Development of the Web Application for Real-Time Monitoring of Accelerator Operation Parameter at KOMAC

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1. Introduction

A distributed control system based on the Experimental Physics and Industrial Control System (EPICS) has been implemented at the Korea Multi-purpose Accelerator Complex (KOMAC) as a closed, independent network. Each local control system is controlled and monitored by EPICS Input and Output Controller (IOC) and it is connected to a control network. The Process Variables (PVs), which correspond to control points in an IOC, number over about 20,000 at the KOMAC.

The network is at risk of overloading as IOCs receive requests whenever many clients require information of PVs. To prevent overload, the KOMAC has adopted the Channel Access (CA) gateway. The CA gateway remembers the information recently requested from the IOC through the gateway, creates a CA protocol, and responds to requests from other clients. KOMAC operates four CA gateways according to their allocated task. Each gateway logs client requests for PV values in real-time including useful information such as the hostname, written value and time. However, since this information can only be accessed from the filesystem on the linux system, the log monitoring system was required. As a log monitoring system, the system was opted for a web-based solution for integrated data management and ease of accessibility. This paper introduces the web service for live logging at the KOMAC. Figure 1 introduces the architecture of developed web application.

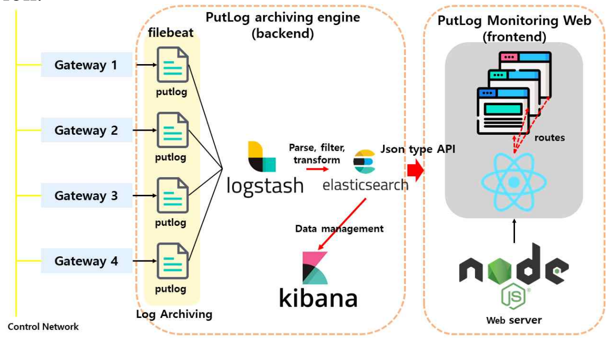
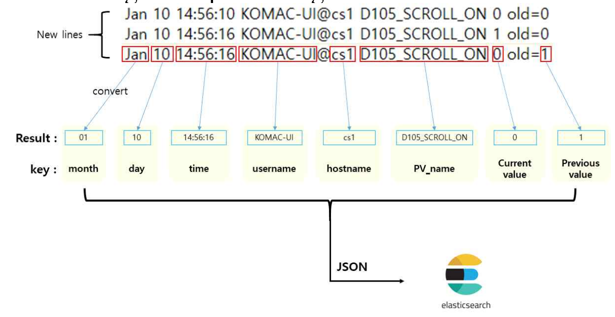


Fig. 1. The architecture of web-service and data archiving engine.

2. Implementation of log archiving service

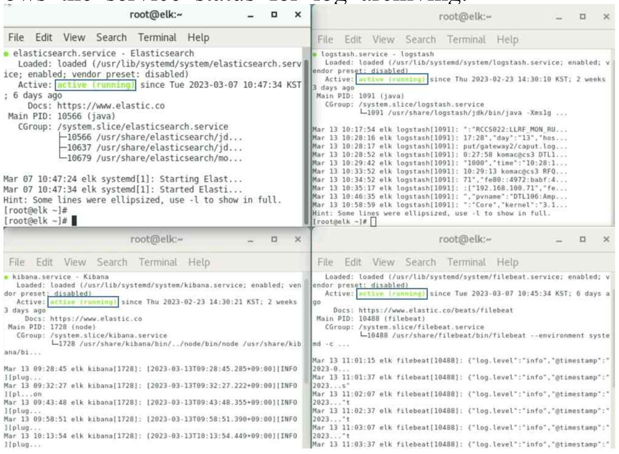
Each gateway writes in a log file with the extension '.log' at the end of the line when clients request the PV value. Elasticsearch, Logstash, Kibana (ELK), and Filebeat are selected for data archiving services since Filebeat and Logstash can remember past lines and monitor new lines. When a change occurs, Filebeat collects the changes and sends them to Logstash. Logstash processes the logs using filter and sends them to Elasticsearch. Since each line of log data is just a chunk of information, the filters are used to parse, delete unnecessary elements, and convert the data types. The filtering method is introduced using example in Figure 2.



```
Jan 10 14:56:10 KOMAC-UI@cs1 D105_SCROLL_ON 0 old=0
Jan 10 14:56:16 KOMAC-UI@cs1 D105_SCROLL_ON 1 old=0
Jan 10 14:56:16 KOMAC-UI@cs1 D105_SCROLL_ON 0 old=1
```

