Redesigning CAM-SE on Sunway TaihuLight for Peta-Scale Performance

Lin Gan

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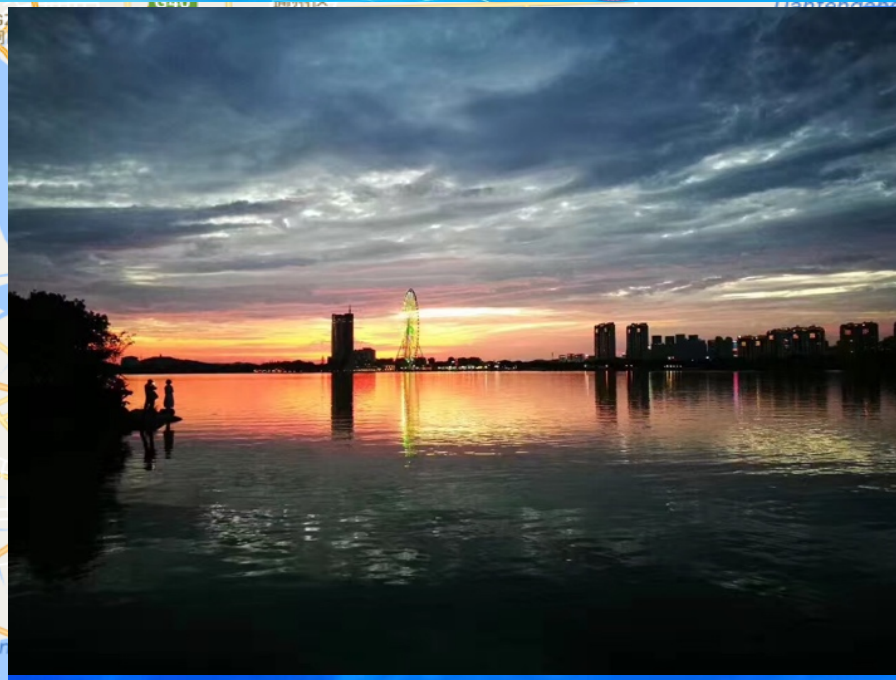
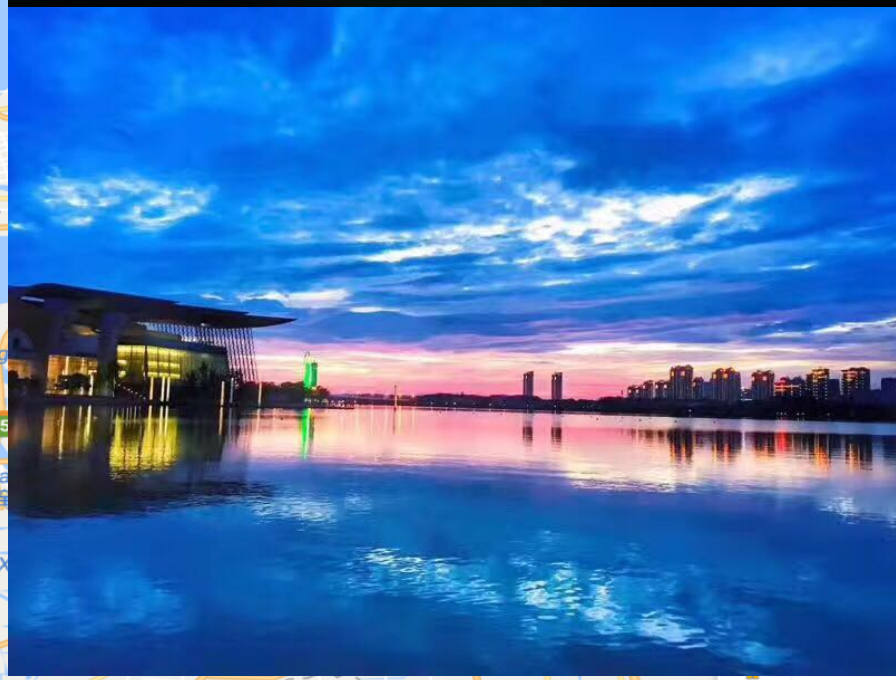
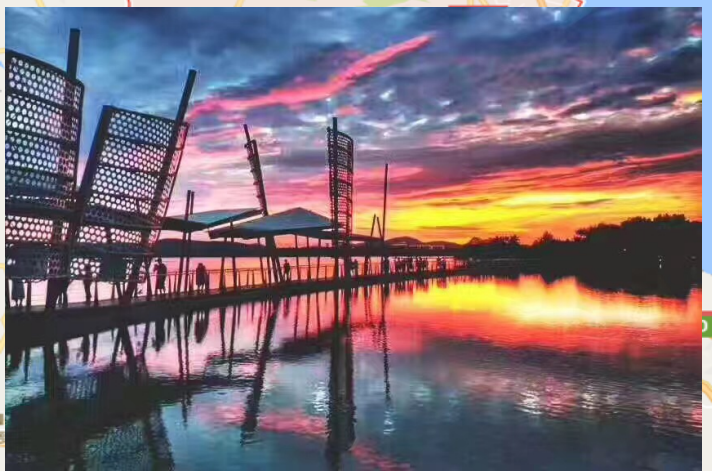
Tsinghua University, Beijing

5th ENES HPC Workshop, May. 17, Lecce, Italy

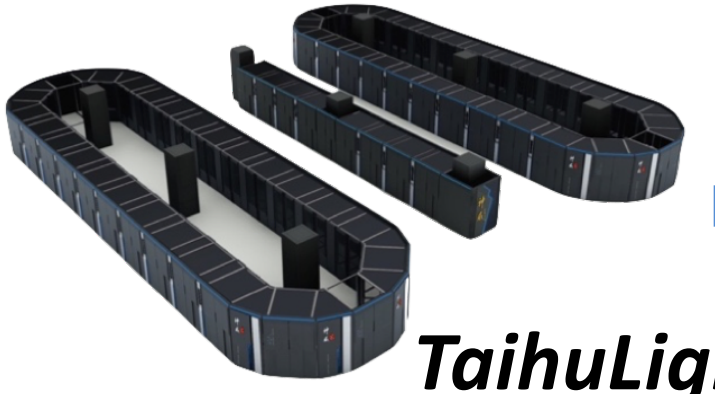






Taihu Lake

Changzhou 常州市
Wuxi 无锡市
Suzhou 苏州市
Huzhou 湖州市
Yangtze River
Taihu Lake 太湖



40x

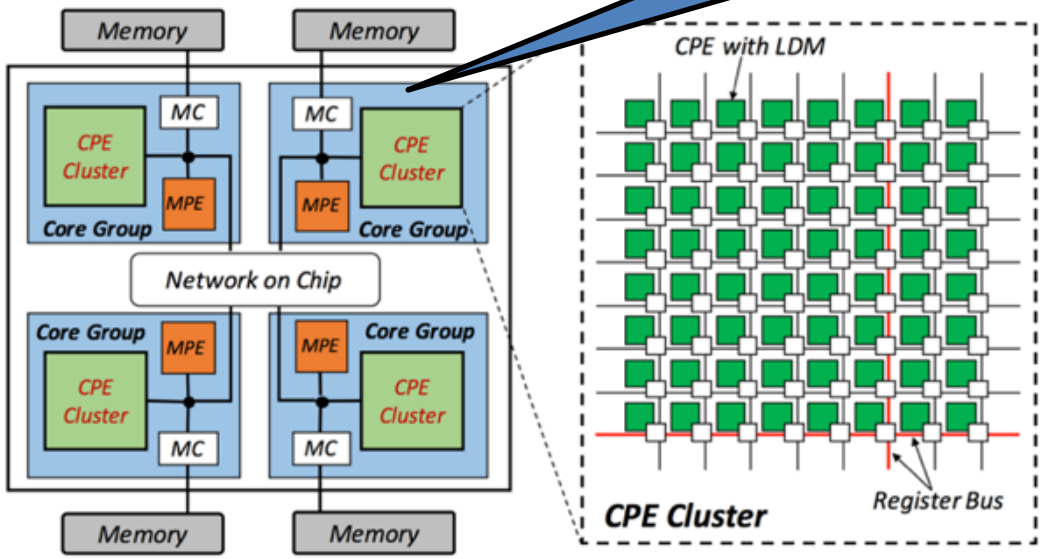
4x

256

TaihuLight　　Rack　　Supernode　　CPU

Homegrown CPU

Core Group / MPI



Programming Methods on Sunway

MPI → OpenACC → Athread

OpenACC
More Science, Less Programming

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The first real-world Application on Sunway system

Target Application: CAM

CAM presents the level of complexity of around 750,000 LOCs, over 300 kernels with no obvious hotspot

Selected Platform: TaihuLight

Based on a brand new many-core CPU with 260 cores, LDM instead of cache, few application/software support

Tsinghua University
National Supercomputing Center in Wuxi
Shandong University
Beijing Normal University
Imperial College London
National Research Center of Parallel Computing

