



# Improving Energy Consumption of Java Programming Language

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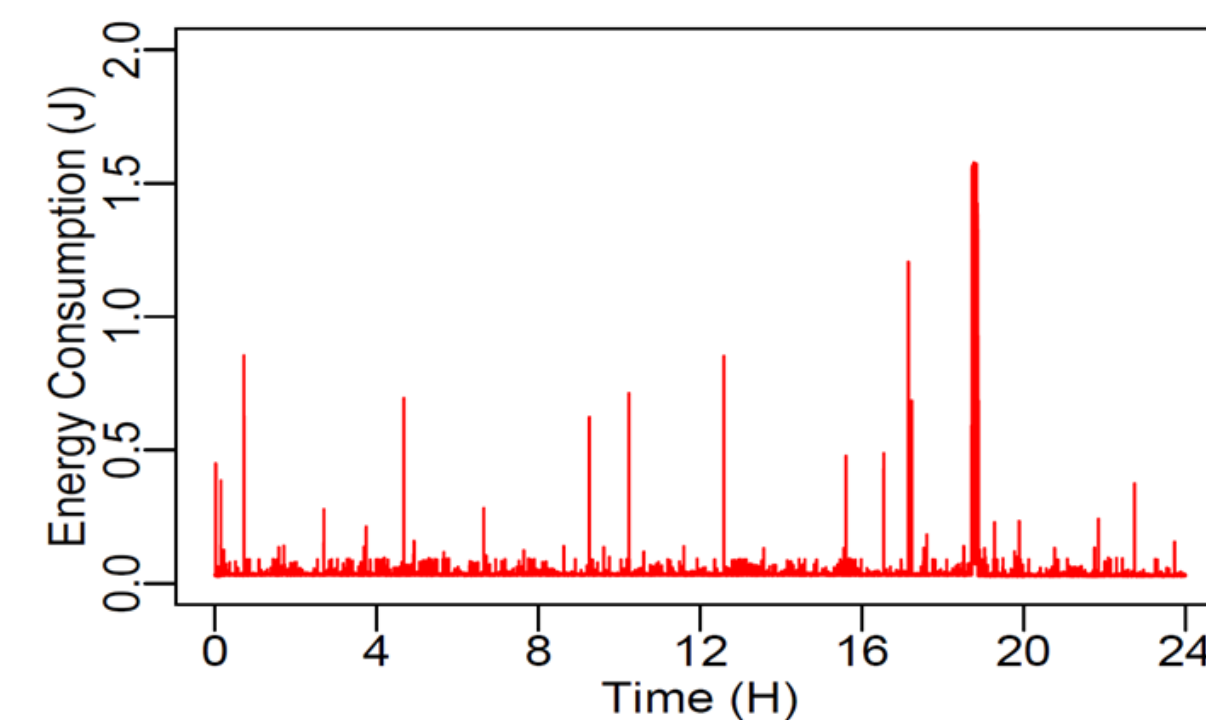


## Introduction

- ❖ Information and Communications Technology (ICT) systems
  - Consume 10% of world energy
  - 3% of overall carbon footprint
- ❖ ICT systems hardware energy efficiency
  - Clock gating
  - Power gating
  - Dynamic voltage/frequency scaling (DVFS)
- ❖ ICT systems software energy efficiency
  - still in infancy stage.....

## Background

- ❖ Running Average Power Limit (RAPL)
- ❖ System
  - Intel Fog Node (IFN)
  - Intel Fog Node
  - Laptop
- ❖ Set Up
  - CPU governor - *powersave mode*
  - Linux *perf* tool
  - Multithread parallel garbage collector
  - Just-in-time (JIT) compilation
- ❖ Idle energy consumption

