Improvement of Log Pattern Extracting Algorithm Using Text Similarity

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CNGrid & LARGE

❖ China National HPC Environment

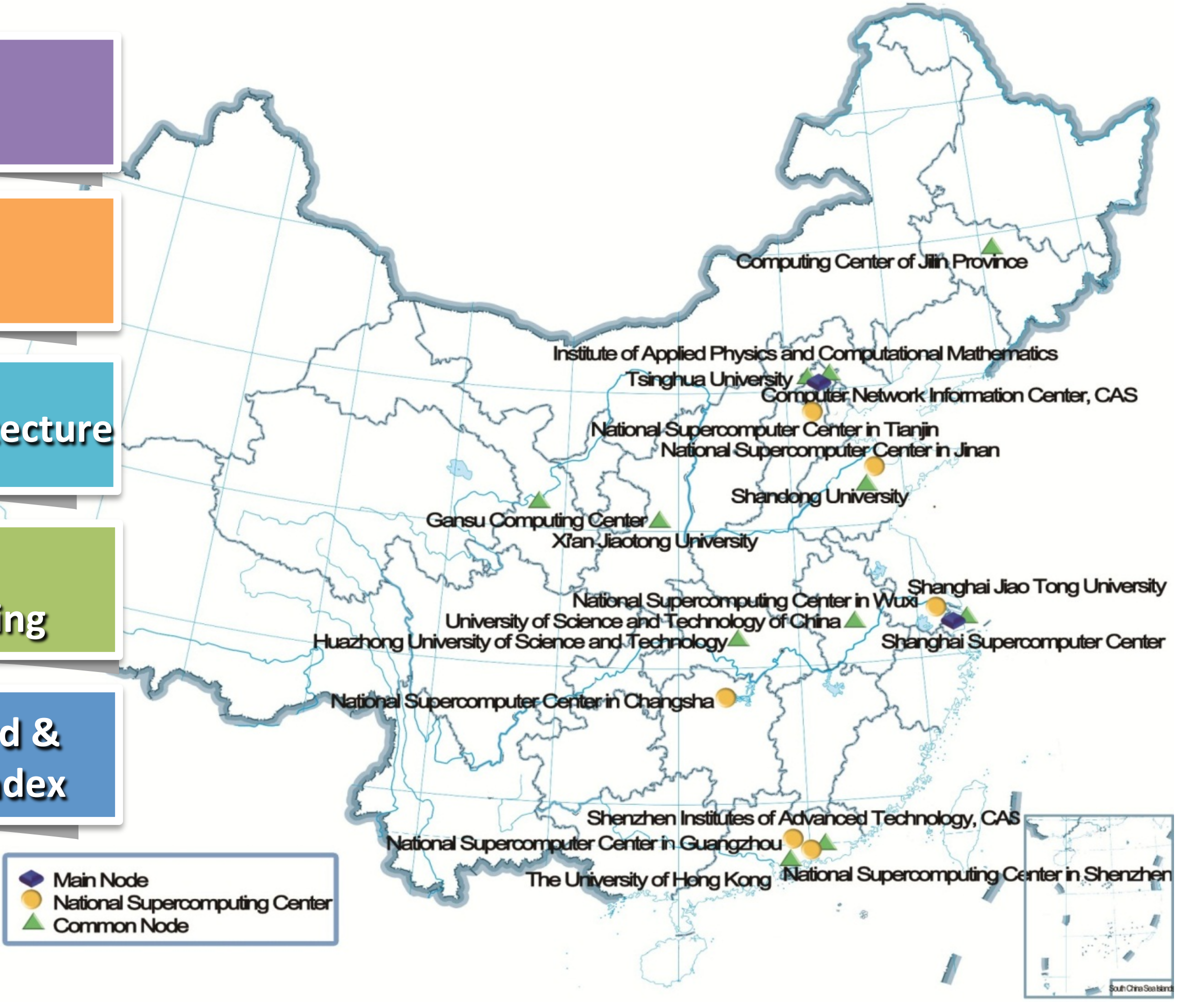
2 Operating Centers
(Beijing / Hefei)

