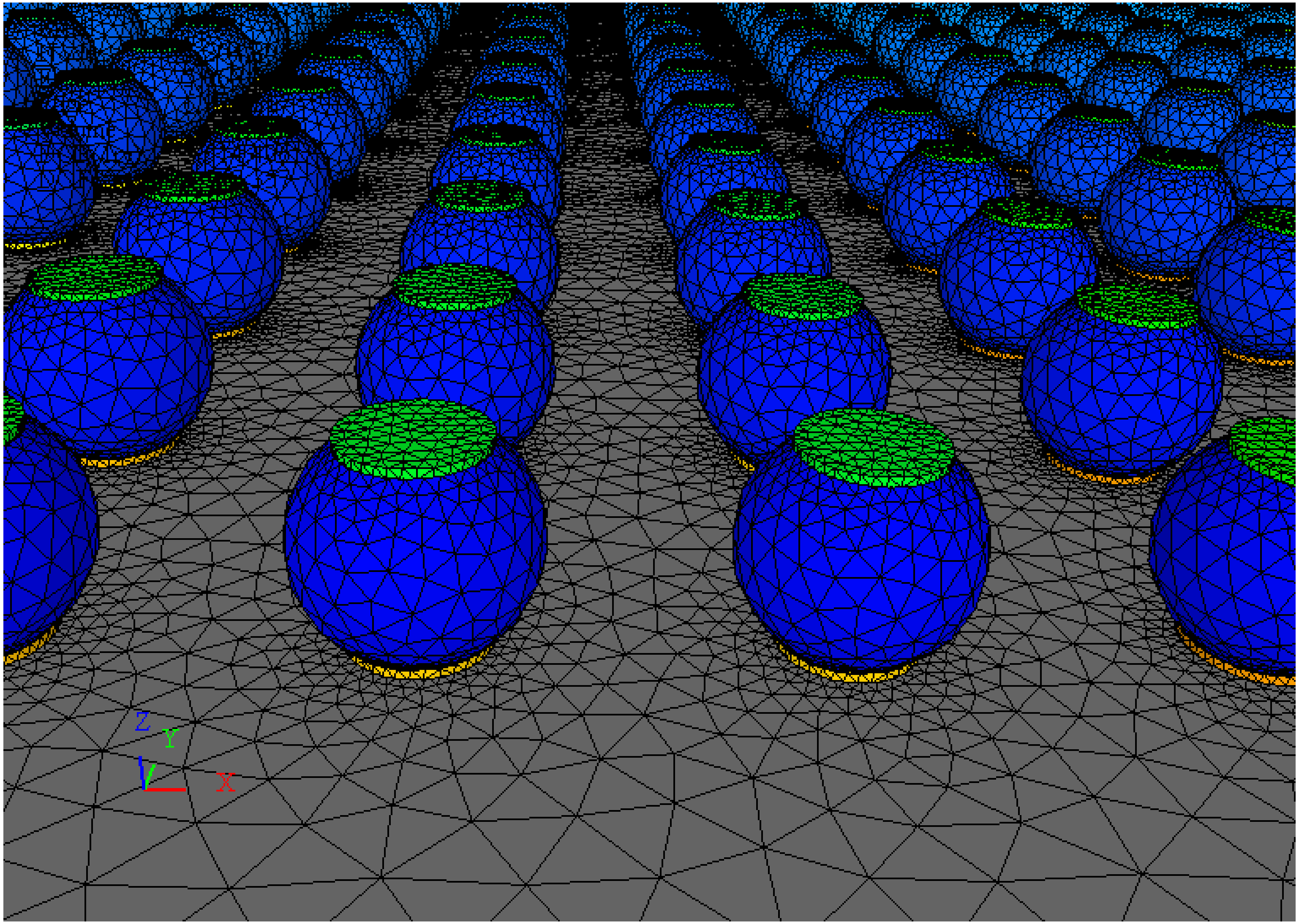
Generated mesh

Industrial products are composed of a large number of components

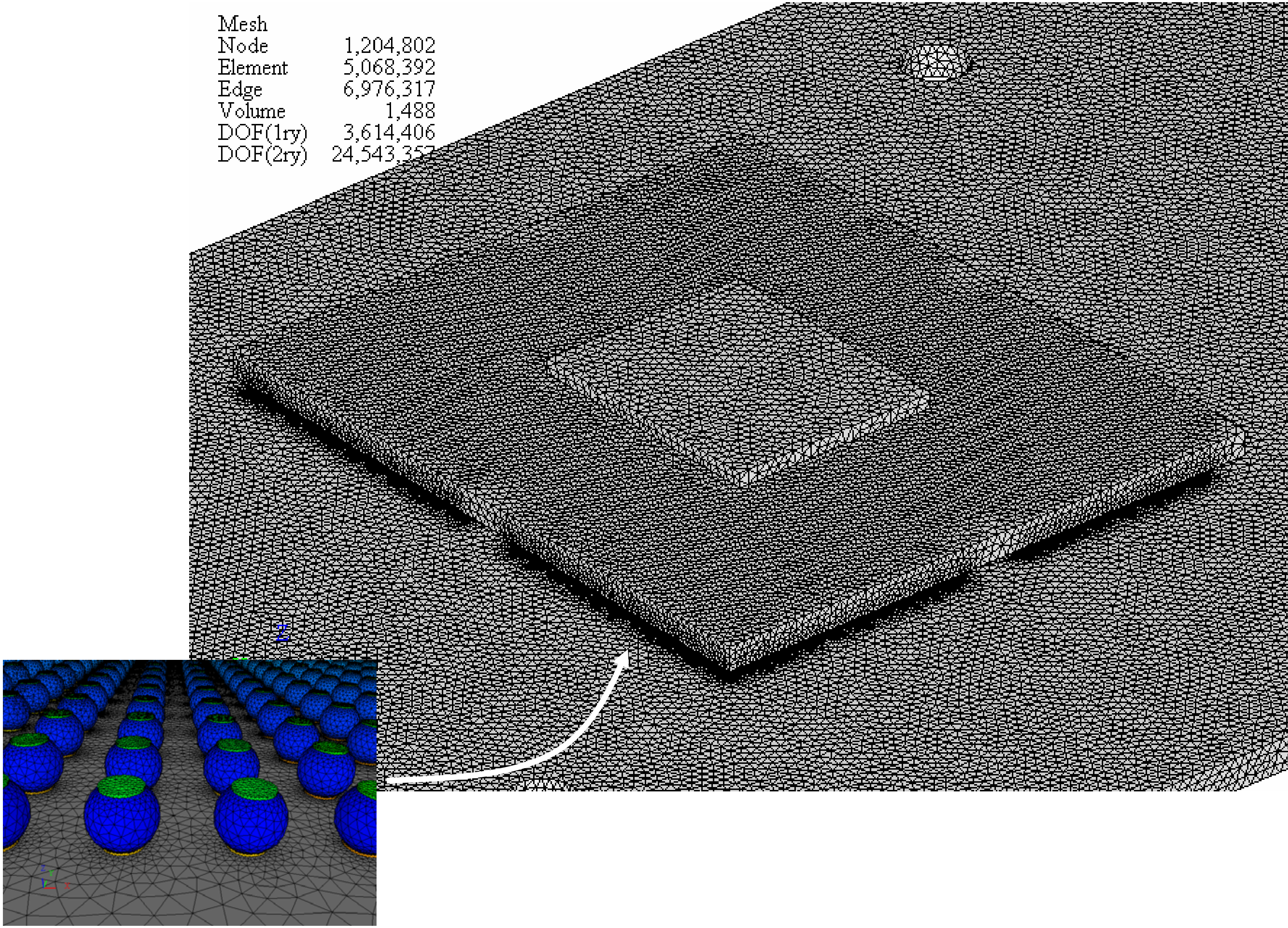


Industrial products are composed of a large number of components

—— Solder balls



Model of industrial products is getting larger

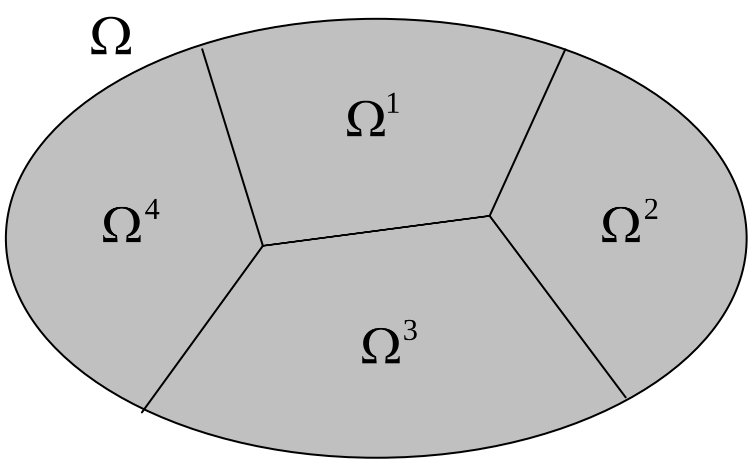