With thanks to Rich Loft and John Dennis from NCAR

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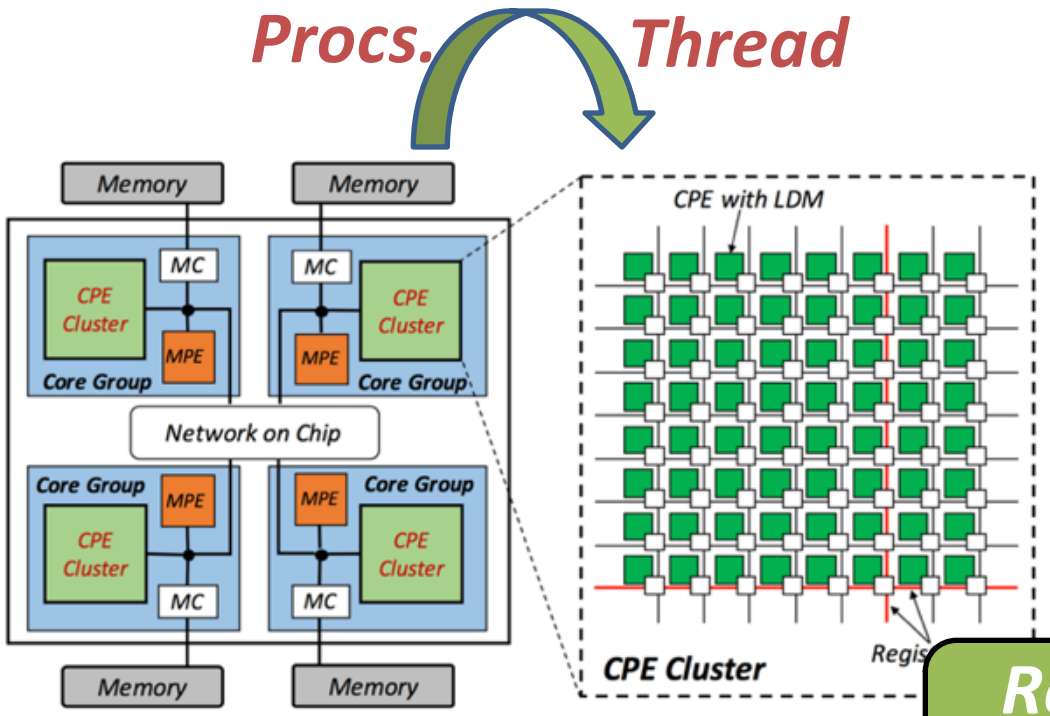

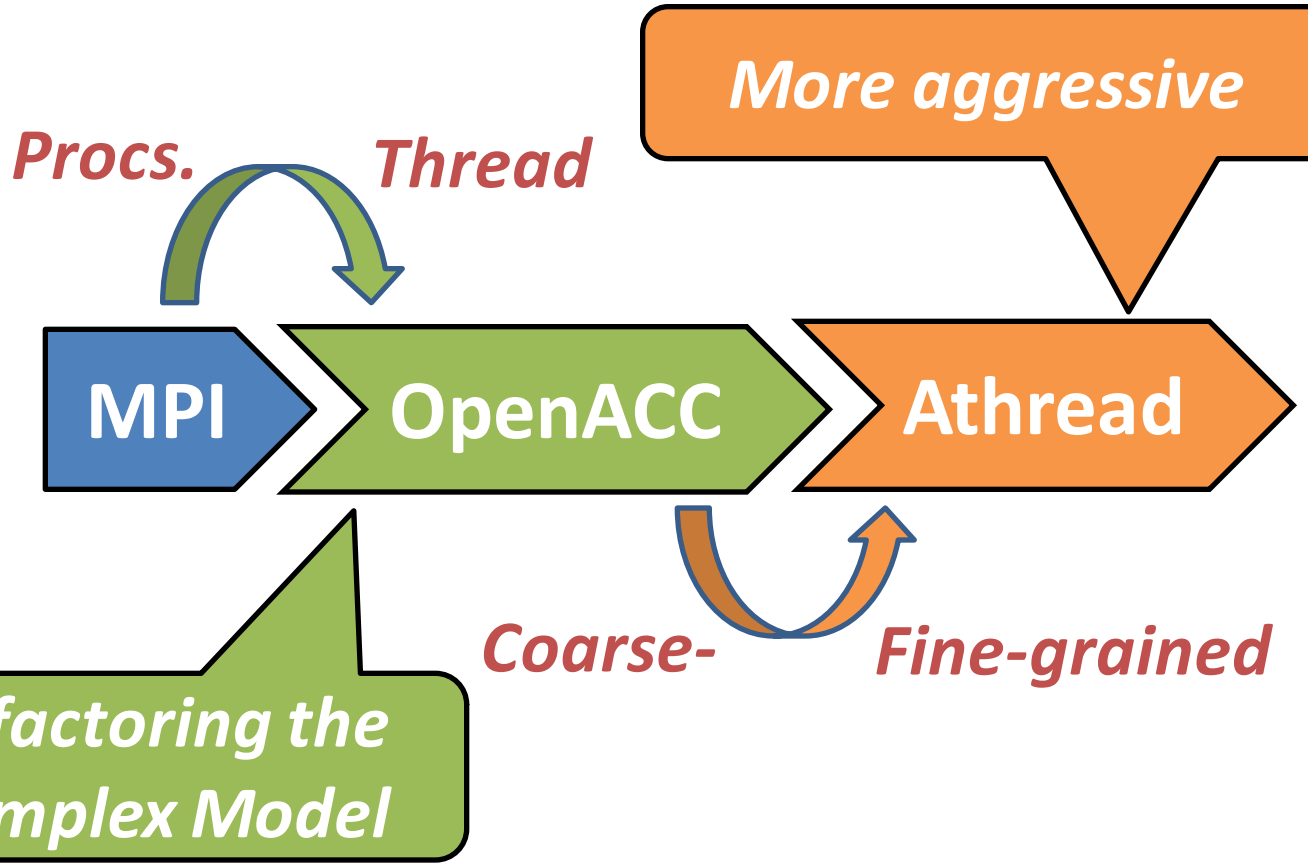

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Target Application: CAM

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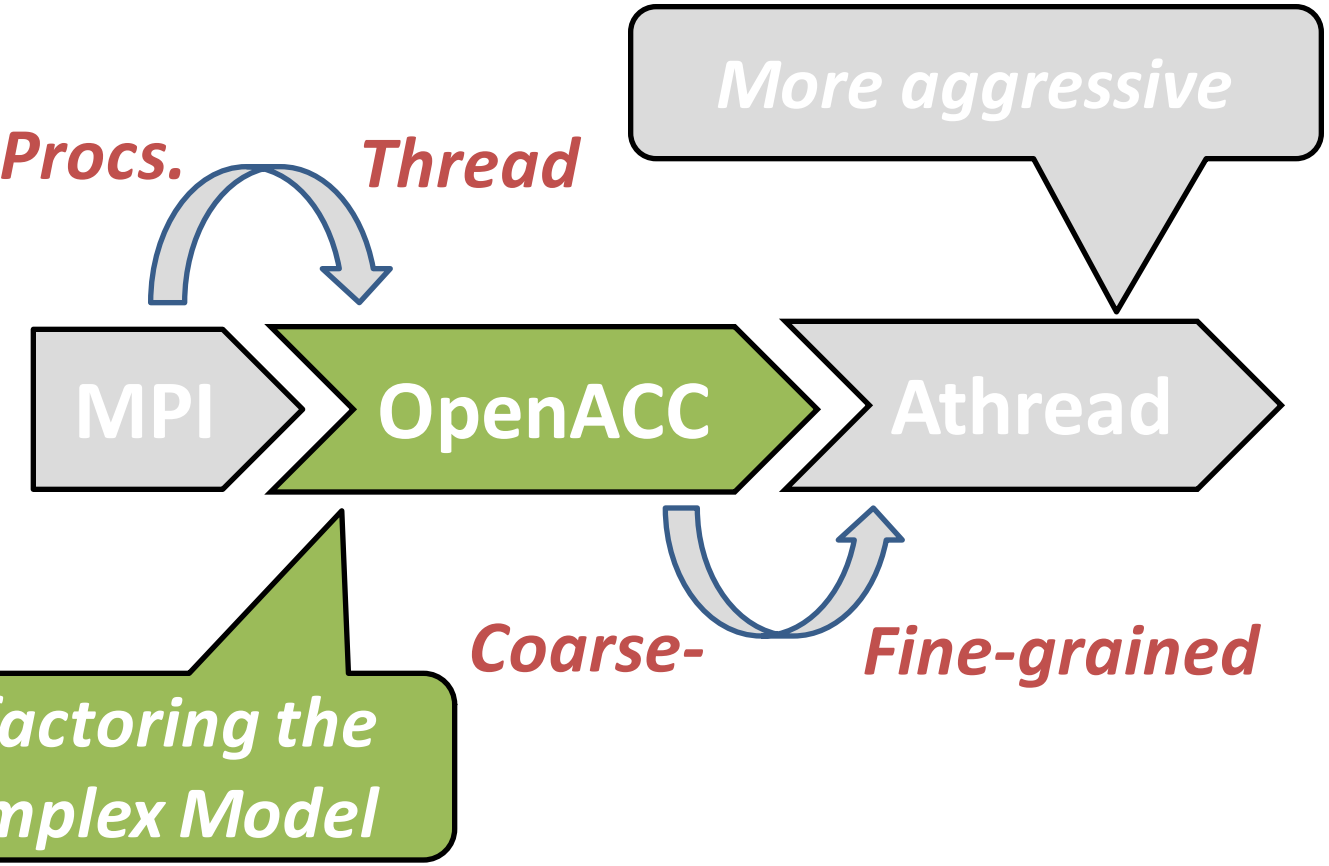
Loop transformation tool to expose the right level of parallelism and data size



