Extracting Log Patterns from System Logs in LARGE

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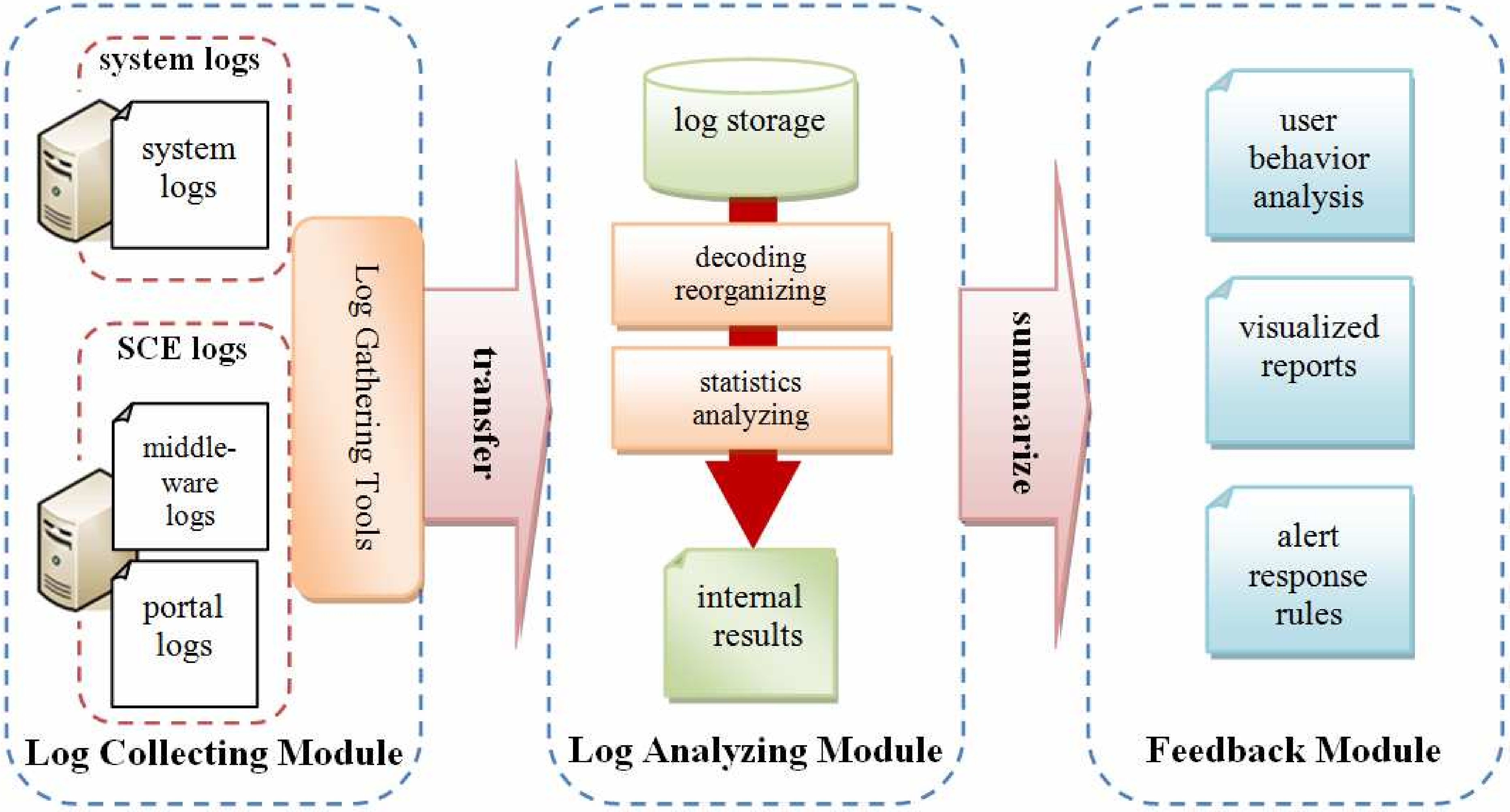
ScGrid in CAS

- Scientific Computing Grid Environment
- Integrated by many supercomputing centers in China
  - CNIC the head center
  - 8 national centers
  - 18 institute centers
- Using SCE middleware developed by SCCAS
- Provide computing resources
  to researches in various fields
  - Meteorology, Metal Forging,
    Fluid Mechanics, High Energy Physics,
    Computational Chemistry, Astrology…

The System of LARGE

- Log Analyzing fRamework in Grid Environments
- Processing logs produced by the environment
  - gathering logs
  - processing, doing statistics and analyzing
  - producing feedbacks
- Two major types of logs
  - system logs – by log service in operating systems
  - SCE logs – by SCE middleware and job scheduling processes
- Helping the environment run correctly and steadily
  - generate alerts for particular patterns of logs
  - provide data for system analysis and maintenance
    - ➢ user behavior report
    - ➢ system errors and faults

The System of LARGE



Log Patterns – Why?

