
Concurrent Systems (ComS/CprE 527)

Ali Jannesari

Department of Computer Science

Iowa State University, Spring 2023

ADMINISTRATION AND CLASS INFORMATION

Outline

- Administrative stuff
 - Who I am, TAs, general information, etc.
 - Course organization and syllabus
 - Schedule and structure of this class
 - Research @ SwAPP Lab

About me

- Instructor: Ali Jannesari (Assist. Prof. at CS department)
- My background: PhD at KIT (Germany), RWTH Aachen, TU Darmstadt, UC Berkeley and ISU
- Research: HPC (parallelism) , Deep Learning, Software engineering,, : <https://www.cs.iastate.edu/swapp/>
- Teaching: I enjoy interactive classes and discussions
- Contact me
 - jannesar@iastate.edu
 - Atanasoff, Room 110, office hours: Tue 3-4 pm and by arrangements (<https://iastate.webex.com/meet/jannesar>)
 - Emails to me regarding the class must include "527" in subject line.

TA

- Sixing Yu (CS PhD Student)
- Email: yusx@iastate.edu
- TA office hours: Thursday 3:30-5:30PM
- Location:
Atanasoff B04 or Webex <https://iastate.webex.com/meet/yusx> (if needed)

Your background?

- How good are you in programming?
 - Java, C/C++, Python?
- How many programs have you written?
 - Which programming languages do you use?
 - Which IDEs?
 - How big are your programs? 100 LOC? 1k? 5k?
- How familiar are you with parallelism, concurrency, and deep learning?
- Are you familiar with HPC, GPUs or multicore systems?
- What about software development methods and software engineering?

General information

Canvas: <https://canvas.iastate.edu/courses/98815>

- Gives you access to the course material, etc.
- Class schedule
 - Lecture: Mon Wed Fri, 9:55 AM - 10:45 AM Central Time (Spring 2023)
 - In-Class: **1126 Sweeney**
 - Lab activities and project meetings: TBA (mostly Fridays)
- Email communication must start with "527:" in the subject line
- Prerequisite:
 - COM S 352 (Pre-Req Waiver Form)
 - Knowledge of programming

Course description

- Fundamentals and advances in concurrent systems in the context of GPUs, TPUs, multicore and HPC systems with specific focus on parallel programming models. Discussion of high-performance computing, GPGPU, scaling (ML/DL algorithms) deep neural network training, high-performance deep learning, engineering parallel software and parallel design patterns.

Learning objectives

- Be familiar with
 - Parallel computing
 - Deep learning
 - High performance deep learning
 - Multicore systems
 - Manycore systems (GPGPU)
 - Clusters
 - Programming models (OpenMP, CUDA, MPI,...)
 - Tools and frameworks
 - Performance engineering (different applications such as deep learning applications and parallel programs)

What you need to do

- Attending lectures/lab activities and project meetings **1%**
(bonus)
- Homework assignments **25%**
- A main term project (portfolio) **50%**
 - 10% proposal; 15% final presentation and slides; 25% project content
 - Milestones and checkpoints
- Paper presentation **25%**

Assignments

- Homework assignments
 - Problems for you to do (individual)
 - Code and explanations (comment your code)
 - **Mandatory**
 - TBA (including report format and submission check list)
 - Selected solutions for code walk, explanation and demonstration during lecture sessions

Project

- A term project **50%**
 - 10% proposal; 15% final presentation and slides; 25% project content
 - Milestones and checkpoints & lab activities and demonstrations
 - Novel ideas of HPC, parallel computing, deep learning (HPDL), software analytics, and HPC embedded systems
- Proposals will be due a week before midterm (max. 1 page, Week 5-7).
- Final report (max. 5 pages)
 - due by the beginning of the final exam week
- 25-minute presentation/demonstration at the end of the semester

Paper presentation

- Paper presentation
 - Based on online articles and recently published papers
 - 25% of your final grades
 - Presentation slides and max. 2 pages summary of the paper are required (5%)
 - In-class 15-20 min presentation (20%)