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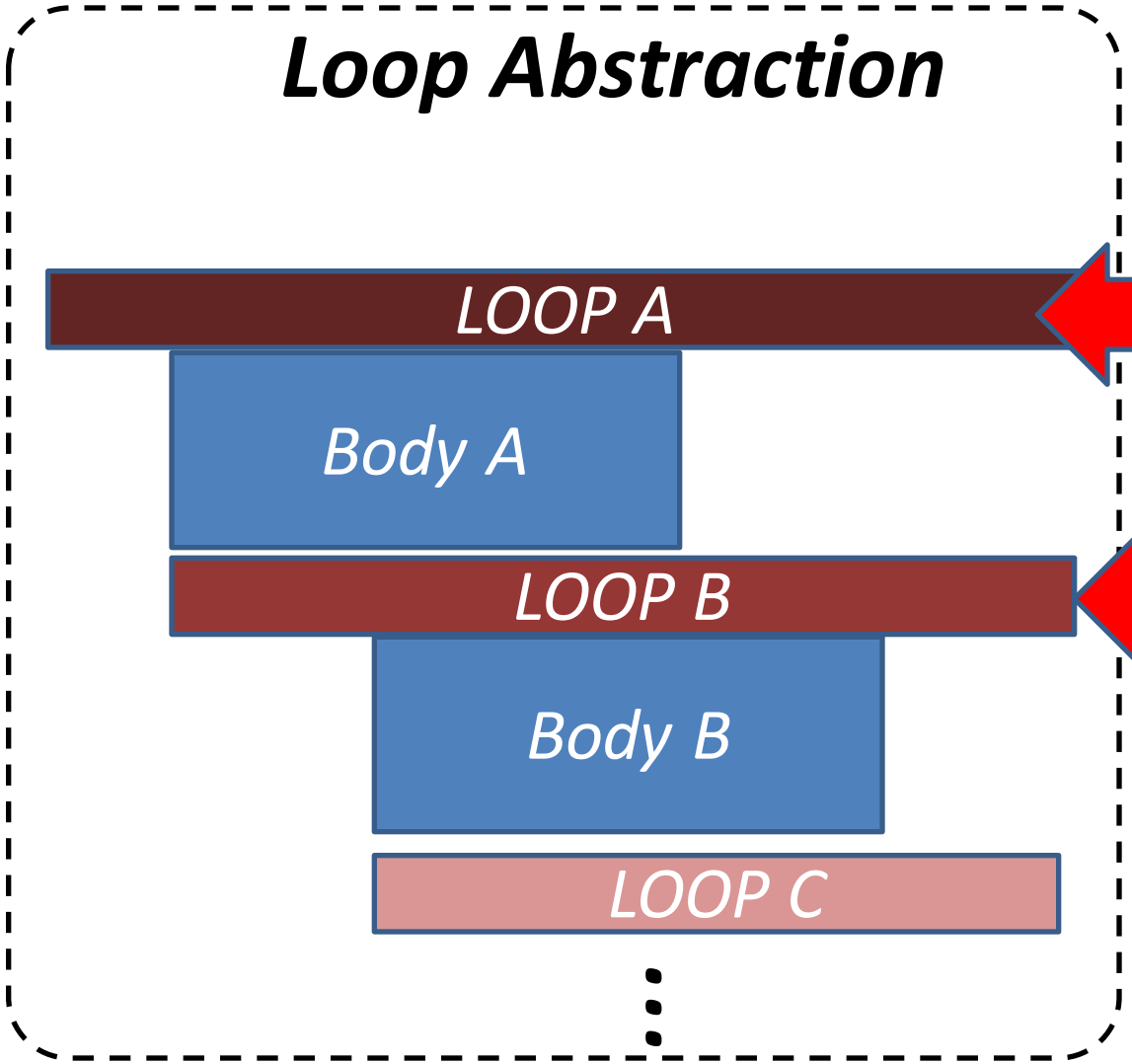
OpenACC for Refactoring (exp. 1)



Originally designed for multi-core system with cache

Small loop size

Fastest direction

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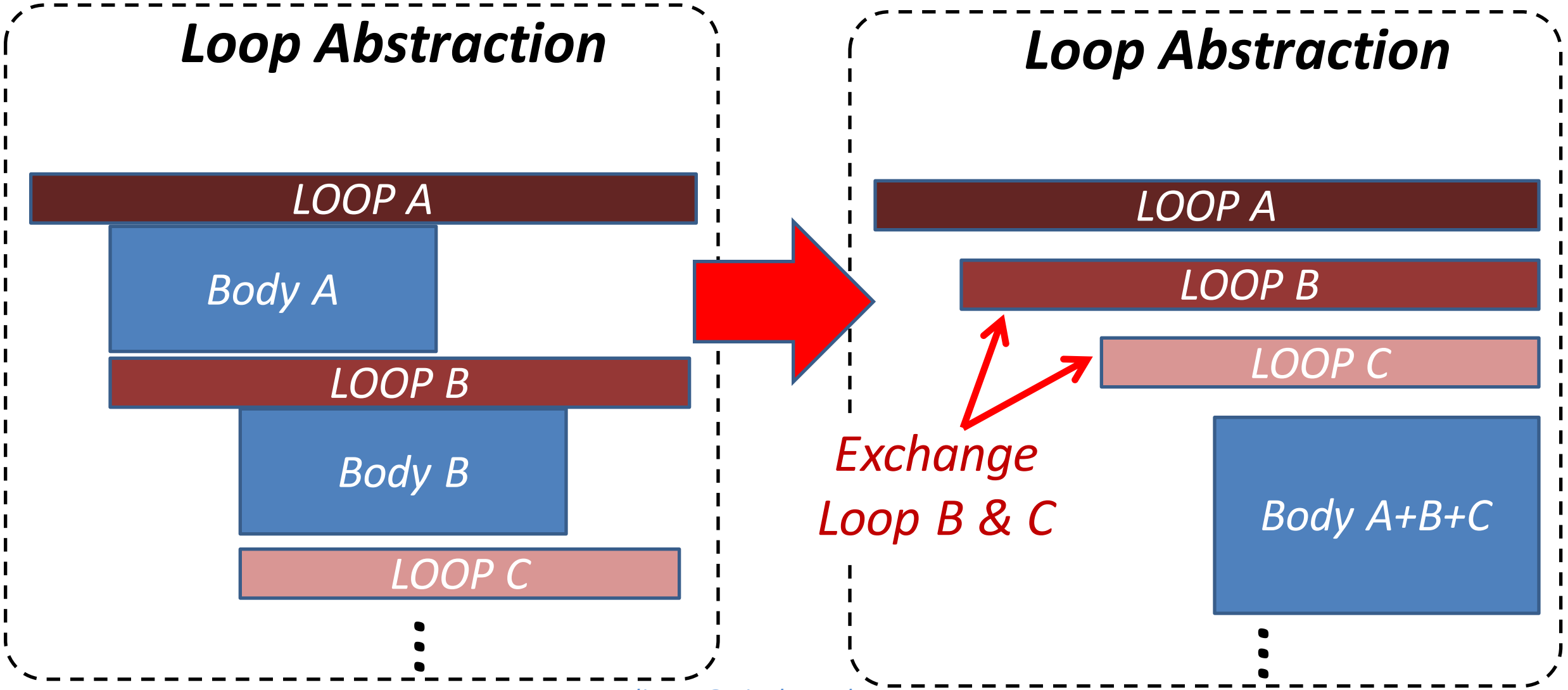
OpenACC for Refactoring (exp. 1)



