

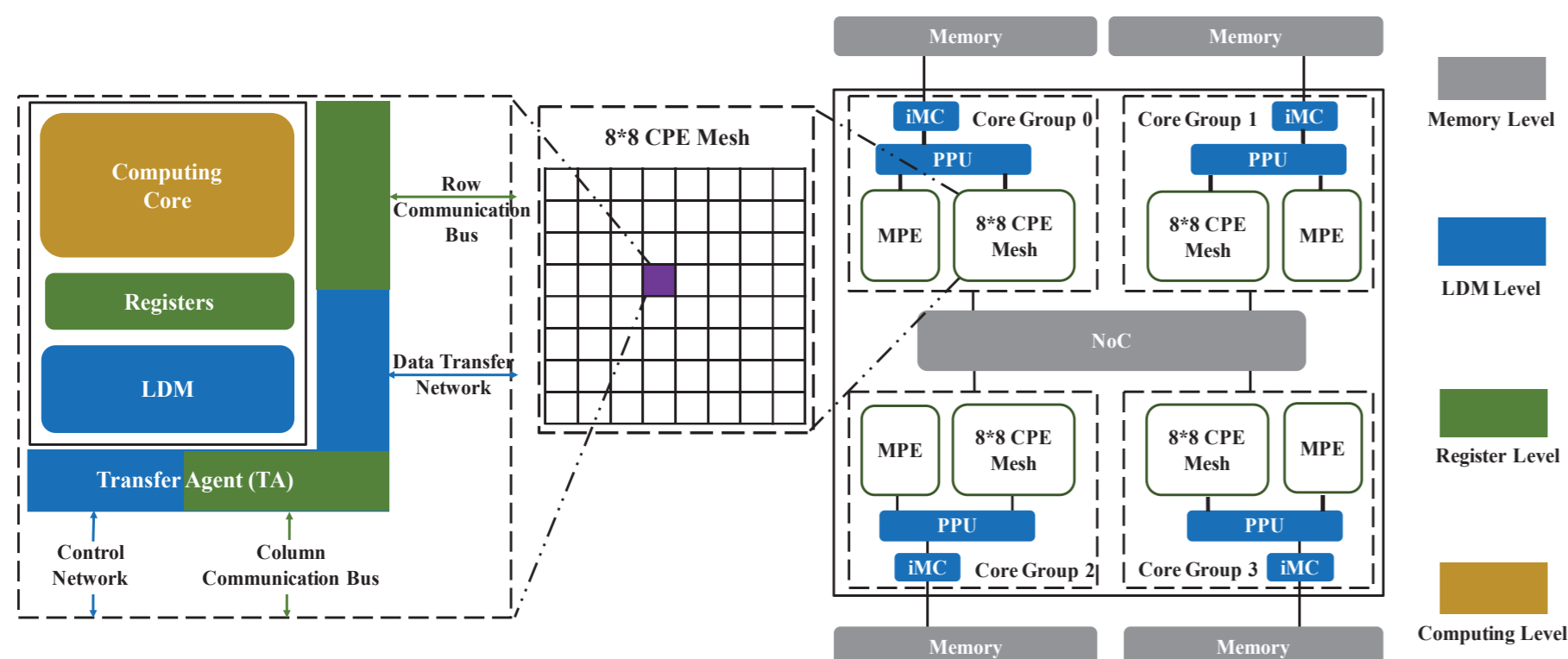
# Transplant and Optimize OpenFOAM On Sunway TaihuLight Supercomputer

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## 1. Introduction

### “SW26010” processor characteristics:

- 4 core-groups (CGs) in a processor
- one management core (MPE) and one 8x8 computing core (MPE) mesh in a CG
- Every 64 MPEs share a 4M local device memory (LDM).