Miscellaneous

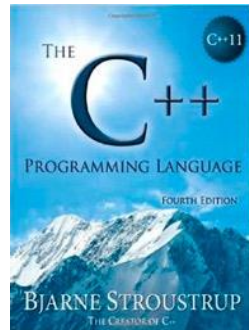
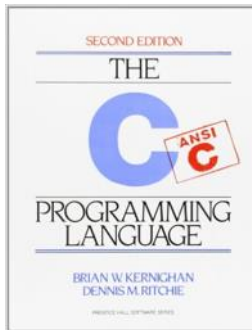
- Some lectures will be assigned for project works and lab activities (TBA)
- Start early, look for online materials, tutorials on web for C/C++, CUDA/OpenMP/Python and deep learning concepts
- In case you copy/paste any code available in public domain you need to cite it in your source code!
- Slides will be available in PDF on Canvas
 - Only for the purpose of this class. **Redistribution not permitted!**

Philosophy

- Interactive style – physical presence strongly recommended but not monitored
 - No video recording (except by Webex on Canvas y Instructor)
- No full coverage of programming standard – rather in-depth study of key concepts
- Sound track not always mirrored on slides – please take notes or rely on books for reference

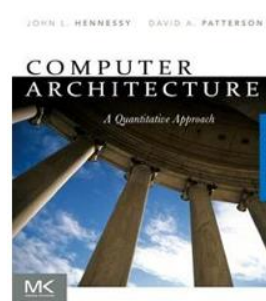
Literature - C/C++

- The C Programming Language
 - Brian W. Kernighan, Dennis M. Ritchie
- The C++ Programming Language
 - Bjarne Stroustrup, 4th edition, Addison Wesley, 2013



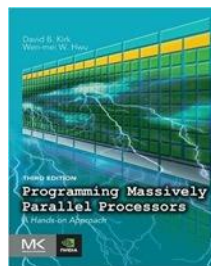
Literature – Computer architecture

- Structured Computer Organization
 - Andrew S. Tanenbaum, Todd Austin, Pearson
- Computer Organization and Design
 - David A. Patterson, John L. Hennessy, Morgan Kaufmann
- Computer Architecture – A Quantitative Approach
 - John L. Hennessy, David A. Patterson, Morgan Kaufmann



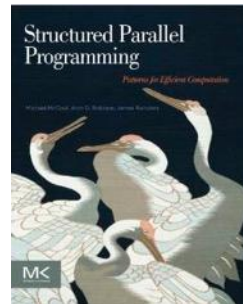
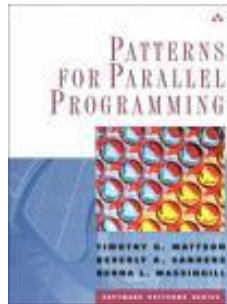
Literature – Parallel programming models

- Using MPI
 - William Gropp, Ewing Lusk, Anthony Skjellum, MIT Press
- Parallel Programming in OpenMP
 - R. Chandra, L. Dagum, D. Kohr, D. Maydan, J. McDonald, R. Meno, Morgan Kaufmann
- Programming Massively Parallel Processors
 - David B. Kirk, Wen-mei W. Hwu, Morgan Kaufmann



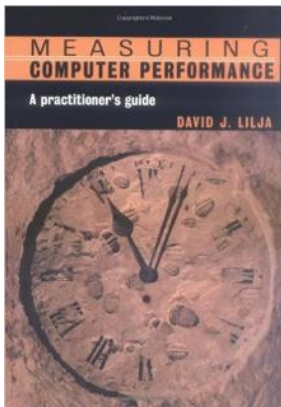
Literature – Parallel algorithms and design patterns

- An Introduction to Parallel Algorithms
 - Joseph JáJá, Addison Wesley
- Patterns for Parallel Programming
 - Timothy G. Mattson, Beverly Sanders, Berna Massingill, Addison-Wesley
- Structured Parallel Programming
 - Michael McCool, Arch D. Robison, James Reinders, Morgan Kaufmann