19 Sites
(200PF + 162PB)

Portal with Micro-Service Architecture

Application oriented
Global Scheduling & Predicting

Resource Evaluation Standard &
Comprehensive Evaluation Index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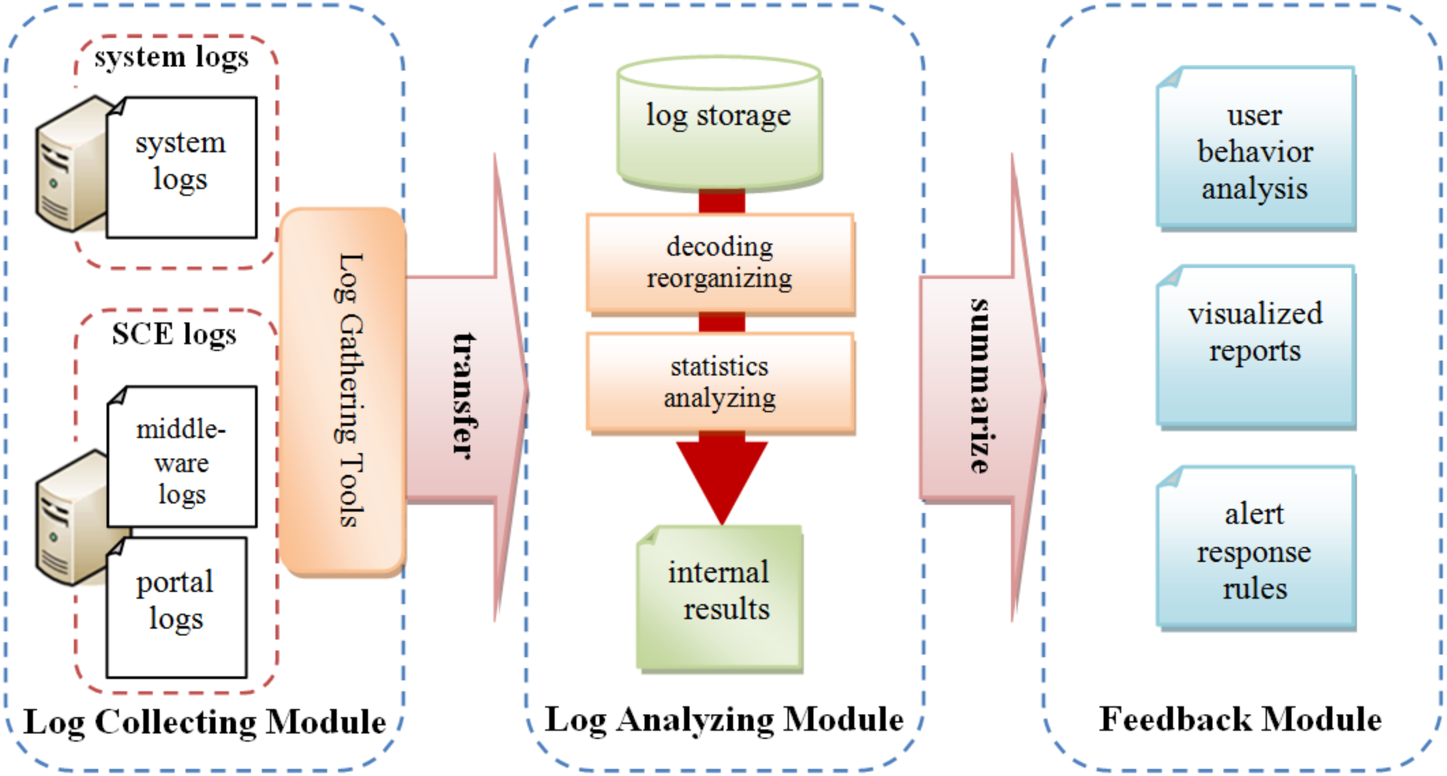
National Supercomputer Center in Guangzhou
The University of Hong Kong
National Supercomputing Center in Shenzhen
South China Sea Islands
Main Node
National Supercomputing Center
Common Node

