

OPTIMIZING HIGH-PERFORMANCE DATA PROCESSING FOR LARGE-SCALE WEB CRAWLERS

PG Mall

Group D

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List of Contents

- Introduction
- Targeted website & Data Field
- System Architecture
- Tools & Frameworks
- Data Collection
- Data Processing
- Optimization Techniques
- Performance Evaluation
- Challenges & Limitations
- Conclusion

Introduction

This project develops a scalable solution for extracting, cleaning, and analyzing real-world e-commerce data, focusing on web crawling, data preprocessing, and evaluating text-processing libraries under performance constraints.

Objectives:

- **Build a web crawler that extracts $\geq 100,000$ data from the PG Mall**
- **Perform text processing and data cleaning on the scraped data using text normalisation and noise removal techniques.**
- **Compare text processing libraries based on key performance indicators**
- **Apply high-performance computing techniques to optimise the text processing pipeline.**
- **Evaluate the system's performance, identifying bottlenecks and discussing improvements made.**

Targeted Website & Data Field



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Search Here...

Home > Health & Beauty

Filter

Product Categories

- Health & Beauty
 - Kids Cosmetic
 - Makeup
 - Medical Supplies
 - Personal Care
 - Feminine Care
 - Adult Wellness
 - Eye Care
 - Oral Care
 - Hair Care
 - Bath & Body
 - Fragrances
 - Skincare
 - Dietary Supplements
 - Beauty Tools

217194 Item Found In Health & Beauty

Sort By Default

Product Image	Product Name	Price	Location	Discount
	Sobella Primer Make up	RM 36.00	Kedah	-32%
	Sobella Setting spray	RM 38.00	Kedah	-50%
	BCM PLUS SIZE KNEE PAD - NON-SLIP AND BREATHABLE	RM 19.50 - RM 3...	Selangor	-32%
	(INDIVIDUAL PACKED) WJS Sanitary Hygiene Mouth Shield Transparent Mouth Shield Transparent Face Shield Face	RM 0.88 - RM 1.08	Selangor	-40%
	BCM CUTE YELLOW DUCK BATH BOMB 150g - FOR KIDS AND ADULTS	RM 9.00 - RM 27...	Selangor	-50%

☐ Include non-muslim friendly products

<https://pgmall.my/p/2744/0937>

Targeted Website & Data Field



- **Product Name**

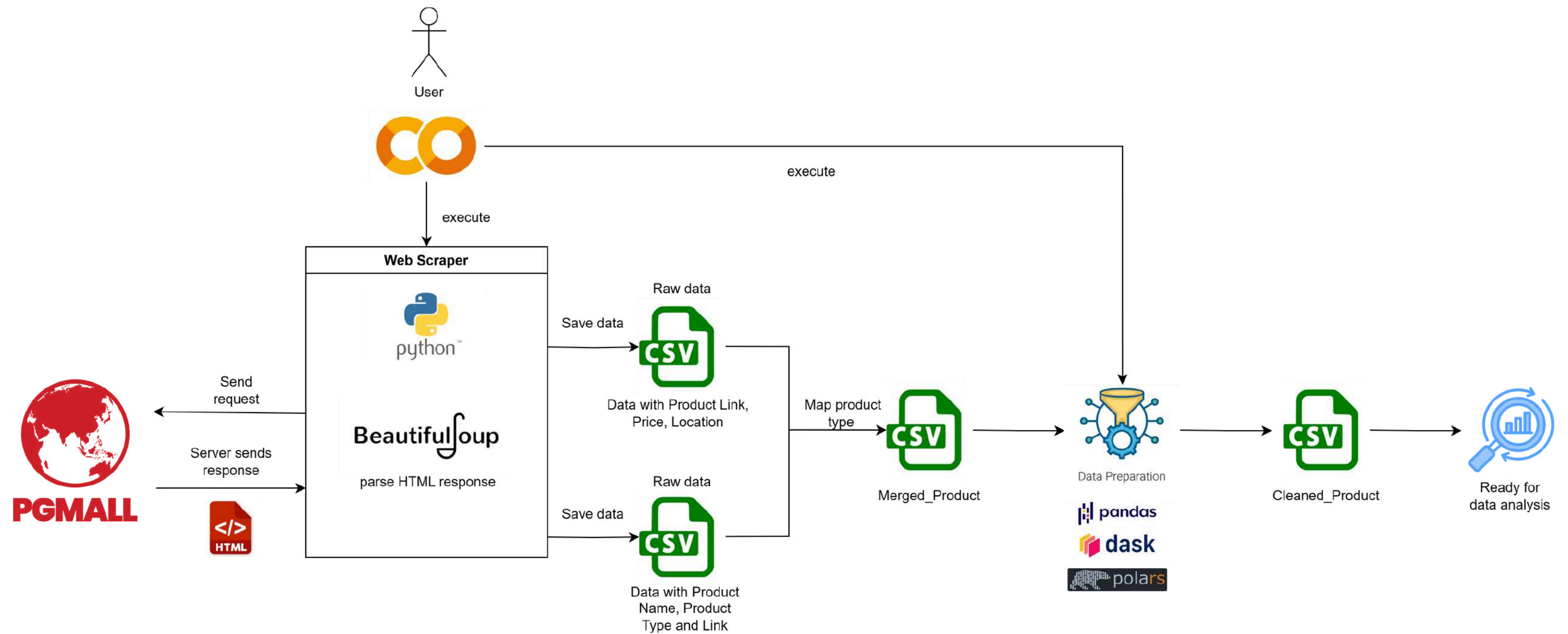
- **Link** *extracted from HTML

- **Price**

- **Location**

- **Product Type** *added during mapping phase

System Architecture



Tools & Frameworks

BeautifulSoup



 pandas



 dask



Data Collection

Data Field and Method

Data field	Initial Status
product_name	Contain characters outside of the normal ASCII
link	No problem
price	String type instead of float, has a range of prices and string "RM" in cells
location	Contain null cells
product_type	Contain null cells

- Sequential Pagination via While Loop
- Retry-Logic and Concurrency Control (max_workers = 5)
- Multithreaded Implementation (concurrent.futures.ThreadPoolExecutor)

Ethical Consideration

- Respects Retry–After headers during rate limiting
- Uses a generic User–Agent string to mimic a browser
- Manually checked robot.txt and confirmed using code

```
def check_robots_txt():  
    """Check robots.txt before scraping"""  
    rp = urllib.robotparser.RobotFileParser()  
    rp.set_url("https://pgmall.my/robots.txt ")  
    try:  
        rp.read()  
    except Exception as e:  
        print(f"Error reading robots.txt: {e}")  
        return False  
  
    can_fetch = rp.can_fetch("*", "https://pgmall.my/category ")  
    if not can_fetch:  
        print("⚠️ Scraping disallowed by robots.txt.")  
    else:  
        print("✅ Scraping allowed by robots.txt.")  
    return can_fetch
```

```
✅ Scraping allowed by robots.txt.  
Scraping page 1...  
Page 1 scraped and saved (50 items). Total: 50
```