Fig. 2. The logstash filters logs and output the result to elasticsearch.

Logstash uses the HTTP protocol to send the results of filtering in json format to Elasticsearch. When a user requests documents under an index, Elasticsearch API routes the result of the request. Kibana is a dashboard service for data visualization and it is also used for index management since it applies some settings, such as 'max_result_window', to an index. Currently, ELK and Filebeat are installed and operated on a single node, and clustering is being considered as the usage of ELK expands for increased processing ability and stability. Figure 3 shows the service status for log archiving.



```
● elasticsearch.service - Elasticsearch
   Loaded: loaded (/usr/lib/systemd/system/elasticsearch.serv
ice; enabled; vendor preset: disabled)
   Active: active (running) since Tue 2023-03-07 10:47:34 KST
; 6 days ago
     Docs: https://www.elastic.co
 Main PID: 10566 (java)
   CGroup: /system.slice/elasticsearch.service
           ├─10566 /usr/share/elasticsearch/jd...
           ├─10637 /usr/share/elasticsearch/jd...
           └─10679 /usr/share/elasticsearch/mo...

Mar 07 10:47:24 elk systemd[1]: Starting Elast...
Mar 07 10:47:34 elk systemd[1]: Started Elasti...
Hint: Some lines were ellipsized, use -l to show in full.
[root@elk ~]#
[root@elk ~]#
```

```
● logstash.service - logstash
   Loaded: loaded (/usr/lib/systemd/system/logstash.service; enabled; v
endor preset: disabled)
   Active: active (running) since Thu 2023-02-23 14:30:10 KST; 2 weeks
3 days ago
 Main PID: 1091 (java)
   CGroup: /system.slice/logstash.service
           └─1091 /usr/share/logstash/jdk/bin/java -Xms1g ...

Mar 13 10:17:54 elk logstash[1091]: ":"RCCS022:LLRF_MON_RU...
Mar 13 10:28:16 elk logstash[1091]: 17:28","day":"13","hos...
Mar 13 10:28:17 elk logstash[1091]: put/gateway2/caput.log...
Mar 13 10:28:52 elk logstash[1091]: 0:27:58 komac@cs3 DTL1...
Mar 13 10:29:42 elk logstash[1091]: "1000","time":"10:28:1...
Mar 13 10:33:52 elk logstash[1091]: 10:29:13 komac@cs3 RFQ...
Mar 13 10:34:52 elk logstash[1091]: 71","fe80::4972:babf:4...
Mar 13 10:35:17 elk logstash[1091]: :["192.168.100.71","fe...
Mar 13 10:46:35 elk logstash[1091]: ","pvname":"DTL106:Amp...
Mar 13 10:58:59 elk logstash[1091]: ":"Core","kernel":"3.1...
Hint: Some lines were ellipsized, use -l to show in full.
[root@elk ~]#
```

```
● kibana.service - Kibana
   Loaded: loaded (/usr/lib/systemd/system/kibana.service; enabled; ven
dor preset: disabled)
   Active: active (running) since Thu 2023-02-23 14:30:21 KST; 2 weeks
3 days ago
     Docs: https://www.elastic.co
 Main PID: 1728 (node)
   CGroup: /system.slice/kibana.service
           └─1728 /usr/share/kibana/bin/../node/bin/node /usr/share/kib
ana/bi...

Mar 13 09:28:45 elk kibana[1728]: [2023-03-13T09:28:45.285+09:00][INFO
][plug...
Mar 13 09:32:27 elk kibana[1728]: [2023-03-13T09:32:27.222+09:00][INFO
][pl...on
Mar 13 09:43:48 elk kibana[1728]: [2023-03-13T09:43:48.355+09:00][INFO
][plug...
Mar 13 09:58:51 elk kibana[1728]: [2023-03-13T09:58:51.390+09:00][INFO
][plug...
Mar 13 10:13:54 elk kibana[1728]: [2023-03-13T10:13:54.449+09:00][INFO
][plug...
```

```
   Loaded: loaded (/usr/lib/systemd/system/filebeat.service; enabled; v
endor preset: disabled)
   Active: active (running) since Tue 2023-03-07 10:45:34 KST; 6 days a
go
     Docs: https://www.elastic.co/beats/filebeat
 Main PID: 10488 (filebeat)
   CGroup: /system.slice/filebeat.service
           └─10488 /usr/share/filebeat/bin/filebeat --environment syste
md -c ...

Mar 13 11:01:15 elk filebeat[10488]: {"log.level":"info","@timestamp":"
2023-0...
Mar 13 11:01:37 elk filebeat[10488]: {"log.level":"info","@timestamp":"
2023...s"
Mar 13 11:02:07 elk filebeat[10488]: {"log.level":"info","@timestamp":"
2023..."t
Mar 13 11:02:37 elk filebeat[10488]: {"log.level":"info","@timestamp":"
2023..."t
Mar 13 11:03:07 elk filebeat[10488]: {"log.level":"info","@timestamp":"
2023..."t
Mar 13 11:03:37 elk filebeat[10488]: {"log.level":"info","@timestamp":"
```