CNGrid & LARGE

- Log Analyzing fRamework in Grid Environment



Log Patterns & Extracting Algorithm

- 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 log pattern extraction algorithms 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 Identical Word Rate

- 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

$$\text{identical(i,l,l')} = \begin{cases} 1, & \mathrm{w_i} = \mathrm{x_i} \\ 0, & \mathrm{w_i} \neq \mathrm{x_i} \end{cases}$$

  - 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

$$\text{r(l, l')} = \begin{cases} \frac{\sum_{\mathrm{i=1}}^{\mathrm{n}} identical(i,l,l')}{\mathrm{n}}, & n = m \\ 0, & n \neq m \end{cases}$$

- 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
- Significant Limitation
  - Logs with different length has IWR of ZERO!

Text Similarity Based Approach (1)

- Using Text Similarity to resolve the problem
  - S = P x O
  - S: similarity, P: propotion of common words, O: order factor

- Two logs l_1 and l_2, L_1 and L_2 are word sets respectively
  - define P: $P(l_1, l_2) = (|L_1 \cap L_2| \times 2) / (|L_1| + |L_2|)$
  - define O: $O(l_1, l_2) = SeqSim(l_1, l_2) / |L_1 \cap L_2|$
  - hence S: $S(l_1, l_2) = (SeqSim(l_1, l_2) \times 2) / (|L_1| + |L_2|)$

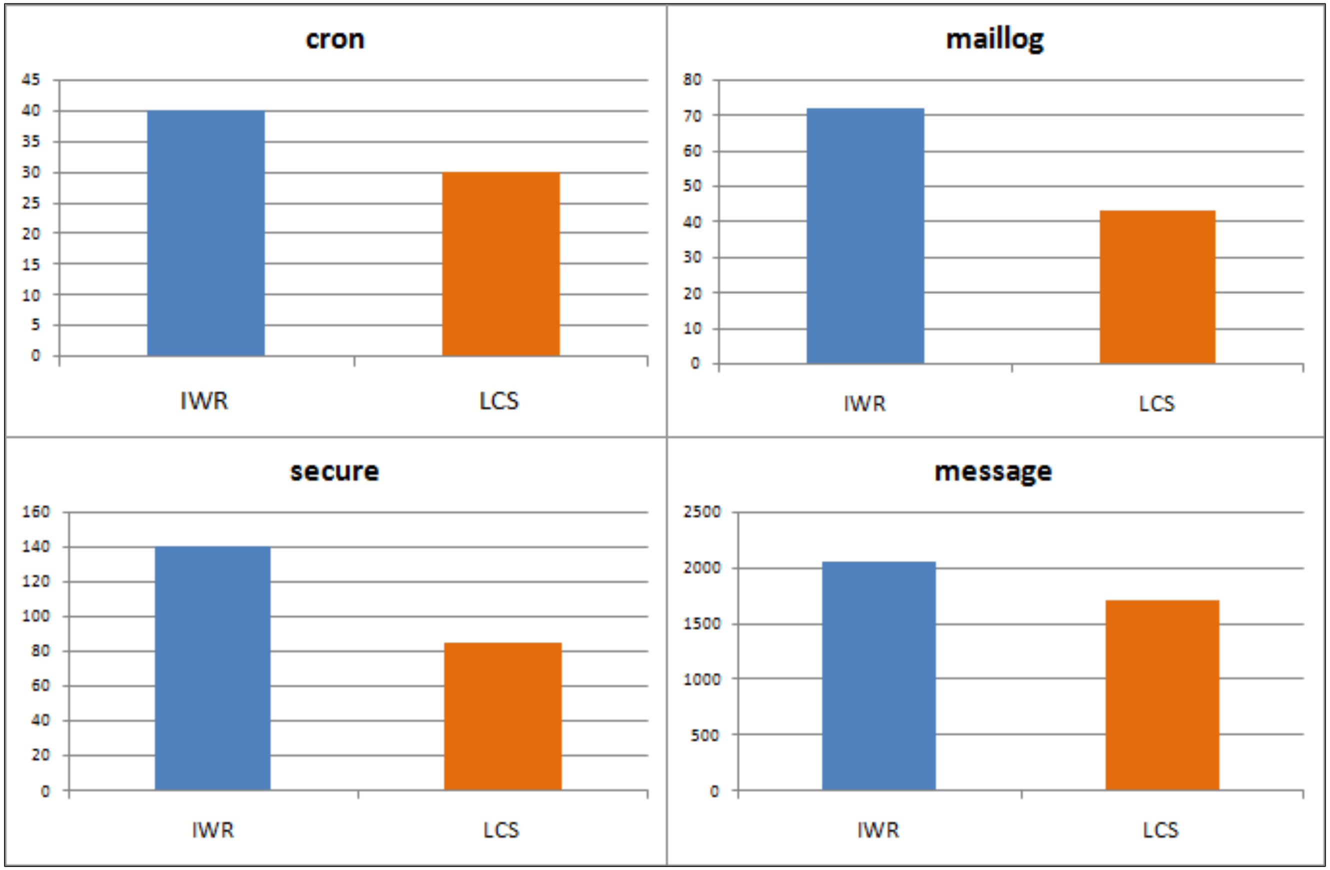
- By this, logs in different lengths can be compared