Data Processing

MAPPING PHASE

product_name	link	price	location
MuscleRulz L-Carnit	https://pgm:	RM128.00	Selangor
MuscleRulz Iso Rulz	https://pgm:	RM314.00	Selangor
Kevin Levrone Gold	https://pgm:	RM265.00	Selangor
CNI RJ Moisturizer	https://pgm:	RM17.60	Selangor
CNI RJ Hair Cream	https://pgm:	RM13.40	Selangor
CNI RJ Shower Crea	https://pgm:	RM17.20	Selangor
CNI Siang-Siang (10	https://pgm:	RM11.10	Selangor
CNI RJ Intimate Was	https://pgm:	RM18.80	Selangor
ALHA ALFA ROYAL PF	https://pgm:	RM59.90	Selangor

Item_list.csv

product_name	link	product_type
Xiaomi Smart Scale S200	https://pgmall.my/p	Bekalan Perubatan
Morilins Pain Relief Patch	https://pgmall.my/p	Bekalan Perubatan
TYNOR KNEE CAP WITH PAT	https://pgmall.my/p	Bekalan Perubatan
MEGA GAZGO 200MG 10 SO	https://pgmall.my/p	Bekalan Perubatan
HmbG Borosilicate Glass B	https://pgmall.my/p	Bekalan Perubatan
Potassium Iodide AR / ACS	https://pgmall.my/p	Bekalan Perubatan
TOPSEAL Sterile Plain Gauz	https://pgmall.my/p	Bekalan Perubatan
TOPSEAL Sterile Plain Gauz	https://pgmall.my/p	Bekalan Perubatan

merged_product_list.csv

product_name	link	price	location	product_type
ANZEN Intelligent	https://pgmall.my/	RM58.88	Selangor	Alat Kecantikan
Madeshow Akeme	https://pgmall.my/	RM140.00	Selangor	Alat Kecantikan
Madeshow Akeme	https://pgmall.my/	RM125.00	Selangor	Alat Kecantikan
WAHL Super Tape	https://pgmall.my/	RM288.00	Selangor	Alat Kecantikan
[BeautyVault] RE	https://pgmall.my/	RM6.00	Selangor	Alat Kecantikan
Pensonic Hair Dry	https://pgmall.my/	RM48.00	Kelantan	Alat Kecantikan
Hair Dryer 1400W/	https://pgmall.my/	RM 19.90 - RM 45	Selangor	Alat Kecantikan
(STONG SUCTION	https://pgmall.my/	RM14.99	Selangor	Alat Kecantikan
ANZEN Intelligent	https://pgmall.my/	RM58.88	Selangor	Alat Kecantikan

updated_item_list.csv

DATA CLEANING

Load & Initial Check

- Loaded updated_item_list.csv
- Checked for: Duplicate entries & Null values

Duplicate & Null Handling

- Dropped 7 duplicated records
- Replaced nulls with "Unknown" in location & product_type

Raw Data Issues

- Product names had unreadable characters
- Prices stored as ranges with "RM" prefix

Finalization

- Renamed cleaned data fields
- Saved cleaned dataset as Item_list_cleaned.csv

Product Name Cleaning

- Removed unreadable characters

Price Cleaning

- Extracted numeric value from string
- Selected lowest value if price is a range



DATA STRUCTURE

Product Name	Link	Location	Product Type	Price
MuscleRulz L-Carnitine 3000mg (33 Servings) (READ DESCRIPTION)	https://pgmall.my/p/2740/8004	Selangor	Unknown	128
MuscleRulz Iso Rulz (5LBS)	https://pgmall.my/p/2740/6329	Selangor	Unknown	314
Kevin Levrone Gold Whey (2kg)	https://pgmall.my/p/2740/6306	Selangor	Unknown	265
CNI RJ Moisturizer	https://pgmall.my/p/2740/6267	Selangor	Unknown	17.6
CNI RJ Hair Cream	https://pgmall.my/p/2740/6266	Selangor	Unknown	13.4
CNI RJ Shower Cream 300ml	https://pgmall.my/p/2740/6258	Selangor	Unknown	17.2
CNI Siang-Siang (100g) - Body Talc Absorbs Perspiration	https://pgmall.my/p/2740/6256	Selangor	Unknown	11.1
CNI RJ Intimate Wash	https://pgmall.my/p/2740/6251	Selangor	Unknown	18.8
ALHA ALFA ROYAL PROPOLIS LUMINOUS SILK FOUNDATION	https://pgmall.my/p/2740/1287	Selangor	Penjagaan mulut	59.9
ALHA ALFA FLAWMINOUS CUSHION FOUNDATION	https://pgmall.my/p/2740/0510	Selangor	Alat solek	79.9
Xiaomi Smart Scale S200 High-precision sensor 180 cm x 25.4 cm	https://pgmall.my/p/2740/0500	Selangor	Bekalan Perubatan	59
[BeautyVault] READY STOCK RHODE - Pocket Blush	https://pgmall.my/p/2230/3788	Selangor	Alat solek	196
Dettol Shower Gel Refill Pouch 800ml/ 850ml / Dettol Onza 800ml	https://pgmall.my/p/Y714/0413	Selangor	Mandian	10.9
Zen Basil Seeds edible basil seeds usda organic, kosher, 1lb	https://pgmall.my/p/2739/4542	New Jersey	Makanan Tambahan	259
[BeautyVault] READY STOCK ARIANA GRANDE FRAGRANCE	https://pgmall.my/p/J226/0608	Selangor	Wangian	350
Morilins Pain Relief Patch 1bag 5pcs	https://pgmall.my/p/2739/4336	Johor	Bekalan Perubatan	13.35
SKINTIFIC 3x Acid Intensive Acne Spot Gel (15ml)	https://pgmall.my/p/2739/4075	Selangor	Penjagaan kulit	59
HAUS MAGICKISS GLITTER LIPSTICK 4G	https://pgmall.my/p/2739/4071	Selangor	Alat solek	27
HAUS POPSY SUPERSTAY LIPMATTE 3ML	https://pgmall.my/p/2739/4065	Selangor	Penjagaan kulit	27