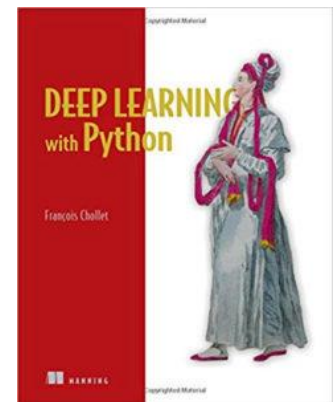
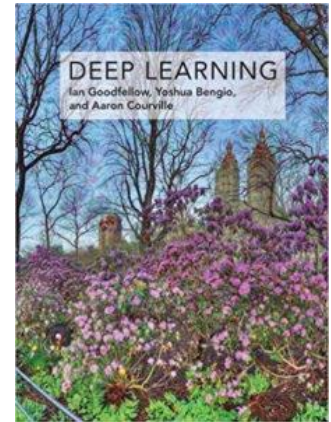
Literature – Performance analysis

- Measuring Computer Performance - A Practitioner's Guide
 - David J. Lilja, Cambridge University Press

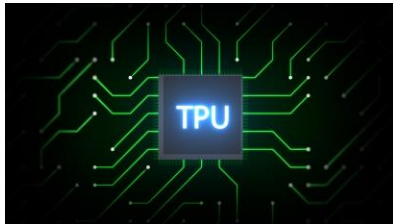
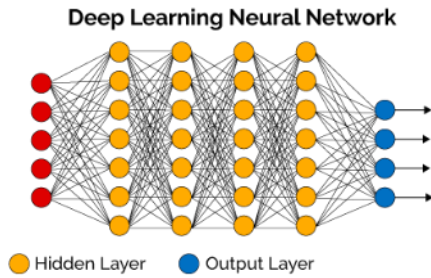


Literature – Deep learning

- Goodfellow, Bengio, and Courville's [Deep Learning text](#).
- Deep Learning with Python, Francois Chollet, Google AI researcher and creator of the popular Keras deep learning library, published his book, Deep Learning with Python in October 2017.