- We want to be alerted for logs in certain patterns, but…
  - too many logs for human to read
  - need to summarize patterns before defining alert rules
- Set of log patterns in our context:
  - patterns are different from each other
  - covering all logs in original set
  - significantly less than original
- The process of using log patterns
  - filter and remove frequent normal logs
  - use algorithms of extracting log patterns to get the set of patterns
  - manually check the set and pick out abnormal patterns
  - define rules to generate alerts for these patterns

Algorithm of IWR

- Algorithm of identical word rate – a straight forward way
  - identical words
    - 2 words that are identical
    - and in the same position in 2 original logs
  - identical word rate: (number of identical words) / (total words)
  - predefined threshold *t*
- If IWR is greater than *t*, the two logs are in one pattern
- Logs with different length has IWR of ZERO!

```
It is a good day
It isn’t a bad day
```

→

t = 0.66

IWR = 60%

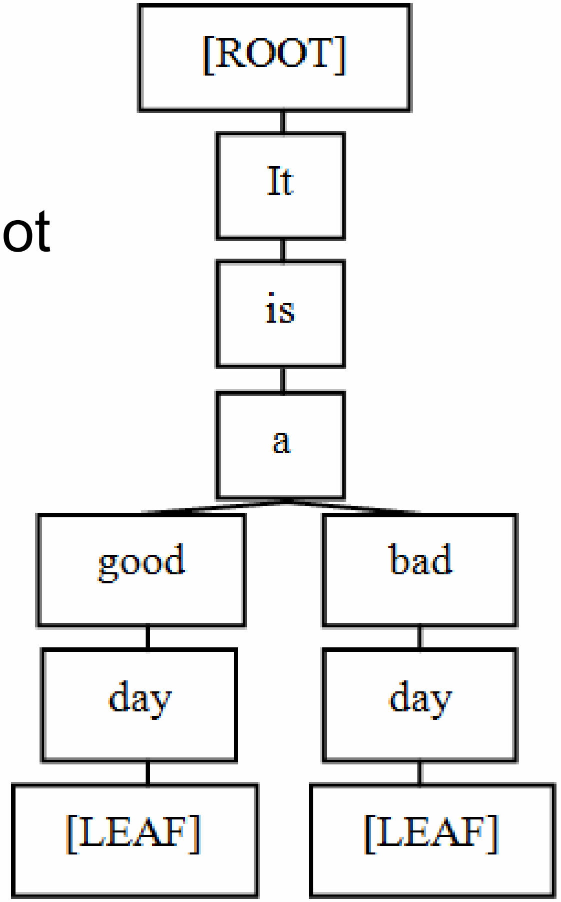
NOT in the same pattern!

Algorithm of IWR

- Process of algorithm of IWR
  - set threshold *t* and initial empty pattern set *P*
  - for each new incoming logs, compute IWR with each pattern in *P*
  - if pattern matched, skip to next; if none matched, add to *P*
- *P* will be affected by order of input
  - 3 logs, *L1:{a, b, c} L2:{a, b, d} L3:{d, b, c}*, *t* = 0.6
  - in order of *l1, l2, L3*, only 1 pattern left
  - in order of *l2, l1, l3*, 2 patterns left
- Not ideal in complexity
  - $O(n^2)$

Algorithm of Tree-matching

- Different in storing and matching structure with IWR
- Words stored orderly in a tree
  - branches for different words
- When performing the algorithm
  - compare each word in the incoming log from root
  - if successfully matched to leaf, check next
  - if unmatched found, create a new branch
- To get pattern set, use depth-first traverse
- Better complexity, but worse result
  - O(n *log*(n))
  - unacceptable number of patterns
  - need optimizations

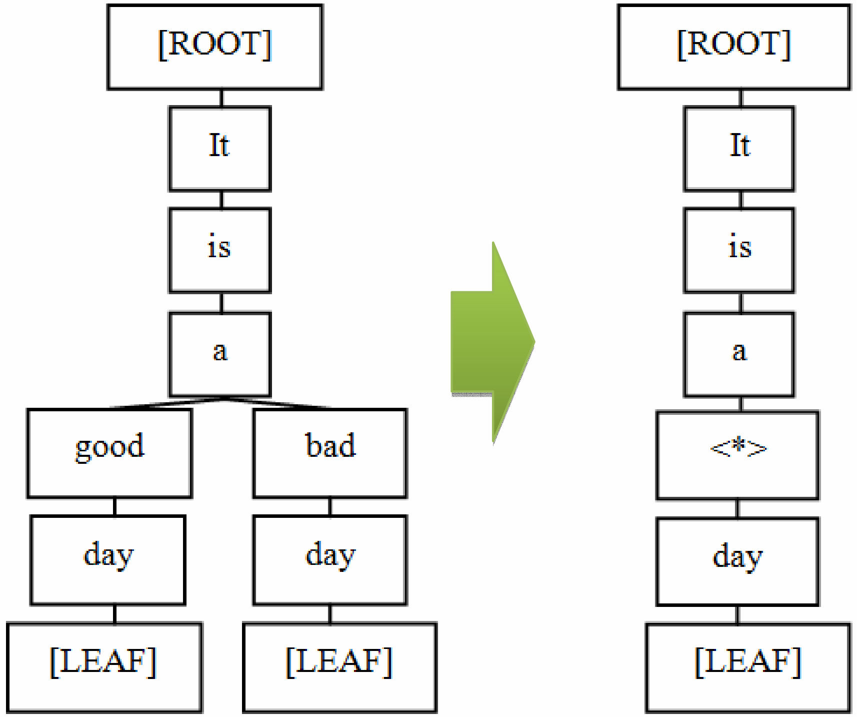


Algorithm Optimizations

- Tree pruning
  - if two nodes has same subtrees, merge to a key node (<*>)
  - after previous step, merge all key nodes to keep uniqueness
  - key node can be matched to any word, but only the last option
  - we can do this because…