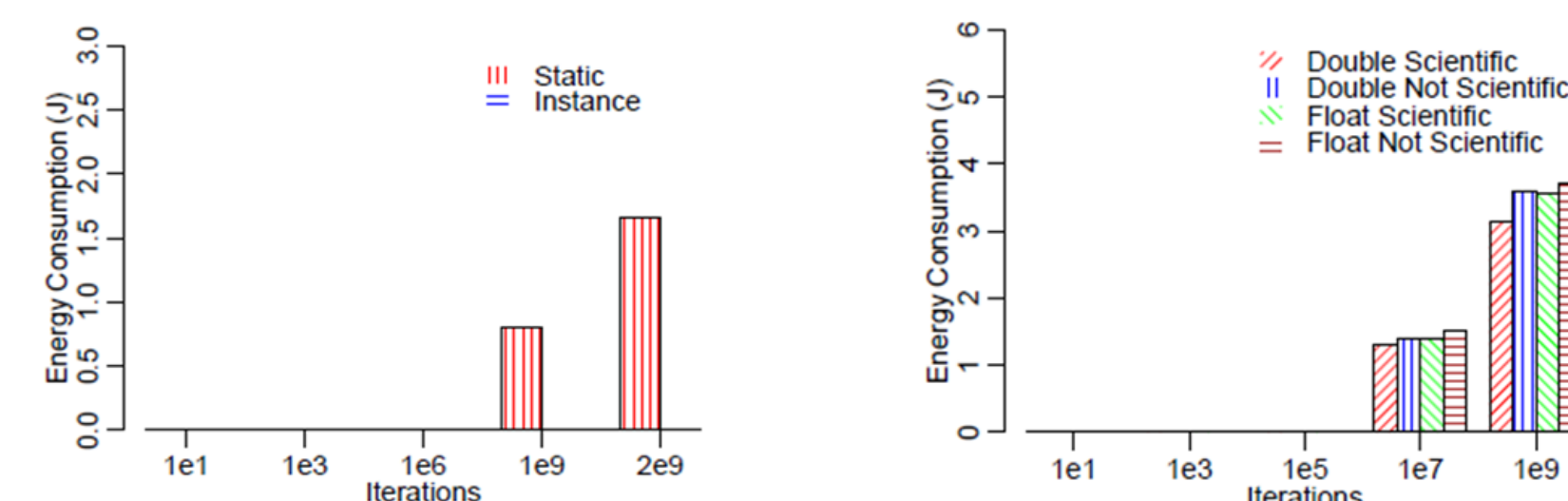
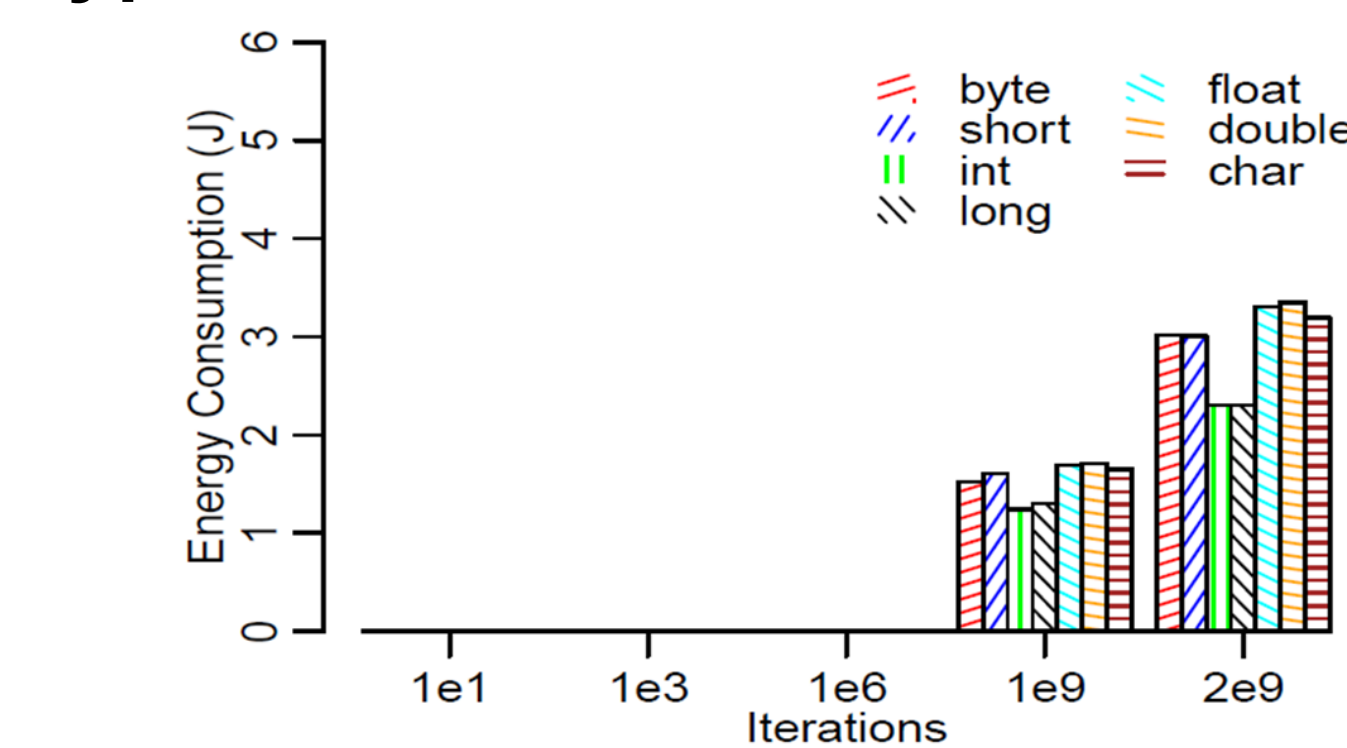