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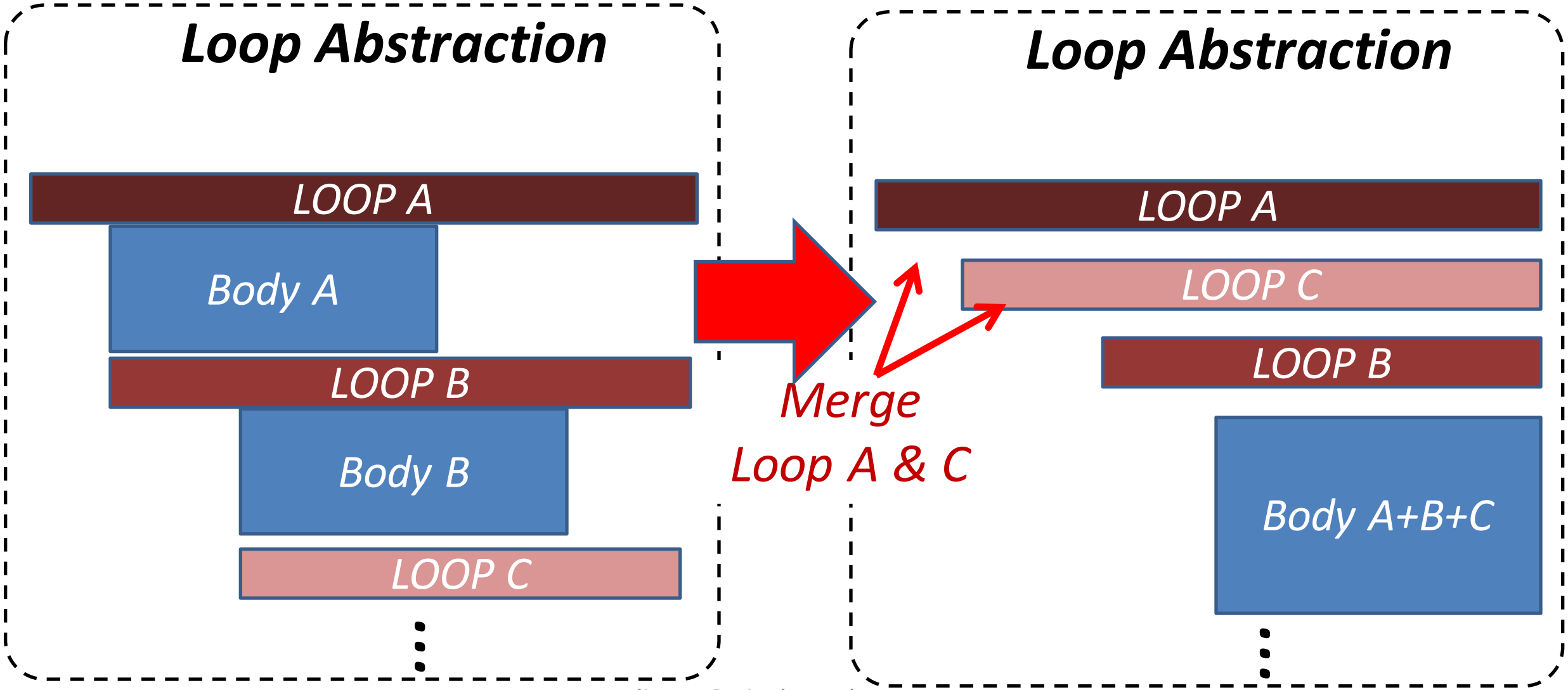
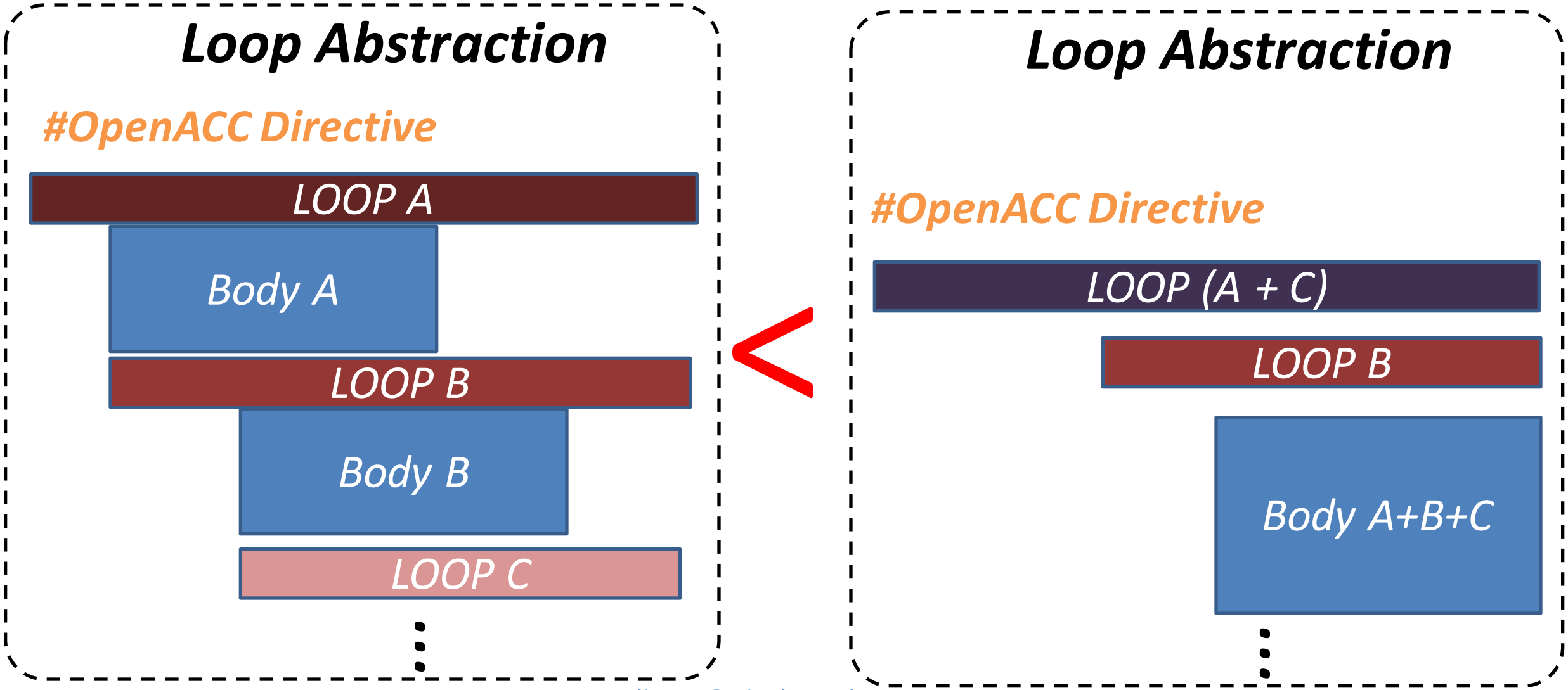
OpenACC for Refactoring (exp. 1)



OpenACC for Refactoring (exp. 1)



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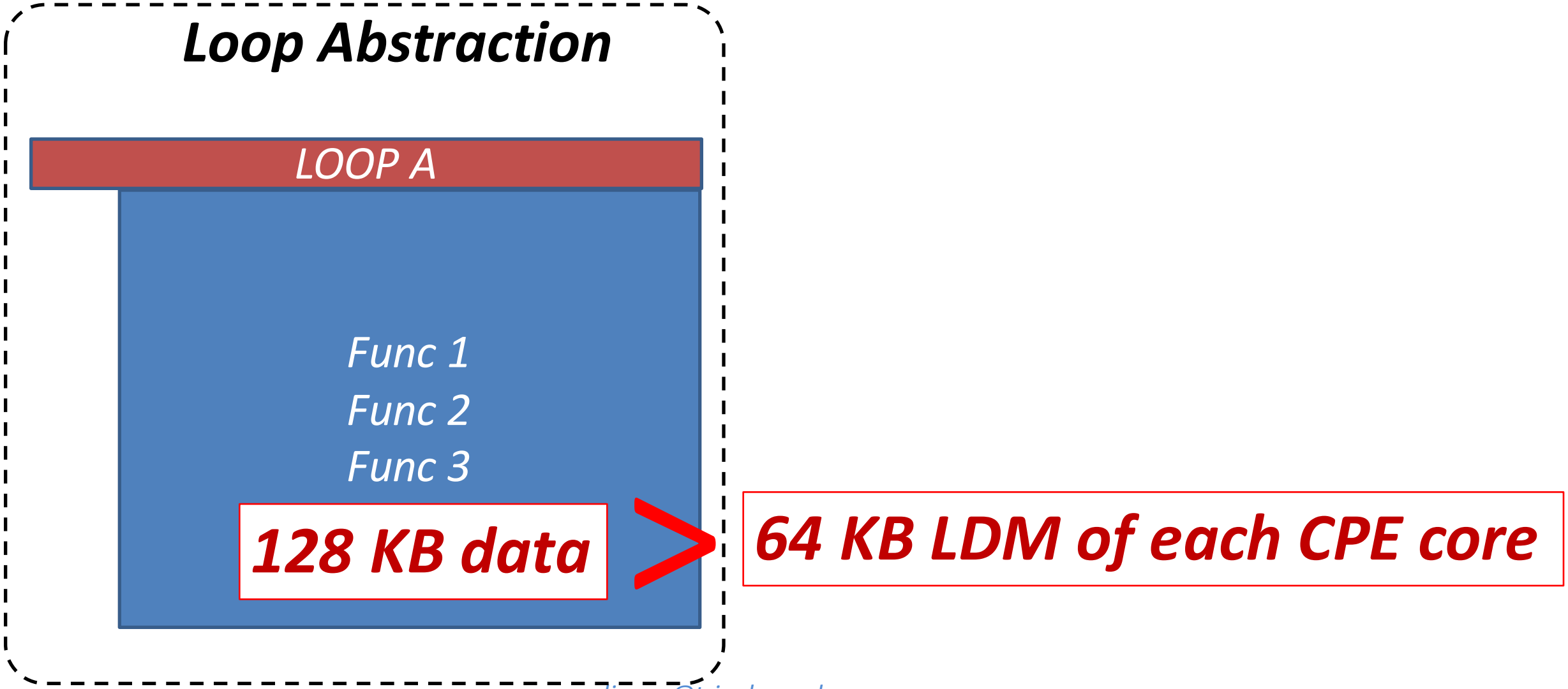
OpenACC for Refactoring (exp. 2)