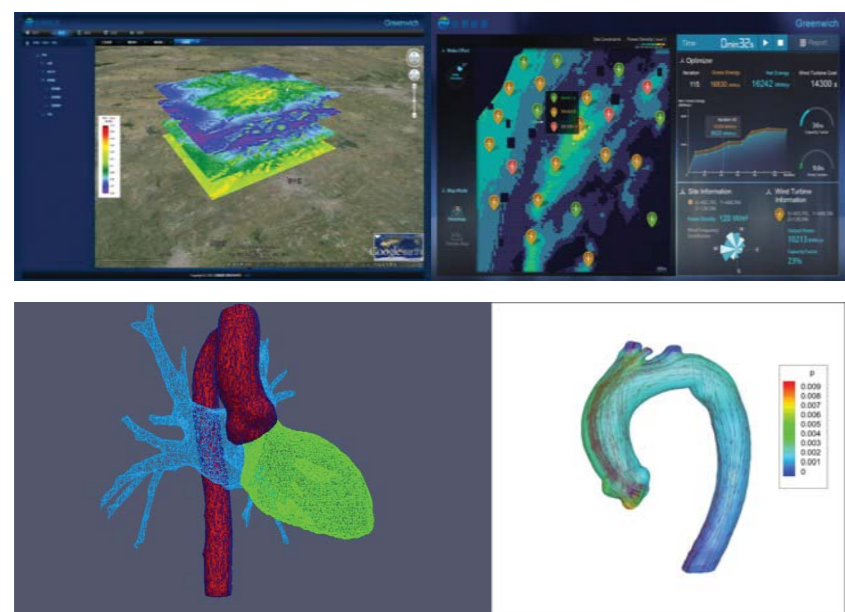


### Challenges to transplant and optimize OpenFOAM:

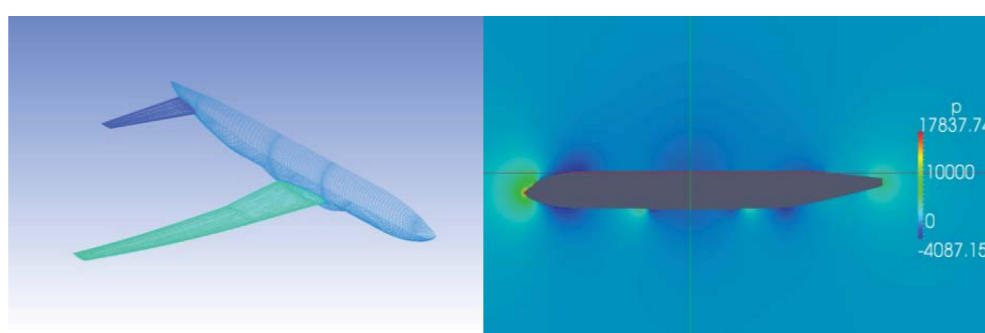
- unstructured mesh and data layout (irregular memory fetching)
- relatively limited memory bandwidth (38GB/s to 3TFlops)
- restrictions on parallelism in algorithms (Gauss Seidel etc.)
- templated and polymorphic coding
- shared-library-oriented build system

## 2. Applications

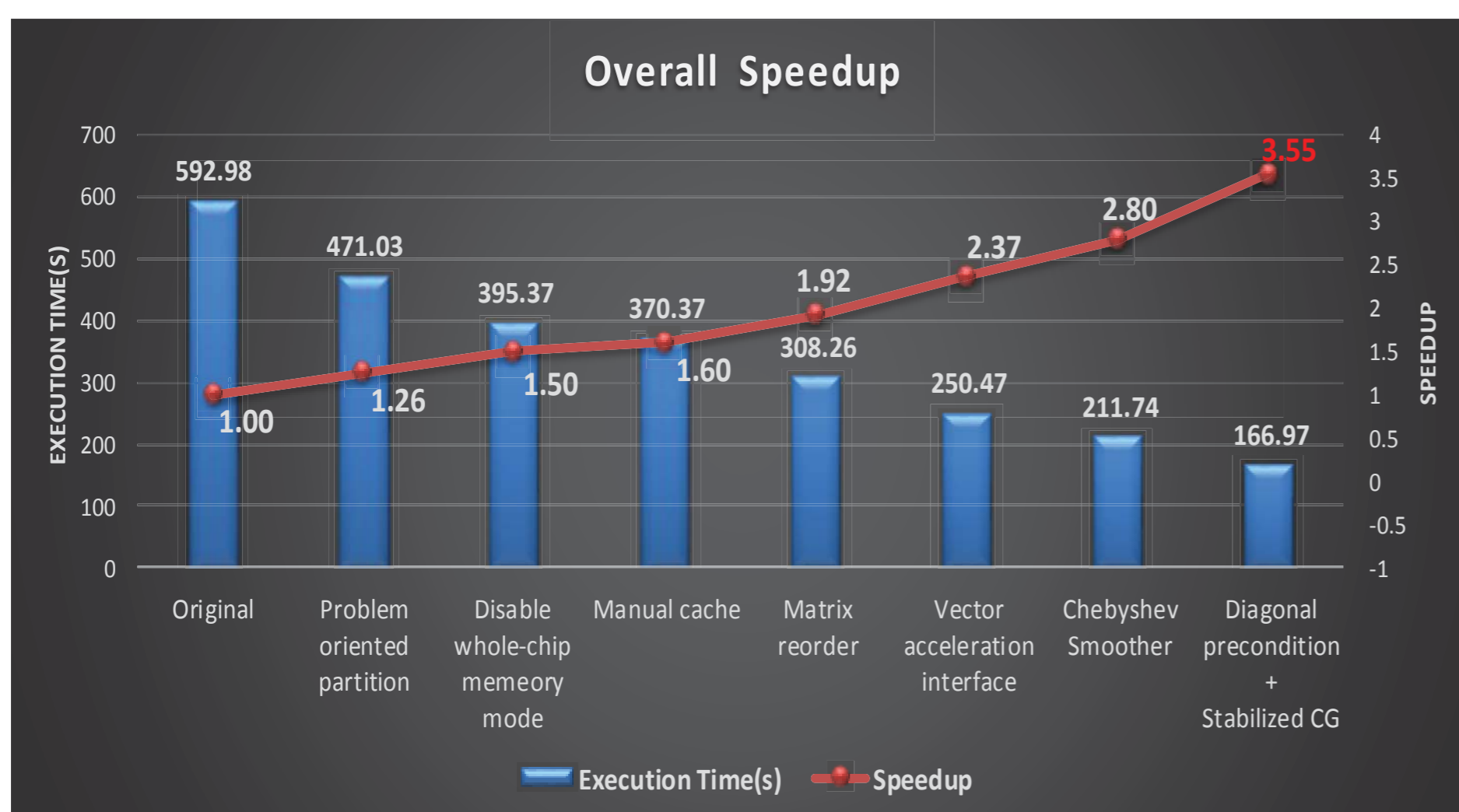
### CFD simulations with OpenFOAM on Sunway TaihuLight:



