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

Vivek Kumar

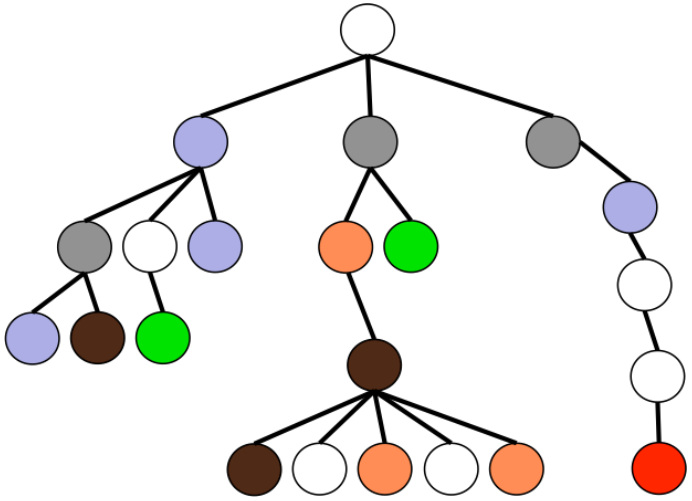
IIIT Delhi, India

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

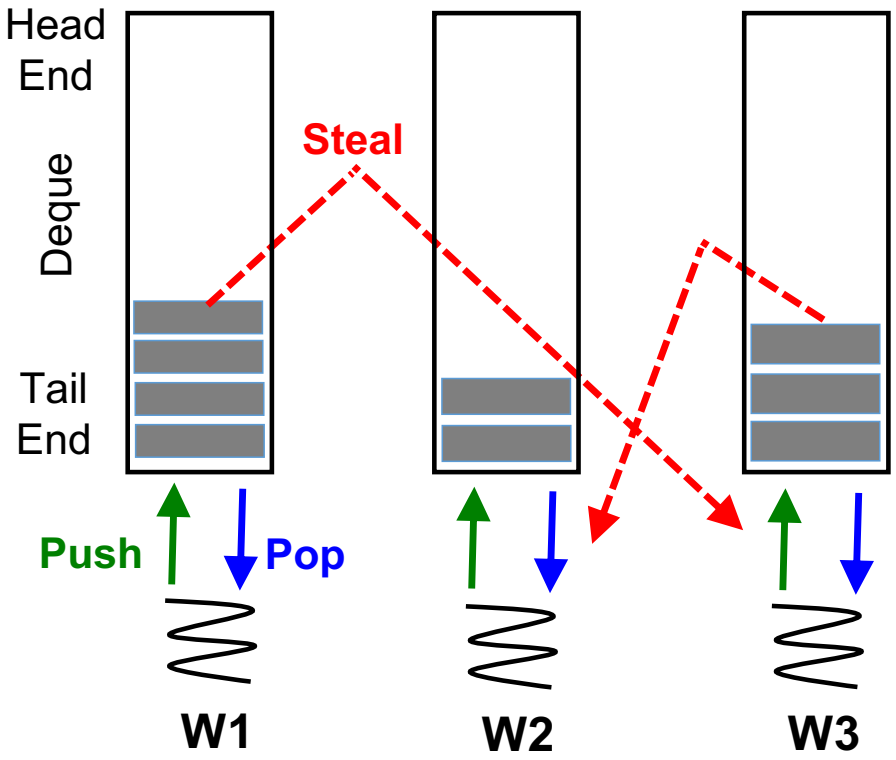
Outline

- Introduction and background
- Contributions
- Teaching methodology
- Retrospective of three years offering
- Challenges and lessons learnt
- Summary