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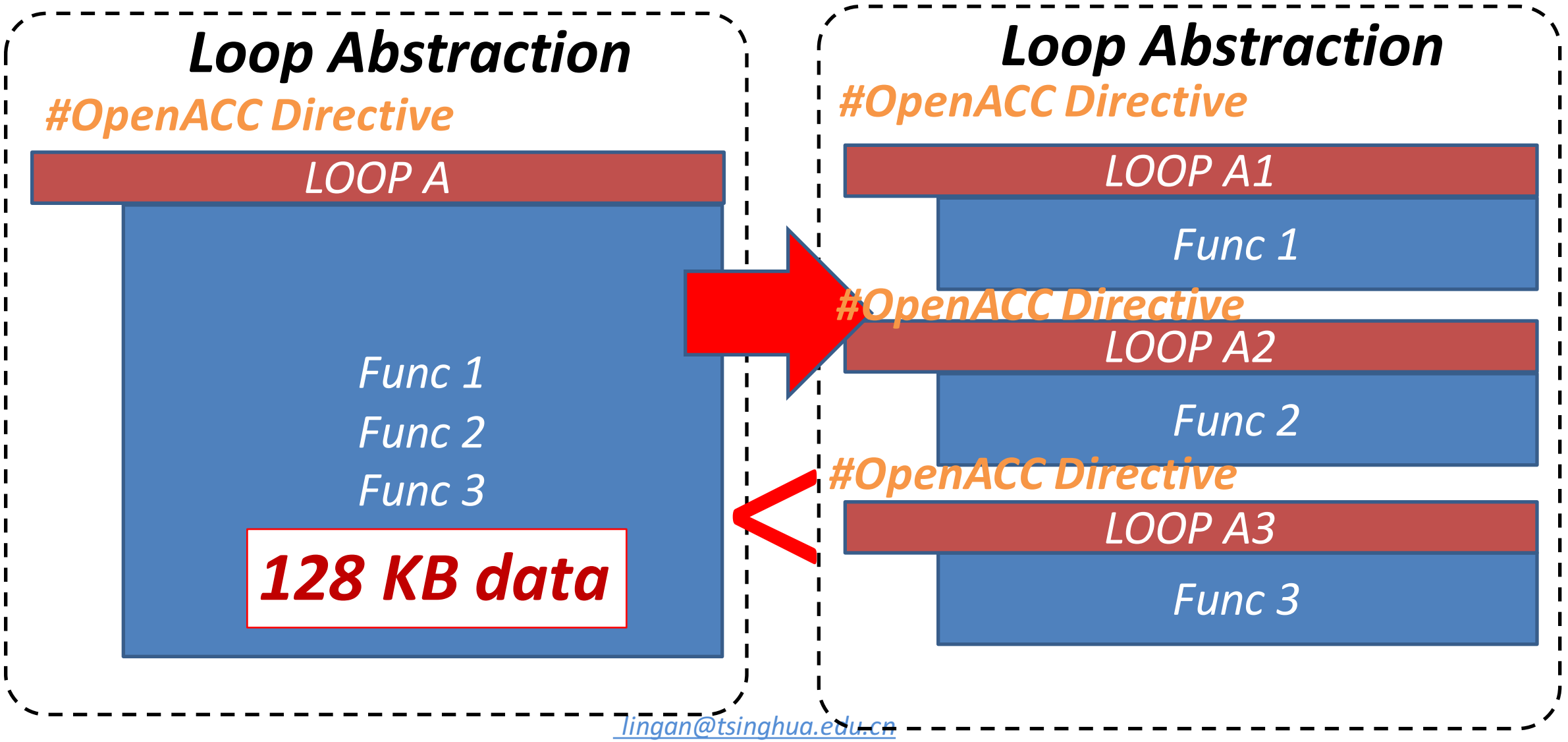
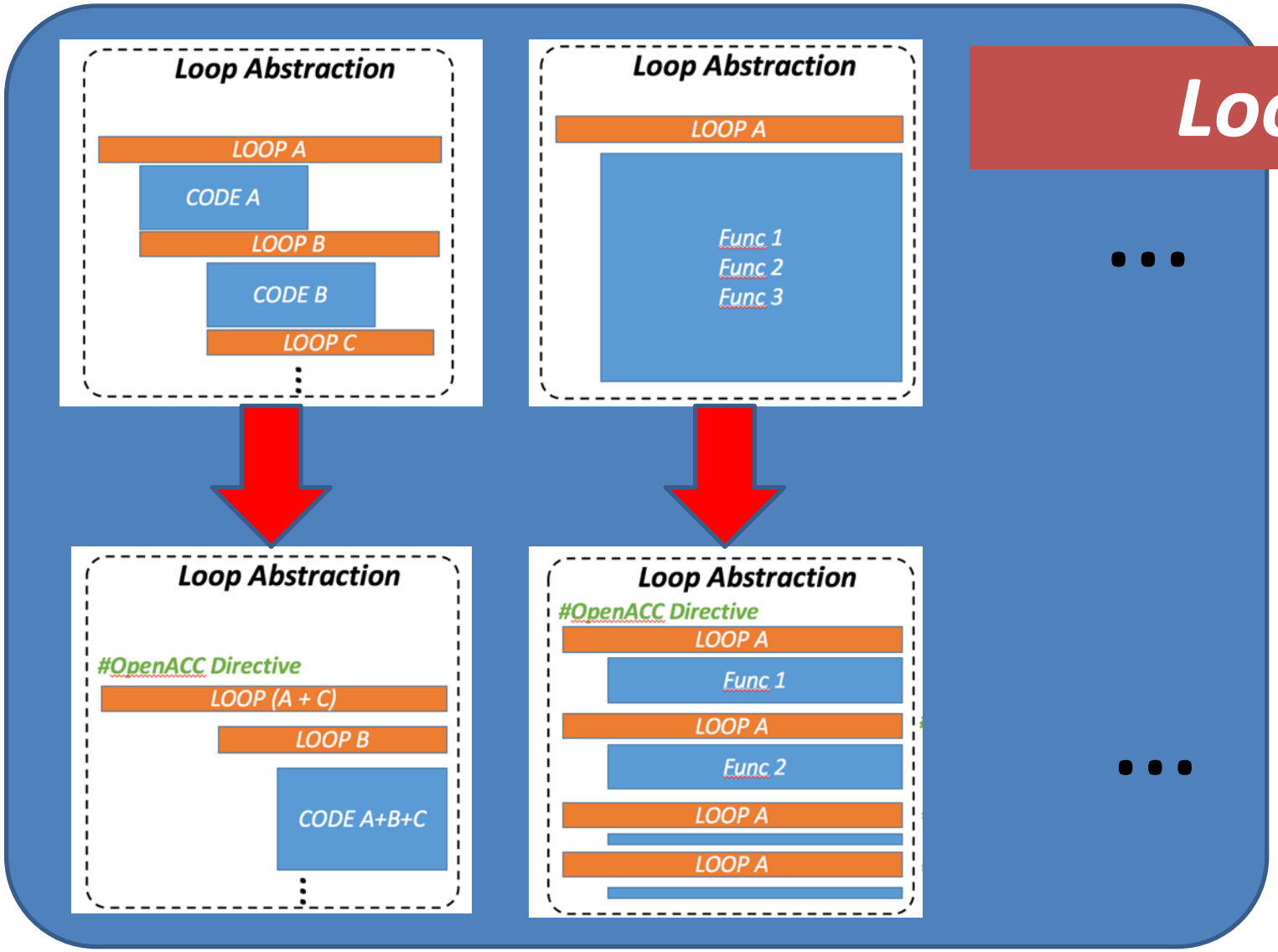
OpenACC for Refactoring (exp. 2)



Tools for OpenACC Implementation



Loop Transform.