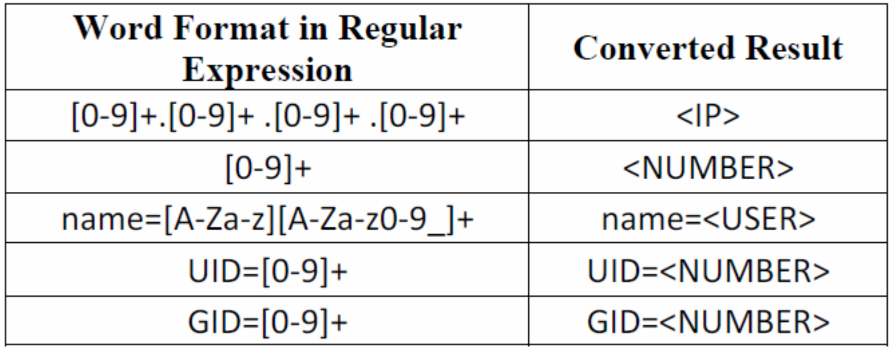
```
Login failed from user alice: password failed
Login failed from user bob: password failed
Login failed from user chris: password failed
```

key information position



Algorithm Optimizations

- Word converting function
  - a preprocessing optimization
  - converting commonly appeared expressions to predefined strings
- We can do this because…
  - At this stage, IPs, usernames, etc. are not essential
  - could be a distraction for extracting and enlarge pattern set
- Helpful for tree-matching, but not IWR
  - IWR has higher tolerance for differences of words
  - Tree-matching is more sensitive

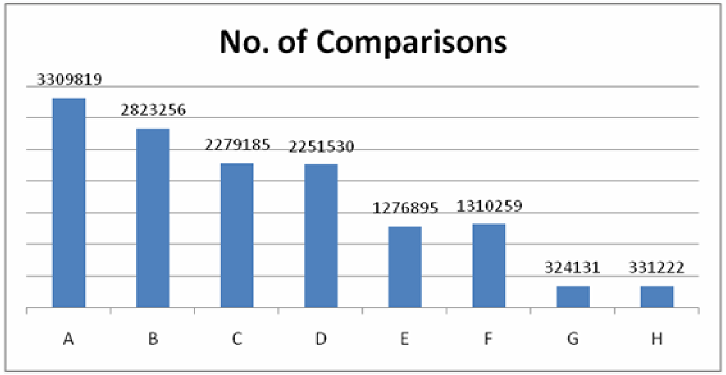


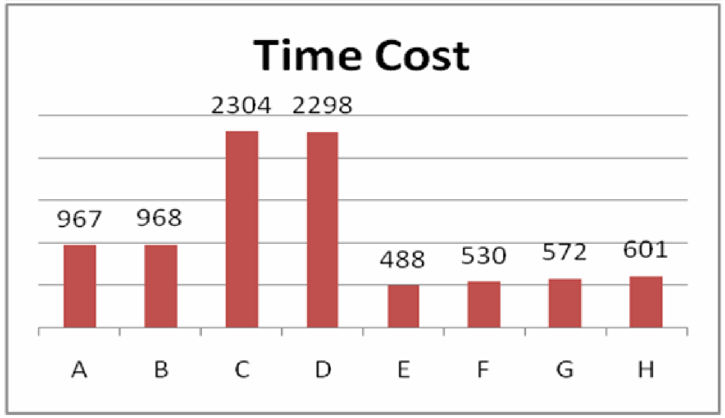
Word Format in Regular Expression	Converted Result
[0-9]+.[0-9]+ .[0-9]+ .[0-9]+	<IP>
[0-9]+	<NUMBER>
name=[A-Za-z][A-Za-z0-9_]+	name=<USER>
UID=[0-9]+	UID=<NUMBER>
GID=[0-9]+	GID=<NUMBER>

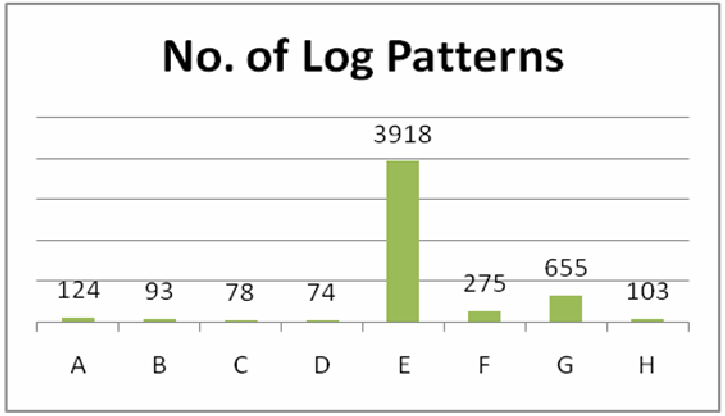
Comparisons on Performances

original: 49079 input logs

A. IWR, t = 0.66
B. IWR, t = 0.6
C. IWR + word converting, t = 0.66
D. IWR + word converting, t = 0.6
E. Tree-matching
F. Tree-matching + pruning
G. Tree-maching + word converting
H. Tree-matching + both