Task Based Parallel Programming Model

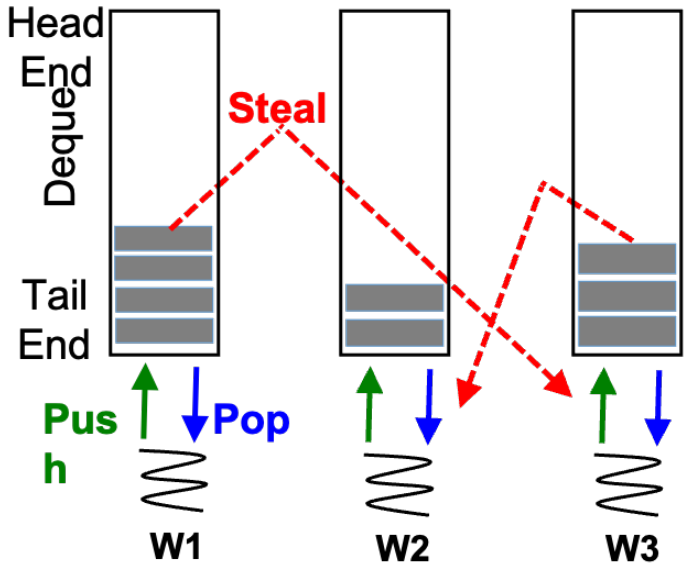


```
finish ([=]() {
  for(int i=0; i<node->nChild; i++) {
    async ([=]() {
      recurse(node->child[i]); //Tasks
    });
  }
}); //Task synchronization
```



Where Existing Courses Fall Short?

- **Runtime overheads (Module 1)**
  - How many tasks?
  - How to store tasks?
  - How to scale on NUMA?
- **Concurrency issues (Module 2)**
  - How to trace/replay tasks?
  - Can user-level threads perform equally well?
- **Efficient strategies (Module 3)**
  - How to scale over heterogeneous architectures?
  - How to enable resiliency?
  - 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

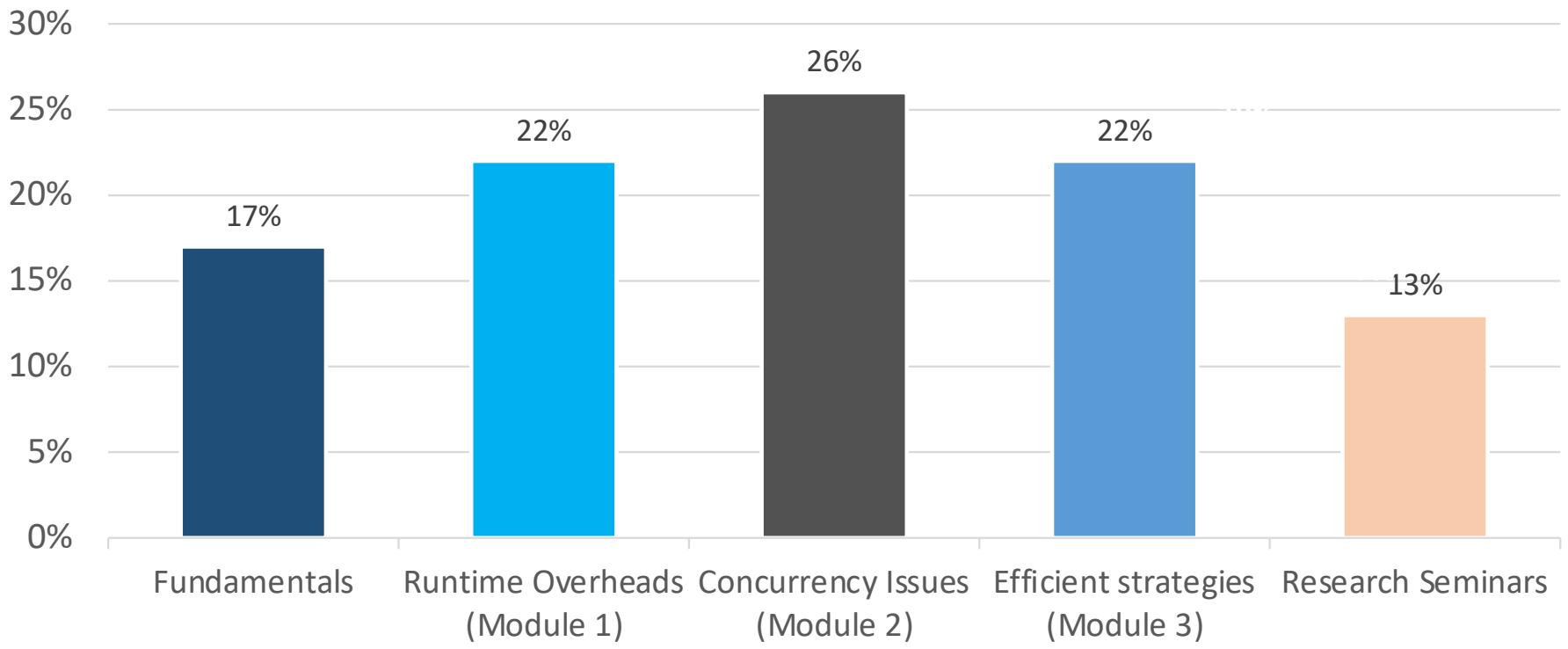
- ✓ Programming intensive course evaluation