Tools for auto-refactoring

DYN and PHY

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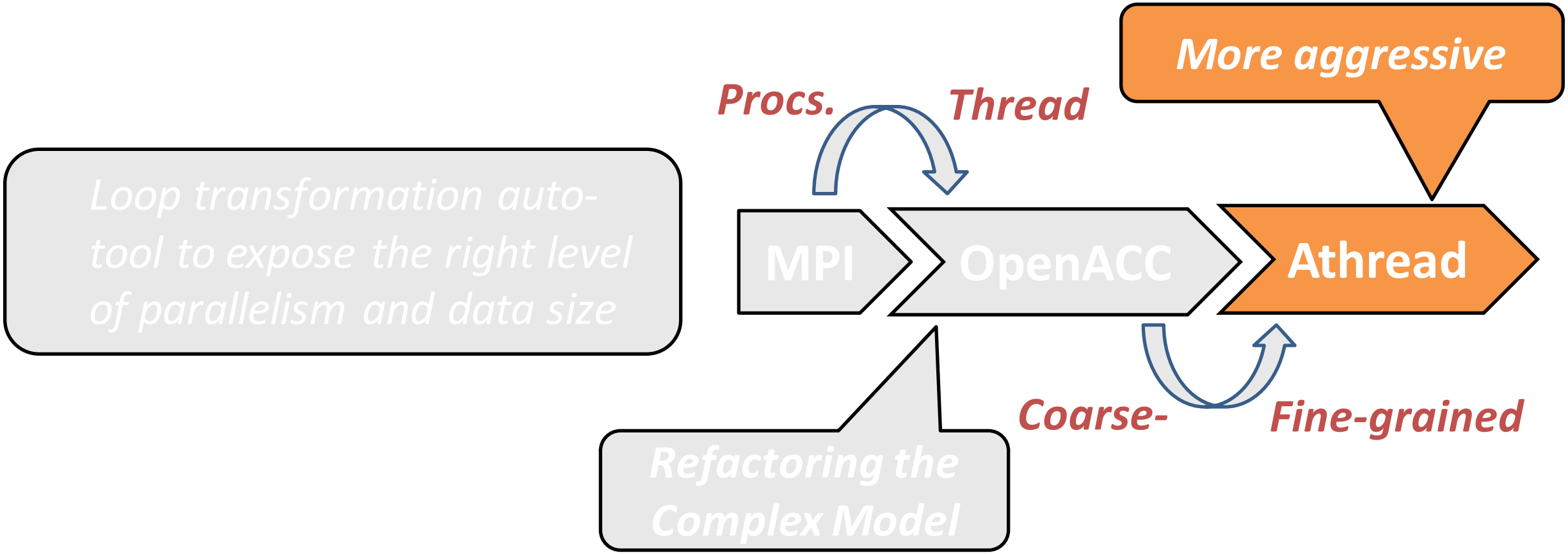

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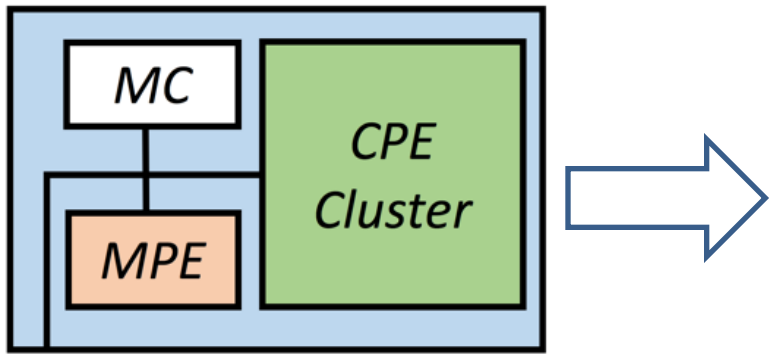
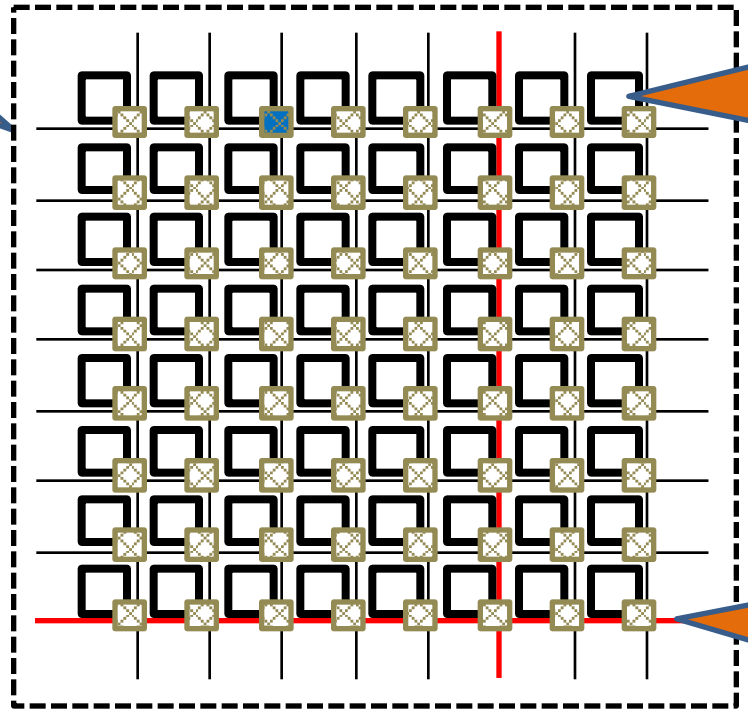
Parallel scheme using 64 CPES



Heterogeneous arch.



One CPE
64 KB Local data memory (LDM)

Between CPE
Fast register communication

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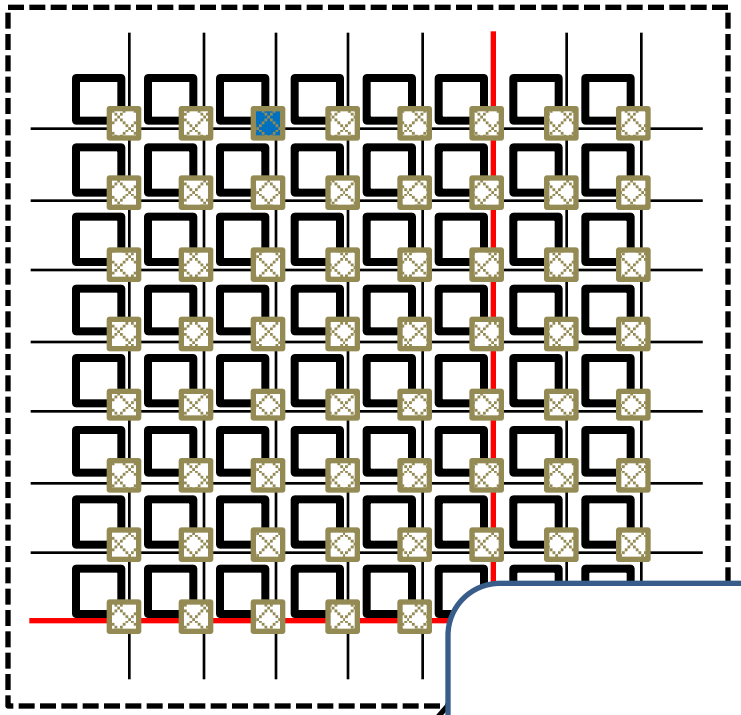
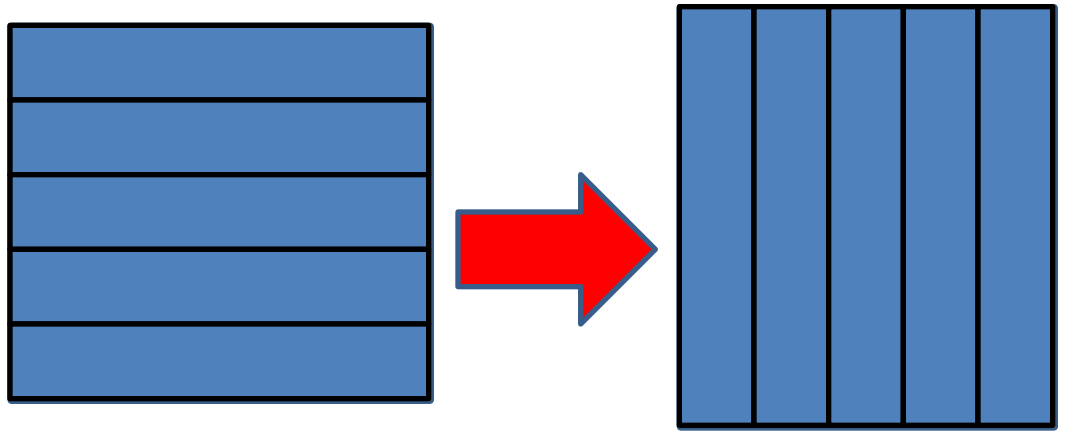
Array Transposition by Register Communication