Fig. 3. The status of ELK and Filebeat services

3. Front-end web development with React

The front-end of the web service was developed using React with Node.js. React was chosen for its rapid rendering and development speed. The application was implemented using the routing method and the react-router-dom was used to define different route for each page. The components of each page w ere also configured to be accessed through their cor responding routes. Figure 4 shows the architecture of web application.

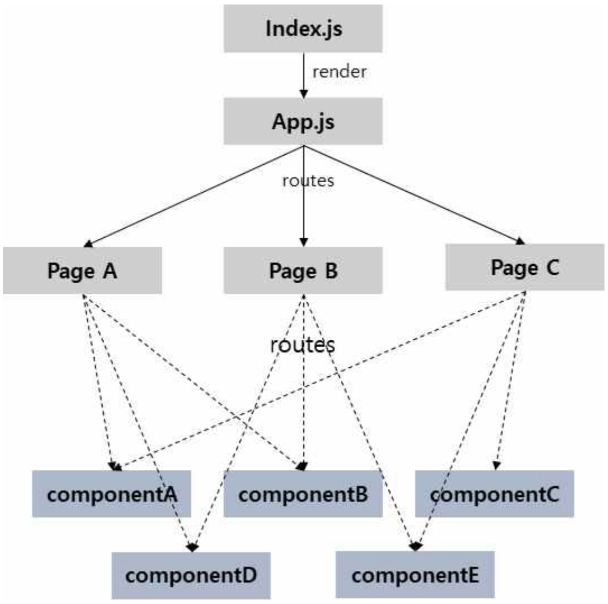
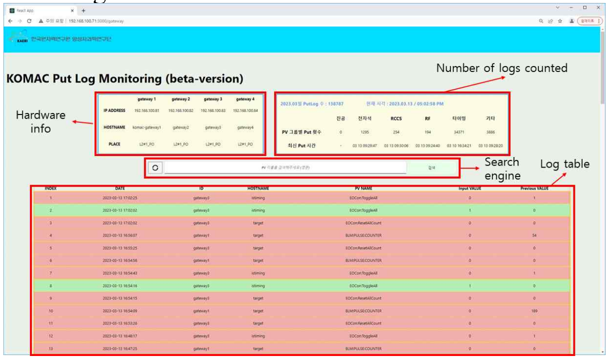