  That uses a novel approach of chaining assignments and project

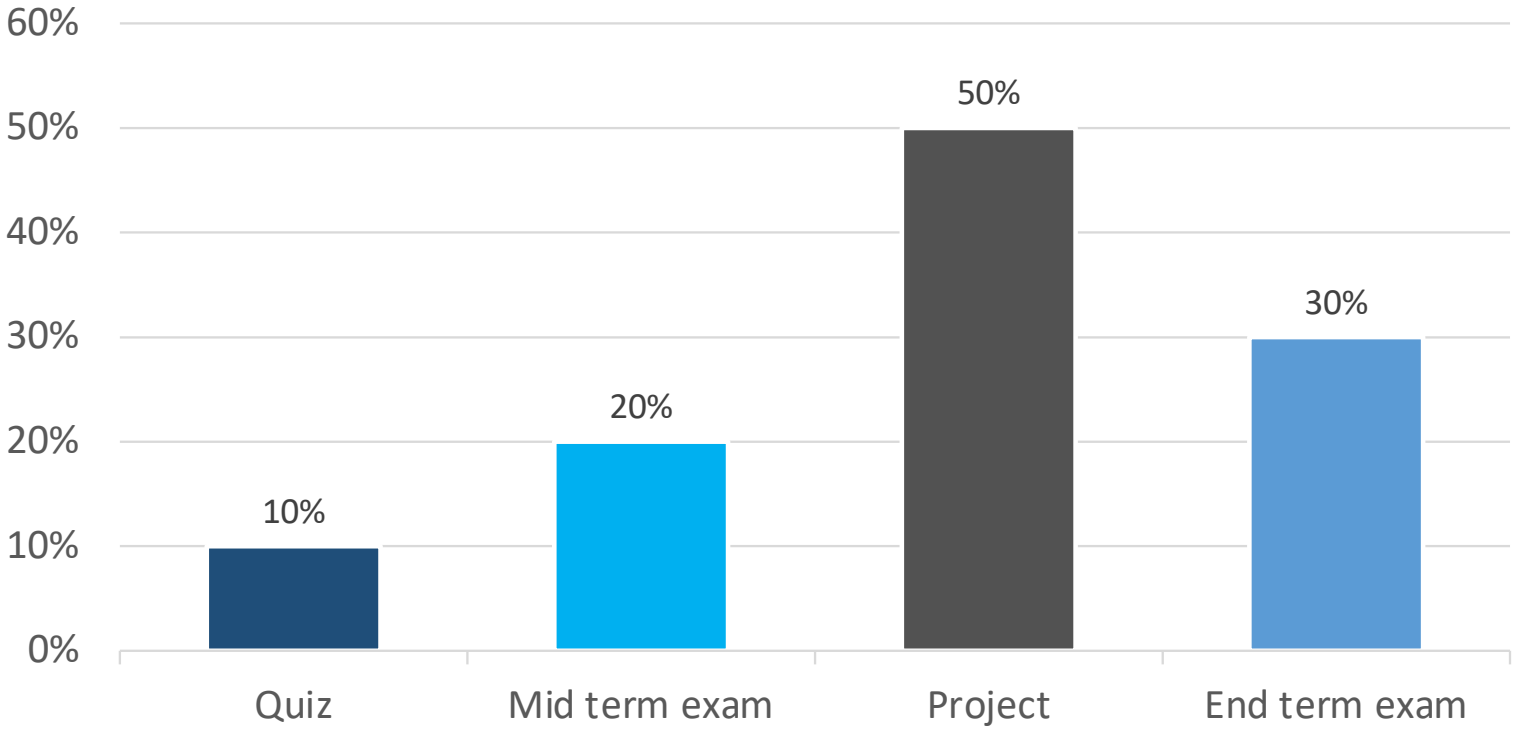
- ✓ Detailed analysis of past three offerings of PRMP