Cleaned dataset with product name,
link location, price and product type

Optimization Techniques

Pandas

- Uses standard Pandas operations
- Processes data in-memory as a single chunk
- Applies functions row-by-row using .apply()
- Shows typical performance characteristics of unoptimized Pandas code

```
import pandas as pd
```

```
# Start performance timer and process monitor
start_time = time.time()
process = psutil.Process(os.getpid())
# Drop duplicate rows
df = df.drop_duplicates()

# Fill in null
df['location'].fillna('Unknown', inplace=True)
df['product_type'].fillna('Unknown', inplace=True)

# Standardize price format
df['cleaned_price'] = df['price'].apply(extract_lowest_price)
df['cleaned_price'] = df['cleaned_price'].round(2)

df.drop(columns=['price'], inplace=True)

# Clean unreadable characters from product_name
df['product_name'] = df['product_name'].apply(lambda x: re.sub(r"^\x00-\x7F+", '', str(x)))

df.rename(columns={
    'product_name': 'Product Name',
    'cleaned_price': 'Price',
    'location': 'Location',
    'link': 'Link',
    'product_type': 'Product Type'
}, inplace=True)

# Save cleaned data
df.to_csv("Item_list_cleaned.csv", index=False, float_format='%.2f')

# Log performance metrics
end_time = time.time()
elapsed_time = end_time - start_time
cpu_percent = process.cpu_percent(interval=1)
memory_usage_mb = process.memory_info().rss / 1024 ** 2
throughput = df.shape[0] / elapsed_time
```


Dask

- Leverages Dask's parallel processing capabilities
- Uses lazy evaluation with explicit computation triggers
- Processes data in partitions for memory efficiency
- Demonstrates distributed computing benefits

```
import dask.dataframe as dd
```

```
# Rename columns
df = df.rename(columns={
    'product_name': 'Product Name',
    'cleaned_price': 'Price',
    'location': 'Location',
    'link': 'Link',
    'product_type': 'Product Type'
})

# Drop the original 'price' column
df = df.drop('price', axis=1)

# Compute the result and round the price
result = df.compute()
result['Price'] = result['Price'].round(2)

# Save to CSV
result.to_csv("Item_list_cleaned_dask.csv", index=False, float_format='%.2f')

# Performance metrics
end_time = time.time()
elapsed_time = end_time - start_time
cpu_percent = process.cpu_percent(interval=1)
memory_usage_mb = process.memory_info().rss / 1024 ** 2
throughput = result.shape[0] / elapsed_time
```


Polars

- Utilizes Polars' Rust-based, columnar data processing
- Employs vectorized operations and expression-based transformations
- Shows native string operations and regex optimizations
- Demonstrates high-performance data frame operations

```
import polars as pl
```

```
# Fill nulls with default values
df = df.with_columns([
    pl.col("location").fill_null("Unknown"),
    pl.col("product_type").fill_null("Unknown")
])

# Extract cleaned versions first
df = df.with_columns([
    pl.col("price").str.extract(r"(\d+(?:\.\d+)?)").cast(pl.Float64).round(2).alias("price"),
    pl.col("product_name").str.replace_all(r"^[^x00-\x7F]+", "").alias("product_name")
])

# Reorder columns if needed
df = df.select([
    "product_name", "price", "location", "link", "product_type"
])

# Rename columns
df = df.rename({
    "product_name": "Product Name",
    "price": "Price",
    "location": "Location",
    "link": "Link",
    "product_type": "Product Type"
})

# Save cleaned CSV
df.write_csv("Item_list_cleaned_optimized.csv")

# End performance tracking
end_time = time.time()
elapsed_time = end_time - start_time
cpu_percent = process.cpu_percent(interval=1)
memory_usage_mb = process.memory_info().rss / 1024 ** 2
throughput = df.shape[0] / elapsed_time
```