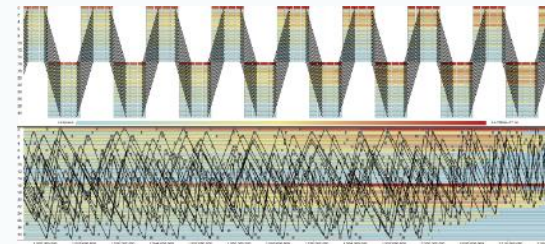
Artificial Intelligence



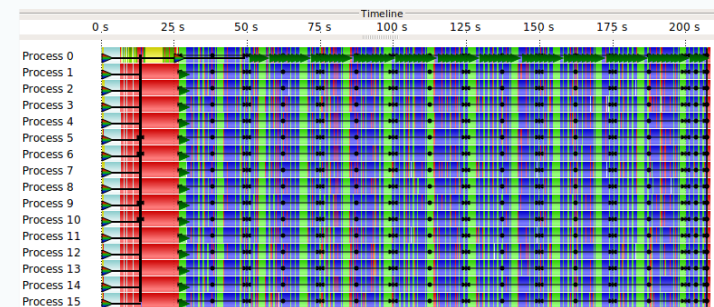
Performance



ORNL - Summit



LLNL - Ravel



Vampir



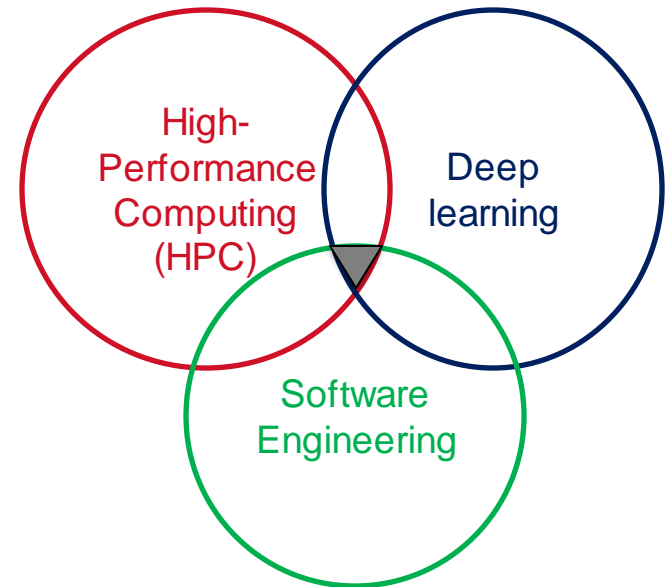
Performance modeling

Parallelism discovery

Methods, tools, and
algorithms for
HPC/parallel and deep
learning applications

Software Analytics

AI & deep learning
applications

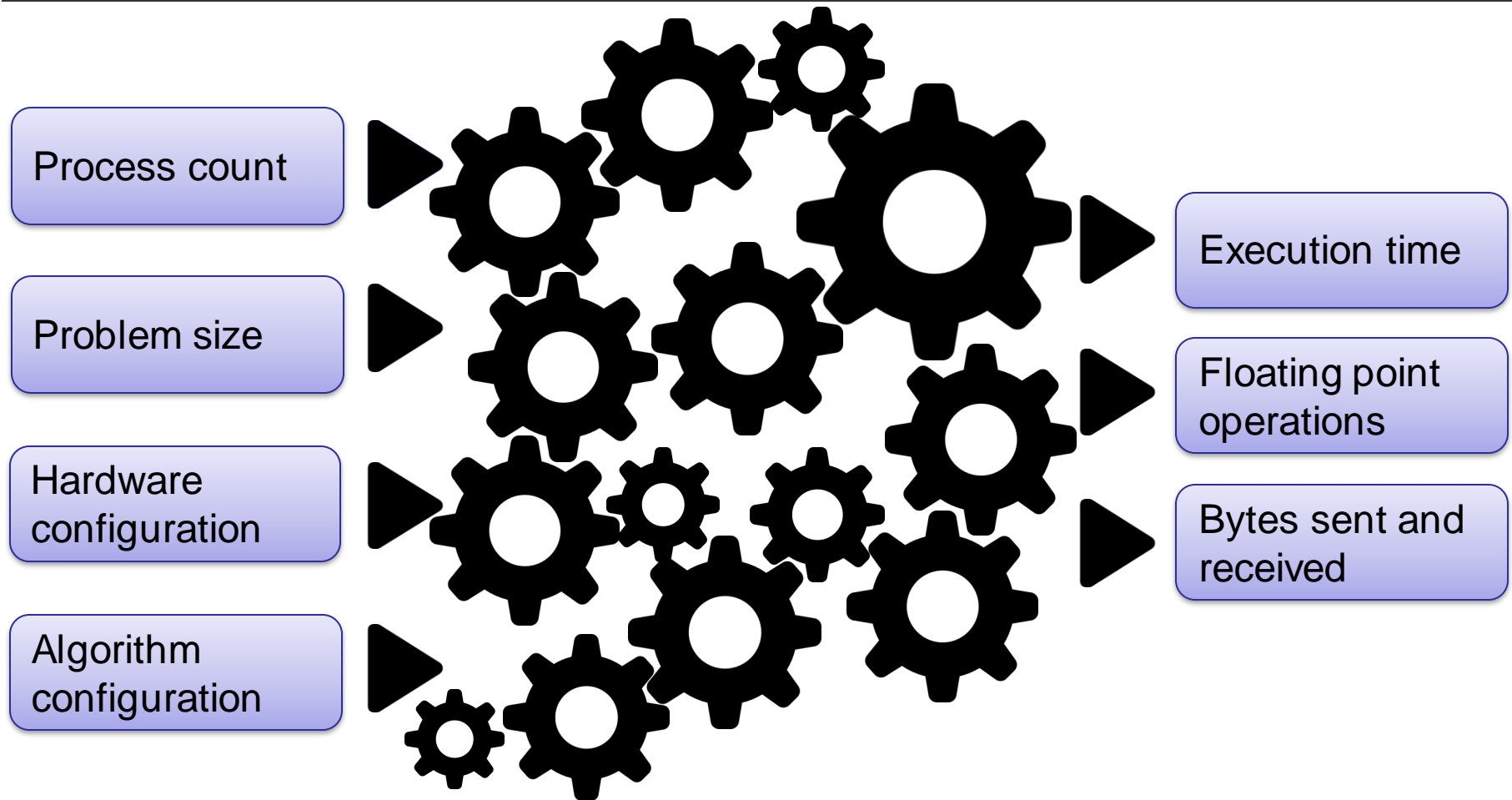


<https://www.cs.iastate.edu/swapp/>

Deep Learning & High-Performance DL

- Deep learning and HPDL
 - Computer vision
 - Compression and pruning
 - Performance portability of DNN applications (Boda)
 - Deep learning applications
- Software analytics (ML/DL for software engineering & parallel programming/HPC)
 - Code analysis with ML & RL
 - Bug pattern detection (DeepRace)
 - NL for programming
 - GNN-based Scheduling

