Task Fusion:
Improving Utilization of Multi-user Clusters

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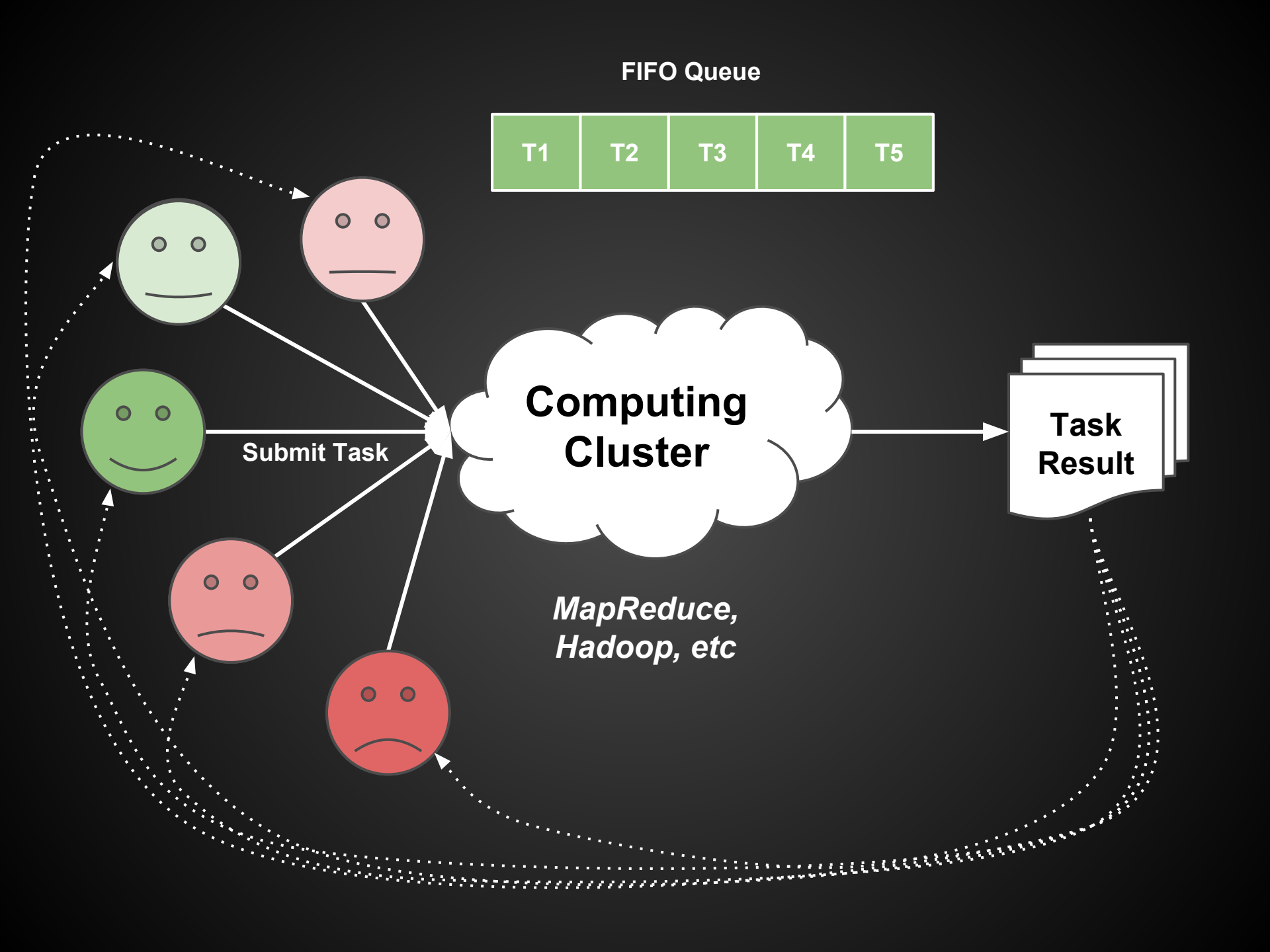
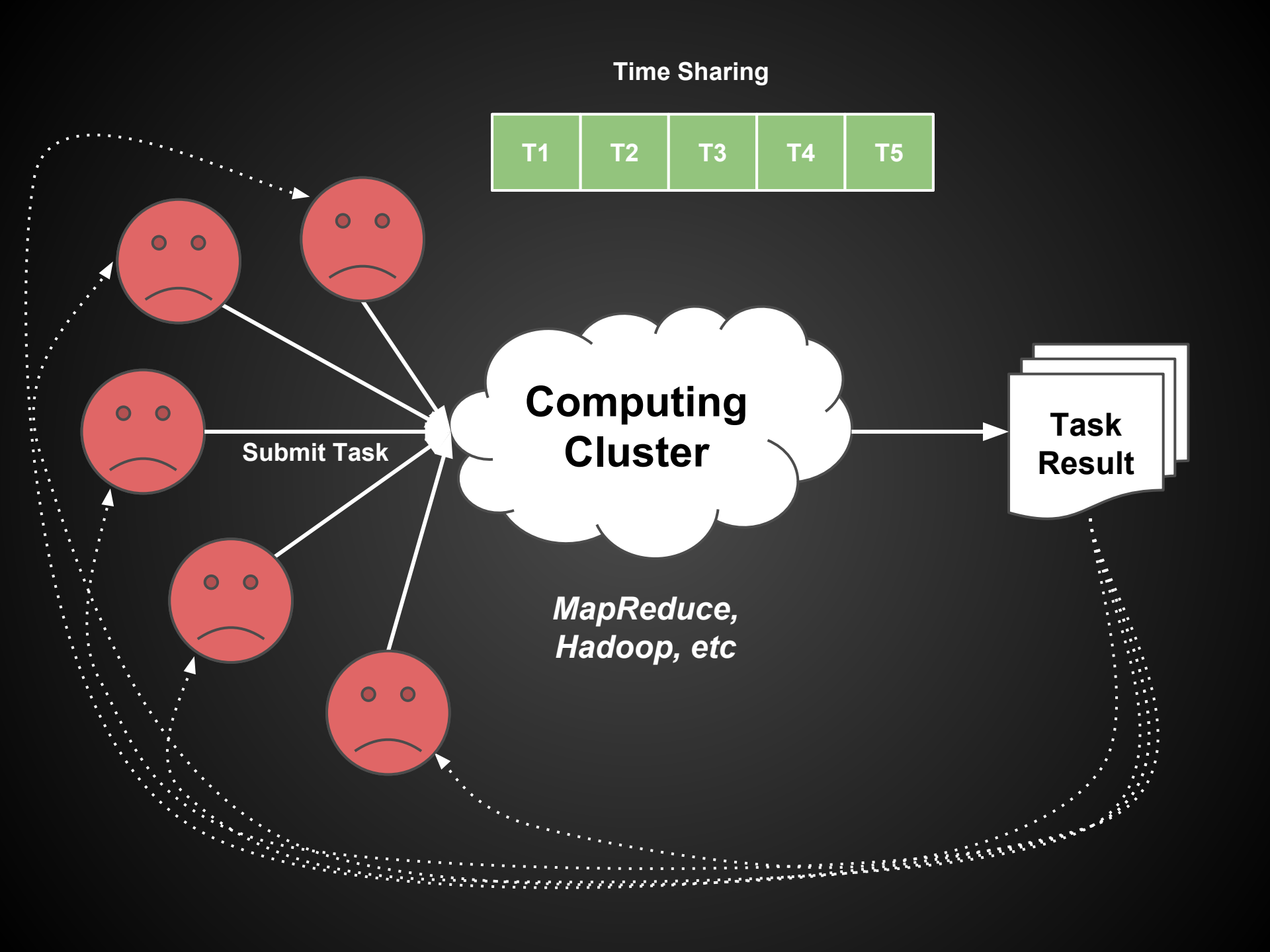

