ODB-10M
New Topcrunch Benchmark Data

Mitsuhiro Makino and Shota Yamada(*)
DYNAPOWER corp. , (*) Fujitsu limited

#6-402 Oyumino 2-34-1, Midori-ku,
Chiba 266-0031 Chiba, Japan

makino@dynapower.co.jp

Abstract

New Benchmark model ODB-10M is 10 million elements model, which consist of refined NCAC Taurus model and LSTC shell ODB barrier model.

*Refined NCAC Taurus model is 9 million elements of type16 shell elements and type2 solid elements, and *CONSTRAINED_SPOTWELD is changed to *CONTACT_SPOTWELD with beam. In LSTC shell barrier, type10 shell element is changed to type16 shell element in order to avoid negative hourglass energy.*

We also discuss about the domain decomposition.

Introduction

In 2006, car2car model, which is 2.5 million elements, was submitted to Topcrunch (1 and 2). To improve the accuracy (3), the demand for using fine mesh is continuously increasing. The usage of fine mesh (= the increase of the number of elements) increases the solution time. On the other hand, the demand of shortening of development time is also very strong. Auto OEMs are challenging to resolve both the improvement of accuracy(= increase solution time) and the reduction of development time. For researching this problem the large car model more than car2car is requested.

Refined Taurus model and LSTC shell barrier

The original Taurus model(4) was developed by NCAC and the number of elements are 1,057,133. In order to create refined Taurus model, shell element is divided to 9 shell elements and solid element is divided to 27 solid elements by dividing the edge length of elements to 1/3. The final number of elements is 9million. The shell elements are type16 quad shell and solid elements are type2 solid. The number of integration points for shell is 3 or 5 for refined Taurus, The spotweld was modeled by *CONSTRAINED_SPOTWELD originally, however, in order to match the recent car crash model the spotweld was modeled by *CONTACT_SPOTWELD with beam.

After several tests, refined Taurus model is unstable, because of short wave length mode by fine solid element and *CONSTRAINED_NODAL_RIGID_BODY with original *SET_NODE.

For solid elements, several parts such as bumper, radiator and engine mounts are large deformation , and change to coarse original mesh. The element type of bumper and radiator is changed to type9 with *MAT_MODIFIED_HONEYCOMB . Although the bumper was using hexa and penta elements, it is remeshed by hexa elements in order to avoid negative volume. The element type of engine mount is changed to type-2 (5) and some of them are remeshed because of severe shear deformation.

For *CONSTRAINED_NODAL_RIGID_BODY, the set of nodes are redefined to add the nodes, which is created by refined mesh, to the original *SET_NODE.

Original LSTC shell barrier (6) consist of tria and type10 quad shell elements. During the initial test of shell barrier, I experienced large negative hourglass energy as shown in Fig. 1. As shown in Fig.2 I redefine the parts in shell barrier, and the quad elements connected to tria element is the source of the negative hourglass energy. In order to avoid the negative hourglass energy, I change all quad elements to type16 quad shell.

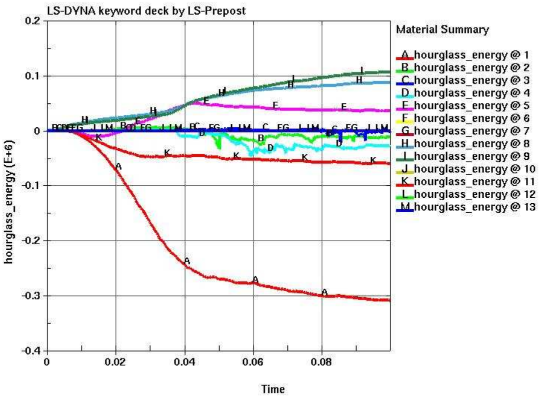


Fig.1 hourglass energy of shell barrier

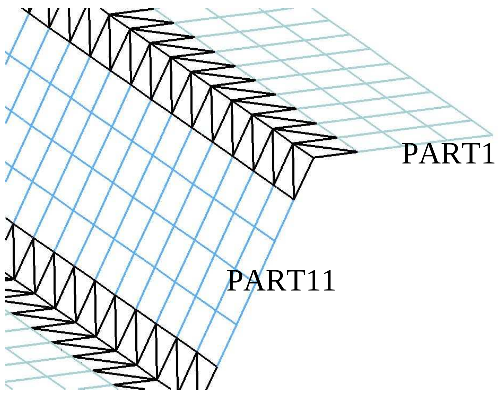


Fig2. shell barrier mesh

The contact definitions in ODB-10M are

C-1 *CONTACT_AUTOMATIC_SINGLE_SURFACE with soft=2, sbopt=3 and depth=5 for refined Taurus,