Domain Decomposition Method

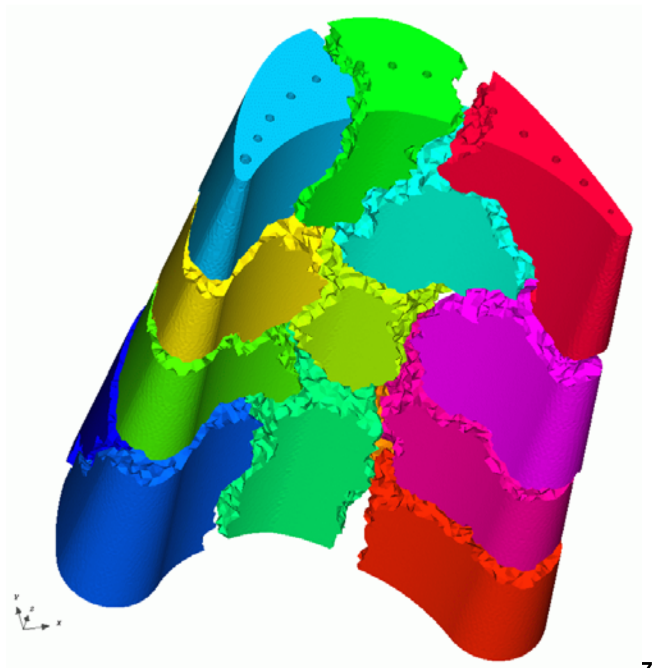
- Analysis object : Ω
- Governing global equation :

$$Ku = f$$

- The space of DOF u: V
- Ω is decomposed into subdomains Ω^I
- The domain decomposition induces decomposed subspaces V^I of V



$$\begin{array}{ccc} \Omega & \text{—} & V \\ | & & | \\ \Omega^I & \text{—} & V^I \end{array}$$