FIFO Queue
T1
T2
T3
T4
T5
Submit Task
Computing Cluster
Task Result
MapReduce, Hadoop, etc


Time Sharing
T1
T2
T3
T4
T5
Submit Task
Computing Cluster
Task Result
MapReduce,
Hadoop, etc

Solutions?

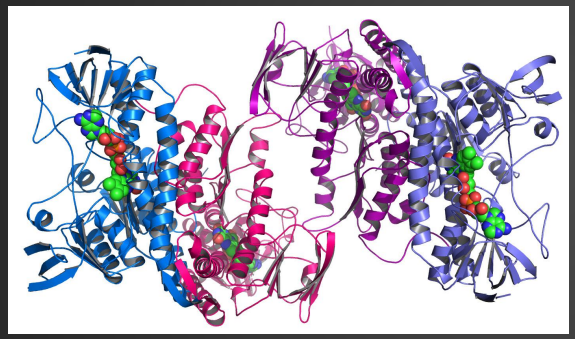
- Scale the hardware
  - Expensive
  - Not always feasible (small businesses, MOOCs, researchers, etc)
- Optimize the software
  - Optimize individual tasks
    - standard program optimizations
    - chain folding [MinerShook12], sibling/MSCR fusion [Chambers10]
  - Optimize multiple tasks
    - manual job merging [MinerShook12]

[Chambers10] Craig Chambers et al., “FlumeJava”, PLDI 2010
[MinerShook12] Donald Miner and Adam Shook, “MapReduce Design Patterns”, O’Reilly, 2012