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

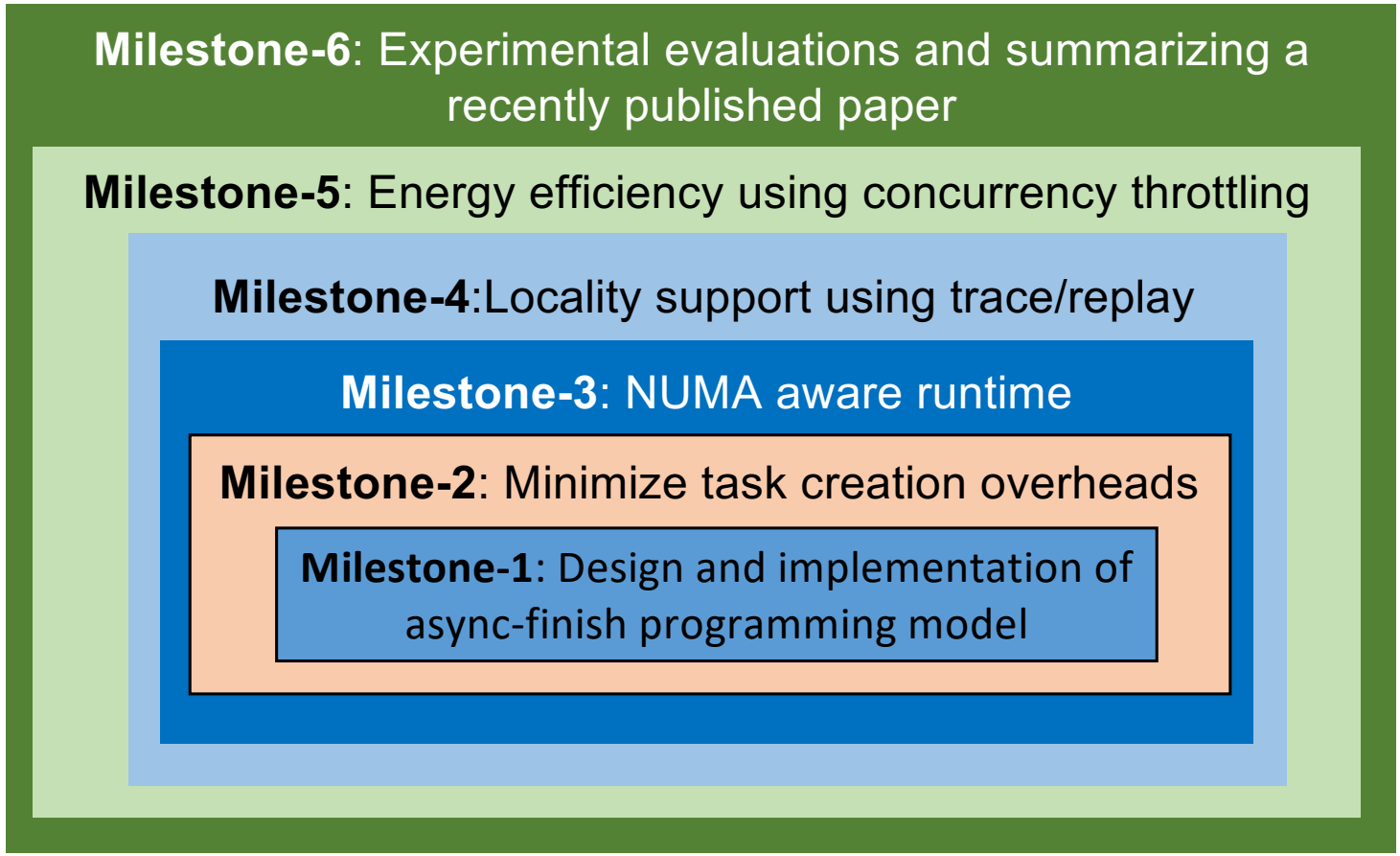
Lecture Topics



Evaluation Components

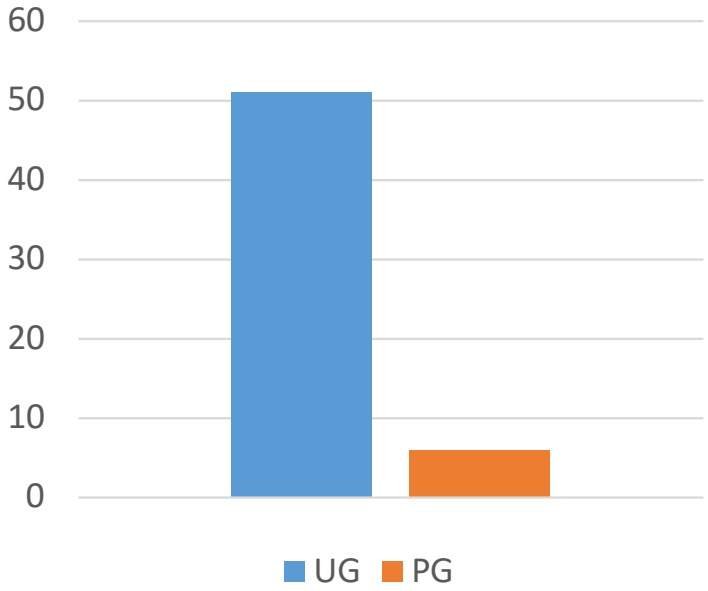


Chaining of Project Deliverables

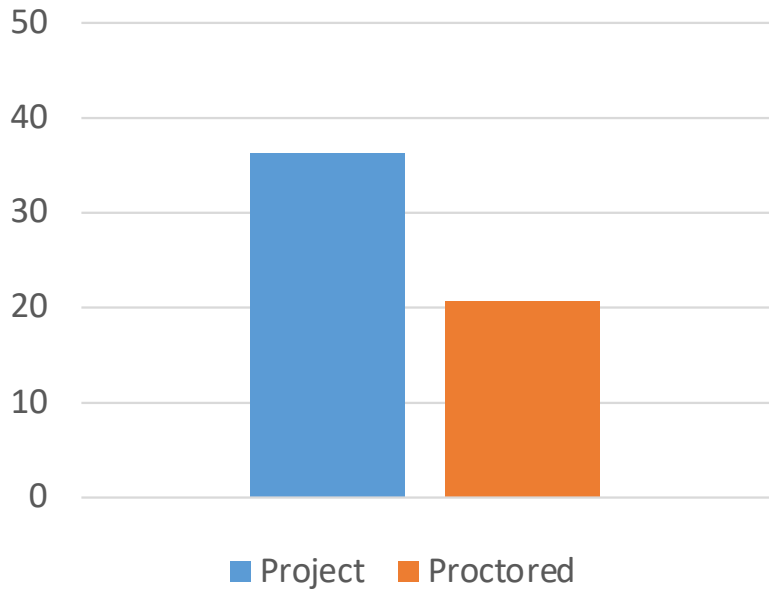


- Pair programming based activities to impart **team spirit**
- Programming heavy milestones to improve the **programming skills**
- Research seminar to improve the **presentation skills**

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