## Key Contributions

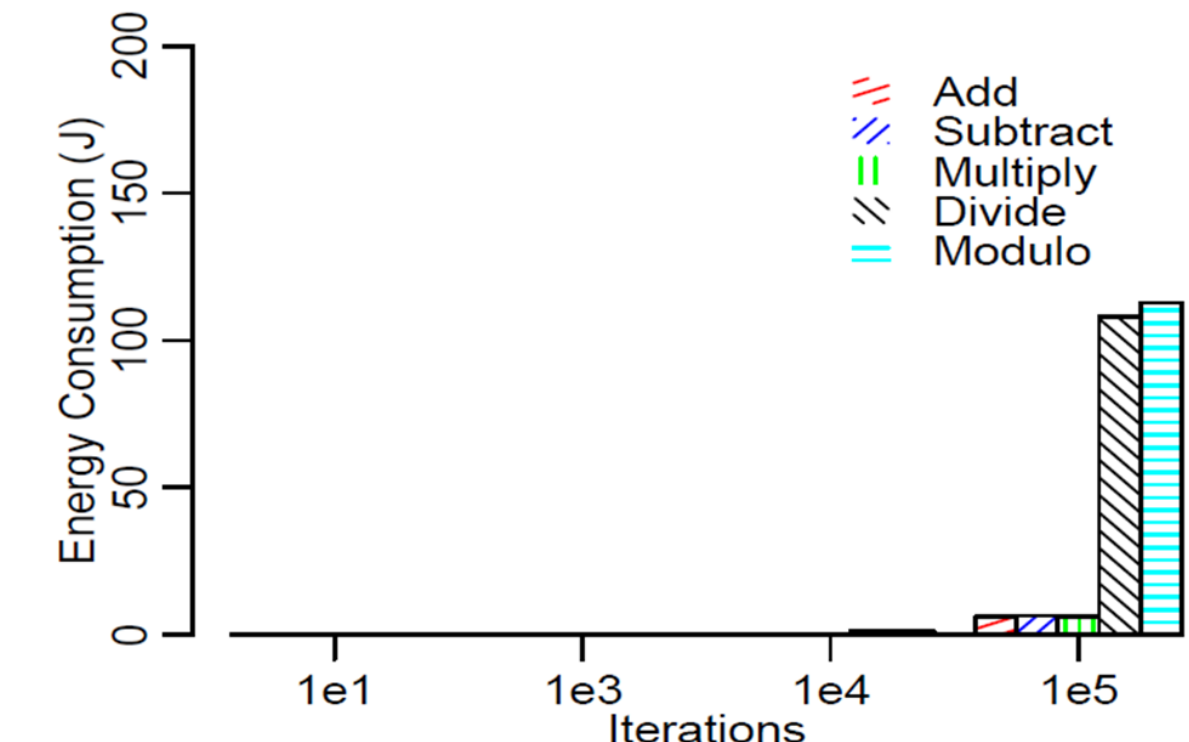
- ❖ Energy consumption analysis of Java programming language
- ❖ Energy consumption analysis of Java command-line options
- ❖ Java Energy Profiler & Optimizer (JEPO)

## Energy Consumption Traits

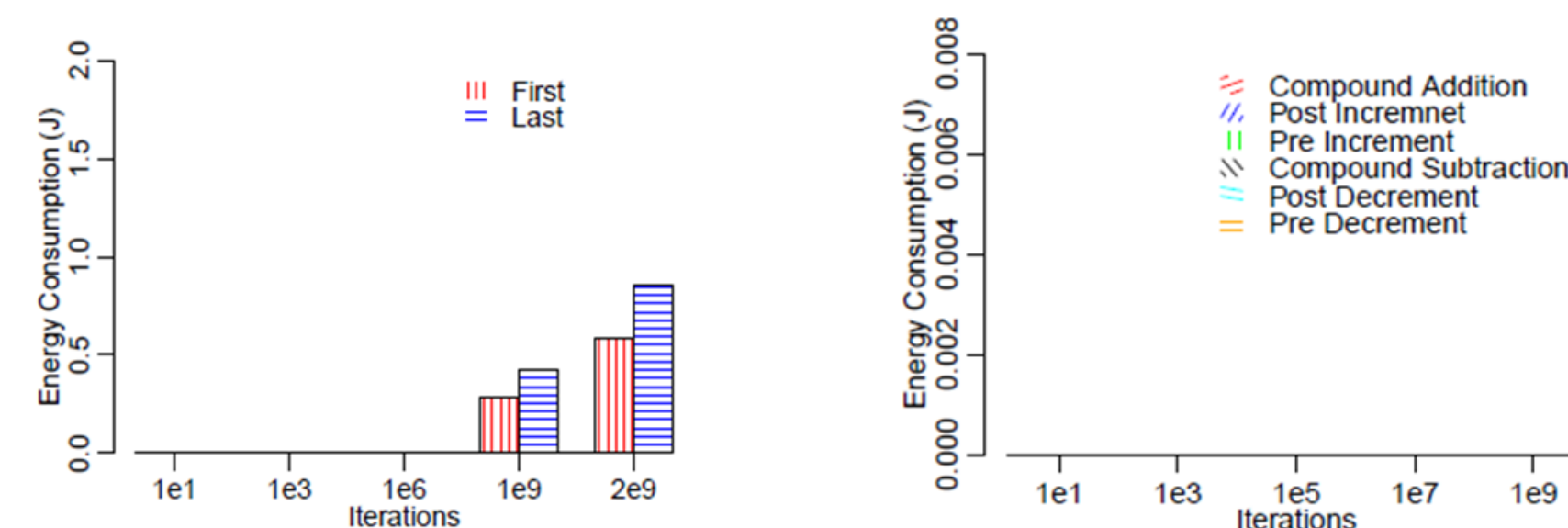
- ❖ Variables
  - int is the most efficient primitive data type
- Static variables consume up to 17,700% more energy
- Scientific notation results in lower energy consumption of decimal numbers



