

Particle-in-Cell System for Snowball Movement Simulation

Team: GroupD Hopwmm

Mentors: Dr. Atsushi Hori, Dr. Seiya Nishizawa

3rd RIKEN R-CCS Youth Workshop

Outline

- Introduction
- Architecture
- Shape estimation
- Parallelization
- Power Savings
- Verification
- Summary

[Picture of colliding snow balls]

Introduction

What is PIC?

- Particle-in-cell system presents the movement of the scattered objects

Problem

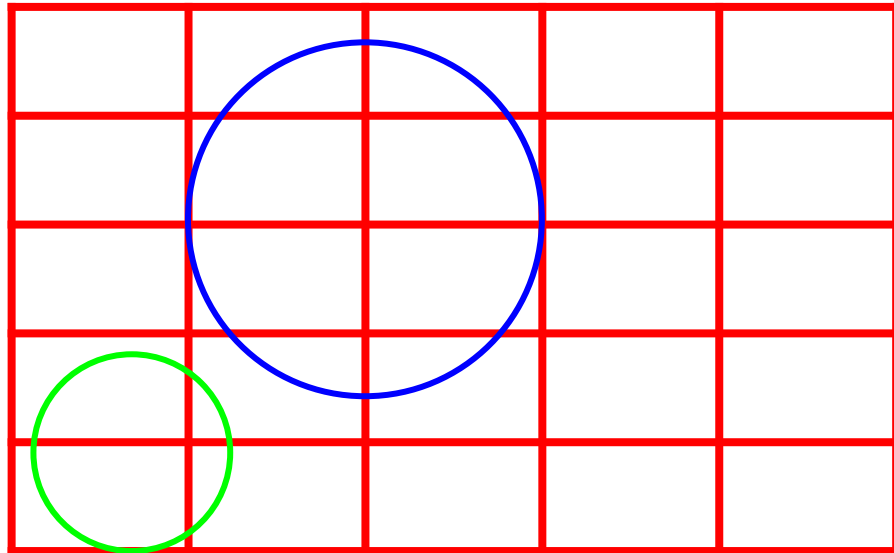
- Imbalanced calculation workload

Solutions

- Design an optimized PIC system by using 5 optimization techniques from teammates' domain knowledge

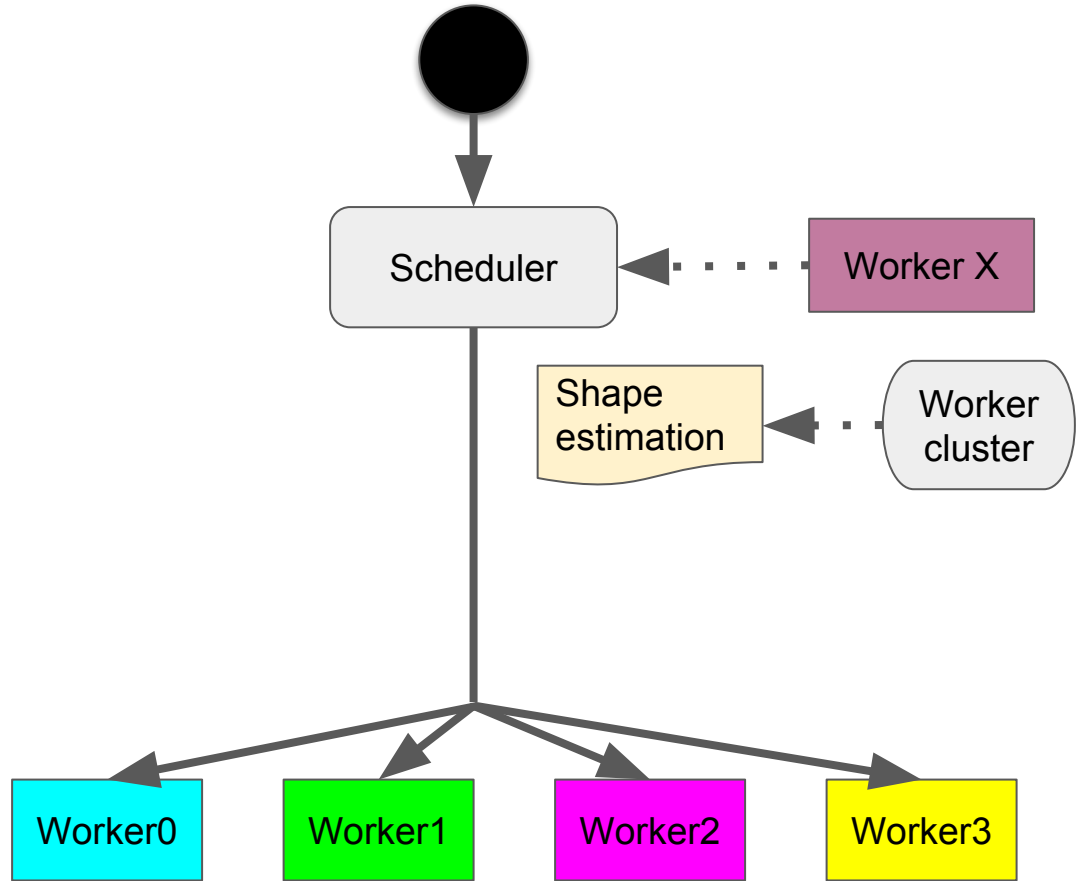
Performance experiment: Post-post K computer