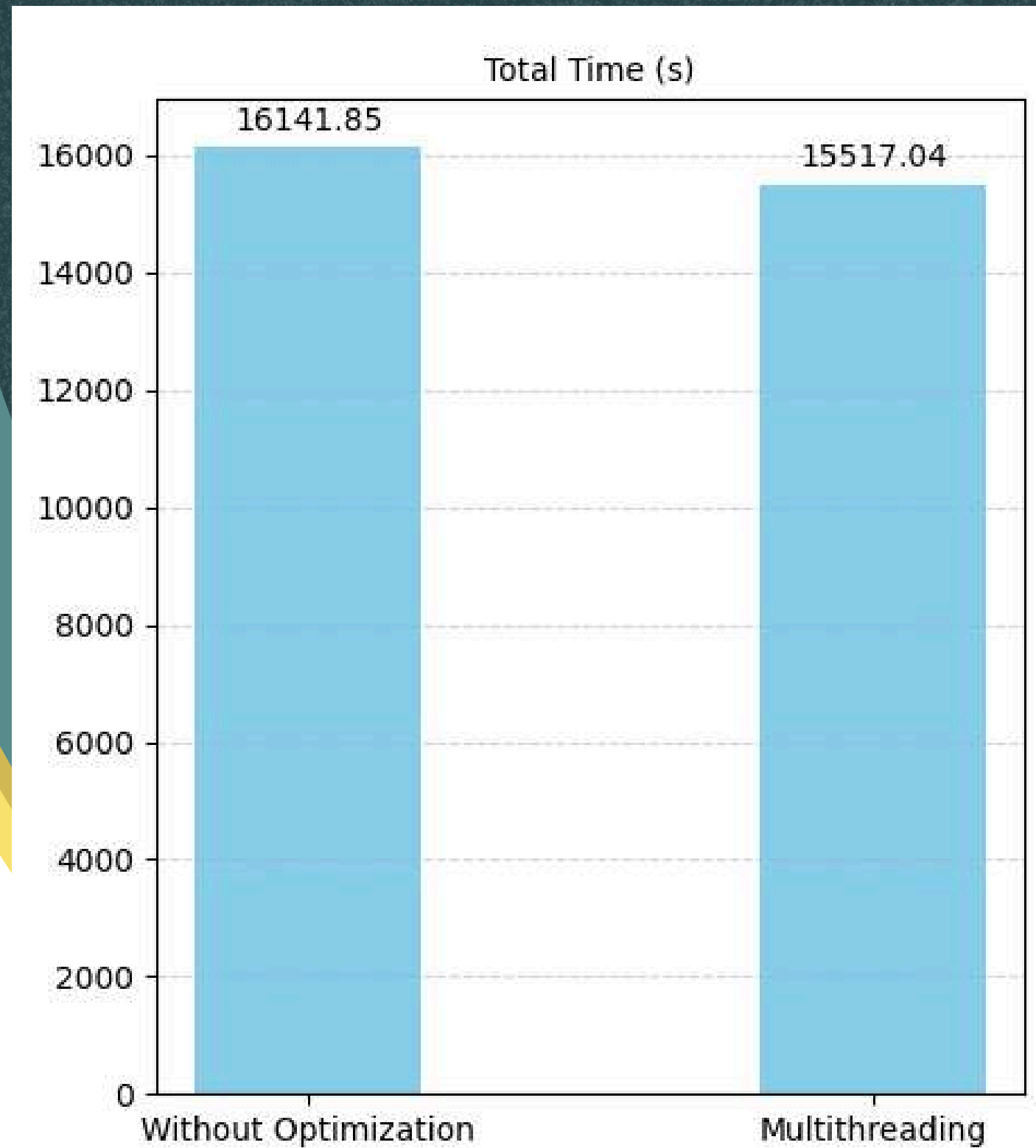

Performance Evaluation

Web Scrapping

Table 6.0.1 Performance Evaluation of Web Scrapping

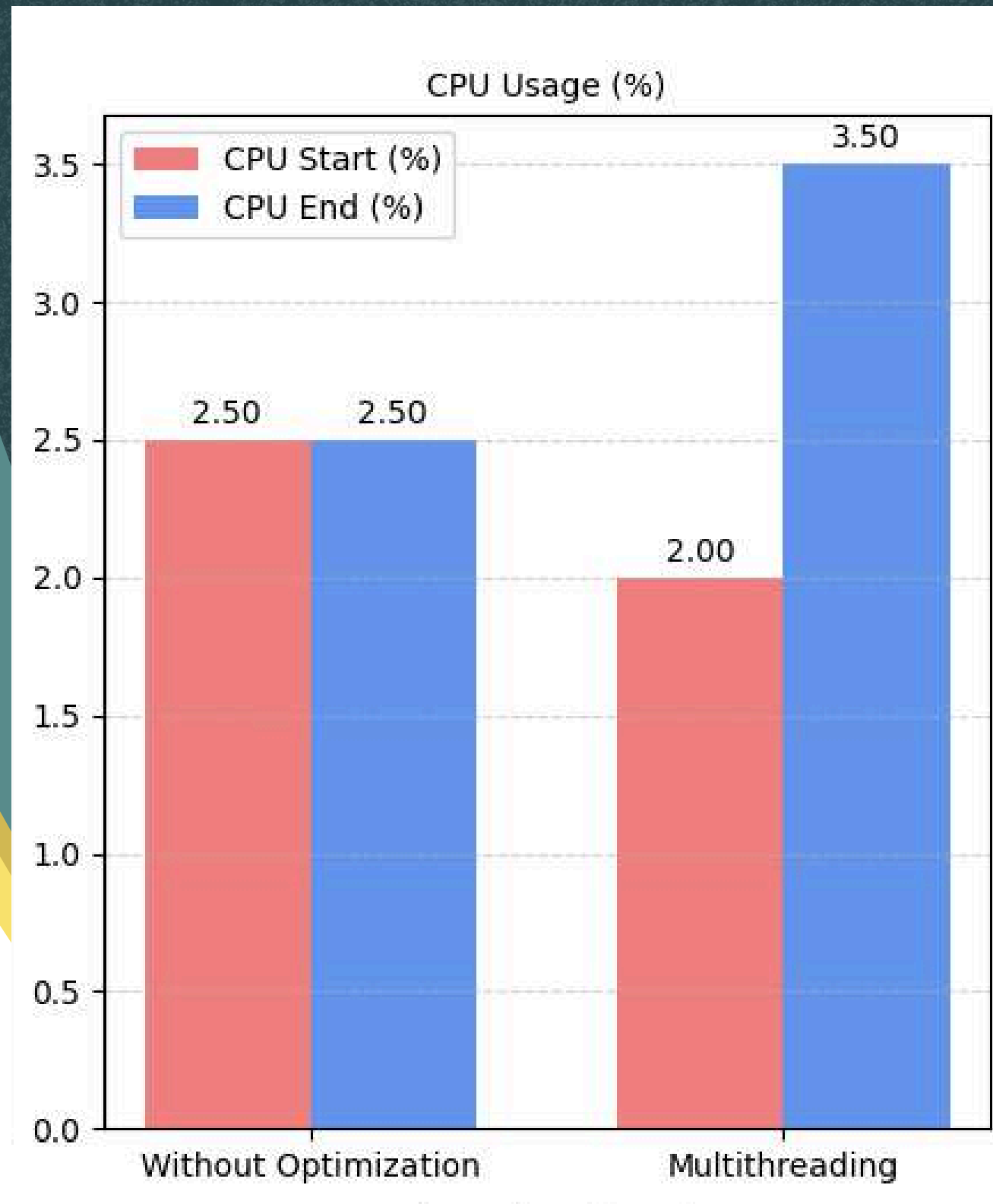
Metric	Without optimization	With optimization using multithreading
Total data scraped	200009 rows	200010 rows
Total time taken	16141.85 seconds (4 hours 28 minutes 58 seconds)	15517.04 seconds (4 hours 18 minutes 36 seconds)
Start CPU	2.5%	2.0%
End CPU	2.5%	3.5%
Start memory	166.88MB	167.01 MB
End memory	197.24 MB	274.76 MB
Used memory	30.36 MB	107.75 MB
Throughput	12.39 rec/s	12.89 rec/s