General algorithm for large global equation

- Stiffness equation is solved by a preconditioned CG method

$$GKu = Gf$$

where G is a global precondition matrix

- G can be represented in the form:

$$G = \sum_I G^I$$

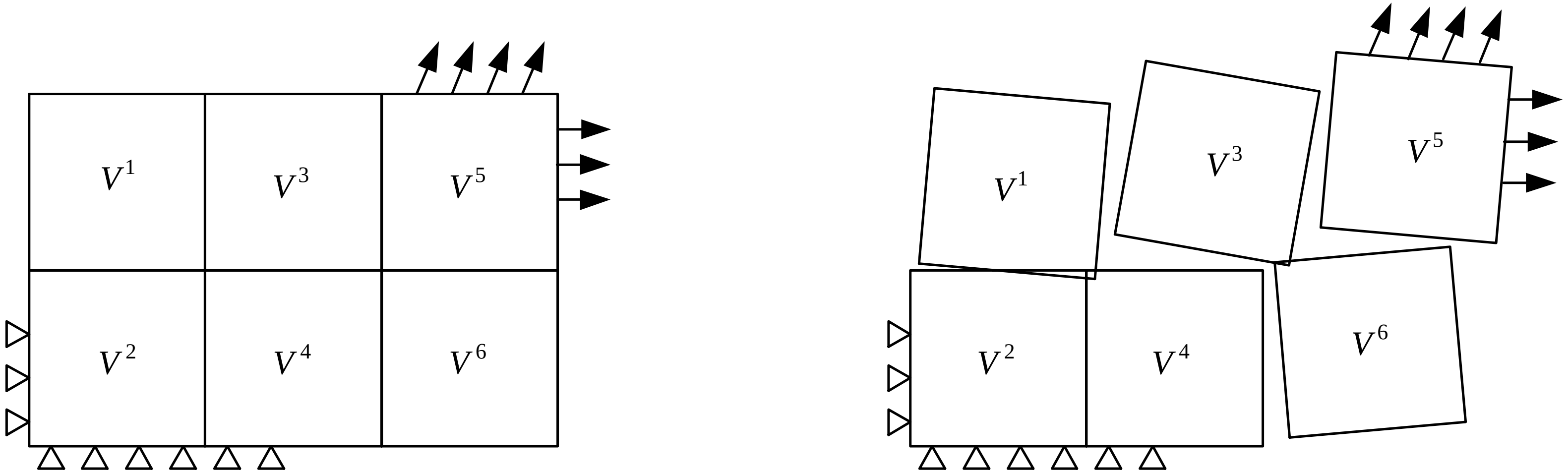
where G^I corresponds to the subspace V^I