[Picture of colliding snow balls]



Architecture

Worker 0	Worker 1
Worker 2	Worker 3

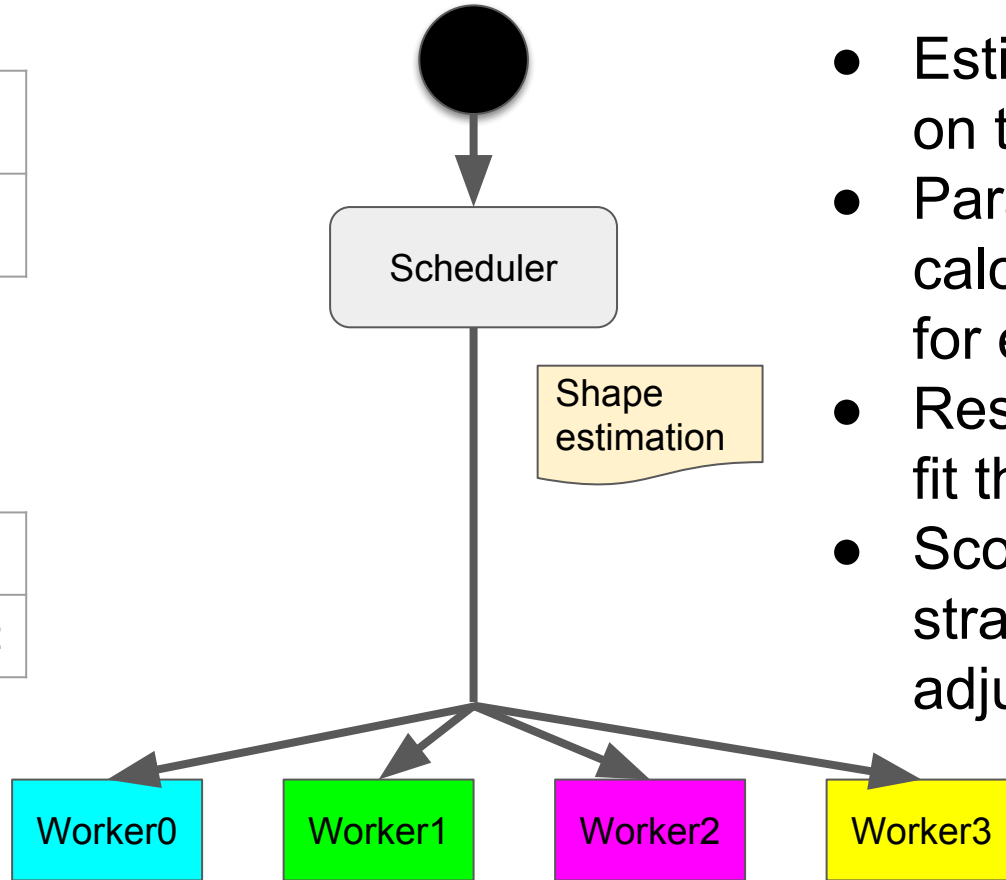


Architecture

w0	w1
w2	w3

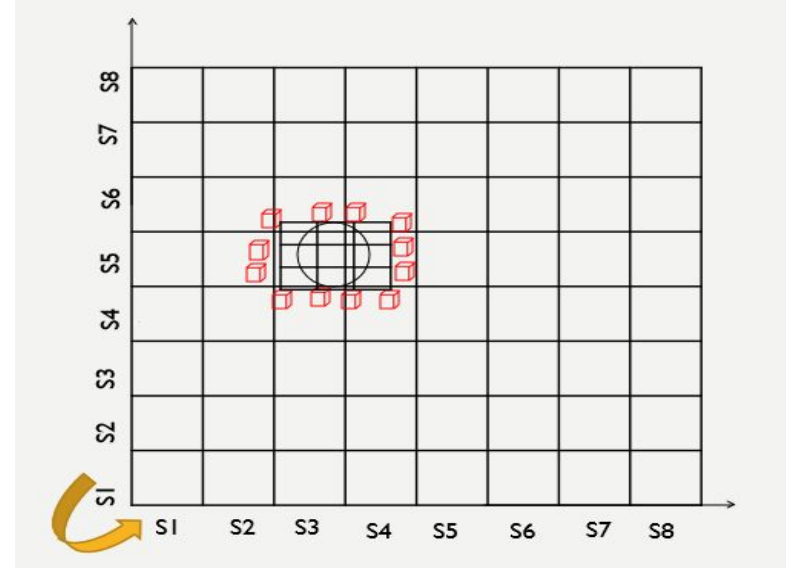