Web Scraping – Total Processing Time



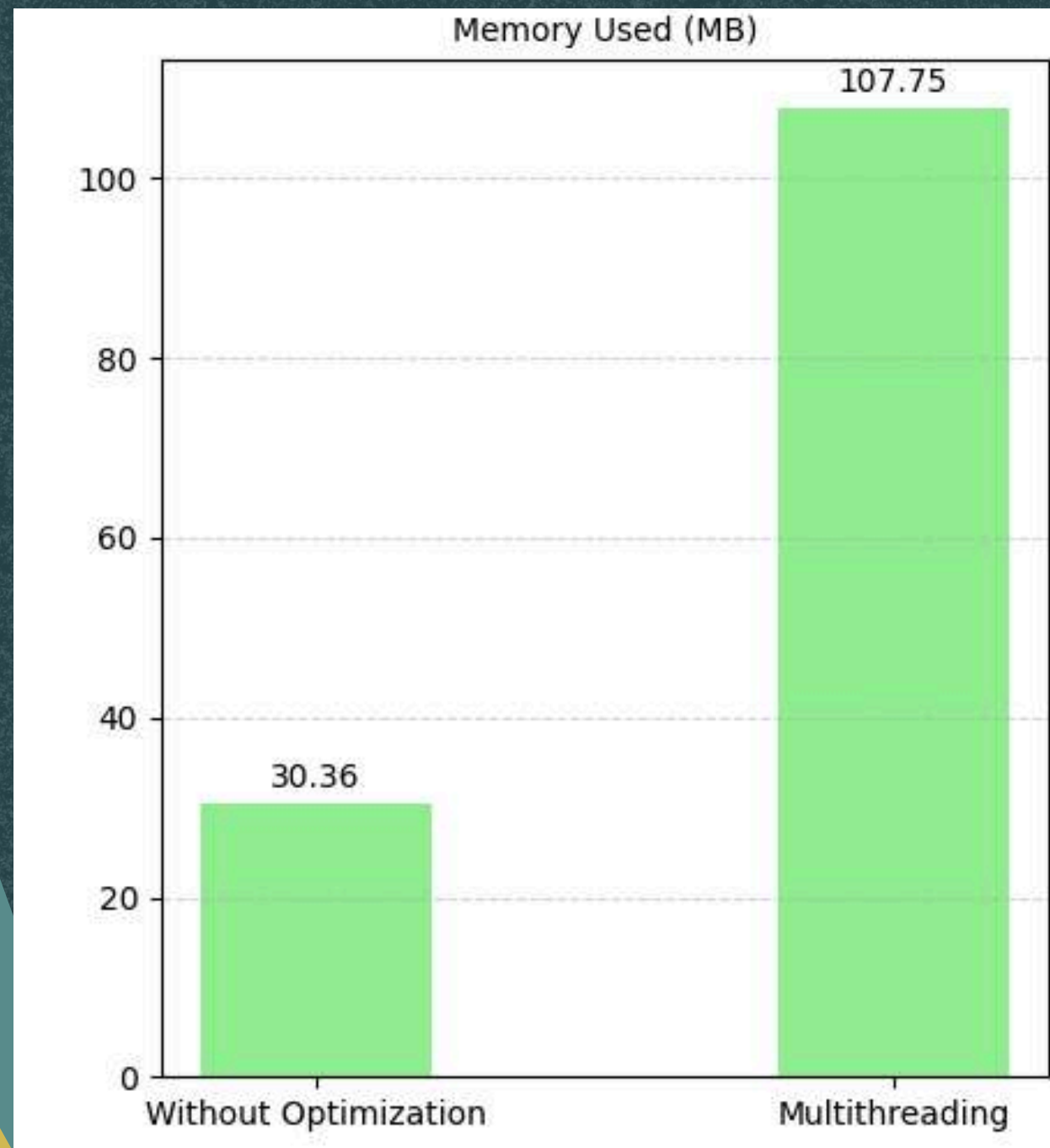
- **Basic scraping: 16141.85 seconds**
- **Optimized scraping: 15517.04 seconds**
- **4% faster with multithreading**

Web Scrapping – CPU Usage



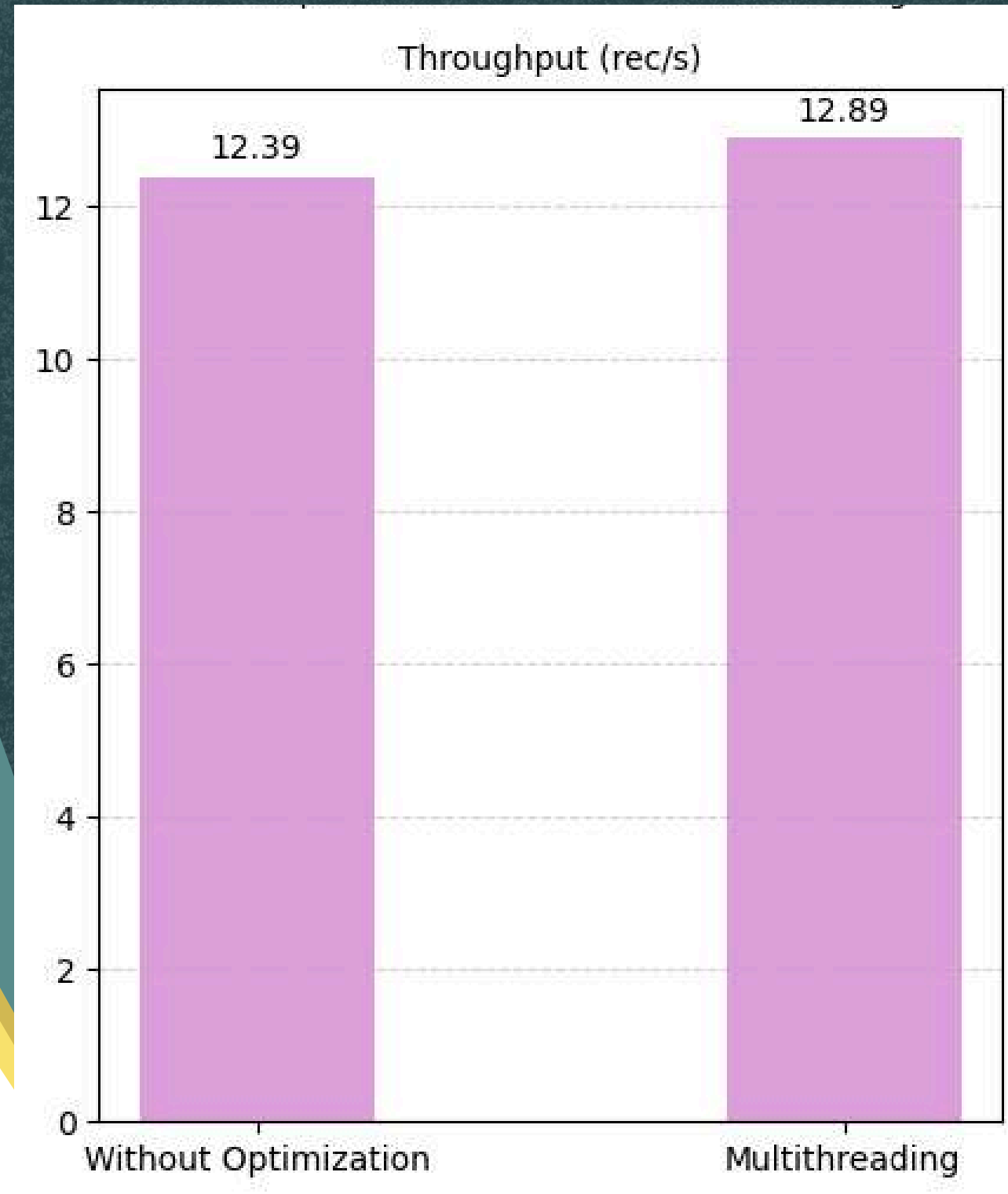
- **Without optimization: Stable at 2.50%**
- **With optimization: Increased from 2.0% to 3.5%**
- **Multithreading uses more CPU for concurrent tasks**