- Variation exists corresponding to the framework of the iteration method and choice of the precondition matrix

$$\begin{tikzcd}
\Omega \arrow[r, dash] \arrow[d, dash] & V \arrow[r, leftrightarrow] \arrow[d, dash] & G \arrow[d, dash] \\
\Omega^I \arrow[r, dash] & V^I \arrow[r, leftrightarrow] & G^I
\end{tikzcd}$$

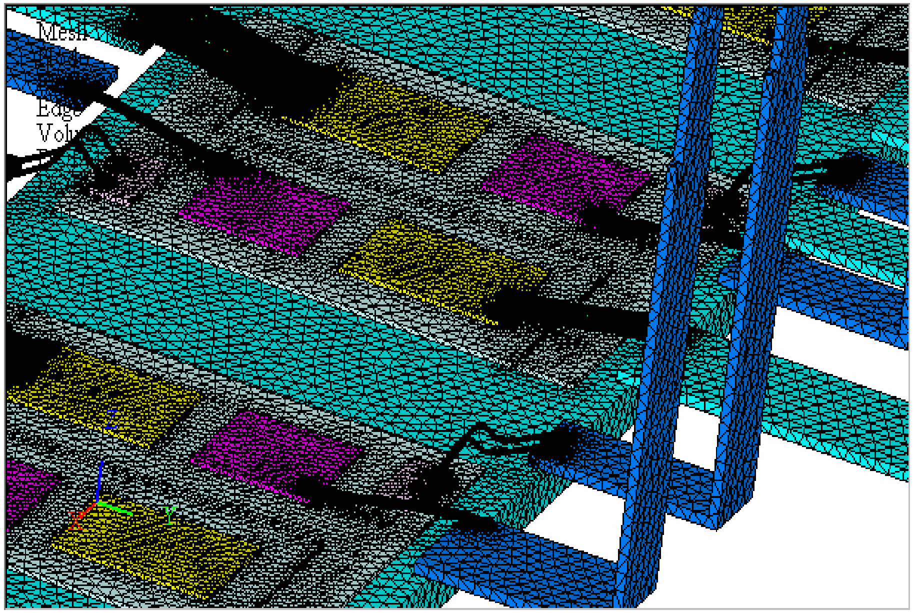
CGCG method of ADVC

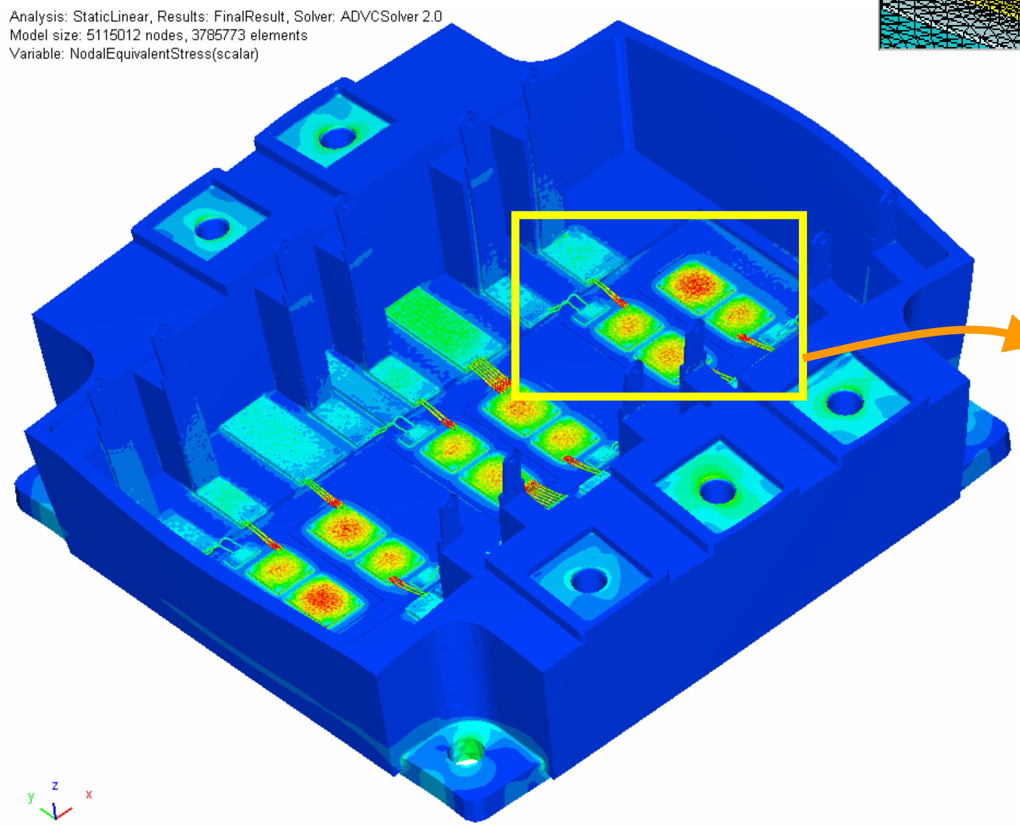
- CG iteration on the whole domain
- Global coarse grid motion on the decomposed subdomains is taken into the local and global precondition