Fig. 4. Routing the web browser by react

A specific page has been developed for putlog m onitoring and other pages are also under developme nt. An array of logs can be requested in json form at through the Elasticsearch API. A filtering functio n has been developed to sort and search the data. The filtered results are rendered using the HTML <table> tag. To prevent slow performance due to excessive log data, the number of <td> tags per pa ge has been limited to 100, with pagination used t o display additional pages in page component if ne eded. The searching engine has also been implemen ted to allow users to search for logging about a sp ecific PV name. Figure 5 shows the result of page rendering.



KOMAC Put Log Monitoring (beta-version)

	gateway 1	gateway 2	gateway 3	gateway 4
IP ADDRESS	192.168.100.81	192.168.100.82	192.168.100.83	192.168.100.84
HOSTNAME	komac-gateway1	gateway2	gateway3	gateway4
PLACE	L2#1_PO	L2#1_PO	L2#1_PO	L2#1_PO

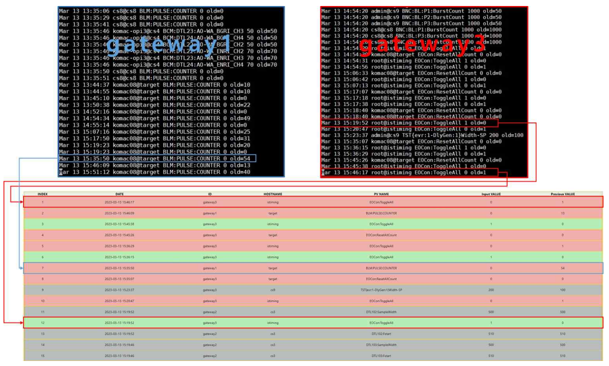
2023.03월 PutLog 수 : 138787　　현재 시각 : 2023.03.13 / 05:02:58 PM

	진공	전자석	RCCS	RF	타이밍	기타
PV 그룹별 Put 횟수	0	1295	254	194	34371	3886
최신 Put 시간	-	03 13 09:29:47	03 13 09:30:06	03 13 09:24:40	03 10 16:34:21	03 13 09:28:20

INDEX	DATE	ID	HOSTNAME	PV NAME	Input VALUE	Previous VALUE
1	2023-03-13 17:02:25	gateway3	istiming	EOCon:ToggleAll	0	1
2	2023-03-13 17:02:02	gateway3	istiming	EOCon:ToggleAll	1	0
3	2023-03-13 17:02:02	gateway3	target	EOCon:ResetAllCount	0	0
4	2023-03-13 16:56:07	gateway1	target	BLM:PULSE:COUNTER	0	54
5	2023-03-13 16:55:25	gateway3	target	EOCon:ResetAllCount	0	0
6	2023-03-13 16:54:58	gateway1	target	BLM:PULSE:COUNTER	0	0
7	2023-03-13 16:54:43	gateway3	istiming	EOCon:ToggleAll	0	1
8	2023-03-13 16:54:16	gateway3	istiming	EOCon:ToggleAll	1	0
9	2023-03-13 16:54:15	gateway3	target	EOCon:ResetAllCount	0	0
10	2023-03-13 16:54:09	gateway1	target	BLM:PULSE:COUNTER	0	189
11	2023-03-13 16:53:26	gateway3	target	EOCon:ResetAllCount	0	0
12	2023-03-13 16:48:17	gateway3	istiming	EOCon:ToggleAll	0	1
13	2023-03-13 16:47:25	gateway1	target	BLM:PULSE:COUNTER	0	0