Web Scrapping – Memory Usage



- **Without optimization: 30.36 MB**
- **With optimization: 107.75 MB**
- **Multithreading increases memory usage due to parallel threads**

Web Scrapping – Throughput



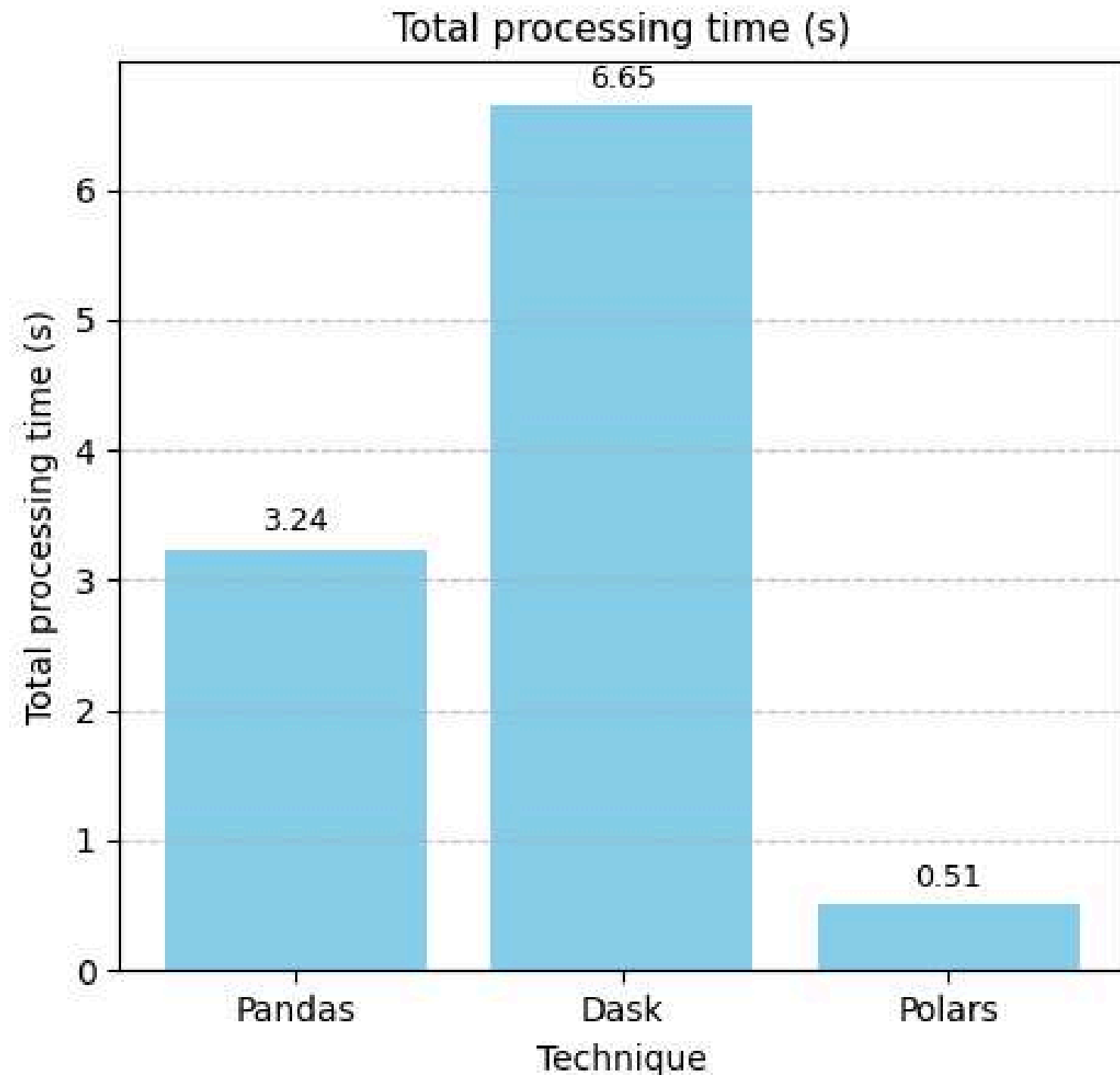
- **Without optimization: 12.39 rec/s**
- **With optimization: 12.89 rec/s**
- **4% higher throughput with optimization**