Text Similarity Based Approach (2)

- Using Longest Common Subsequence to define SeqSim(l_1,l_2)
  - $S(l_1, l_2) = (|LCS(l_1, l_2)| \times 2) / (|L_1| + |L_2|)$
  - Same pattern if $S(l_1, l_2) \geq t$, where t is the predefined threshold
- The process of improved log pattern extracting algorithm
  - set the threshold value t. Set the initial log pattern set P to be an empty set
  - for a new log l appearing from the input log set L, compute $S_i(l, p_i)$ between l and every $p_i \in P$ using a LCS algorithm
  - if there is no $S_i(l, p_i) \geq t$, add l to P
  - after all logs in L have been checked, return P
- Increase time cost for single comparison
  - but reduce total number of comparisons
  - can be offset by choosing a better LCS algorithm

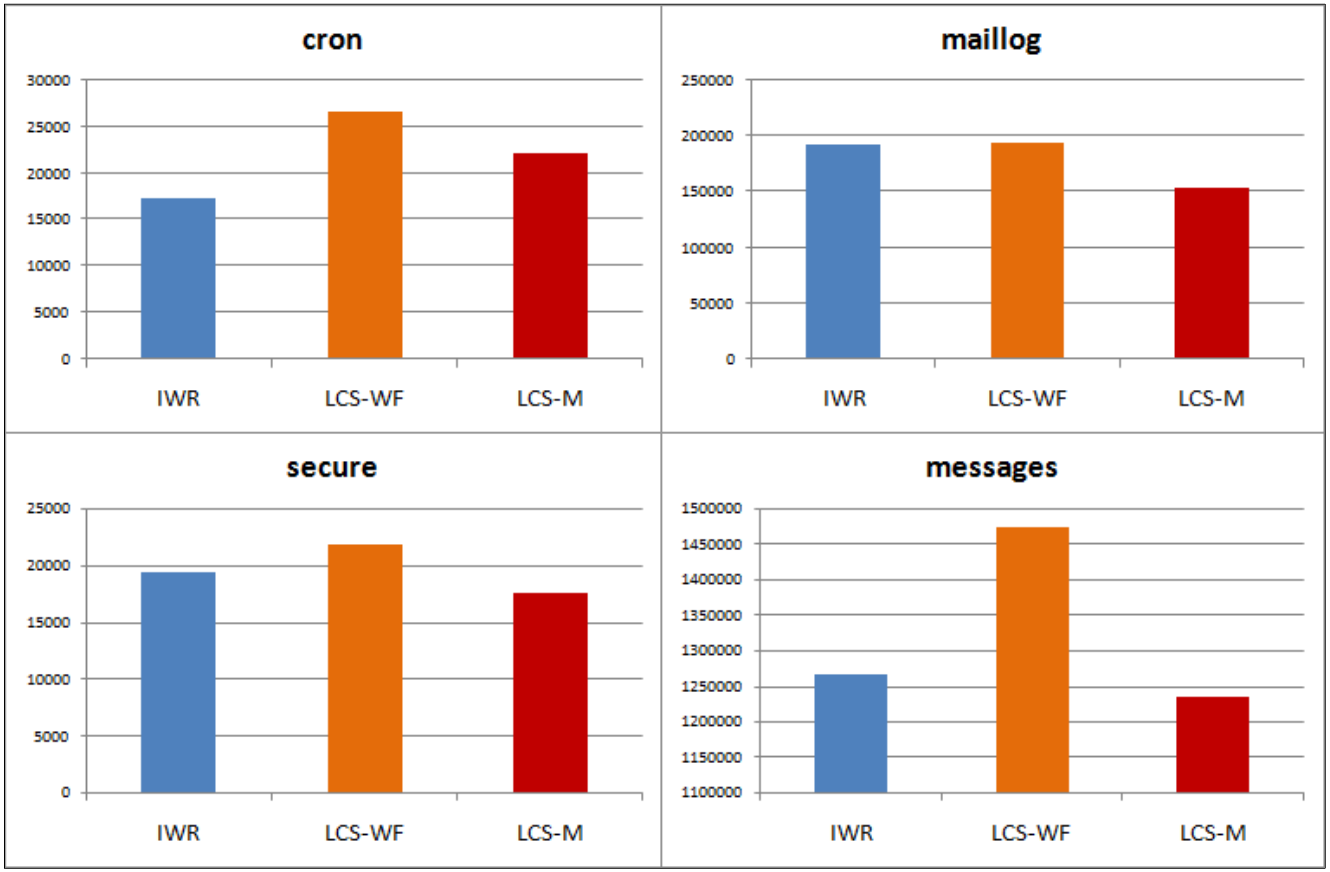
Text Similarity Based Approach (3)

- Experiment result
  - numbers of extracted patterns



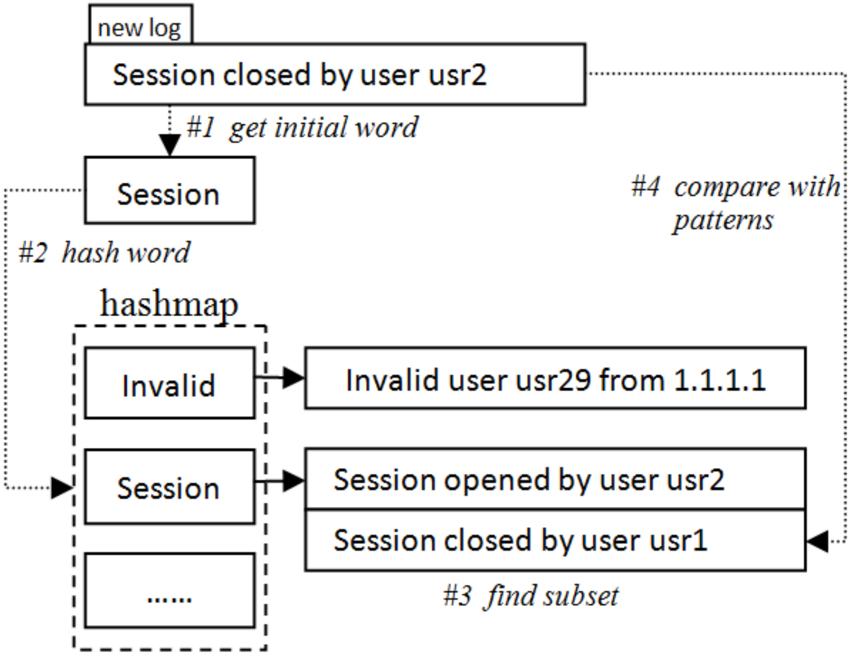
Text Similarity Based Approach (3)