C-2 *CONTACT_AUTOMATIC_NODES_TO_SURFACE between bumper and bumper reinforcement

C-3 *CONTACT_AUTOMATIC_SINGLE_SURFACE Single with soft=0 for shell barrier

C-4 *CONTACT_AUTOMATIC_SURFACE_TO_SURFACE with soft=0 between refined Taurus and shell barrier.

C-5 *CONTACT_AUTOMATIC_NODES_TO_SURFACE with soft=1 between refined Taurus and road.

Initial velocity is -17778mm/s=64km/h, and Gravity force is applied.

Table 1 is the summary of number of elements of refined Taurus and shell barrier.

Table 1. summary of number of elements

	Refined Taurus	Shell barrier	Total
Beam	5223	0	5223
Shell	6931283	1506073	8437356
Solid	2215925	0	2215925
Deformable total	895720	1506073	10653281

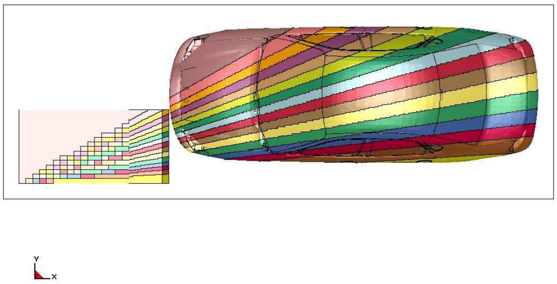
Domain decomposition

LS-DYNA has the information of average elements calculation cost by element type, material type and number of integration points, etc. LS-DYNA is try to equally distribute the elements in the domain in order to get good load balance. However, there are some information, which LS-DYNA can not know from input data and only the engineer knows it. In this case, engineer informs the following knowledge to LS-DYNA as domain decomposition.

There are two important points of domain decomposition:

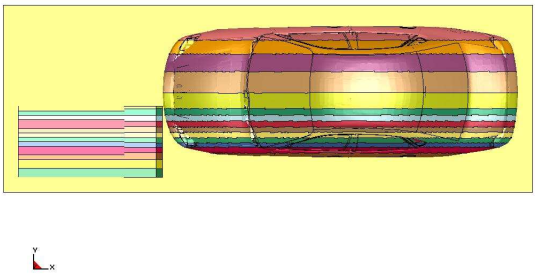
1. Communication for data transfer between processes
2. Load balance
   A. Contact
   B. Element cost change during calculation such as elastic to plastic
   C. Number of removed elements by failure or erosion during calculation.

Two decomposition C2R and SY was tested by Fujitsu Primepower by 10ms execution. (7)



decomposition { numproc 16
c2r -2044. -1000. 0. 0. 0. 1. 1. 0. 0.
sx 0.0
sy 10000000 }

Fig. 3. domain decomposition C2R



decomposition { numproc 16
sy 10000000 }

Fig. 4. domain decomposition SY

The coordinate(-2044,-1000,0.) of C2R is the left and bottom point of shell barrier. C2R is expected that the communication of contact C-4 between barrier and car is better than SY, because the elements related to contact C-4 in the same domain for C2R. The other contact C-1,C-2, C-3 and C-5 are equally distributed each domain, and the load balance is good. For deformation of car, front parts of car are large deformation and becomes plastic, and rear parts of car is elastic. For both C2R and SY, the load balance of element cost change is good.