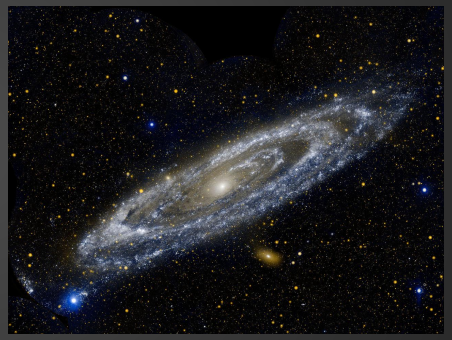
Key Insights

1) People analyze similar data

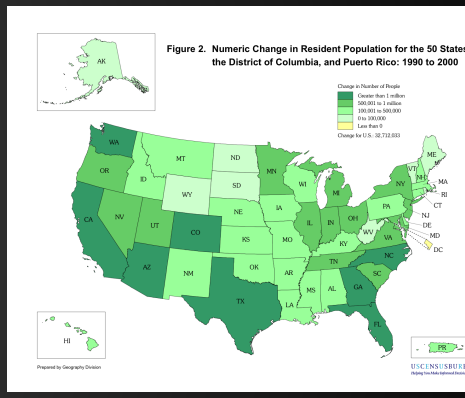
NCDC, NCCS



1k Genomes Project



SDSS



US Census

2) Data-intensive computing

- Loading GB/TB/PB of data takes time

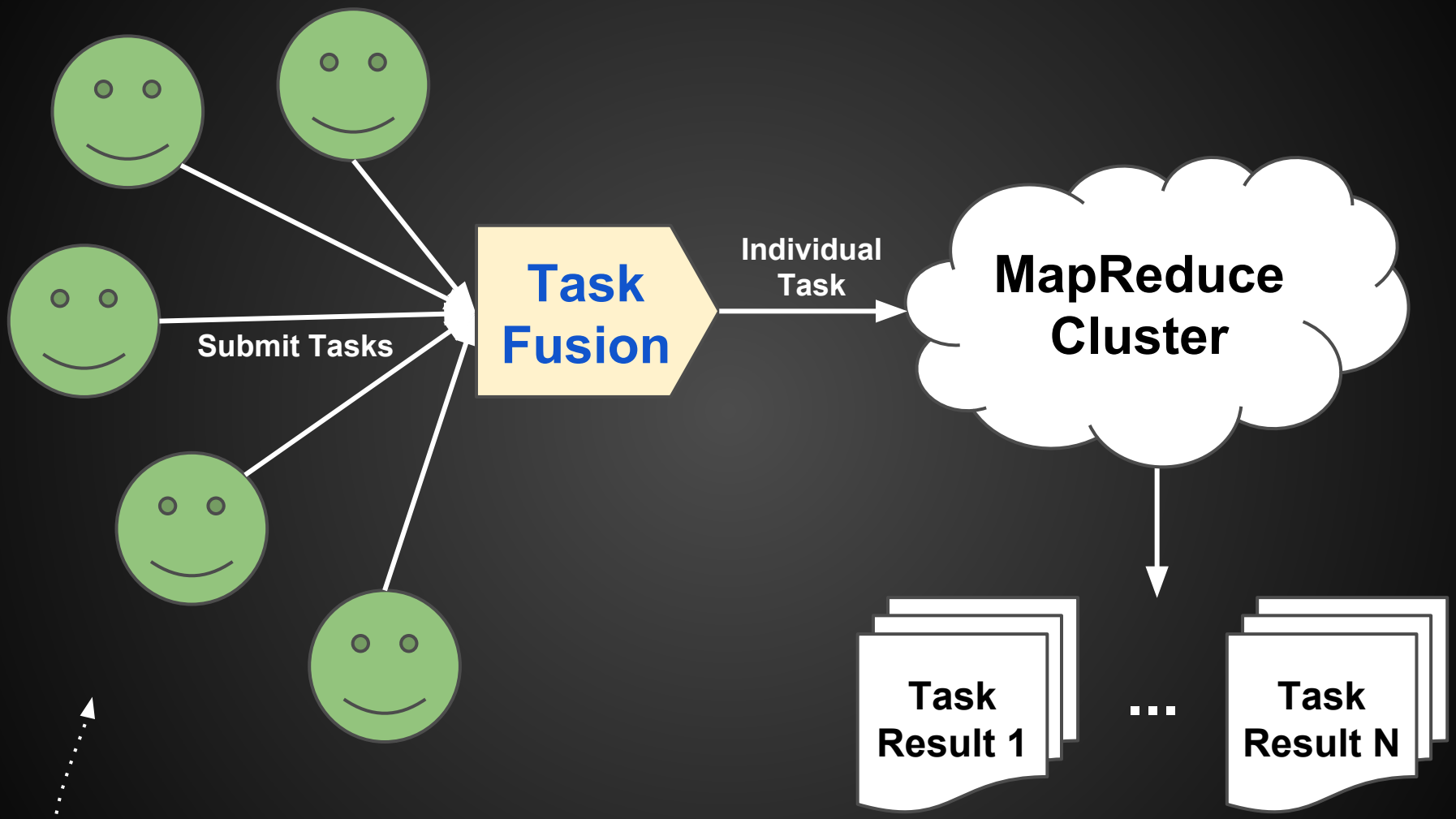
Insight: Load data once, run multiple analyses