Fig. 5. KOMAC putlog monitoring web page

In each element, information including id, data, writer hostname, PV name, and value is displayed. This information can be compared with raw files as shown in Figure 6. When new lines are added to t he file, the changes are reflected on the Elasticsear ch and the web page periodically makes requests to the Elasticsearch API every minute. called elements are sorted on time from each putlog file.



```
Mar 13 13:35:06 cs8@cs8 BLM:PULSE:COUNTER 0 old=0
Mar 13 13:35:29 cs8@cs8 BLM:PULSE:COUNTER 0 old=0
Mar 13 13:35:41 cs8@cs8 BLM:PULSE:COUNTER 0 old=0
Mar 13 13:35:46 komac-opi3@cs4 BCM:DTL23:A0-WA_BGRI_CH3 50 old=50
Mar 13 13:35:46 komac-opi3@cs4 BCM:DTL24:A0-WA_BGRI_CH4 50 old=50
Mar 13 13:35:46 komac-opi3@cs4 BCM:DTL22:A0-WA_BGRI_CH2 50 old=50
Mar 13 13:35:46 komac-opi3@cs4 BCM:DTL22:A0-WA_ENRI_CH2 70 old=70
Mar 13 13:35:46 komac-opi3@cs4 BCM:DTL23:A0-WA_ENRI_CH3 70 old=70
Mar 13 13:35:46 komac-opi3@cs4 BCM:DTL24:A0-WA_ENRI_CH4 70 old=70
Mar 13 13:35:50 cs8@cs8 BLM:PULSE:COUNTER 0 old=0
Mar 13 13:35:51 cs8@cs8 BLM:PULSE:COUNTER 0 old=0
Mar 13 13:44:37 komac08@target BLM:PULSE:COUNTER 0 old=10
Mar 13 13:44:55 komac08@target BLM:PULSE:COUNTER 0 old=10
Mar 13 13:45:10 komac08@target BLM:PULSE:COUNTER 0 old=0
Mar 13 13:50:38 komac08@target BLM:PULSE:COUNTER 0 old=22
Mar 13 14:52:16 komac08@target BLM:PULSE:COUNTER 0 old=0
Mar 13 14:54:34 komac08@target BLM:PULSE:COUNTER 0 old=49
Mar 13 14:55:14 komac08@target BLM:PULSE:COUNTER 0 old=0
Mar 13 15:07:16 komac08@target BLM:PULSE:COUNTER 0 old=25
Mar 13 15:17:50 komac08@target BLM:PULSE:COUNTER 0 old=31
Mar 13 15:19:23 komac08@target BLM:PULSE:COUNTER 0 old=20
Mar 13 15:19:23 komac08@target BLM:PULSE:COUNTER 0 old=0
Mar 13 15:35:50 komac08@target BLM:PULSE:COUNTER 0 old=54
Mar 13 15:46:09 komac08@target BLM:PULSE:COUNTER 0 old=13
Mar 13 15:51:12 komac08@target BLM:PULSE:COUNTER 0 old=40
```

```
Mar 13 14:54:20 admin@cs9 BNC:BL:P1:BurstCount 1000 old=50
Mar 13 14:54:20 admin@cs9 BNC:BL:P2:BurstCount 1000 old=50
Mar 13 14:54:20 admin@cs9 BNC:BL:P3:BurstCount 1000 old=50
Mar 13 14:54:20 cs8@cs8 BNC:BL:P1:BurstCount 1000 old=1000
Mar 13 14:54:20 cs8@cs8 BNC:BL:P3:BurstCount 1000 old=1000
Mar 13 14:54:[illegible] cs8@cs8 BNC:[illegible]:BurstCount 1000 old=1000
Mar 13 14:54:[illegible] root@istiming EOCon:ToggleAll [illegible] old=1
Mar 13 14:54:[illegible] komac08@target EOCon:ResetAllCount 0 old=0
Mar 13 14:54:31 root@istiming EOCon:ToggleAll 1 old=0
Mar 13 14:54:56 root@istiming EOCon:ToggleAll 0 old=1
Mar 13 15:06:33 komac08@target EOCon:ResetAllCount 0 old=0
Mar 13 15:06:42 root@istiming EOCon:ToggleAll 1 old=0
Mar 13 15:07:13 root@istiming EOCon:ToggleAll 0 old=1
Mar 13 15:17:07 komac08@target EOCon:ResetAllCount 0 old=0
Mar 13 15:17:18 root@istiming EOCon:ToggleAll 1 old=0
Mar 13 15:17:38 root@istiming EOCon:ToggleAll 0 old=1
Mar 13 15:18:40 komac08@target EOCon:ResetAllCount 0 old=0
Mar 13 15:18:40 komac08@target EOCon:ResetAllCount 0 old=0
Mar 13 15:19:52 root@istiming EOCon:ToggleAll 1 old=0
Mar 13 15:20:47 root@istiming EOCon:ToggleAll 0 old=1
Mar 13 15:23:37 admin@cs9 TST{evr:1-DlyGen:1}Width-SP 200 old=100
Mar 13 15:35:07 komac08@target EOCon:ResetAllCount 0 old=0
Mar 13 15:36:15 root@istiming EOCon:ToggleAll 1 old=0
Mar 13 15:36:29 root@istiming EOCon:ToggleAll 0 old=1
Mar 13 15:45:26 komac08@target EOCon:ResetAllCount 0 old=0
Mar 13 15:45:38 root@istiming EOCon:ToggleAll 1 old=0
Mar 13 15:46:17 root@istiming EOCon:ToggleAll 0 old=1
```