Data Cleaning

Table 6.0.2 Performance Evaluation of Data Cleaning

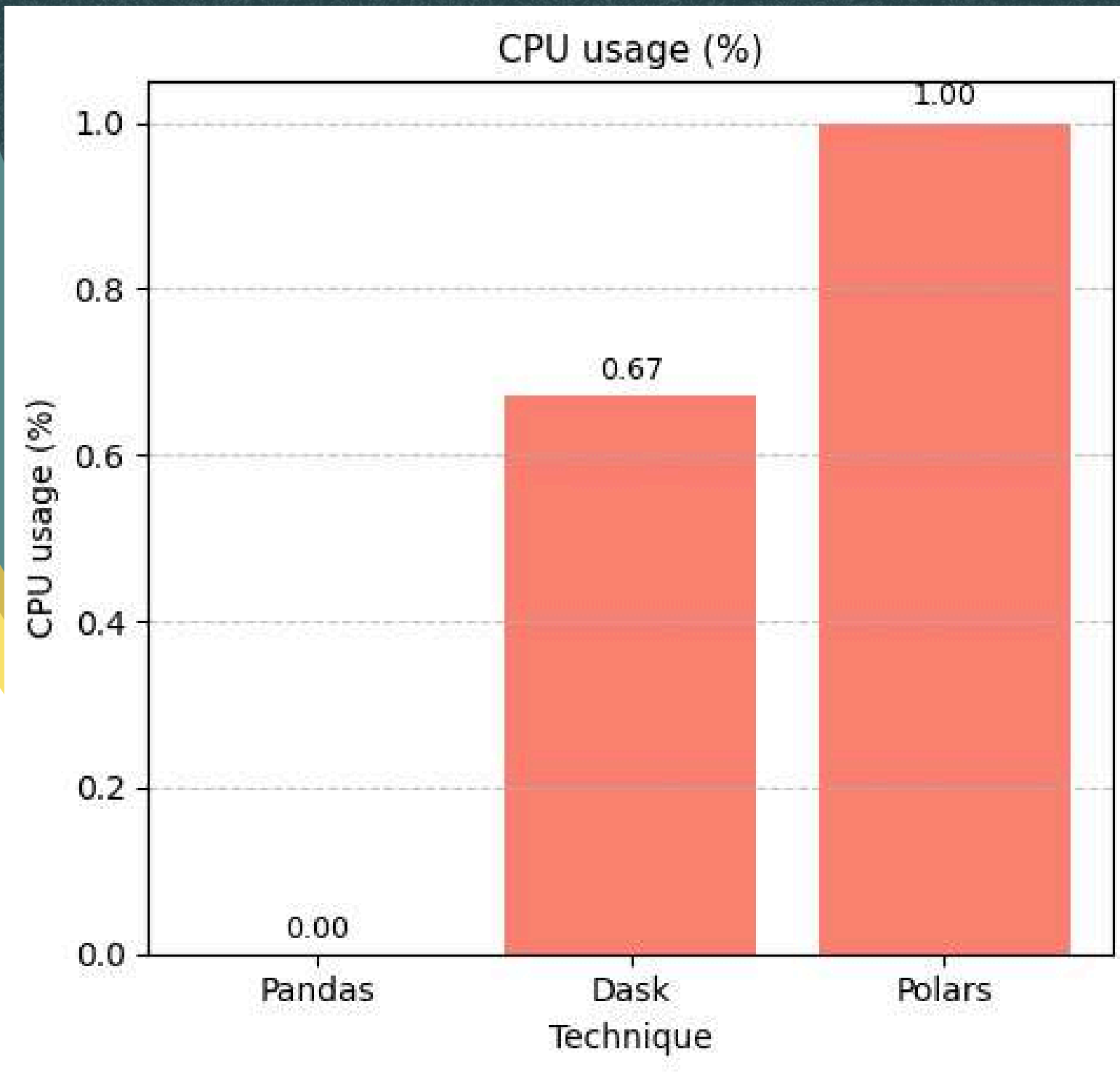
Techniques	<u>Metric</u>	Run 1	Run 2	Run 3	Average
Pandas	Total processing time	4.03 <u>seconds</u>	2.89 <u>seconds</u>	2.80 <u>seconds</u>	3.24 <u>seconds</u>
	Memory usage	269.84 MB	243.20 MB	218.34MB	243.79MB
	CPU usage	0.0%	0.0%	0.0%	0.0%
	Throughput	51029.69 rec/s	71183.34 rec/s	51488.39 rec/s	57900.47 rec/s
Dask	Total processing time	6.70 <u>seconds</u>	6.86 <u>seconds</u>	6.38 <u>seconds</u>	6.65 <u>seconds</u>
	Memory usage	552.43 MB	447.21 MB	395.86 MB	465.17 MB
	CPU usage	1.0%	1.0%	0.0%	0.67 %
	Throughput	30719.88 rec/s	29994.33 rec/s	18149.05 rec/s	26287.75 rec/s
Polar	Total processing time	0.58 <u>seconds</u>	0.35 <u>seconds</u>	0.59 <u>seconds</u>	0.51 <u>seconds</u>
	Memory usage	319.55 MB	203.18 MB	240.30 MB	254.34 MB
	CPU usage	1.0%	1.0%	1.0%	1.0%
	Throughput	356363.62 rec/s	200205.37 rec/s	224245.89 rec/s	260271.63 rec/s

Data Cleaning – Total Processing Time



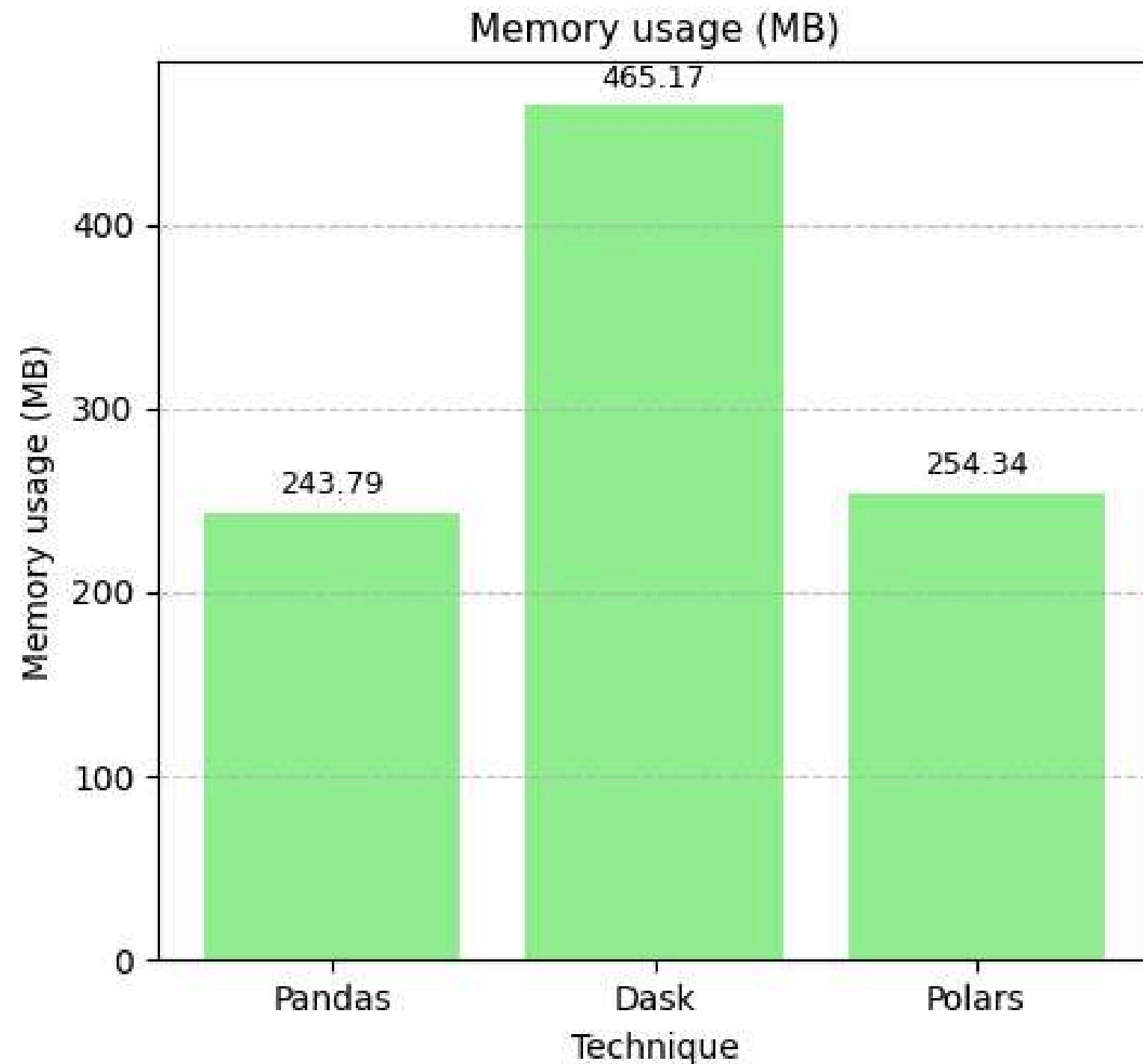
- **Polars: Fastest at 0.51 seconds**
- **Dask: Slowest at 6.65 seconds**
- **Pandas: Moderate speed at 3.24 seconds**
- **Polars wins due to multi-threaded, columnar processing**