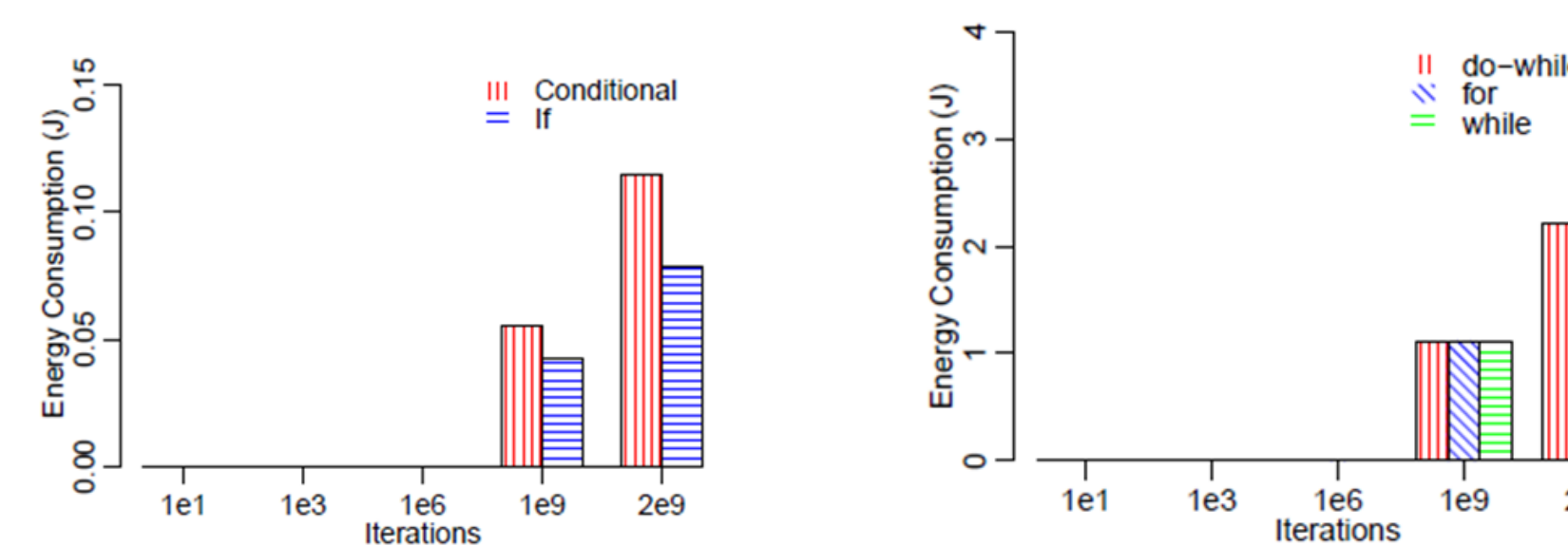
- ❖ Operators
  - Modulus arithmetic operator consumes up to 1,620% more energy



- Putting most common cases can save up to 87% energy
- Increment, and decrement operators consume same energy

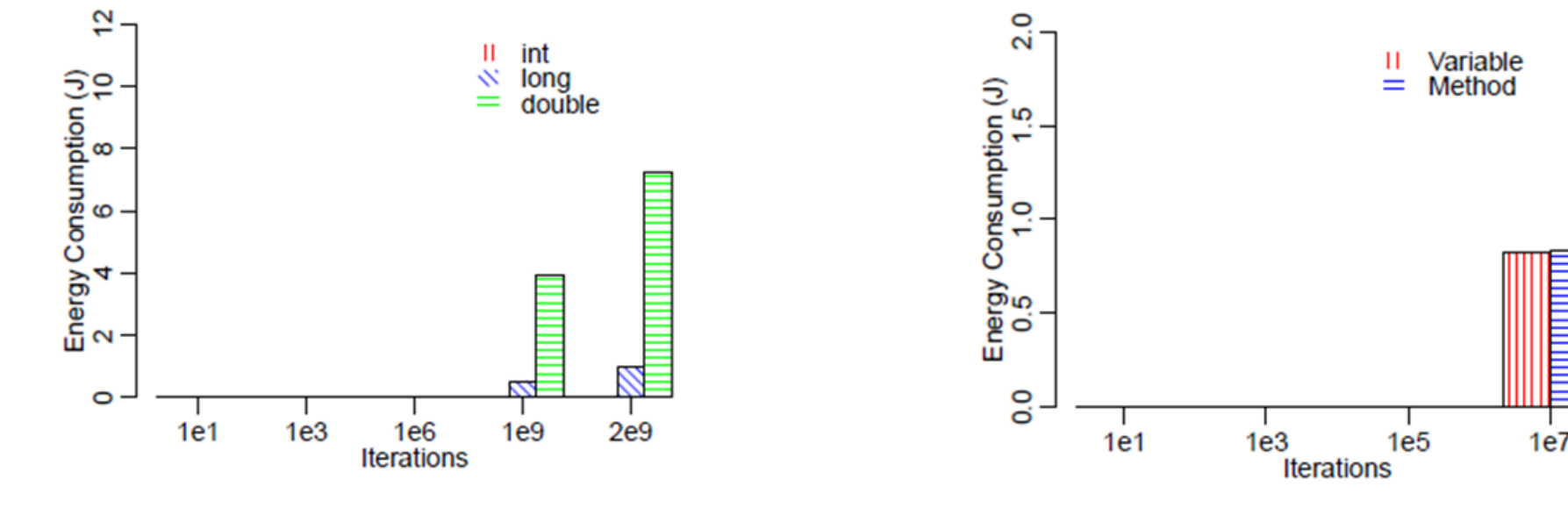


- ❖ Control Statements
  - Ternary operator consume up to 37% more energy
  - for, while and do-while loop statements consume same energy