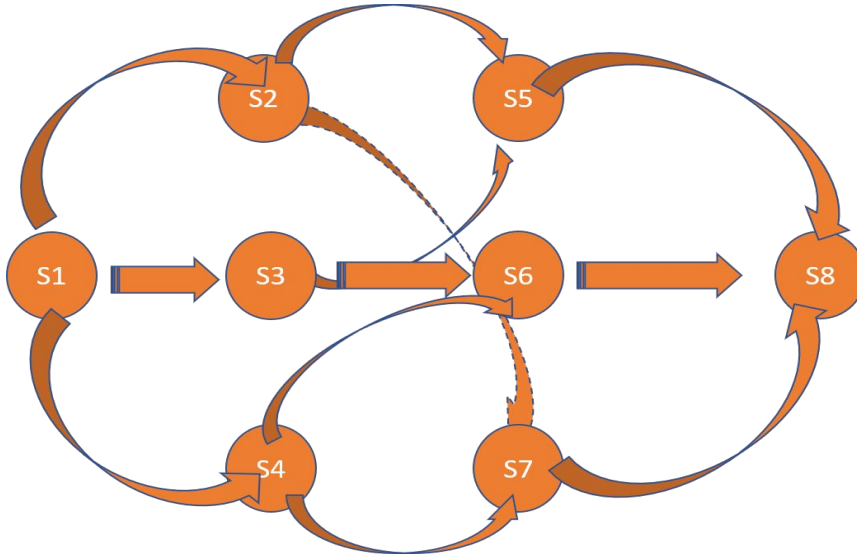


w0	w1
	w2



- Estimate the shape on the next “moment”
- Parallelized calculation for result for estimation
- Resize each area to fit the workloads
- Score current strategy for further adjustment

