Teaching Task-Based Parallel Programming with a Runtime Systems-Aware Perspective

Vivek Kumar
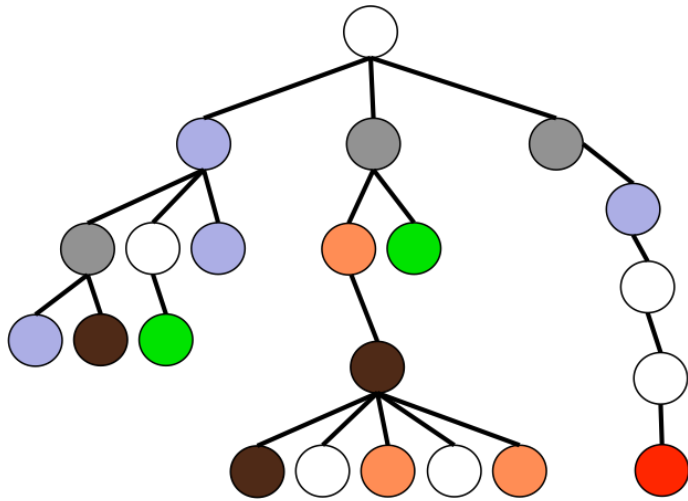
IIIT Delhi, India

(https://hipec.github.io/)

Outline

- Introduction and background

- Contributions

- Teaching methodology

- Retrospective of three years offering

- Challenges and lessons learnt
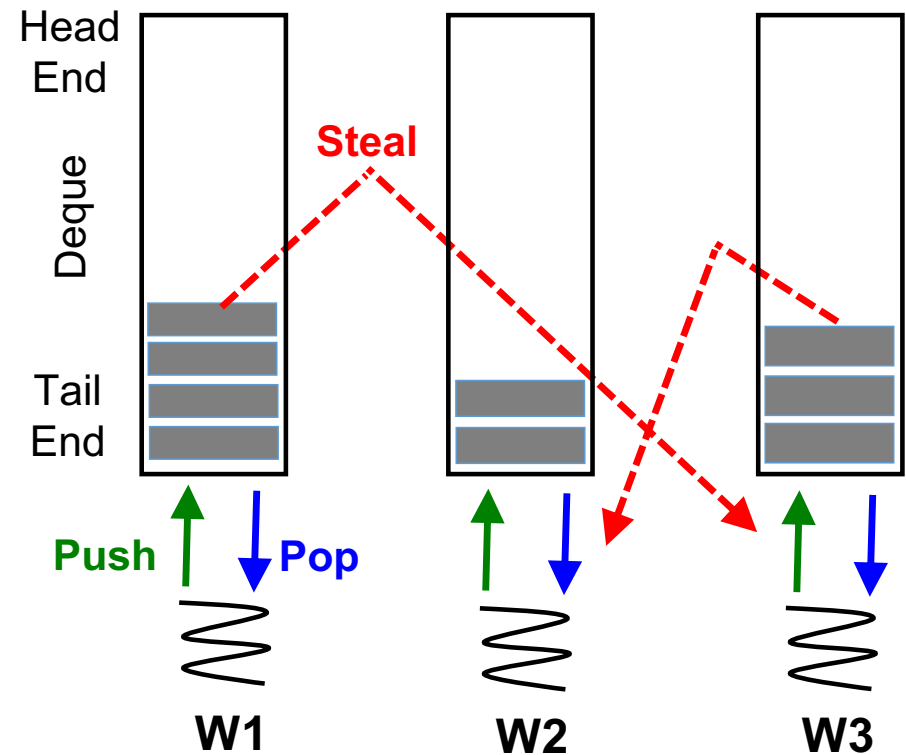
- Summary

Task Based Parallel Programming Model


```
finish ([=]() {
  for(int i=0; i<node->nChild; i++) {
    async ([=]() {
      recurse(node->child[i]); //Tasks
    });
  }
}); //Task synchronization
```