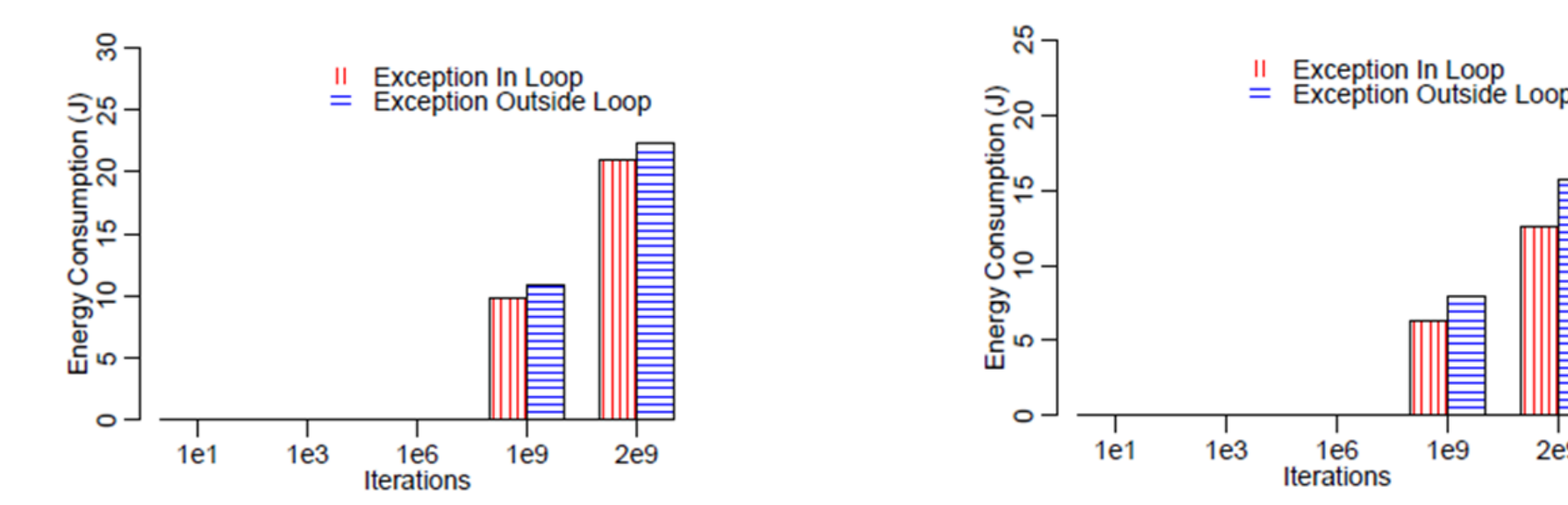


## Energy Consumption Traits

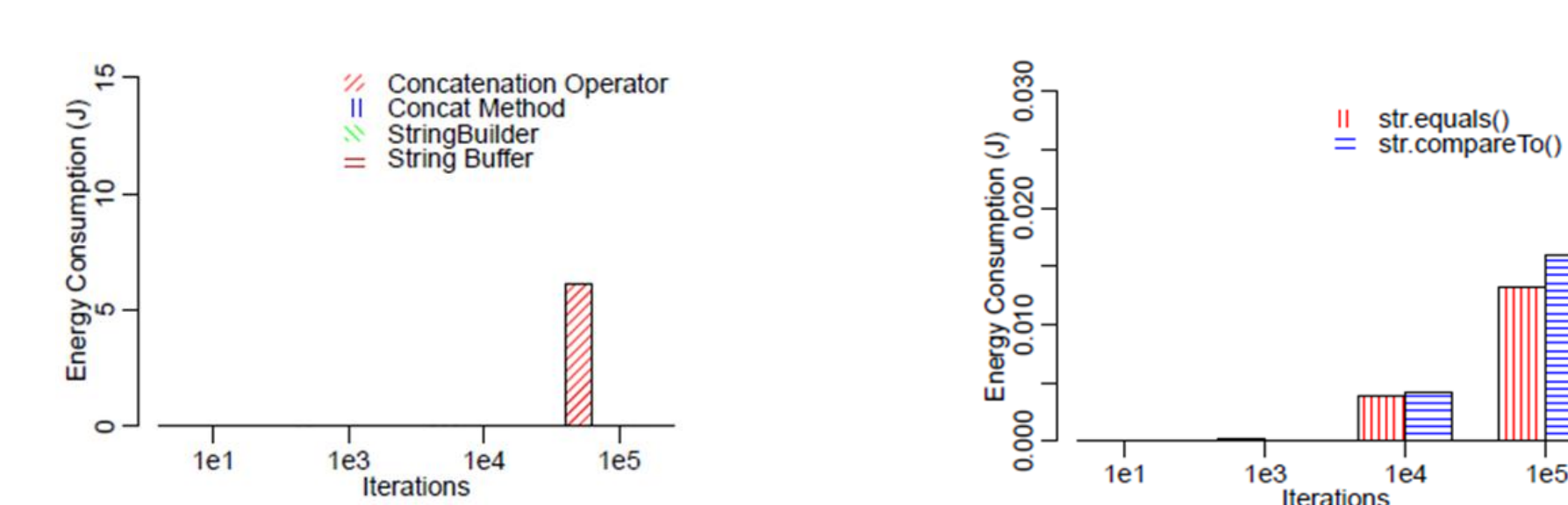
- int is the most energy efficient iteration variable in a loop
- Method termination expression consumes higher energy



