Password decryption with Java Thread

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Parallel Computing, April 2020

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Password Decryption

DES and brute-force attack

Data Encryption Standard (DES)

- is a block cipher algorithm
- is composed by sixteen phases
- adopts a secret key for both crypt and decrypt phase

A brute-force attack

- is used to decrypt any encrypted passwords
- leverages all possible combinations inside the set [a-zA-Z0-9]
- wants to find a secret password

Problem: a lot of combinations to analyze (with 8-character passwords are 68^8)

Dictionary attack and Java Thread

The solution for the brute-force attack time problem

- use dictionary
  - less password to analyze
  - pre-computed 8-characters passwords
- use Java Threads parallelism
  - different threads analyze different dictionary chunks
  - speed up the password analysis process

T.B.N.: need threads synchronization $\Rightarrow$ tree approaches

Sequential approach

Sequential approach

- The hacker knows the DES SecretKey
- Passwords analyzed sequentially

Algorithm 1 Dictionary finder

```
Read the given dictionary
for password in dictionary do
    Encrypt password p to obtain ep
    Compare ep with the target password
    if ep is equal to target password then
        exit and return password
    end if
end for
```

Sequential approach

Very expensive task

- A single process checks all passwords in the dictionary
- Total computational time $\Rightarrow O(l)$

Problem: Typically the dictionary size is 10 GB

Parallel approach

Java Thread approach

- Multiple threads check different dictionary chunks
- Use *Callable* and *Runnable*
- Need threads synchronization $\Rightarrow$ 3 approaches
    - Threads Synchronization
    - ReadWriteLock
    - Atomic

Callable vs Runnable

- Callable return a value, Runnable no
- Callable uses *Future* to store the return value
- Both leverage an *Executor*
  - Creates threads from a pool
  - Does not create extra threads
  - Separates threads creation and management

Threads Synchronization

- Control access of multiple threads to shared resources
- Solve consistency problem and prevent race conditions
- The keyword *synchronized* leverages the lock built in Java Object
- A class *State* is create with a boolean variable
- Two different functions to access to it
    - *getState()*: read the boolean variable
    - *setState()*: set the boolean state

ReadWriteLock

- Gives an advanced thread lock mechanism
- *ReentrantReadWriteLock* allows multiple readings but single writing
- Two different lock, one for reading and one for writing
- A thread can read the true shared resource state
- Same class *State* used in Threads Synchronization

Atomic

- Allows atomic access and updates without synchronization or locks
- Can implement non-blocking, lock-free algorithms solving race conditions
- No need a *State* class, only an Atomic boolean
- Two functions to interact with shared resources
  - *get()*: return the value from the memory
  - *set()*: write the value to memory

Experiments

Testing Hypothesis

- The hacker uses two preset dictionaries
  - *Dictionary_words* contains 19958400 8 letter English words.
  - *Dictionary_data* contains 461313 data from 1600 to 2020
- Two different experiments:
  - The hacker has to find different passwords
  - The hacker can use different threads number
- 10 runs for each testing configuration

Evaluation Metrics

Speedup

- Measures two approaches performance
- Use sequential and parallel time
- Depend on the CPU processor number

$$S_p = t_s / t_p$$

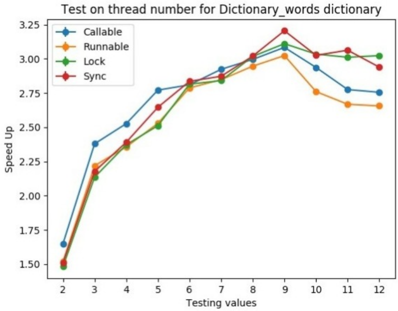
Efficiency

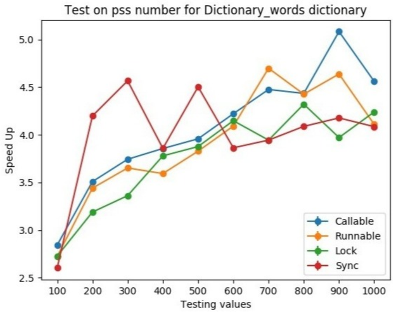
- Measures how well-utilized the processors
- Use the Speedup values
- Depend on the CPU processor number