INDEX	DATE	ID	HOSTNAME	PV NAME	Input VALUE	Previous VALUE
1	2023-03-13 15:46:17	gateway3	istiming	EOCon:ToggleAll	0	1
2	2023-03-13 15:46:09	gateway1	target	BLM:PULSE:COUNTER	0	13
3	2023-03-13 15:45:38	gateway3	istiming	EOCon:ToggleAll	1	0
4	2023-03-13 15:45:26	gateway3	target	EOCon:ResetAllCount	0	0
5	2023-03-13 15:36:29	gateway3	istiming	EOCon:ToggleAll	0	1
6	2023-03-13 15:36:15	gateway3	istiming	EOCon:ToggleAll	1	0
7	2023-03-13 15:35:50	gateway1	target	BLM:PULSE:COUNTER	0	54
8	2023-03-13 15:35:07	gateway3	target	EOCon:ResetAllCount	0	0
9	2023-03-13 15:23:37	gateway3	cs9	TST{evr:1-DlyGen:1}Width-SP	200	100
10	2023-03-13 15:20:47	gateway3	istiming	EOCon:ToggleAll	0	1
11	2023-03-13 15:19:52	gateway2	cs3	DTL102:SampleWidth	500	500
12	2023-03-13 15:19:52	gateway3	istiming	EOCon:ToggleAll	1	0
13	2023-03-13 15:19:52	gateway2	cs3	DTL102:Fstart	510	510
14	2023-03-13 15:19:46	gateway2	cs3	DTL103:SampleWidth	500	500
15	2023-03-13 15:19:46	gateway2	cs3	DTL103:Fstart	510	510

Fig. 6. Compare with log files

4. Conclusions

The data archiving service was implemented usin g ELK and Filebeat to monitor and filter the gatew ay putlog file. The front-end was developed based on React with node.js. A putlog monitoring page w as developed which provided logging information w ith a lightweight search engine. In addition, we pla n to develop several pages on the KOMAC website with enhanced data accessibility to operators and us ers. These web pages will be user-friendly and will be linked with existing systems such as Archiver A ppliance, Olog, and the Phoebus alarm system.

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[4] https://ko.reactjs.org/