Where Existing Courses Fall Short?
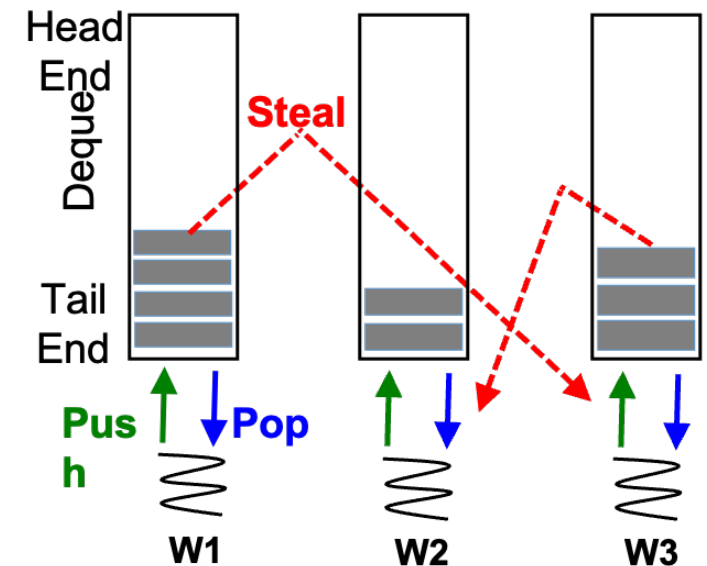
- **Runtime overheads (Module 1)**
  o How many tasks?
  o How to store tasks?
  o How to scale on NUMA?

- **Concurrency issues (Module 2)**
  o How to trace/replay tasks?
  o Can user-level threads perform equally well?

- **Efficient strategies (Module 3)**
  o How to scale over heterogeneous architectures?
  o How to enable resiliency?
  o How to improve energy efficiency?

Contributions

Parallel **R**untimes for **M**odern **P**rocessors (PRMP)

Covers a breadth of topics in optimizing runtime systems for task parallelism

Being offered at IIIT Delhi for the past three years

✔ Emphasizes both productivity and performance

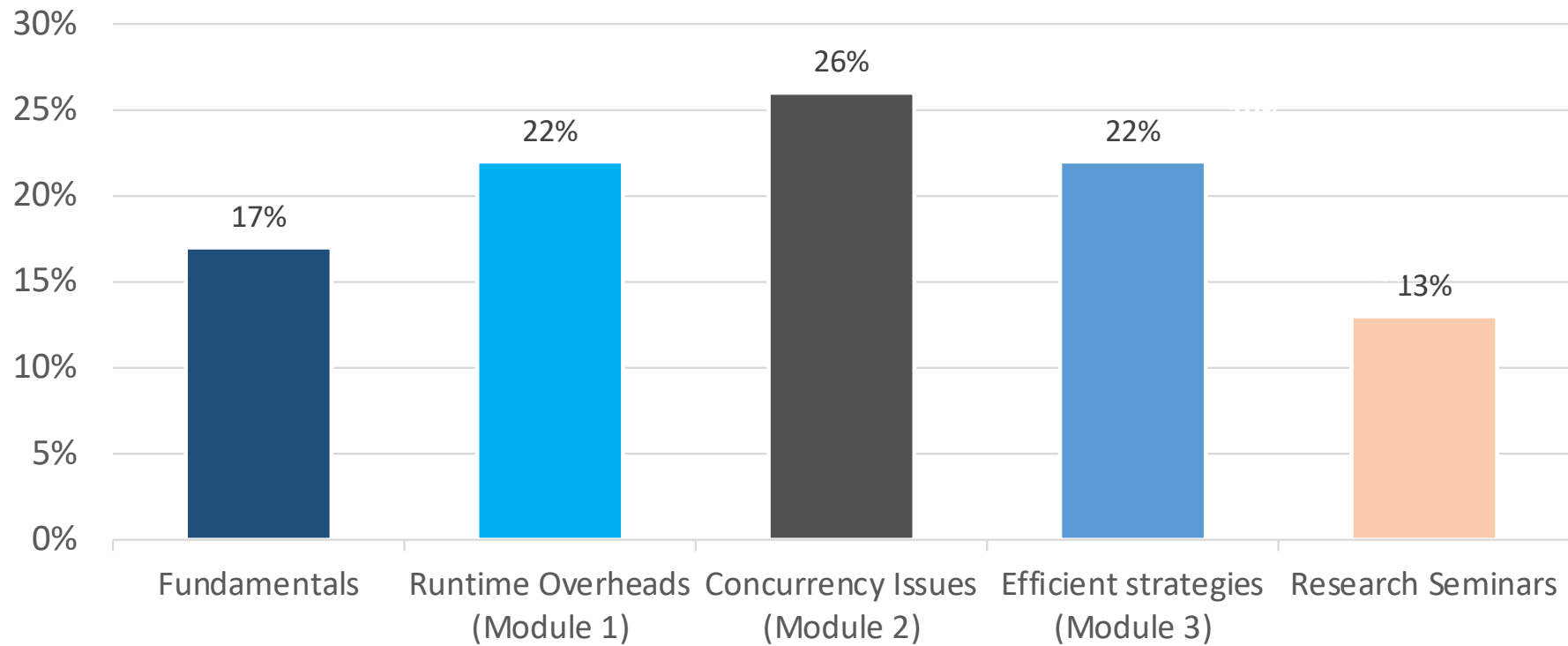Teaches runtime techniques for improving performance in task parallelism