Understanding application performance



Automatic empirical performance modeling

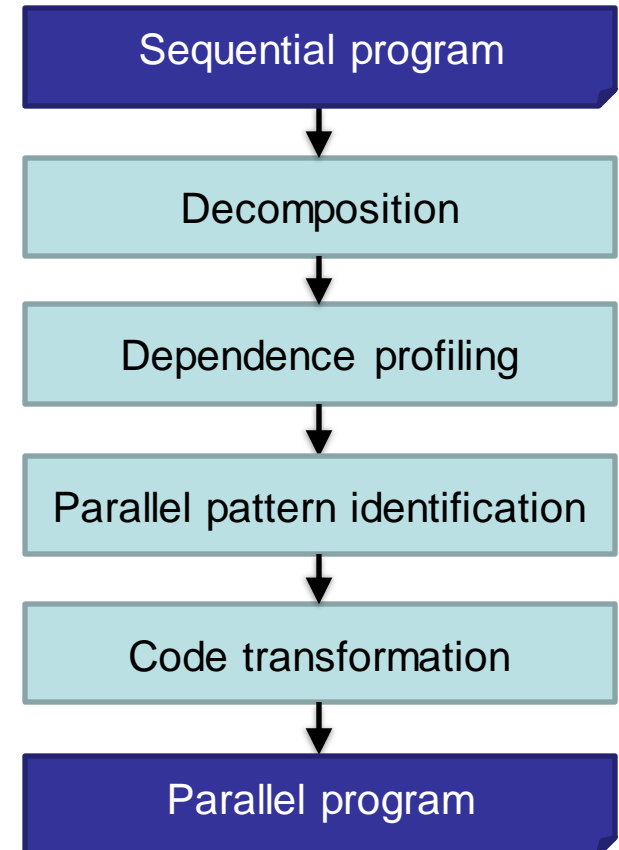
Performance modeling topics

Scalability modeling

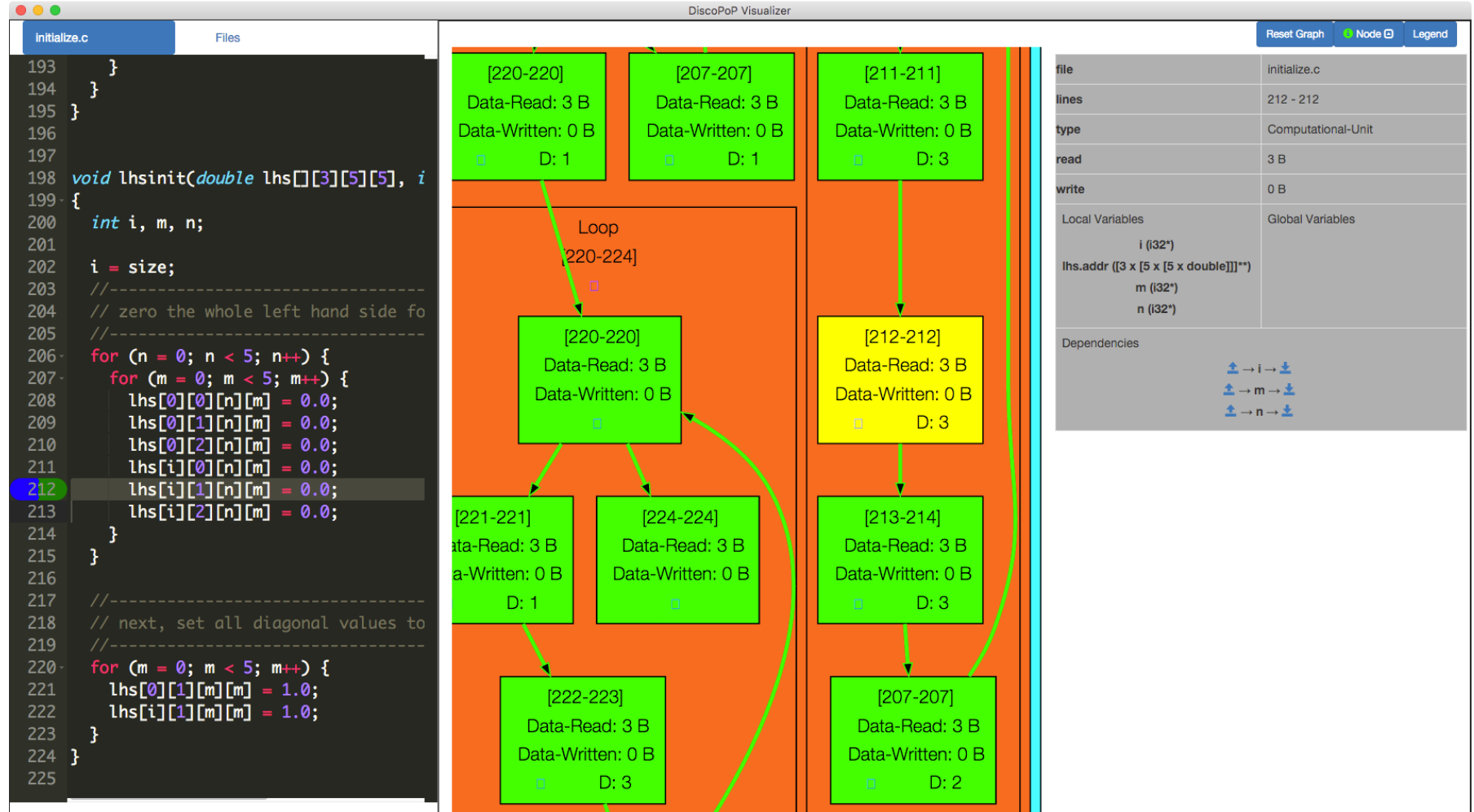
Scalability validation

Parallelism discovery and profiling

- Limited knowledge of data dependences prevents effective parallelization at compile time in the general case
- Idea – abandon idea of fully automatic parallelization. Instead:
 - Point user to likely parallelization opportunities
 - Offer guidance how to design the parallel code
- **www.discopop.org**



Visualization of program dependences



Multicore/Manycore programming topics

Efficient dependence profiling

Parallelism discovery

Parallel design pattern

Code transformation

Correctness analysis

Performance analysis

Static/dynamic and **AI-assisted**
methods

Doing research with SwAPP lab?

Software Analytics
&
Pervasive Parallelism
Lab



- Interested doing research?
 - Contact me at: jannesar@iastate.edu