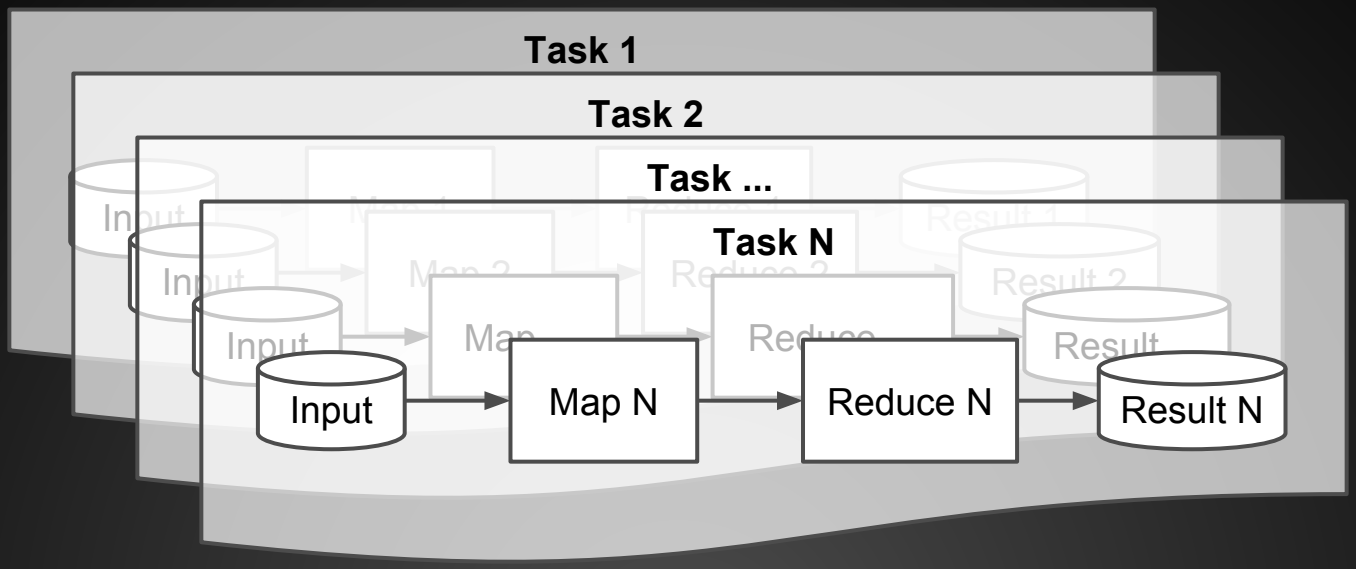
Research Questions

1. Can we **automatically** merge related tasks from **different users**?

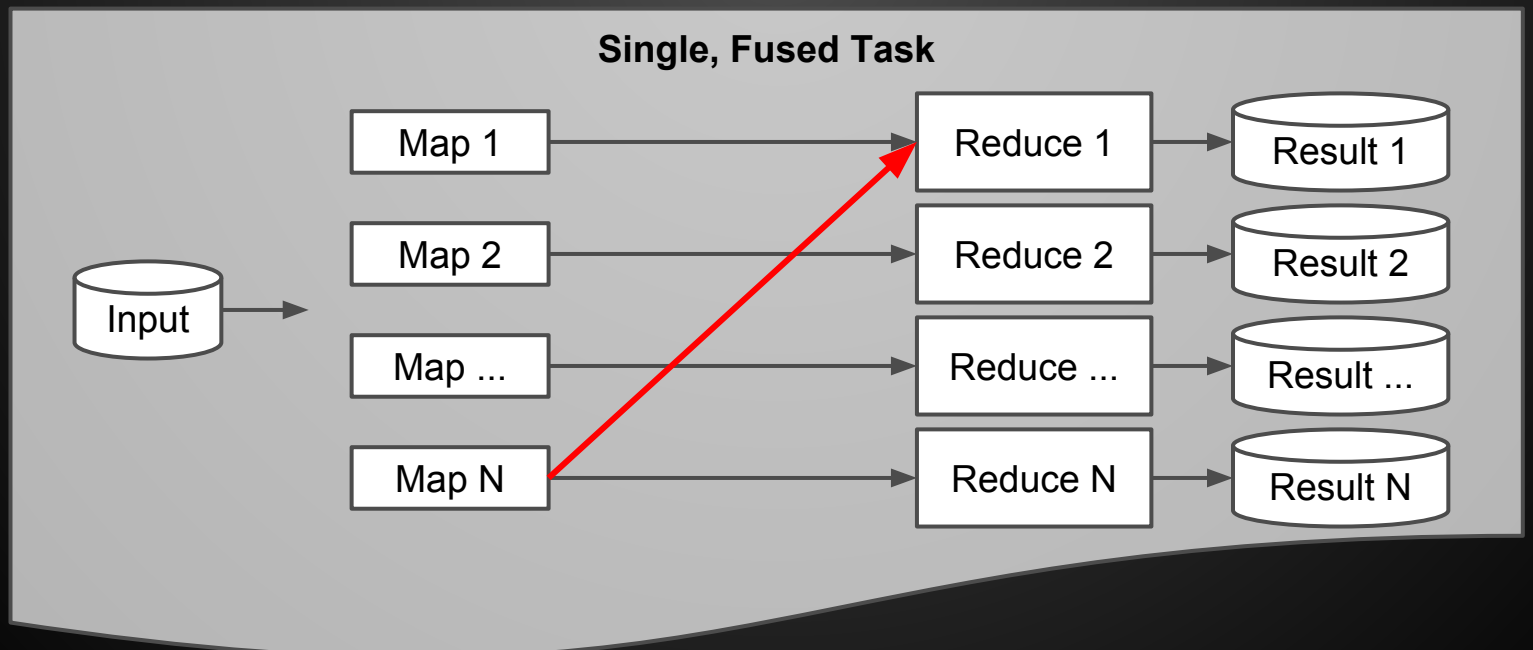
   Answer: **Task Fusion**

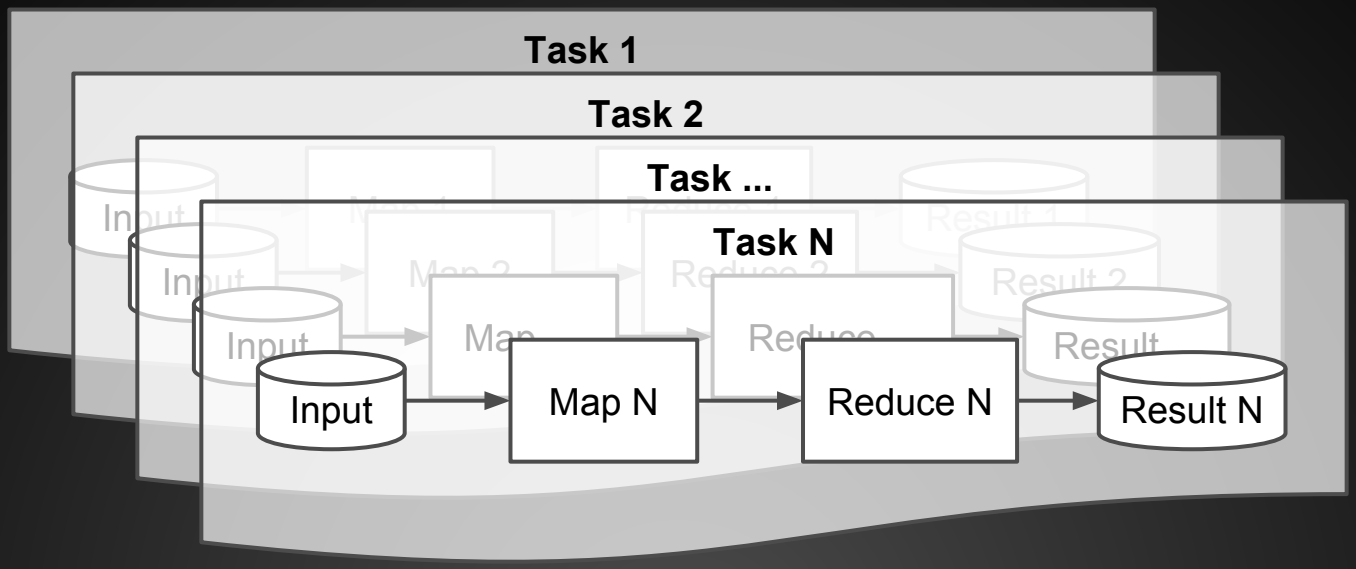