- Experiment result
  - time costs of candidate algorithms (in milliseconds)



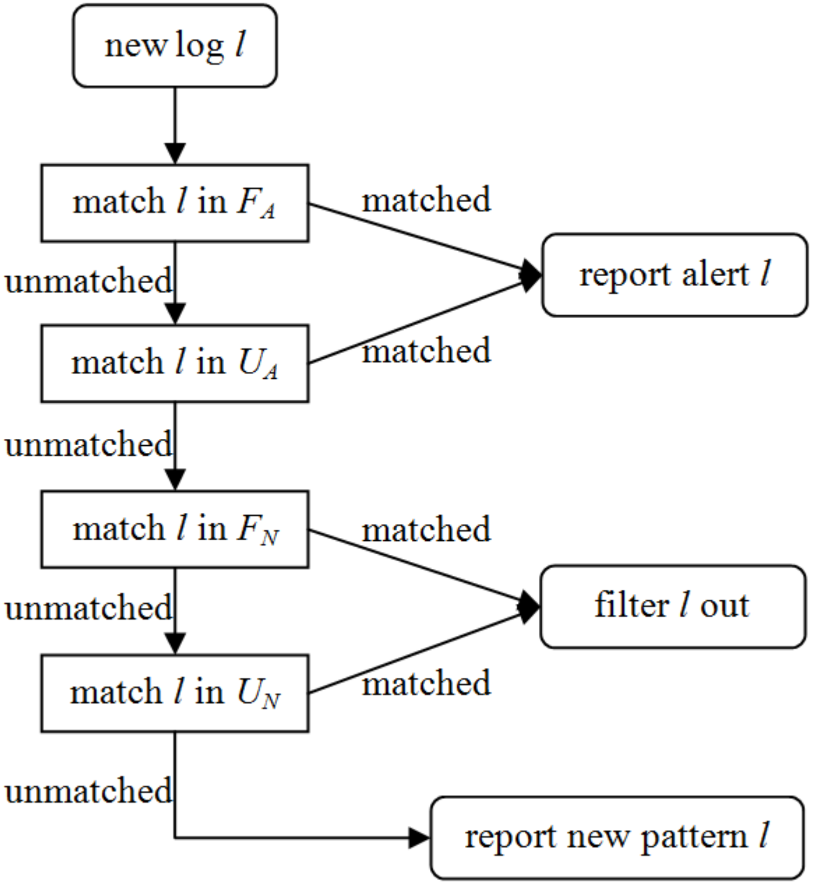
Modified Pattern Comparing Model (1)

- The original model is bad in time cost of searching patterns
  - has to visit all patterns until the one is met
- Use hashmap to accelerate the matching
  - divide pattern set into subsets by initial words
  - skip majority of patterns in irrelevant subsets
- Matching process :
  1. get initial word of the log
  2. hash the word
  3. find desired subset in hashmap
  4. compare with patterns in the subset


new log
Session closed by user usr2
#1 get initial word
Session
#4 compare with patterns
#2 hash word
hashmap
Invalid
Invalid user usr29 from 1.1.1.1
Session
Session opened by user usr2
Session closed by user usr1
......
#3 find subset