Comparisons on Performances

Tree-matching has significantly reduced the number of comparisons

o

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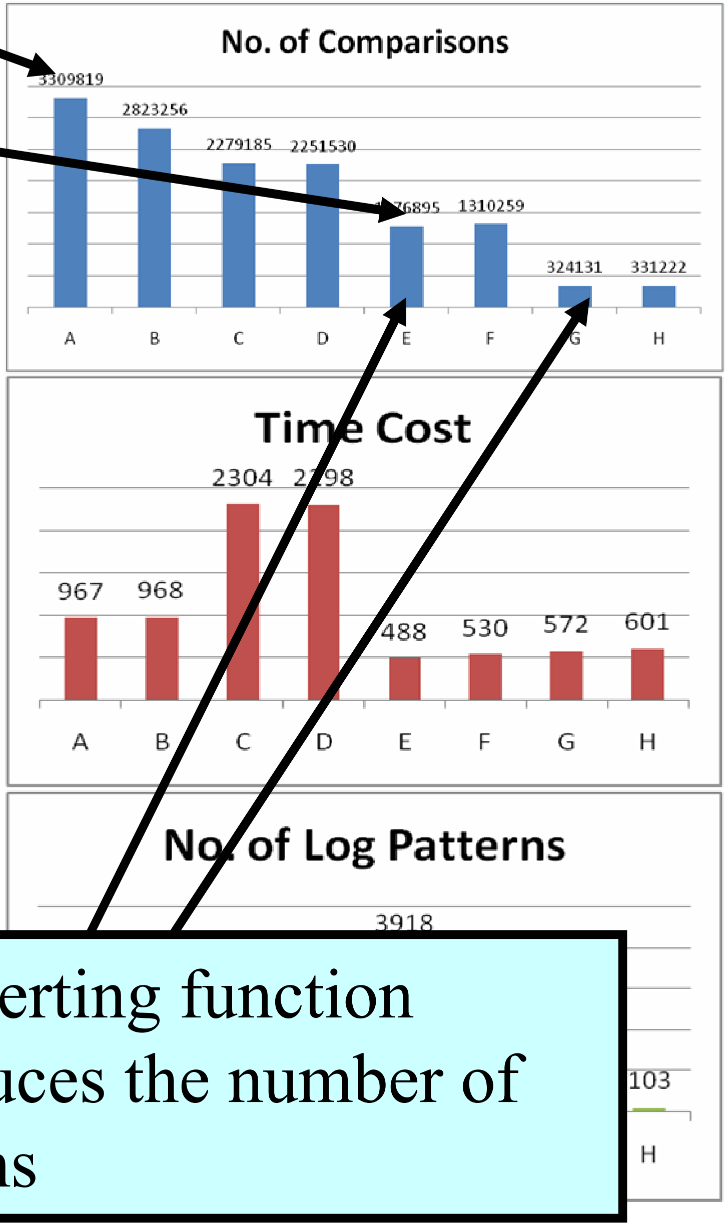

Word converting function further reduces the number of comparisons

Comparisons on Performances

origi

Word converting function is quite time costly

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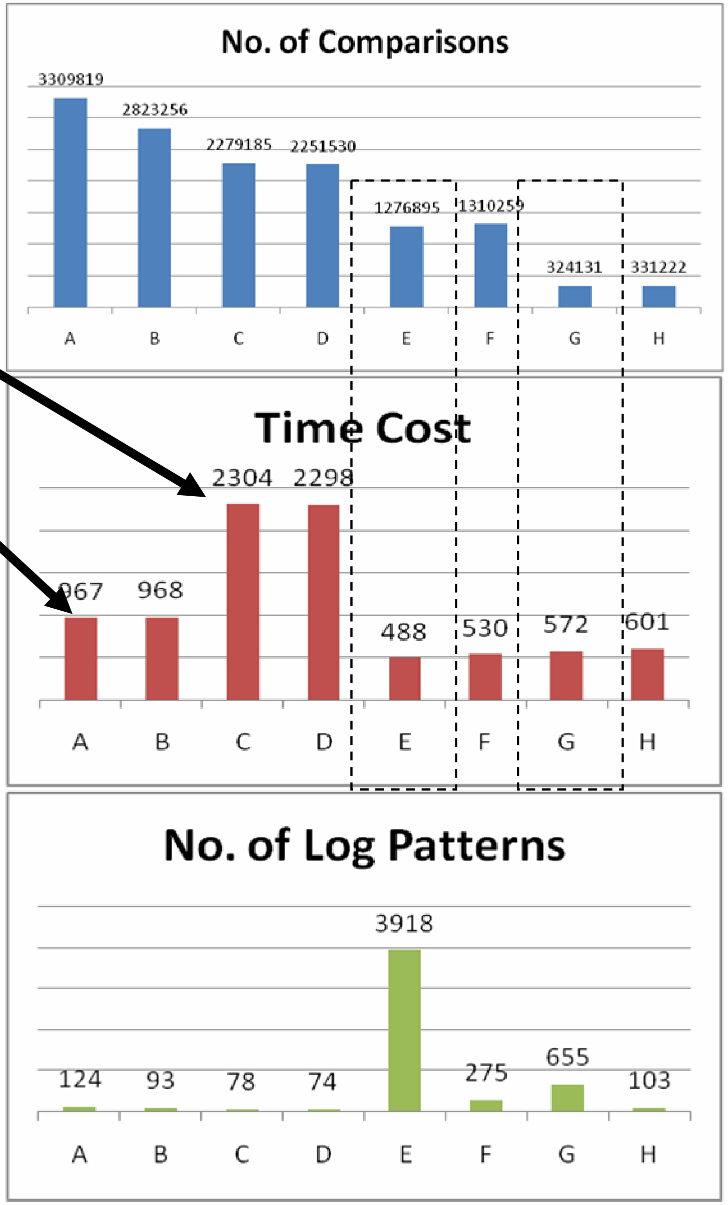