Markov Chain for Shape Estimation



Mathematically,
$$p(i, j) = \mathbf{P}[X_{n+1} = j | X_n = i]$$

Markov Chain for Shape Estimation

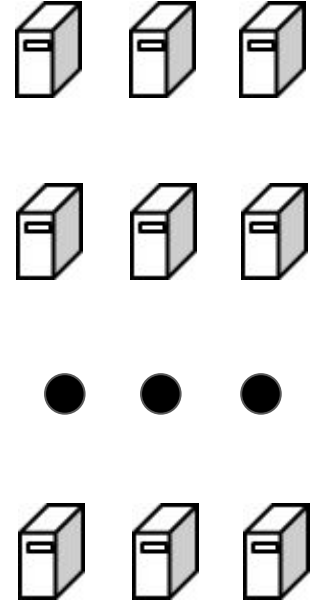
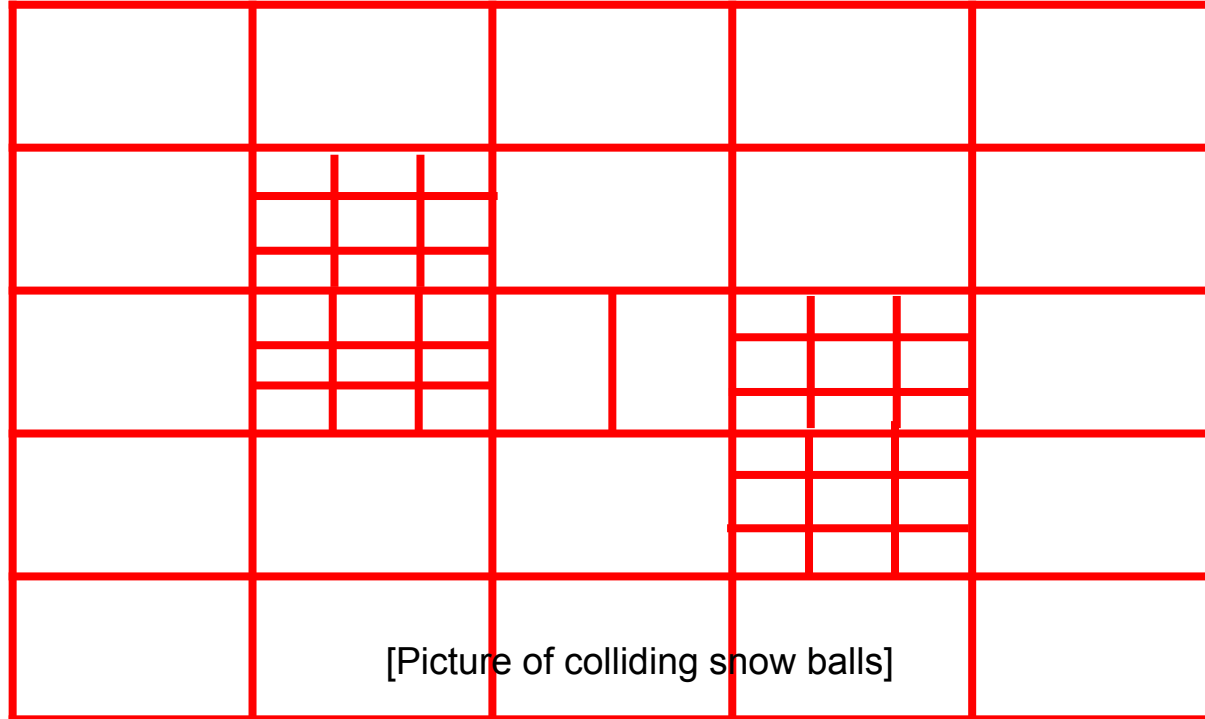
- Markov Chain is used to model the state of the system/Particle at any given time in space/medium.
- The element of the transition Matrix is obtained using the transition diagram.
- The probability of being in the next state is determined as a function of the conditional probability of the being in the current state.
- The Markov Chain helps the scheduler to determine where to assign the computing resources

Mathematically,

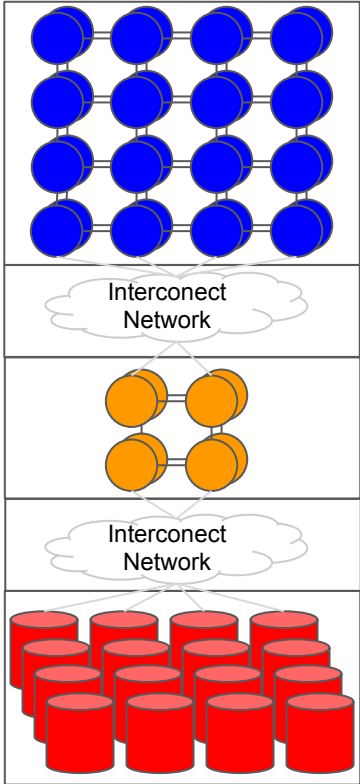
$$\mathbf{p}(\mathbf{i}, \mathbf{j}) = \mathbf{P}[\mathbf{X}_{n+1} = \mathbf{j} | \mathbf{X}_n = \mathbf{i}]$$