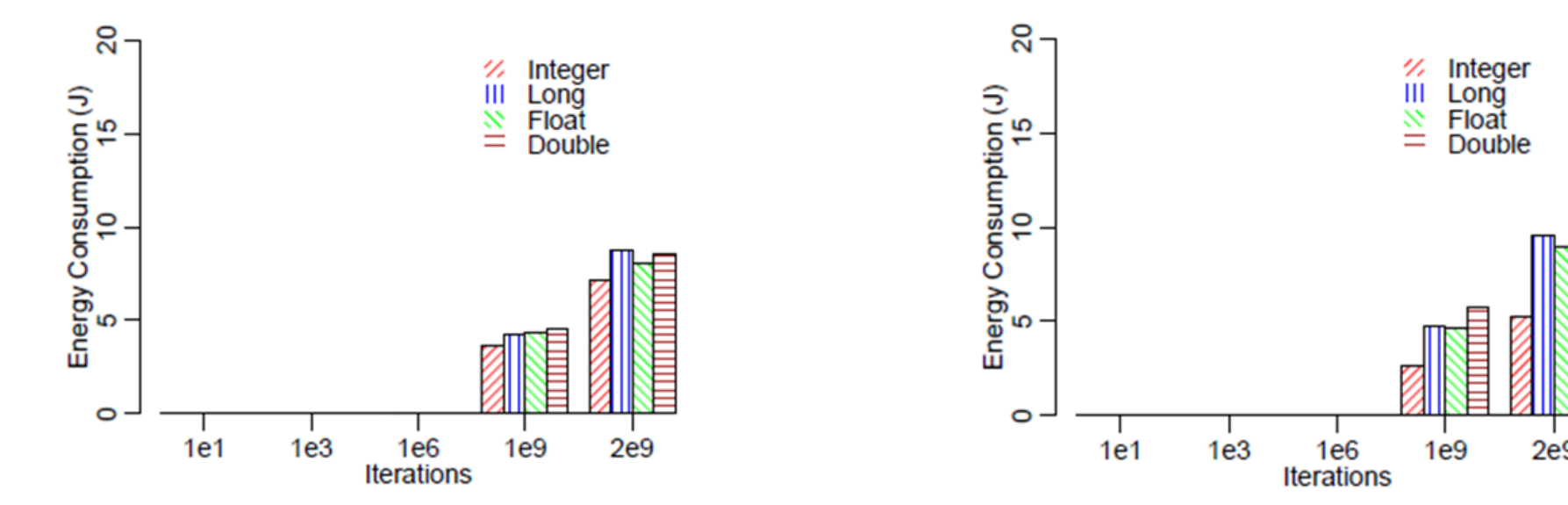
- ❖ Exceptions
  - Try-catch block scope can change how it consume energy



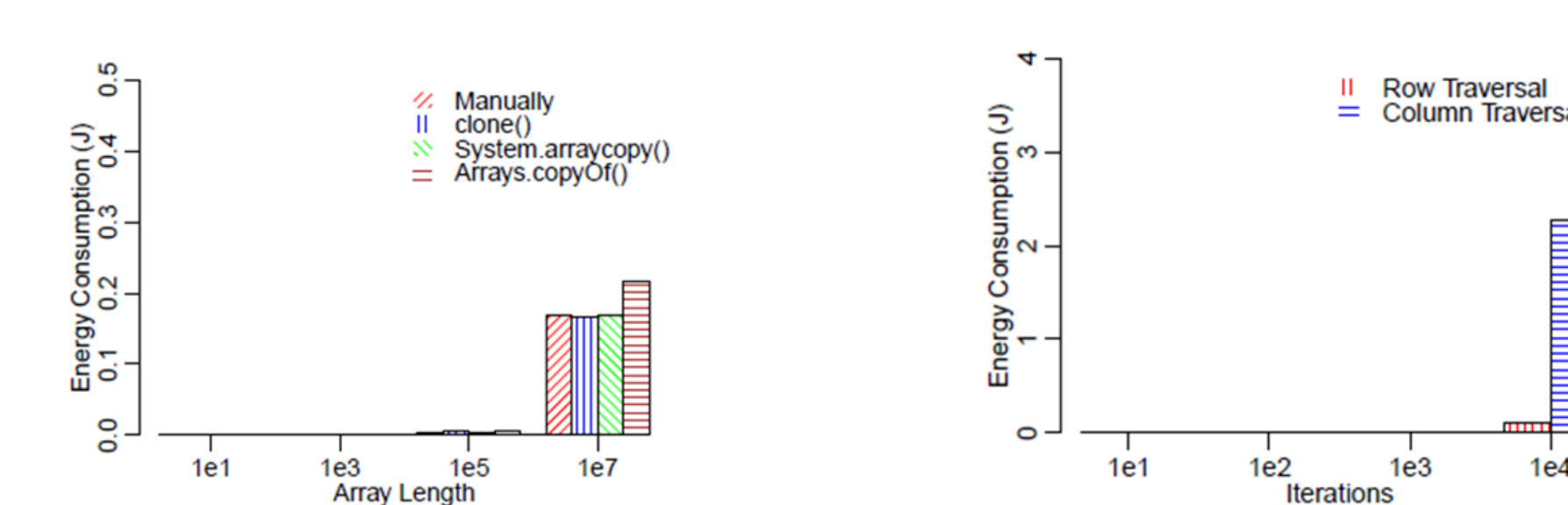
- ❖ String
  - StringBuilder append method consumes up to 1,48,069% lower energy
  - String compareTo method consumes up to 33% more energy