Comparisons on Performances

orig

Extracting efficiency (time and comparison costs): tree-matching is better

A.

B. IWR, t = 0.6

C. IWR + word converting, t = 0.66

D. IWR + word converting, t = 0.6

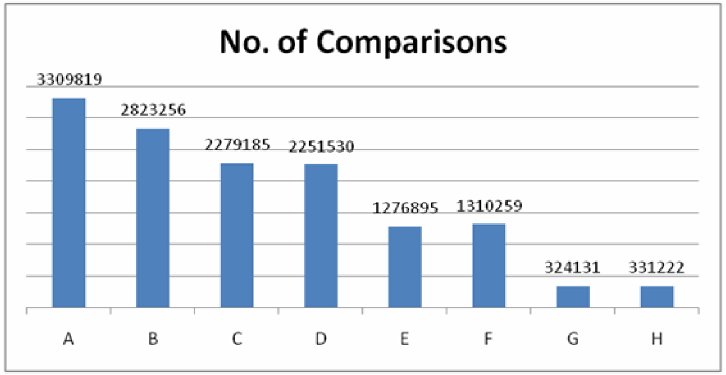
E. Tree-matching

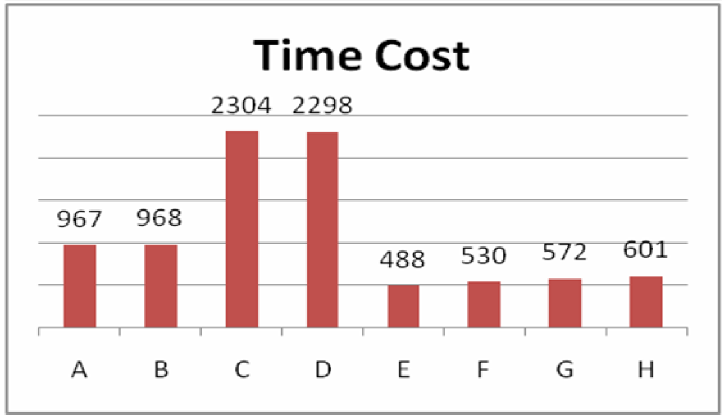
F. Tree-matching + pruning

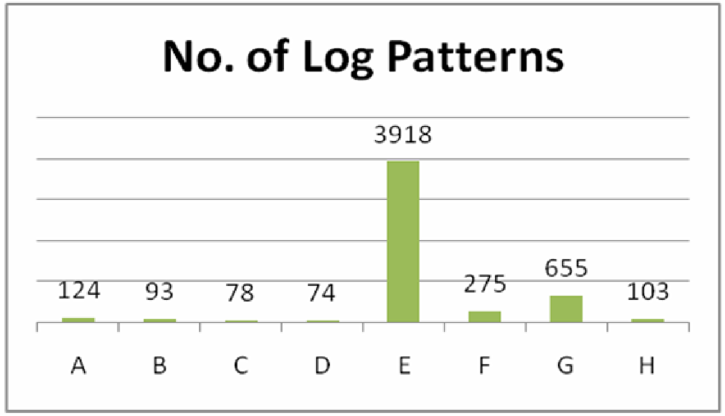
G. Tree-maching + word converting

H.