2. Does *Task Fusion* decrease user wait times in shared computing clusters?


Submit Tasks
Task Fusion
Individual Task
MapReduce Cluster
Task Result 1
...
Task Result N



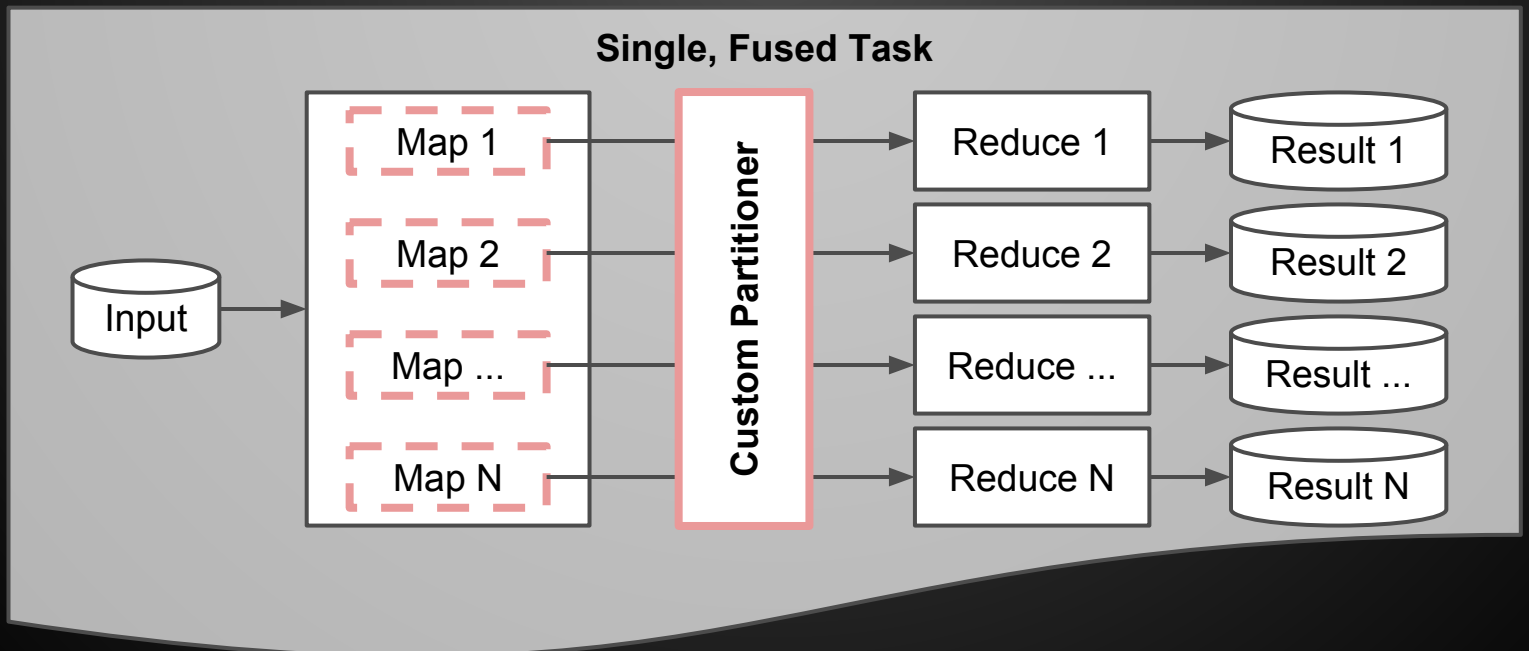
Technical Challenge:
map output == side effect