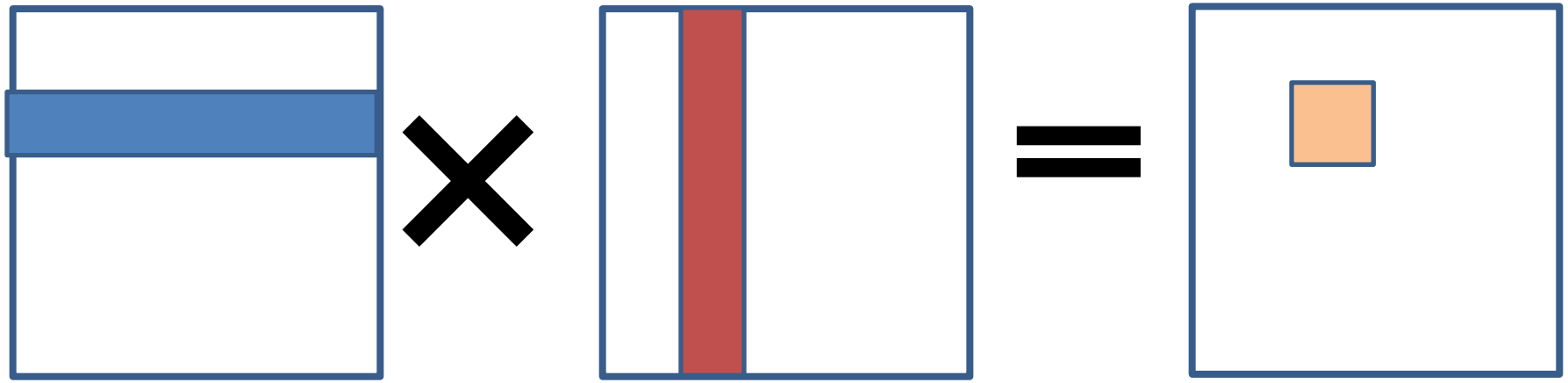


On-the-fly Matrix Transposition



Registe
communic
(~10cycl

Matrix-Matrix Multiplication



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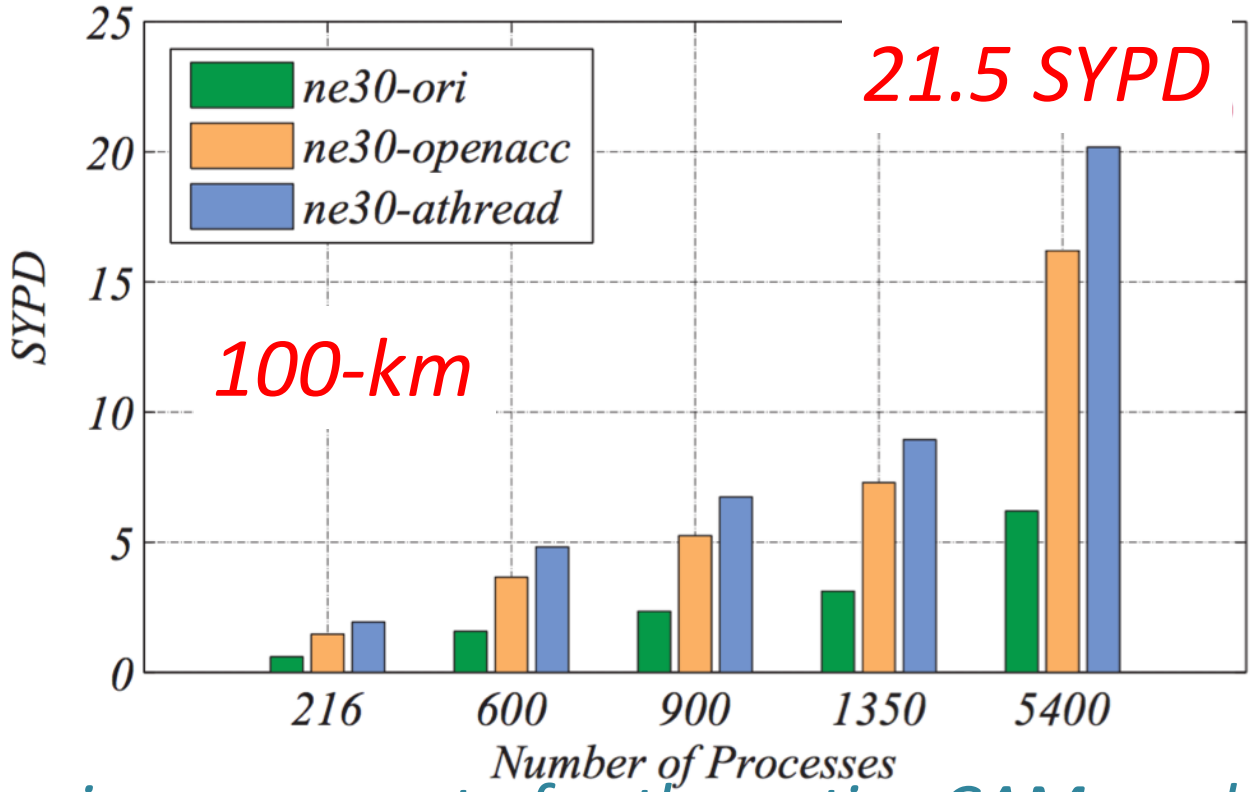
Performance Speedups for CAM on TaihuLIght



The performance improvements for the entire CAM model in ne30 and ne120. ori refers to the original version based on MPE, openacc refers to the usage of OpenACC directive, and athread refers to the further usage of Athread.

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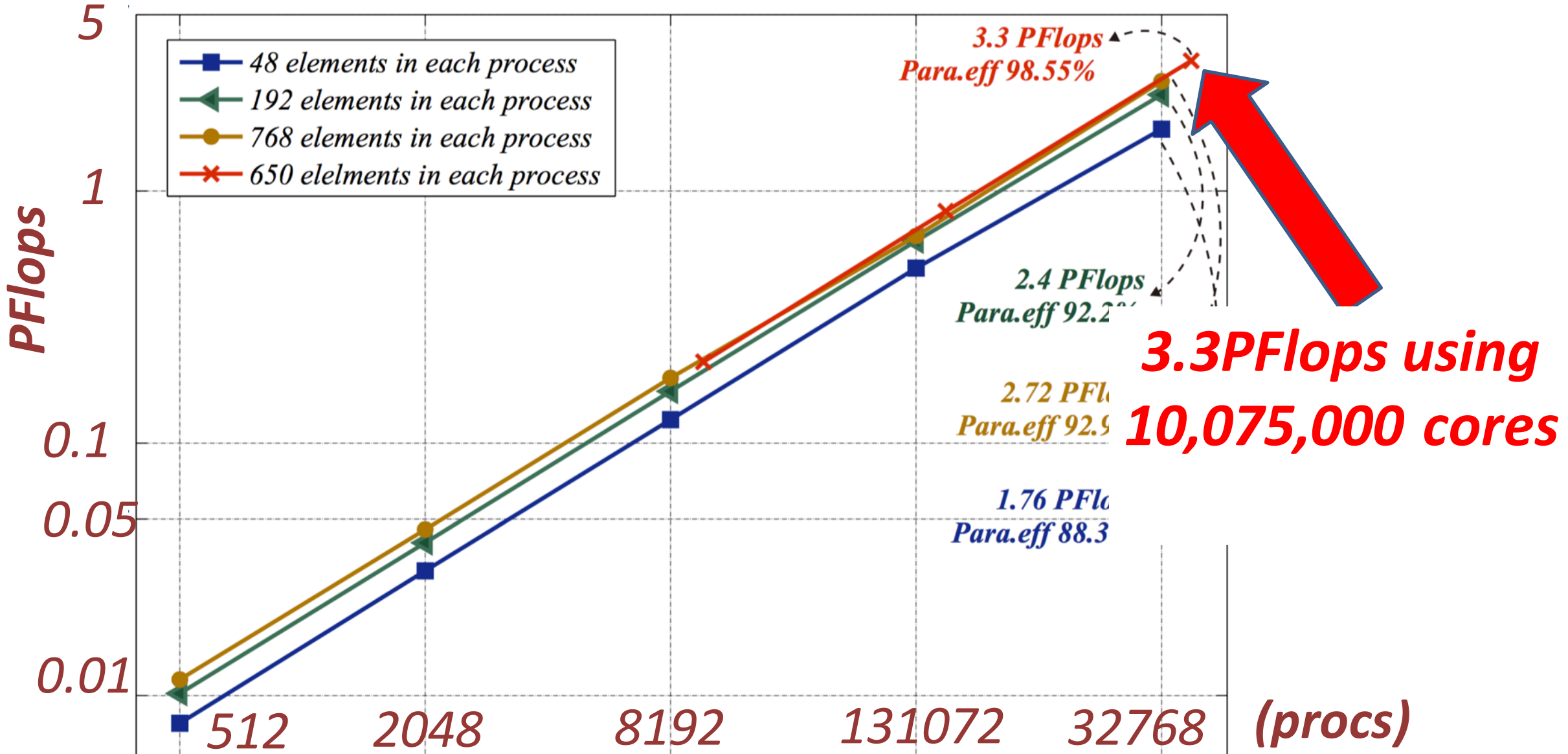
Weak Scaling Performance (DNY)