Parallelization

- The overall grid computation tasks are parallelized; more CPUs share heavy computation area



Power Saving



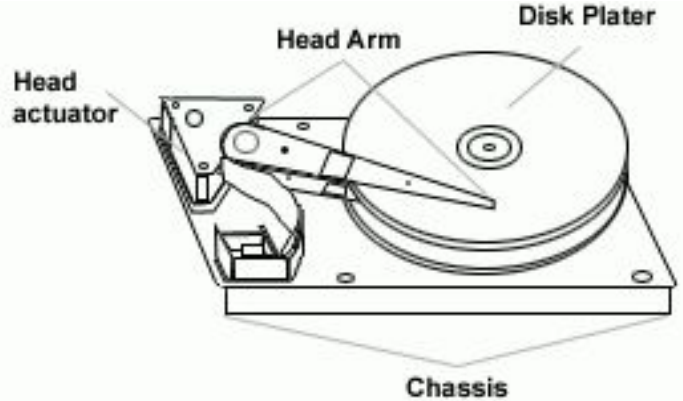
-  Compute Nodes
-  Meta-Data Nodes
-  Data Nodes

Storage Design

SSD Devices



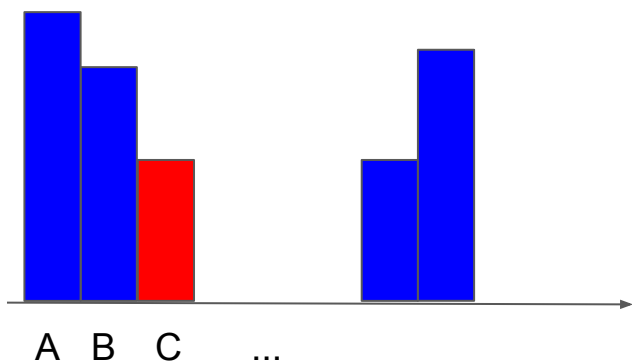
HDD Devices



Power Saving (Scheduler Tasks)

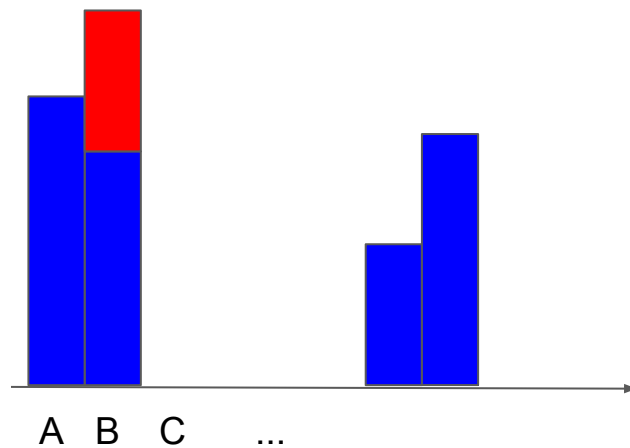
 Task Z

Figure 1



Resource

Figure 2



Resource

Time continuous

Verification

- In this project, the scheduler is critical
- We should find bugs in the scheduler
- Separation Logic is a tool for software verification
 - It can find some memory leak bugs in a given program with high accuracy

Summary

We propose a new PIC system which utilize Markov Chain, high parallelization, power-efficient strategy to handle dynamic and complicated particle movements simulation.

[Picture of colliding snow balls]

Reference

Snow picture:

<https://www.dailymail.co.uk/news/article-3182423/Snowball-case-melts-teen-sues-Detroit-district-arrest.html>(Retrived date: 02/17/2019)