Solution: **modify maps to output composite keys**

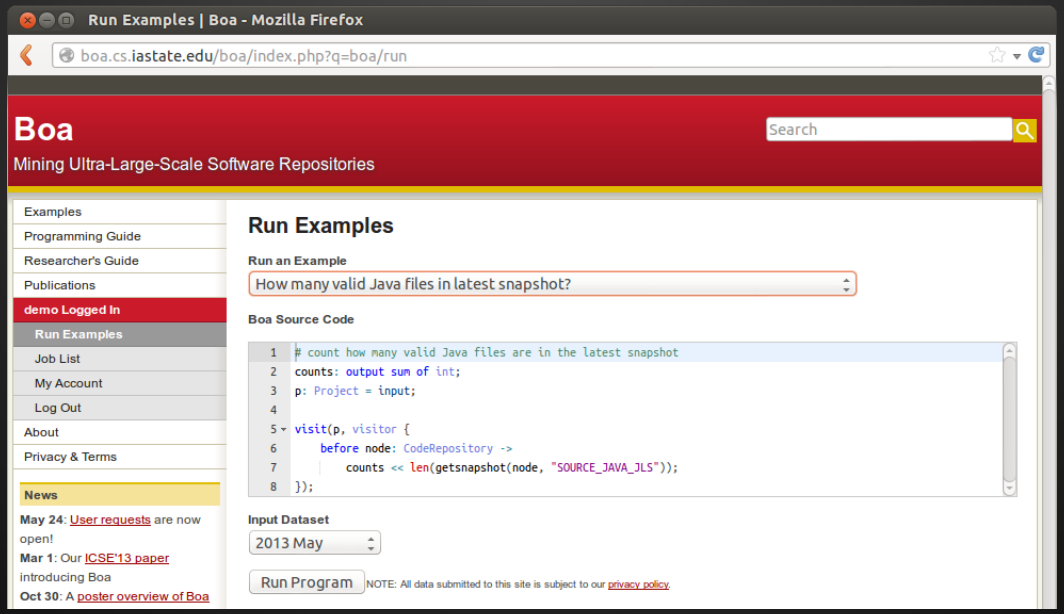
Custom partitioner ensures proper routing



Research Prototype

Task Fusion implemented for Boa

- Large-scale software repository mining
- SourceForge data (700k projects)
- Automatically parallelizes queries