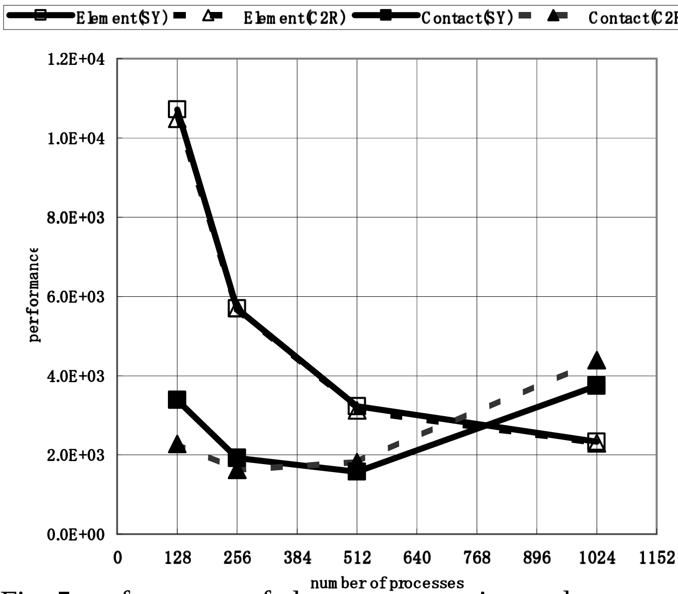


Fig. 5 performance of element processing and contact algorithm

Figure 5 shows that element processing is the same performance between C2R and SY and the time is decreasing as the increase of processes, however, for contact algorithm, until 512 processes, the time of both C2R and SY is decreasing as the number of processes and C2R is better than SY, but for more than 512 the time of both C2R and SY is increasing as processes and SY is better than C2R.

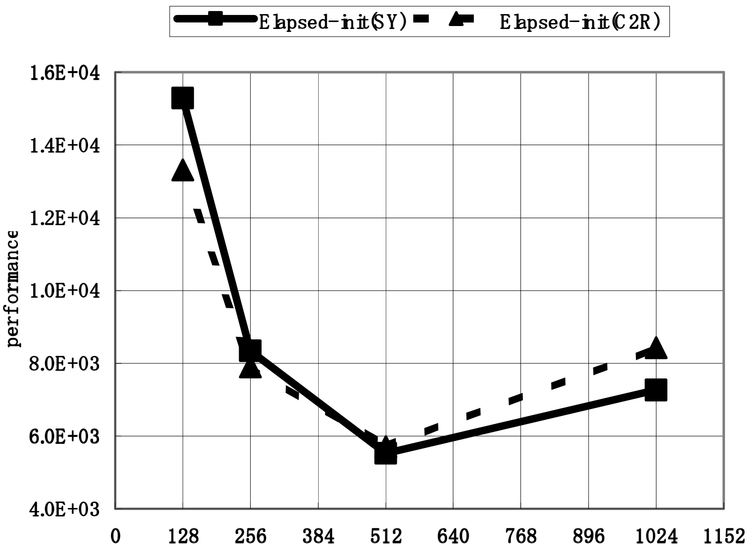


Fig. 6 Total performance of C2R and SY

Figure 6 shows the total performance. For less than 512 processes C2R is better, and for more than 512 processes SY is better. The total performance is determined by the performance of contact algorithm. For BMT data of Topcrunch, SY uses, because the large number of processes simulation is target.