- ❖ Objects
  - Wrapper classes object are more energy expensive

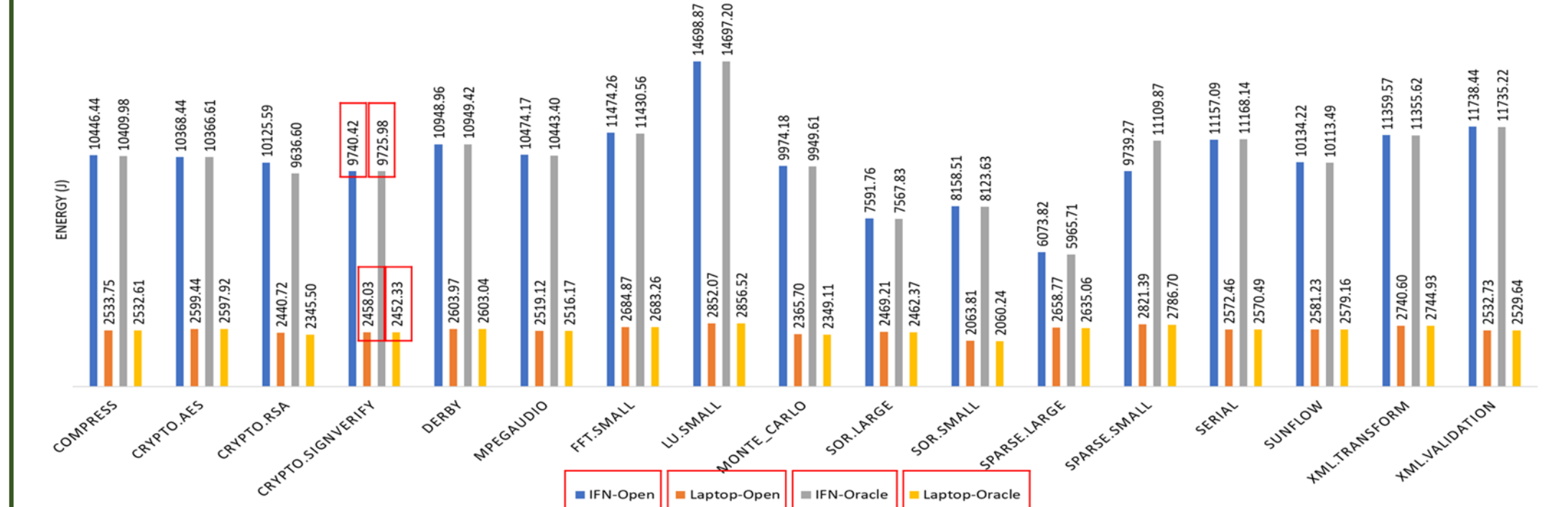


- ❖ Arrays
  - System.arraycopy() is the most energy efficient way to copy Arrays
  - Two-dimensional Array column traversal result in up to 793% more energy