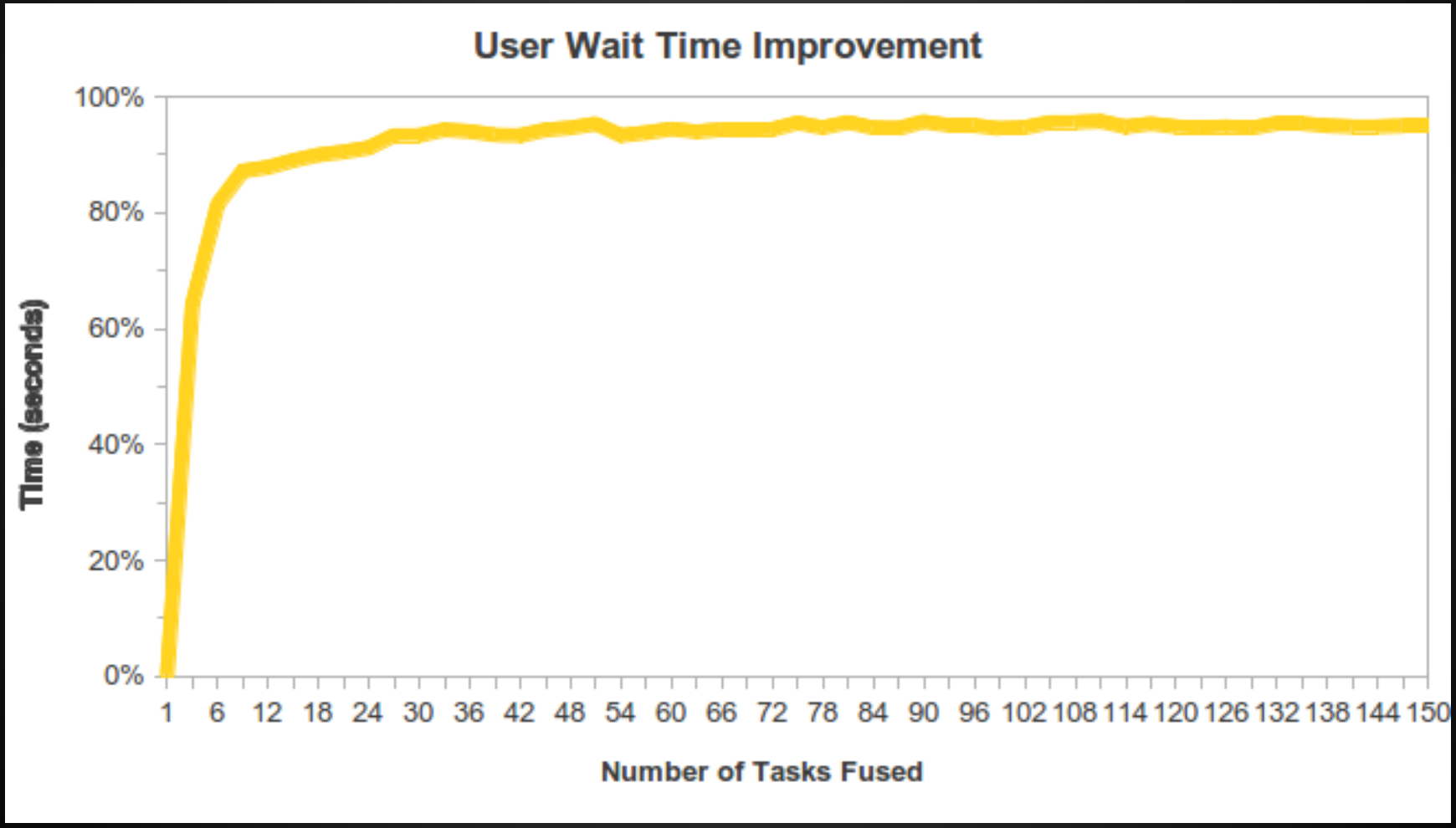


Early Results

Task Size	# of Tasks	Times		Speedup
		No Task Fusion	Task Fusion	
Small[1]	21	8.1m	0.8m	**10.8X**
Medium[2]	22	2.3h	1.8h	**1.3X**
Large[2]	18	4.6h	3.9h	**1.2X**
Mixed[3]	9	1.3h	0.9h	**1.4X**

[1] queries on project and revision metadata only
[2] queries on metadata and millions of source files
[3] 3 small, 3 medium, 3 large

Early Results



Assumptions - Relax Assumptions

1. No shared state
2. No dependency conflicts

   Idea: Separate class spaces (a la OSGi)

3. Controllable side effects

   Idea: Automated program transformations