Wind power companies use OpenFOAM on Sunway TaihuLight to optimize wind fun locations and predict the daily power generation.



## 3. Acceleration Overview



Component	Optimization	Maximum Speedup
ATmul	Matrix reorder	12x
gaussGrad	Manual cache	7x
surfaceInterpolationScheme	Manual cache	8.6x
surfaceIntegrate	Manual cache	6.5x
GAMG	Chebyshev Smooth	5x
PBiCG	Diagonal precondition + Stabilized CG	5x
Array Operations	Vector acceleration interface	18x

National Super-Computing Centre in Wuxi (NSCCWX), is located in Wuxi China, and co-operated by local government and Tsinghua University. It has the world's first supercomputer with peak performance over 100PFlop/s—Sunway TaihuLight. Sunway TaihuLight is composed with over 40K “SW26010” chips, and integrates in total over 10 million cores. Sunway TaihuLight is also the first computer that uses China homegrown processors and occupies the first place on Top500 list for successive 4 times.

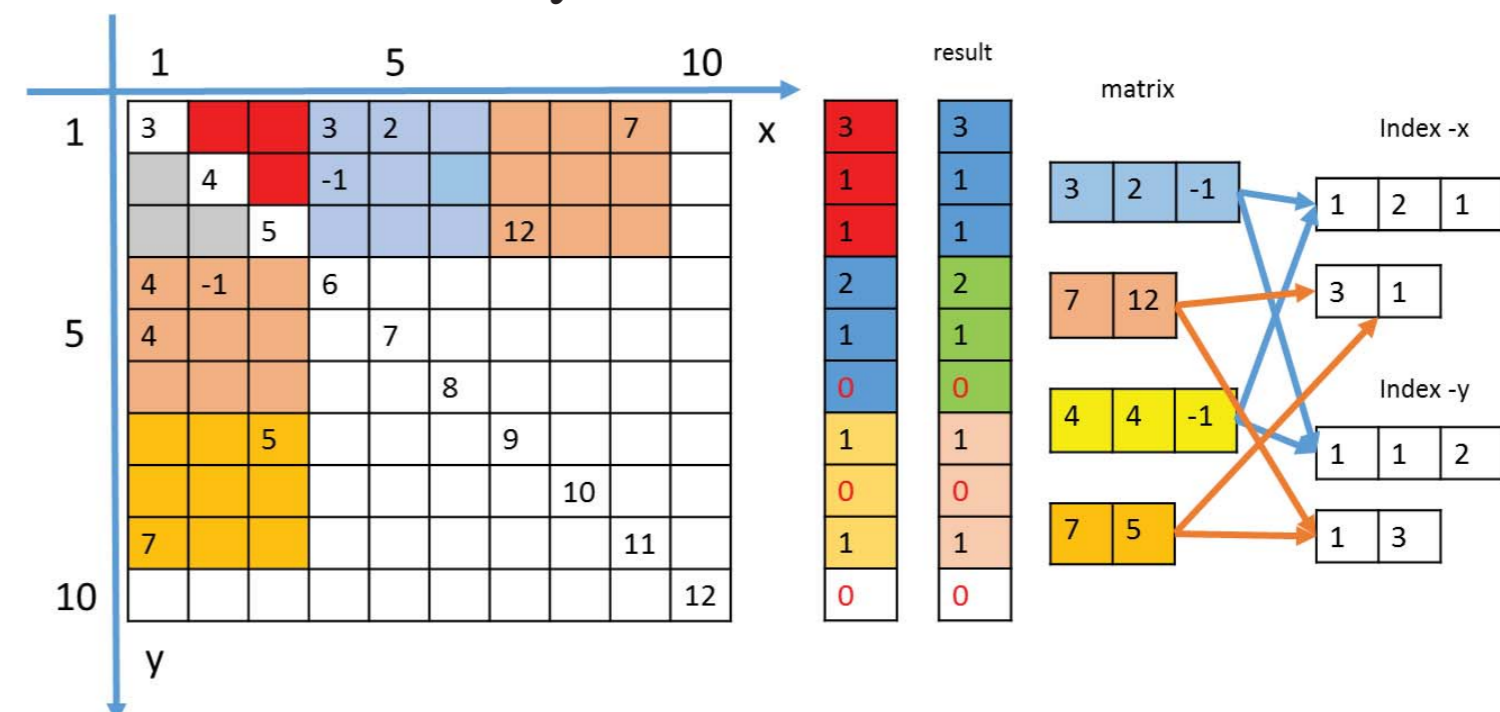
Since June, 2016, over 70 large-scale applications from over 100 research institutes were done, covering 19 application domains, 16 full-scale applications, 18 half-scale, 22 million-core-scale, 5 Gordon Bell Finals, and 2 Gordon Bell Prize.