Extracting effect (number of patterns): IWR is better







Comparisons on Performances

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Lower threshold gives lesser patterns in IWR

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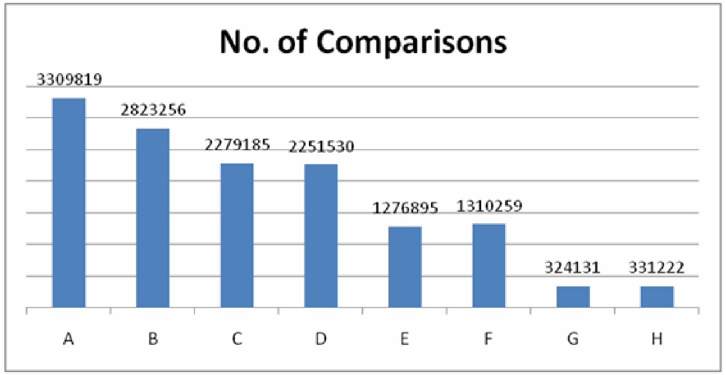

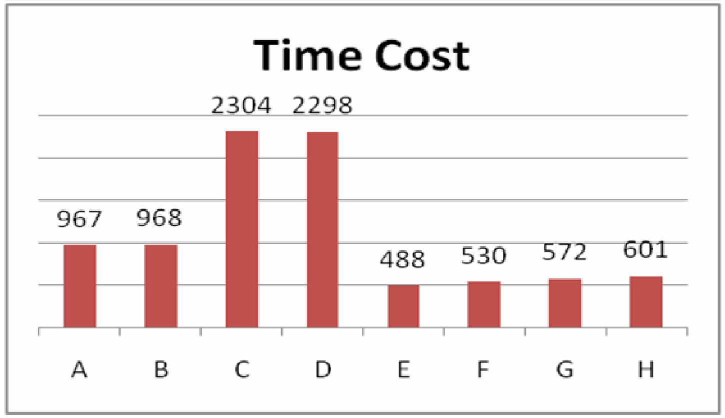

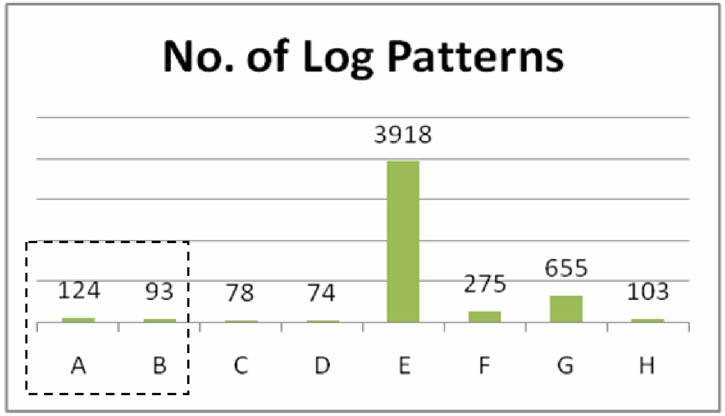

Comparisons on Performances

Number of comparisons has nearly direct proportion to the number of extracted patterns

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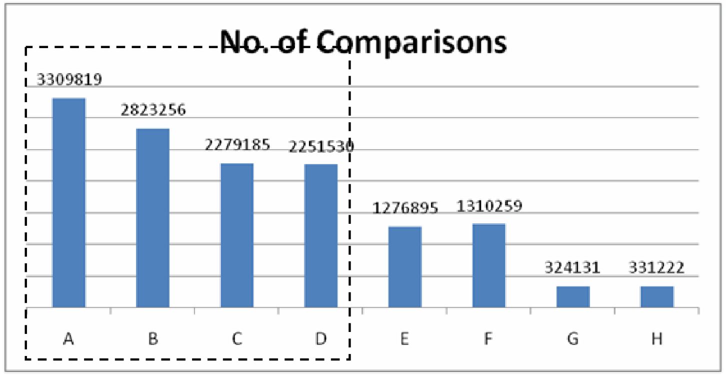

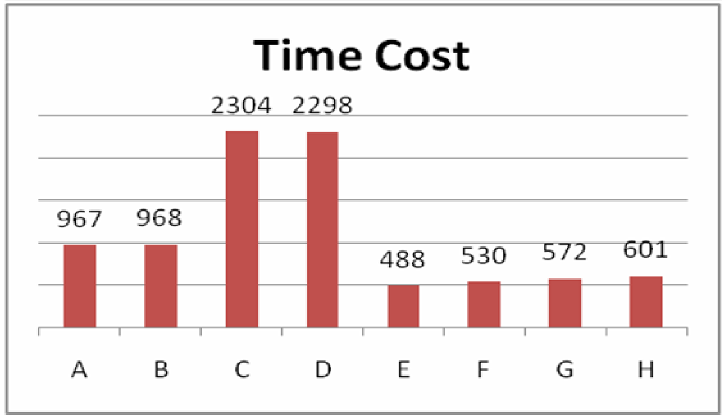

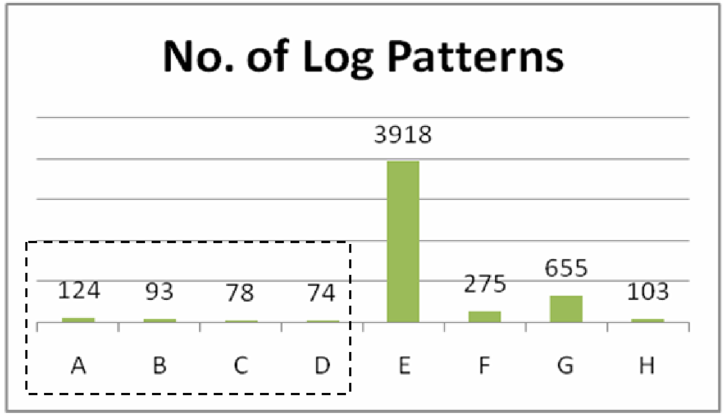

Comparisons on Performances

Pure tree-matching:

good in extract efficiency

very bad in extracting effect

o

A

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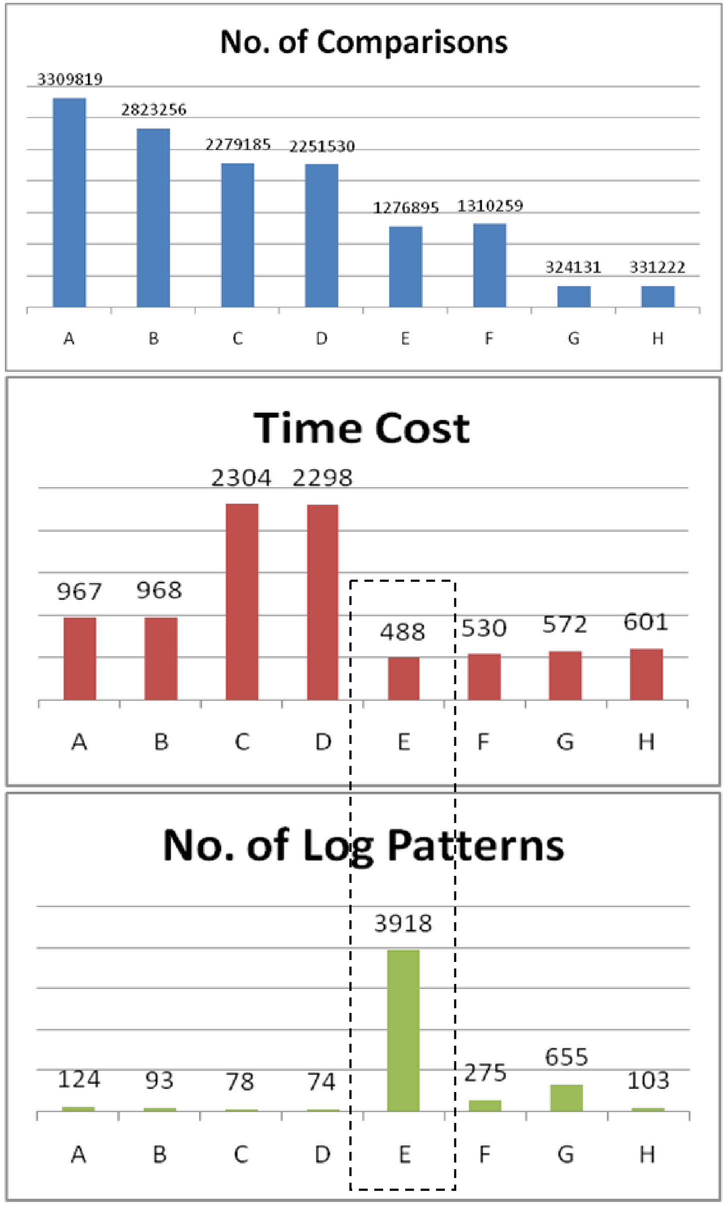

Comparisons on Performances

- Pruning has greatly improved the extracting effect

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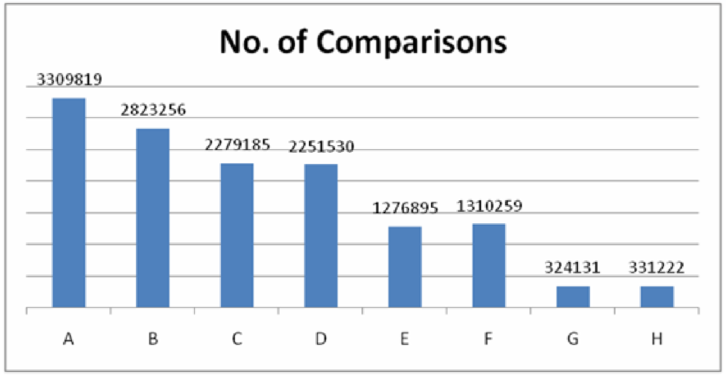