3.3PFlops using 10,075,000 cores

Climate Models on Sunway

CAM

WRF

AM3

POM

MASNUM

CESM

CIESM

Climate Models on Sunway

CAM | WRF | AM3 | POM

MASNUM | CESM | CIESM

Tsinghua University

Beijing Normal University

First Institute of Oceanography

Jiangnan Institute of Computing Technology

National Supercomputing Center in Wuxi

Nanjing University

Nanjing University of Information Science & Technology

Nanjing Forestry University

East China Normal University

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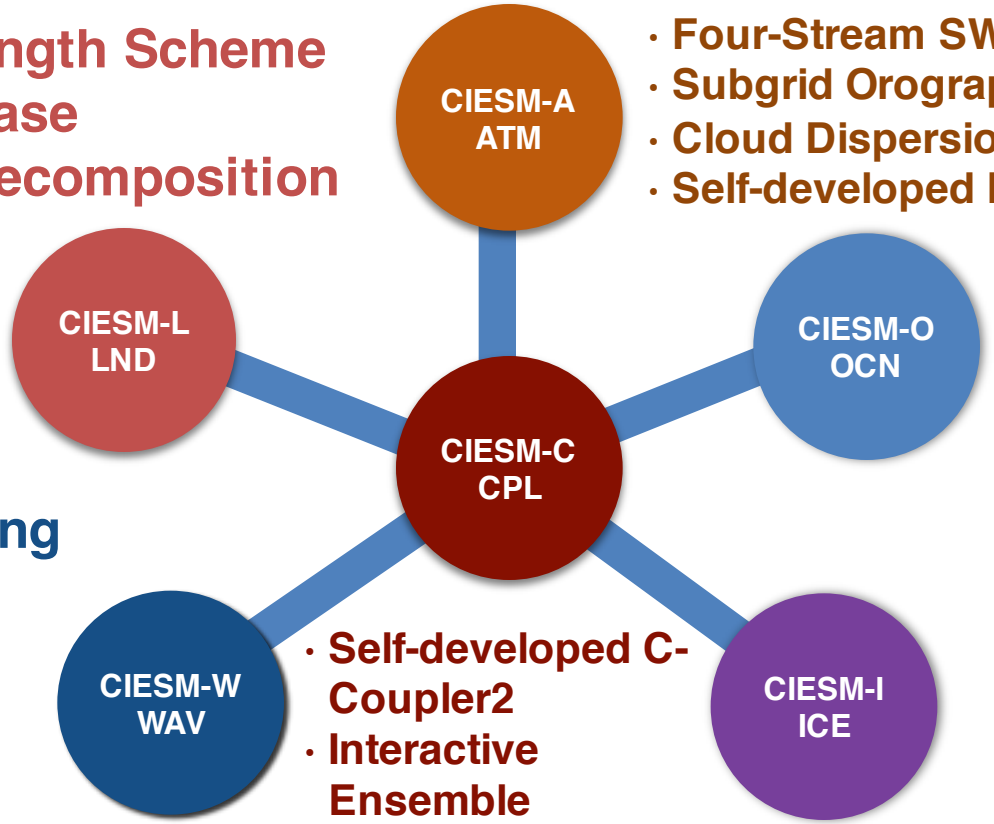
CIESM *(Community Integrated Earth System Model)*

- Modified ZM Convection
- Single-Ice Cloud Physics
- PDF Cloud Micro-Physics
- Four-Stream SW Radiation
- Subgrid Orographic Drag
- Cloud Dispersion
- Self-developed Dynamic Core

- Thermal Roughness Length Scheme
- New Soil Texture Database
- Matrix Approach of C Decomposition



- Conformal Mapping Horizontal Grid
- Highly Scalable PCSI Solver
- A New Air-Sea Flux Parameterization
- Modified Canuto Vertical Mixing
- Sublayer Parameterization
- Wind Speed Dependent Albedo

- Wave Induced Mixing
- Stocks' Drift
- Wave Roughness

- Self-developed C-Coupler2
- Interactive Ensemble
- Mutil-Model Multi-Process Coupling Platform

- Floe-size Dependent Lateral Melting
- Salinity-dependent Freezing

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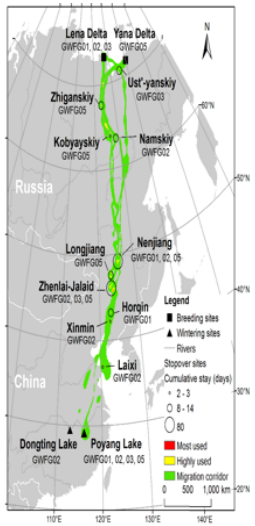
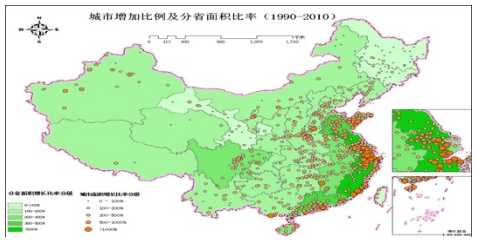
Sunway Deep Learning Platform

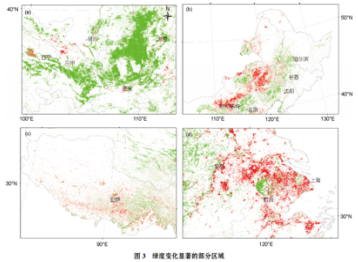
Big Computing + *Big Data*

PaddlePaddle	*TensorFlow*	*swCaffe*
swDNN	*swNet*	*xMath*

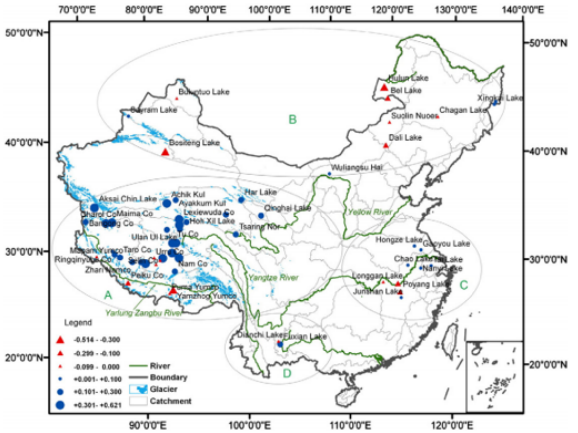
Geo-Science Data

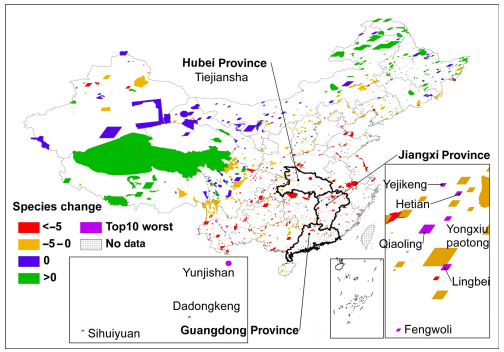


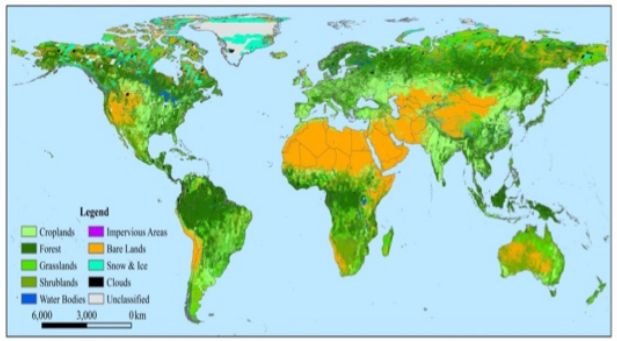




Big Data





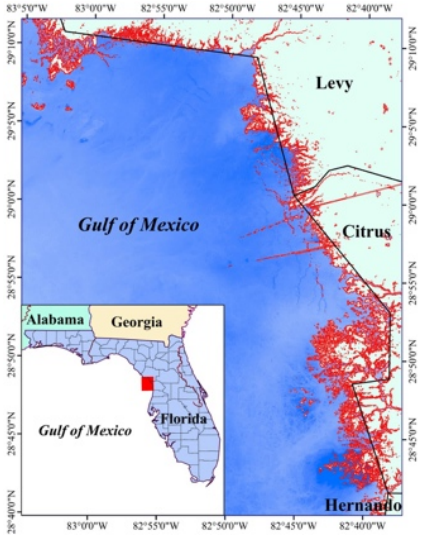


The Opportunities to

Connect

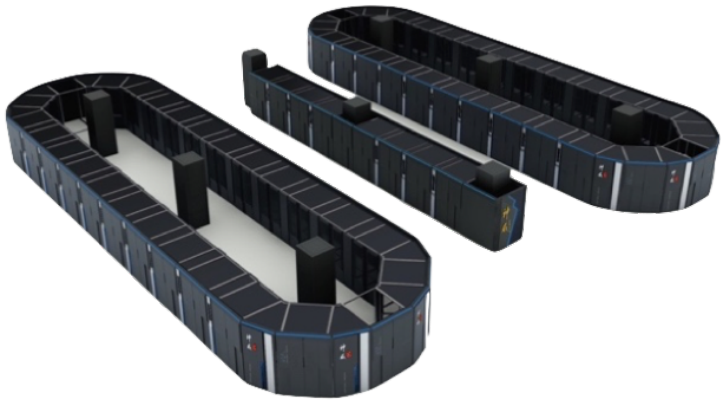
all Problems as one System through

Data *and* **Learning**



Future Plan

application



software

Micro

ExaScale

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Micro

Configuration	
CPU	1 or more
Memory/GB	32, 64, etc

Micro System/Workstation

AI Chip

PaddlePaddle	*TensorFlow*	*swCaffe*
swDNN	*swNet*	*xMath*

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