Results and Performance

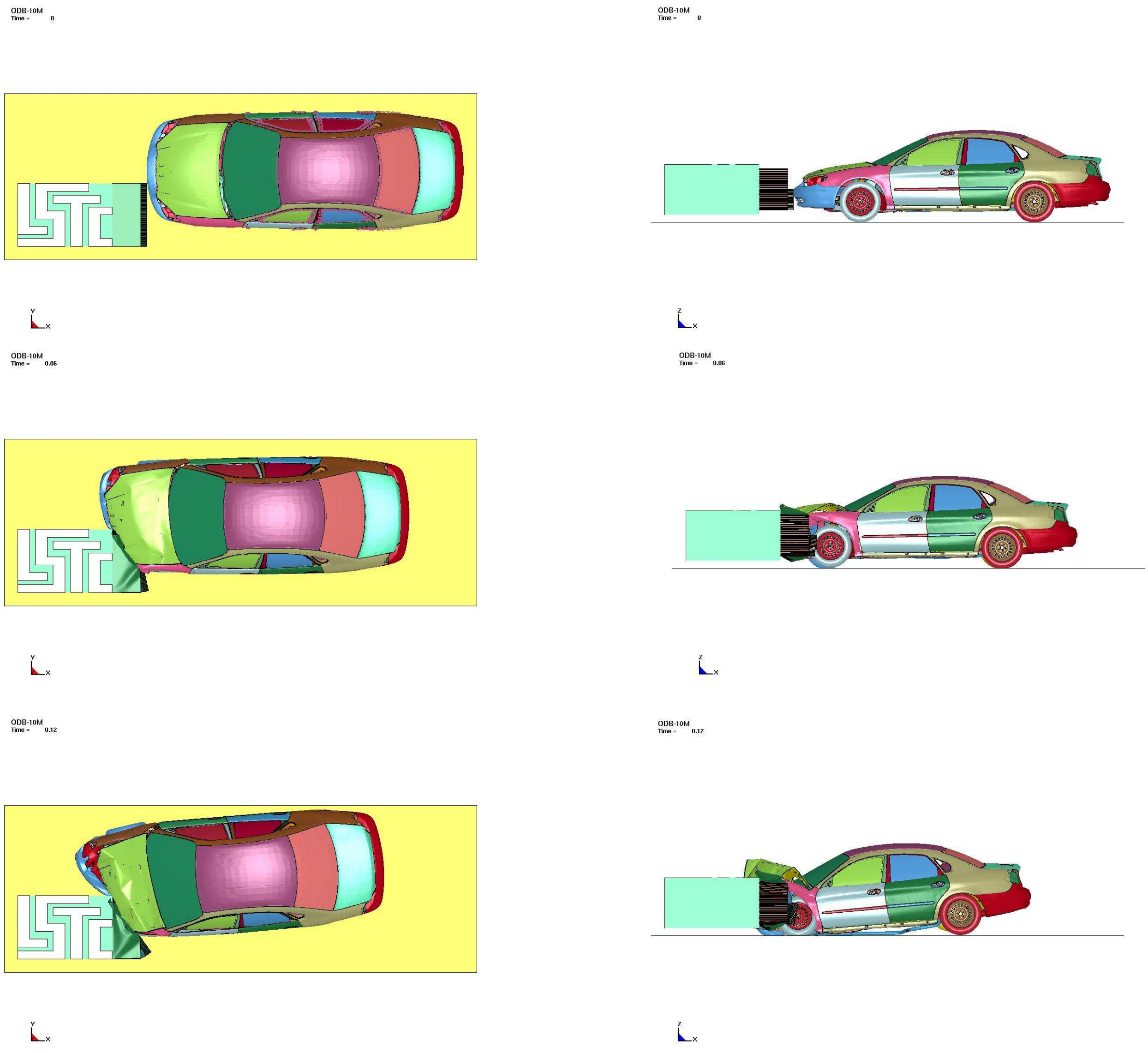


Fig. 7 Top and side view of ODB-10M simulation

This calculation for 120ms takes 187h58m by 20cores AMD phenomII 965 (4core x 5nodes) with gigabit network. The memory is memory=1300m and memory2=300m.

The other timing information for 120ms by Intel E5520 with infiniband is 26h38m for 256Cores, 40h52m for 128Cores and 72h41m for 64Cores.

Discussions

The scalability for large number of processes is mainly limited by contact algorithm as shown in Fig. 5. For improving the performance of contact algorithm, there are two possibilities:

1. Multi-Rail of infiniband (8)
2. Hybrid parallel version of multi-core cpu (9,10 and 11).

The multi-rail of infiniband is multiple the infiniband cards and the throughput of communication is improved. Hybrid parallel version is SMP execution in multi-core cpu and MPP execution between nodes, and the communication within multi-core is removed.

Both methods will be tested by BMT of ODB-10M, since this large model has enough communication size.

Conclusion

1. ODB-10M, which consist of LSTC barrier and refined Taurus, was developed.
2. ODB-10M can executed until 120ms.

Acknowledgements

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