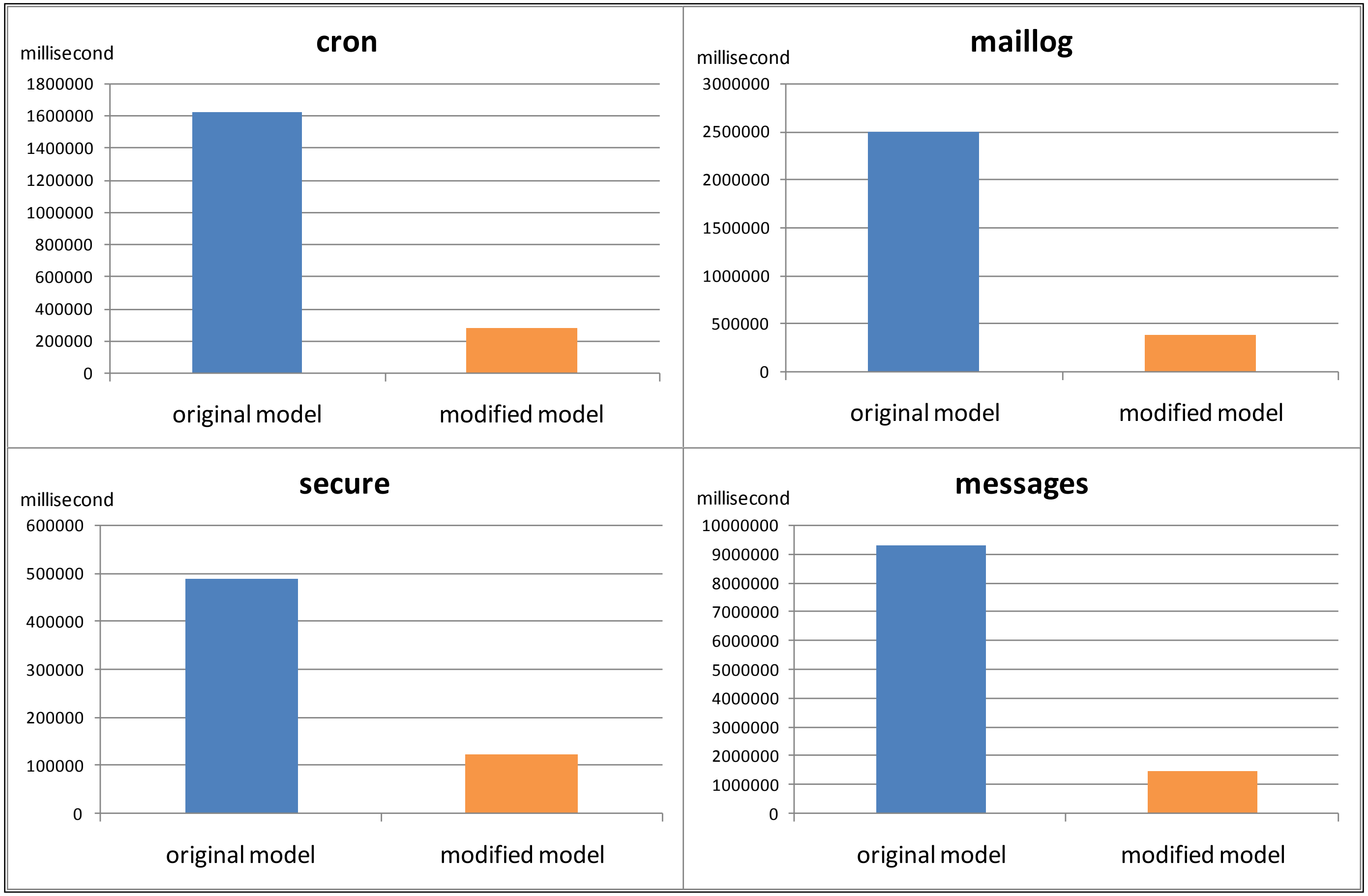
Modified Pattern Comparing Model (2)

- This approach cannot deal with patterns with unfixed initials
  - build an unfixed pattern set
- In real system, we split pattern set in 4 parts:
  - fixed alert pattern set
  - unfixed alert pattern set
  - fixed normal pattern set
  - unfixed normal pattern set
- When a new log comes, it is compared in the 4 sets in turn to decide processing methods



Modified Pattern Comparing Model (3)

- Real time cost comparison between original & modified models



Summary & Future Work

- Log patterns: used to build log recognition
- Algorithm of IWR isn’t capable to match logs in different lengths
- Using the idea of text similarity and LCS to improve the algorithm
- Modify log comparing model to accelerate the process

- Future work: log pattern based analyses in CNGrid
  - log pattern associations
  - log flow feature modeling