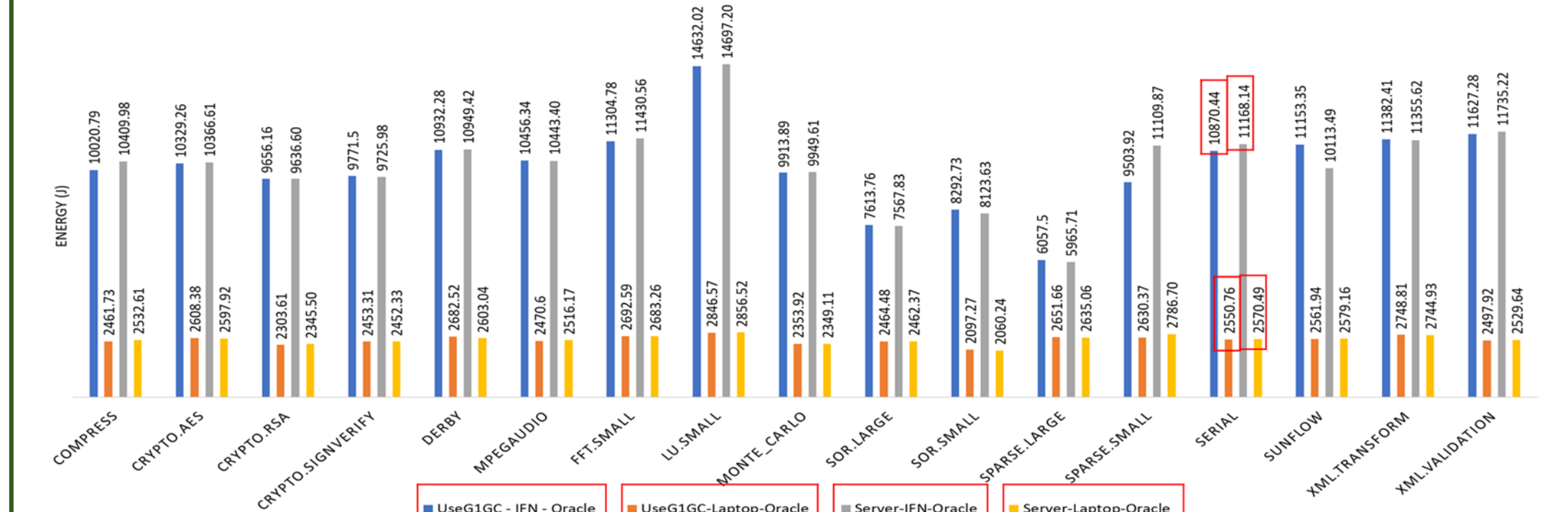


## Java Command-line Options

- ❖ Oracle JDK is more energy efficient than Open JDK (9%)

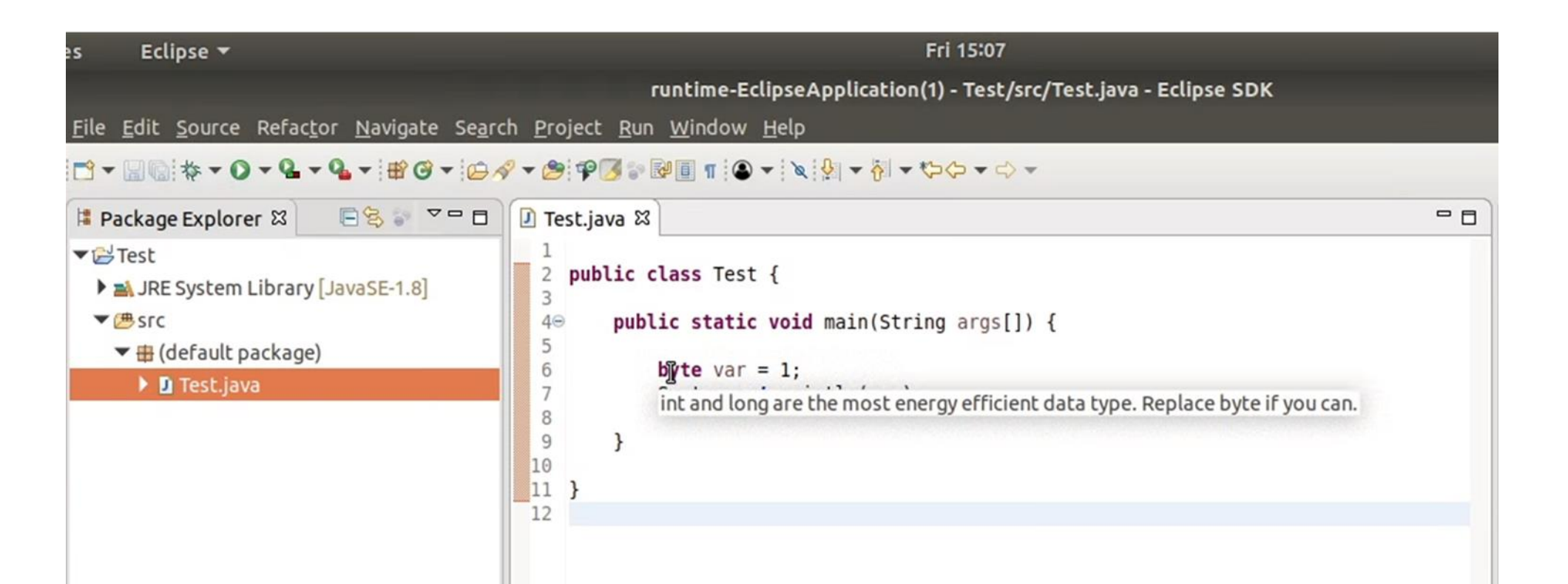


- ❖ UseG1GC is the most energy efficient command-line option (14%)



## Java Energy Profiler & Optimizer

- ❖ Provide suggestions for optimizing active energy



## Conclusion

- ❖ Analyze energy consumption of Java programming language and command-line options
- ❖ Implemented Eclipse plugin to help software developers write energy efficient code in Java

## Contacts and acknowledgement

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