✔ Programming intensive course evaluation

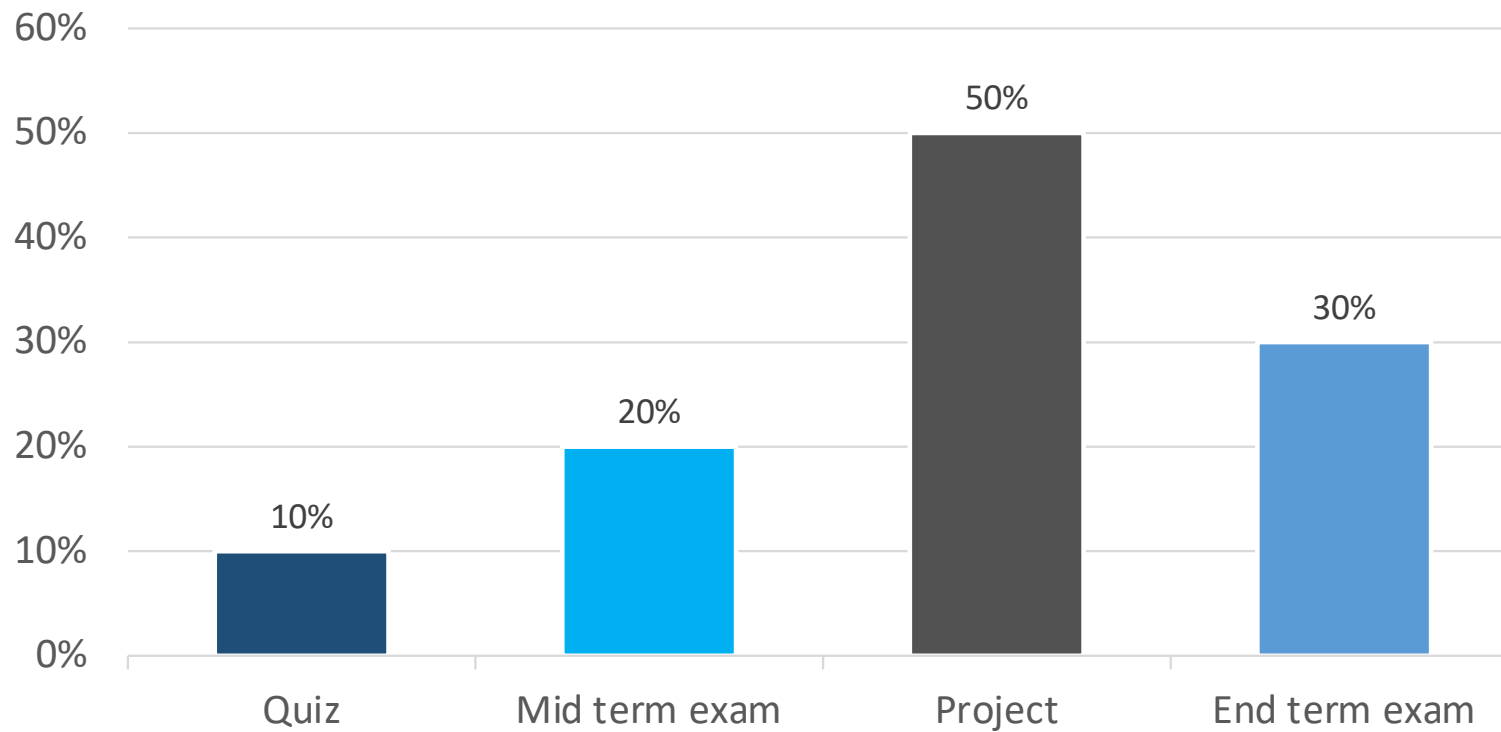That uses a novel approach of chaining assignments and project

✔ Detailed analysis of past three offerings of PRMP

Demonstrating student distribution, marks distribution, student feedback, and challenges