## 4. Optimizations (parts of all)

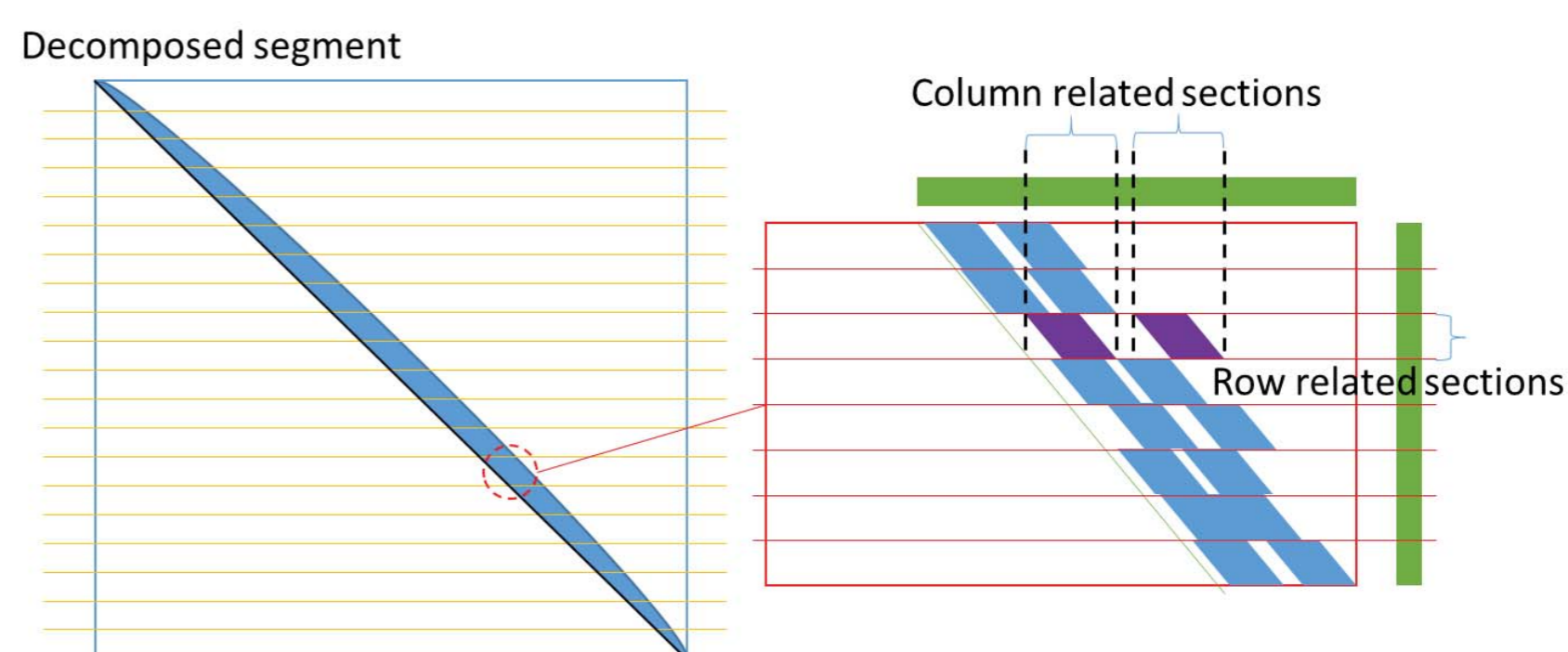
### Matrix Reorder :