Data Cleaning – CPU Usage



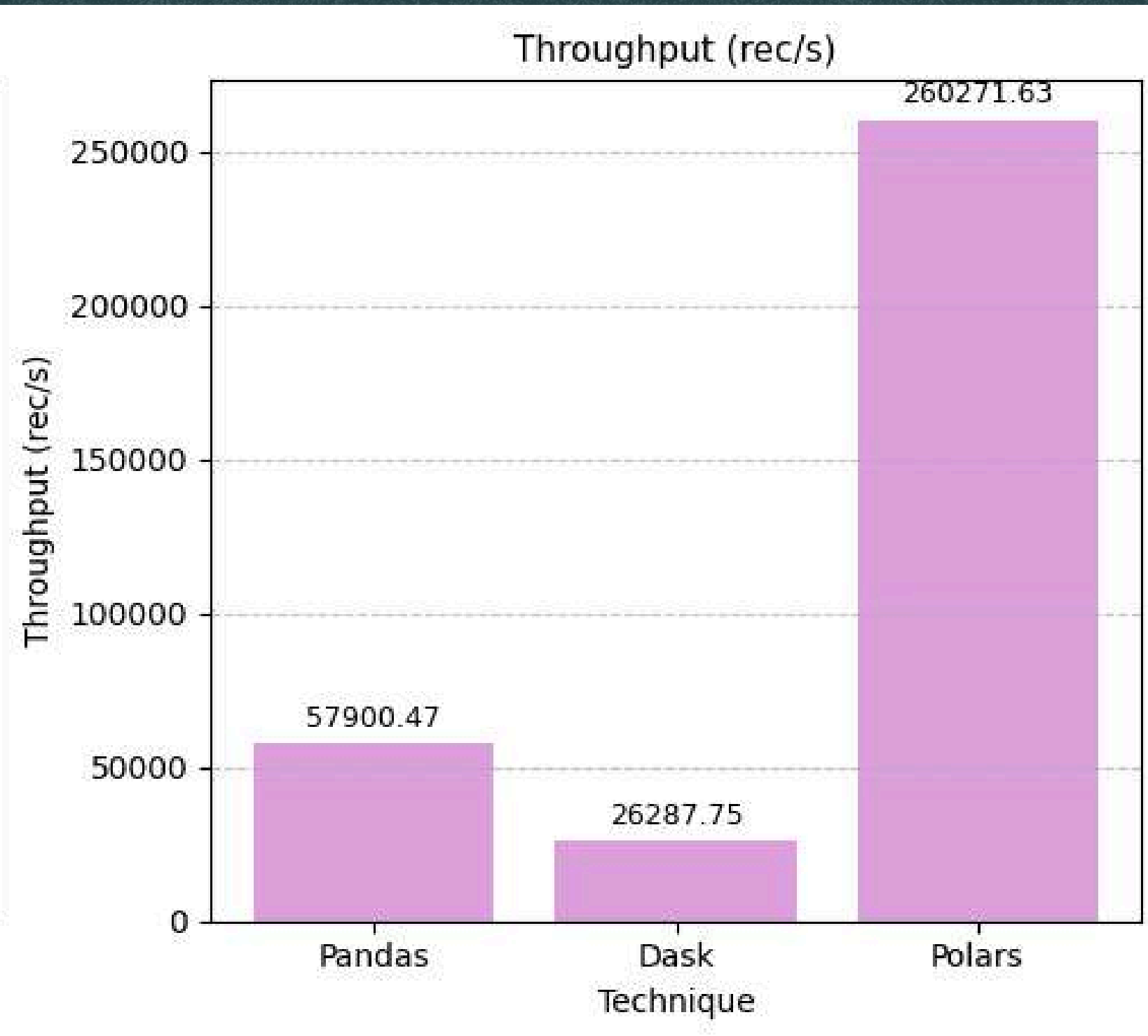
- **Pandas: 0.0%**
- **Dask: 0.67%**
- **Polars: 1.0% (highest – fully utilizes CPU cores)**

Data Cleaning – Memory Usage



- **Pandas: 243.79 MB – least memory used**
- **Polars: 254.34**
- **Dask: 465.17 MB**
- **Dask uses more memory due to parallel partition handling**

Data Cleaning – Throughput



- **Polars: 260271.63 rec/sec - Highest throughput**
- **Pandas: 57900.47rec/s**
- **Dask: 26287.75 rec/sec**
- **Polars processed data most efficiently**

Challenges & Limitations

Challenges	Descriptions
Website Restrictions	Some websites block scraping via CAPTCHAs, rate limiting and dynamic content
Limited Data Availability	Many Malaysian websites have small datasets and some sites paginate data poorly, making large-scale scraping difficult.
Inconsistent Data Structure	Websites change layout, breaking scrapers and some data is hidden behind login walls

Limitations	Descriptions
Hardware Dependencies	Scraping speed varies by CPU/RAM and low-end devices struggle with large-scale scraping
Slow Scraping Process	Polar/Dask clean data fast, but scraping itself bottlenecked by network latency and rate-limiting delays
Maintenance Overload	Scrapers need constant updates if websites change HTML structure and proxy/IP rotation may be needed to avoid bans

Conclusion

Data Collection

- Over 200,000 cleaned records collected from PG Mall's "Health & Beauty" category.

Performance Comparison

- Multithreading offers faster data collection and higher throughput.
- Trade-off: higher CPU and memory usage, but acceptable for large data volumes.

Data Cleaning Framework

- Polars: Most efficient and scalable
- Pandas: Suitable for simplicity and low-memory environments.
- Dask: Best for very large or distributed datasets.

Improvement

- Use proxy rotation and headless browsers
- Expand to more categories or websites
- Use asynchronous requests
- Deploy scraping on cloud platforms (e.g., GCP, AWS)
- Use modular code or public APIs.

THANK YOU