$$E_p = S_p / p.$$

Dictionary_words

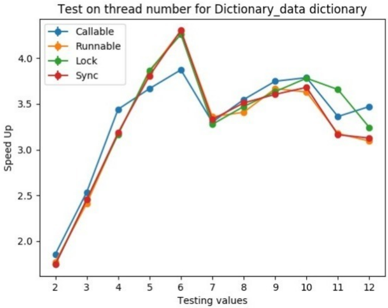
- More threads means more (smaller) dictionary chunks
- More passwords to retrieve increasing Speedup

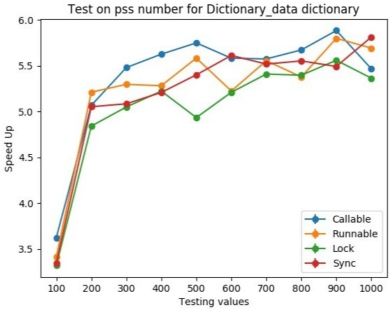




Dictionary_data

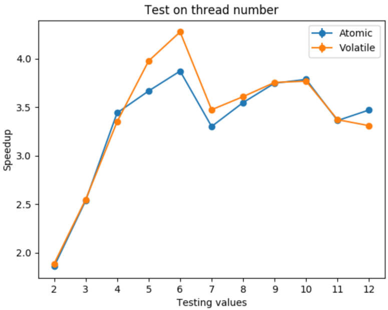
- Similar trend but higher performances
- Smaller dictionary ⇒ higher Speedup
- Password position in chuck affects the result

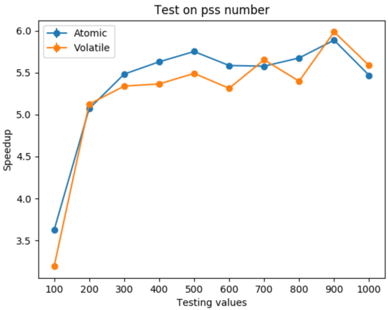




Atomic vs Volatile

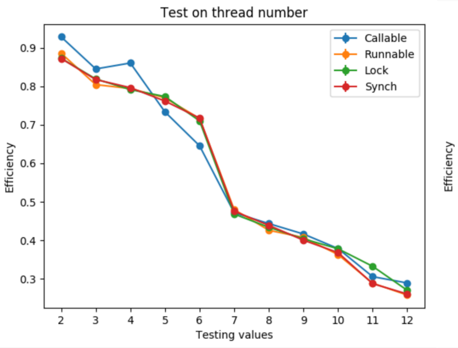
- Volatile variable has atomic reading/writing operations
- One thread updates the shared variable ⇒ few synchronizations
- Similar Speedup values w.r.t. Atomic ones

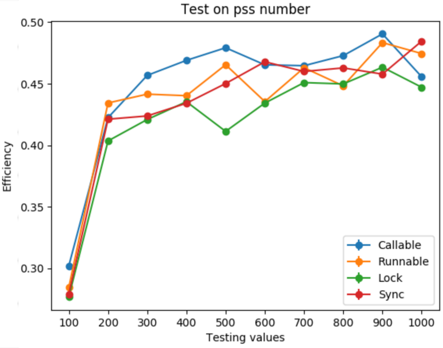




Efficiency

- Fixed passwords number and more thread ⇒ less thread work
- More passwords to retrieve ⇒ more passwords in each chunk





Conclusions

Conclusions

- Parallel approaches improves the computational time
- Bigger dictionary size implies more computational time
- The password position in dictionary affects the results
- Different synchronization methods not change Speedup
- No race conditions, few synchronization $\Rightarrow$ *Volatile*

Thanks for the attention