Lecture Topics

Evaluation Components

Chaining of Project Deliverables

Milestone-6: Experimental evaluations and summarizing a recently published paper

Milestone-5: Energy efficiency using concurrency throttling

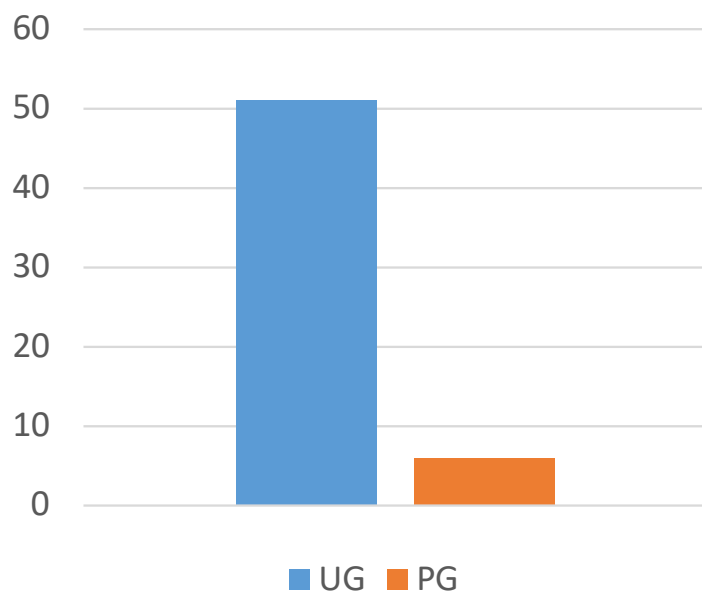**Milestone-4**:Locality support using trace/replay

Milestone-3: NUMA aware runtime

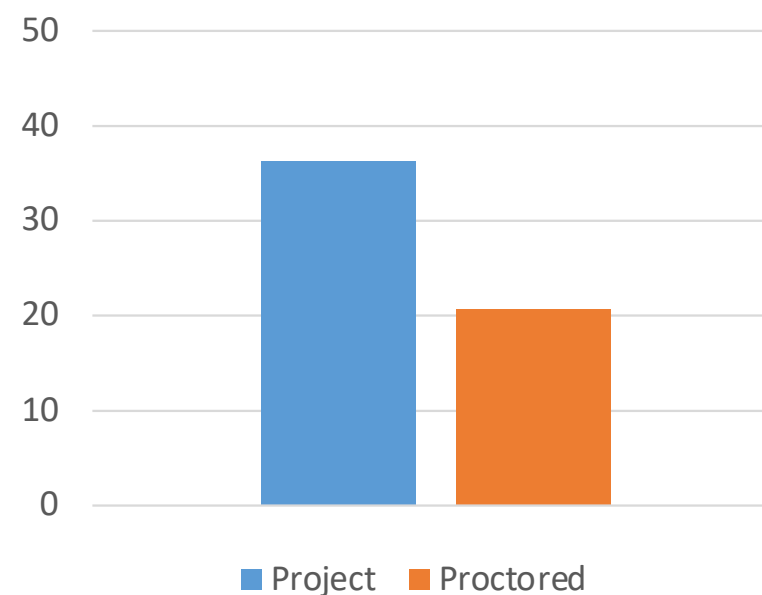**Milestone-2**: Minimize task creation overheads

Milestone-1: Design and implementation of async-finish programming model

- Pair programming based activities to impart **team spirit**

- Programming heavy milestones to improve the **programming skills**

- Research seminar to improve the **presentation skills**

Students and Marks Over Three Years

Student Distribution

Marks Distribution

Challenges and Lessons Learnt

- Complete project dependencies early on
  - Lectures related to project milestones are covered before mid semester exams

- Custom runtime v/s pre-existing library
  - Allowing students to implement project milestones over a work-stealing runtime that was implemented from scratch provided an ease of implementation

- Inclusion of labs
  - Adding lab components can improve the learning of topics covered post mid semester

- AI tools usage in project implementation
  - Total 8% of students reported using AI generated code in more than 25% of their implementations

Summary

- We presented the structure and summary of Parallel Runtimes for Modern Processors (PRMP) course
  - Offered at IIIT Delhi over the past three years to UG/PG students
- Focuses on improving the performance and efficiency of work-stealing runtimes
  - Uses async-finish style task based parallel programming model
- PRMP uses a project oriented course design with milestone chaining

Course Webpage: https://hipec.github.io/courses/cse513.html

IIIT Delhi is actively looking for Faculty Applicants… Please spread the word

https://www.iiitd.ac.in/sites/default/files/docs/positions/2025/Flier-CSE-July-2025.pdf