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Parallel Strategies of High-Speed Contact/Impact Simulation Code

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ABSTRACT

In order to develop the efficient parallel high speed contact/impact code, there are some difficulties. First of all, a fine serial code which can simulate complicate contact should be prepared and it should be parallelized efficiently. Moreover, large scale computing resources are required to evaluate and improve its parallel performance. In this paper, we describe the contact parallel strategies for high speed contact/impact simulation code which is applied to IPSAP/Explcit*[1]* and NET3D*[2]* especially for brittle material and then, evaluate the parallel performance with several applications. The evaluation of parallel performance was conducted in self-made linux cluster, PEGASUS, which consists of 260 node (520CPUs) and Gigabit Network.

PARALLEL PROCEDURE OF NET3D CODE

Parallel contact-impact simulation procedure can be divided by domain partioning procedure, internal force calculation and contact treatment procedure. In order to divide the subdomain, graph partitioning scheme is used with METIS. Before the internal force calculation, it carried out once at the domain partitioning procedure. And the graph information is automatically updated (dynamic load balancing) by communication when the contact search domain size is two times bigger than previous updated subdomain because the mesh structure is changed for the case of element erosion, node split scheme and the amount of calculation of each CPU is unbalanced because the contact search domain size is getting bigger as the number of time step increase.

In order to calculte internal force, neighboring sub domain list (or processor identification number) is made to communicate between processors based on node index. And then it calculate internal force of element and node at inside subdomain as serial procedure. Using neighboring sub domain list, each processor exchanges and adds the internal force of the nodes at the subdoamin boundary. This procedure is shown in Fig.1 schemetically.

Parallel contact force calculation is much more complicate than internal force calculation and requires much more amount of communication. It is shown Fig.2. The contact search domain is defined base on subdomain which is divided at internal force calculation procedure for the parallel efficiecy. The size of contact search domain is ten percent bigger than subdomain along with x,y,z direction. After sharing the size of contact search domain of each CPU, the information required to communication is collected as same procedure at internal force calculation but the element index is used And then, the contact forces at node are calculated as serial procedure. Not like internal force calculation, the calculated contact forces are not exchaned because the contact search domains are duplicated. In order to simulate penetration phenomena, the element erosion and node split scheme is often used. If there is no erosion element or node split scheme, the parallel procedure is much more simple because the connectivity information of mesh is same throughout the whole calculation. But complex communication is required because newely generated node and side informaction at other contact search domains are not known for the node split and eroded element. In order to overcom this difficulty, the mesh structure is stored as graph information at the begining of procedure and this graph information is updated at every time step.

PARALLEL PERFORMANCE

With taylor impact test for internal force calculation and oblique metal sphere impact problem for contact force calculation, scalability test is conducted. Fig. 3 and Fig. 4 show the performance results. 544,885 elements model is used for internal force calculation and 546,489 elements model is used for contact force calculation. The speed up performance of internal force calculation is 12 for 16 CPUs and 5.2 speed up performance obtained for contact force calculation at 8 CPUs. Parallel performance results of 256 and 512 CPUs will be provided in the updated vesion of this abstract.

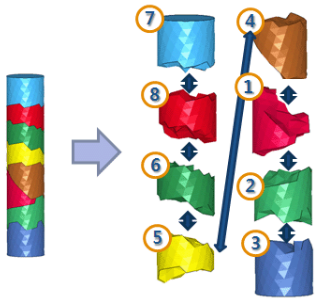

Fig.1 Internal Force Calculation

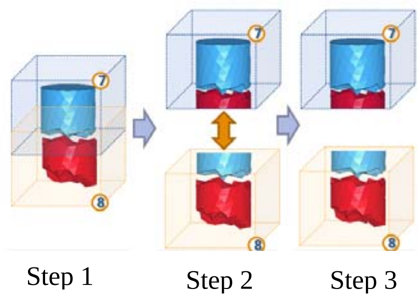

Fig.2 Contact Force Calculation

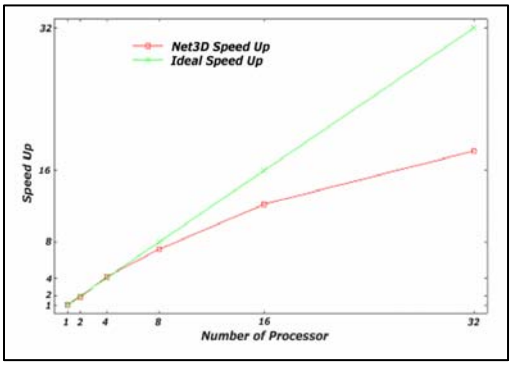

Fig.3 Speed Up Result (Taylor)

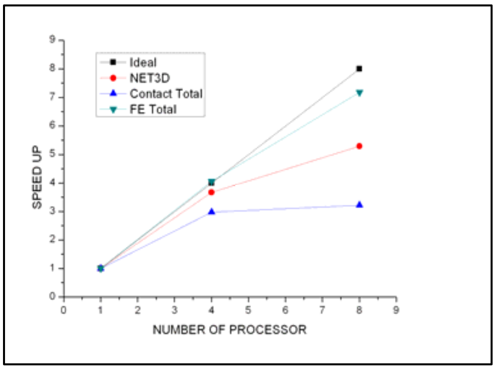

Fig.4 SpeedUp Results (Oblique metal Sphere)

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