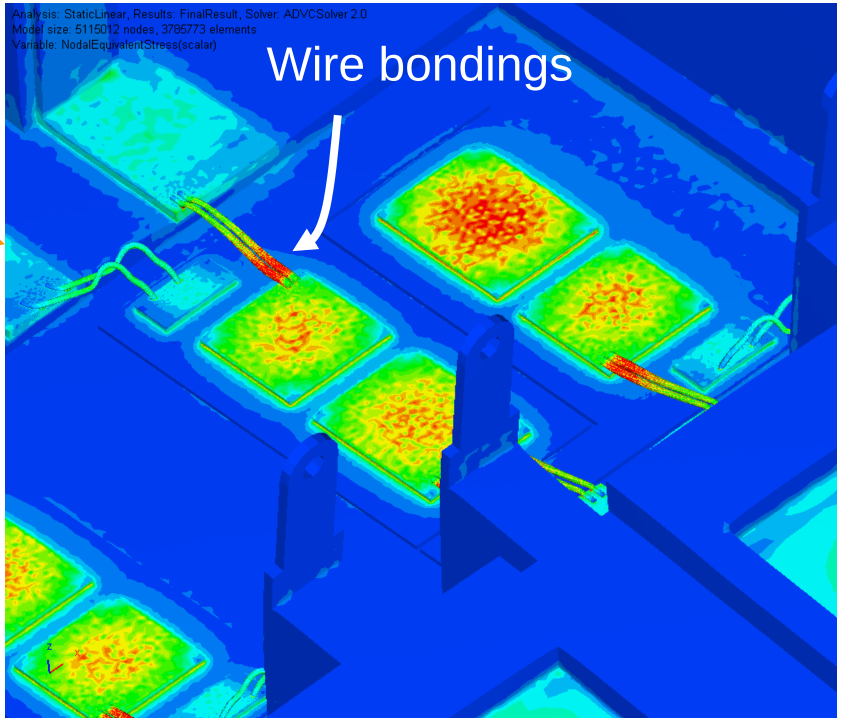


Analysis result of ADVC

—— thermal stress analysis







Performance of ADVC(1)

Large (medium) scale analysis model —— 90 million DOFs problem on BG/L

- Machine component of 30 million nodal points, 90 million DOFs
- BG/L two racks, 2048 nodes
- Elapsed time: 170 seconds

Performance of ADVC(2)

Absolute performance —— Analysis of small scale model

- Machine component of 4 million nodal points, 12 million DOFs
- BG/L one rack, 1024 nodes
- ADVC has CG option. CG and CGCG are compared
- CG method is the simplest. It gives the highest parallel performance in the ADVC's option
- CGCG method is as fast as 13 times of CG. Parallel efficiency is lower than CG but not so bad

CPU time (sec)

No of nodes	64	128	256	512	1024
CG	3678	1917	1023	575	371
CGCG	181	93	66	41	28

13 times

Parallel efficiency on the basis of 64 node results (%)

No of nodes	64	128	256	512	1024
CG	100	95.9	89.9	80	62
CGCG	100	97.3	68.6	55.2	40.4

I have given:

1. Backgrounds
2. Domain decomposition method and CGCG in ADVC
3. Parallel Performance of ADVC on Blue Gene/L

Thank you