Non-zeros were reordered to form box, make sure the row and column related array is located in localized sections



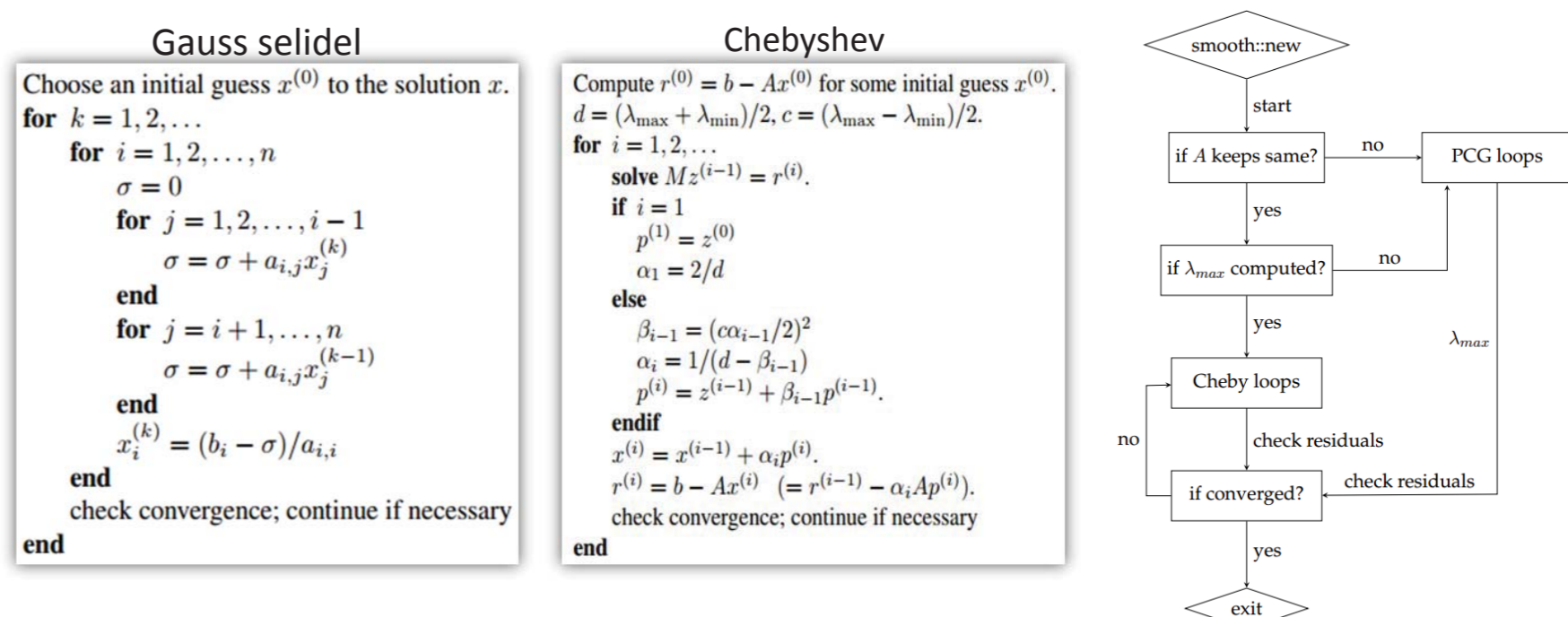
### Manual Cache:

The non-zeros were lumped into sections for each row section, and the array section starts and ends were recorded for manual caching



### Chebyshev smoother:

Gauss Seidel was replaced by Chebyshev in GAMG Solver to release parallelism, and a new procedure was proposed



## 5. Coming soon

- Sophisticated reordering for unstructured mesh and data structure
- Overall acceleration for a series of Solvers
- High performance stand-alone linear solvers on Sunway
- Web base GUI for SW-OpenFOAM and services

