# A NEW REGION-COUPLED FRAMEWORK FOR CONJUGATE HEAT TRANSFER

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For many applications it is desirable to have implicit coupling between different solution domains. The simplest approach – explicit updating of boundary values – amounts to a block Gauss–Seidel approach which can suffer from slow convergence or instability [1, 2].

In this presentation we describe a new framework for solving region-coupled equations implicitly using OPENFOAM® technology. We demonstrate the application of this 'super-matrix' approach to industrial problems in Conjugate Heat Transfer (CHT) using HELYX®.

The new super-matrix approach allows for region-specific equations to be set up and then combined into a single system matrix. This combined matrix may then be solved monolithically using the standard matrix solvers present in the OPENFOAM® libraries, with the coupling between the regions provided via the existing LDU interface machinery. In this way, disparate physics may be coupled implicitly without modifying the existing well-established solver implementations.

The region-coupled solution is first applied to a simple CHT validation problem which is a 2D representation of a motor. In Figure 1, the convergence of coil temperature vs wall clock time is plotted, with the region-coupled solution showing superior convergence speed compared to the standard segregated solver in OPENFOAM®.

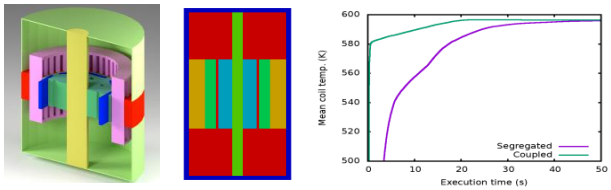


**Figure 1: Representative model of 2D motor and convergence time of segregated vs region-coupled solution**

In Figure 2, a realistic case is shown involving forced cooling of a blade server with 46 separate solid regions and with thermal conductivities varying over three orders of magnitude. Reference results generated using a widely used commercial solver are compared with the region-coupled solution and found to be in good agreement and to exhibit comparable convergence times.

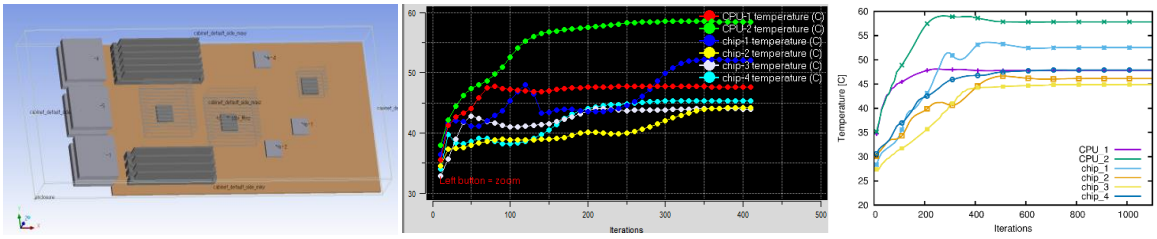


**Figure 2: Convergence of chip temperatures in blade server model (left); comparison of reference data from a third-party solver (centre) and HELYX simulation (right). Model and data courtesy Fujitsu Laboratories of Europe Ltd.**

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**References**

[1] V. Kazemi-Kamyab, A.H. van Zuijlen, H. Bijl, "On the stability of loose and strong partitioned algorithms for thermal coupling of domains using higher order implicit time integration schemes," in *10th World Congress on Computational Mechanics*, São Paolo, Brazil, 2012.

[2] J. Degroote, P. Bruggeman, R. Haelterman, J. Vierendeels, "Stability of a coupling technique for partitioned solvers in FSI applications," *Computers & Structures*, vol. 86 (23–24), pp. 2224–2234, 2008.