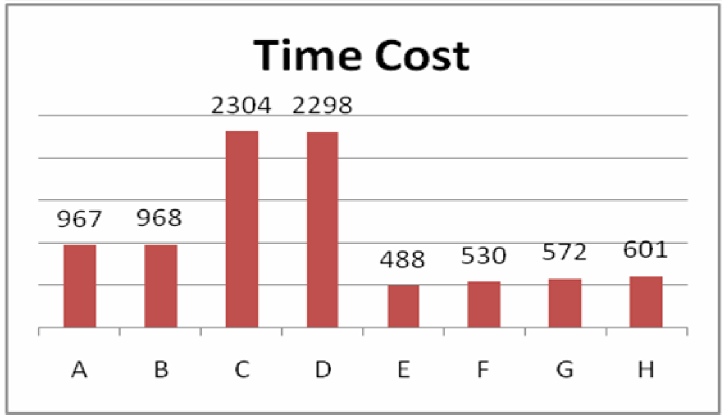

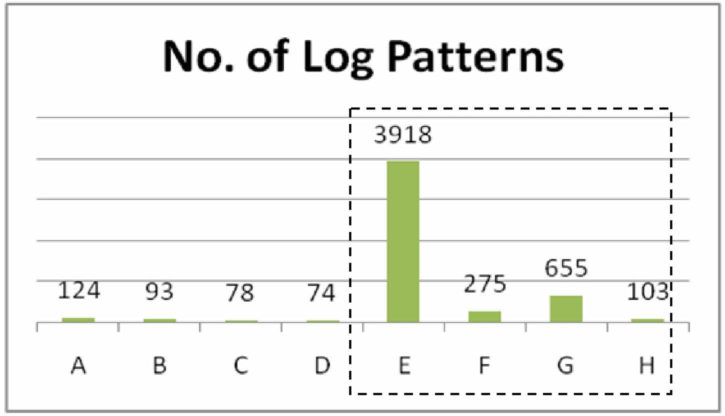

Comparisons on Performances

original: 49079 input logs

Tree-matching with both optimizations: good in extracting efficiency and effect, satisfying algorithm!

A. I

B. I

C. I

D. IWR + word converting, t = 0.6

E. Tree-matching

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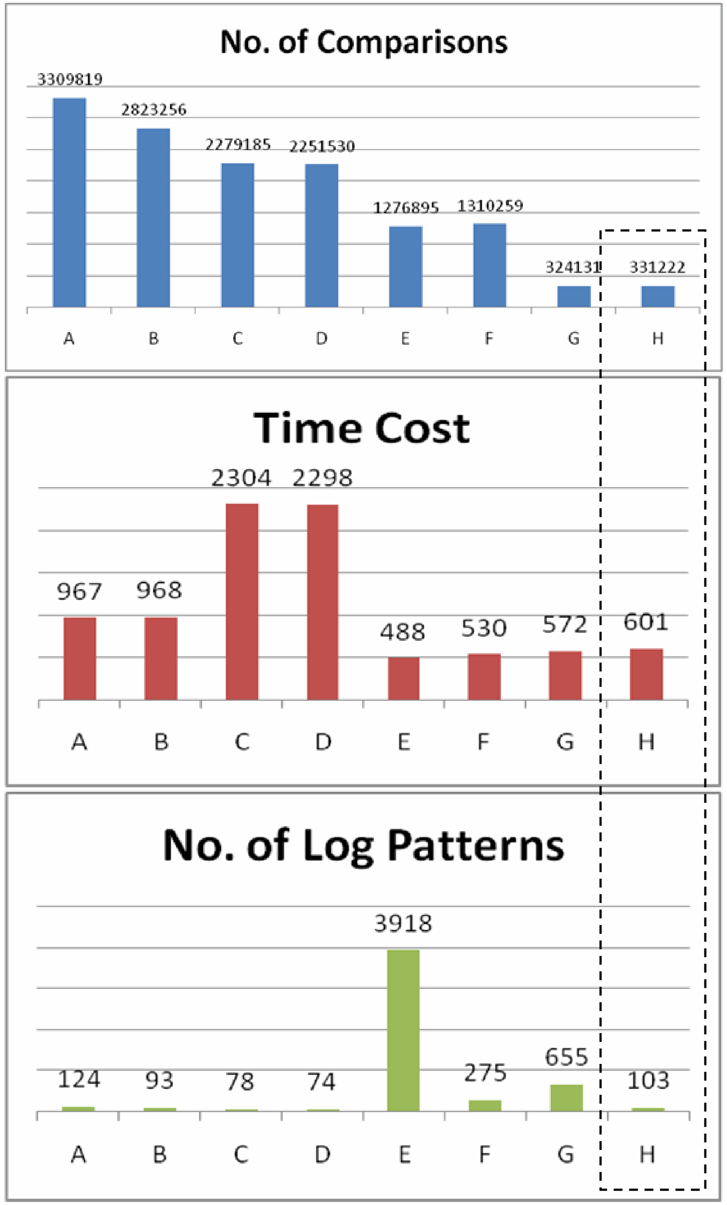

Conclusion

- LARGE is a log analyzing system
- When monitoring system logs, we need to extract log patterns
- Two algorithms: IWR and tree-matching, plus optimizations
  - tree-matching with two optimizations looks good

- Future work
  - what if more than one key position in tree-matching algorithm?
  - we may use parallel computing to accelerate log processing

Thank you!

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Tasks are listed. Press "More" to add new and "Delete" to remove. Press "Select task" to save and modify the task you want to change.

IDName	DicRef	Description		
0 Geometry Optimizatic	matgrid.default	Default task	More	Delete
2 Density of State	matgrid.dos	density of state calculation	More	Delete
3 Band Structure	matgrid.bandStru	Band Structure	More	Delete
4 Band Gap	matgrid.bandgap	Band Gap	More	Delete