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Dissertation Phase-IV Report on

Software Simulator for Orbit60 Development

Submitted in partial fulfilment of the requirement for the degree of

MASTER OF TECHNOLOGY

(COMPUTER SCIENCE AND ENGINEERING)

Submitted by

Mr. Swarup Babaso Fule (2019MTECSCO003)

¹ *Under the guidance of*

Dr. N.L.Gavankar

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Mentor

Computer Science & Engg. Dept,
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Mumbai.**

2020-2021

① *Dedicated to
my parents*

Declaration

I, hereby declare that work reported in dissertation titled, “**Software simulator for Orbit60 Development**” submitted herein has been carried out by me in Baker Hughes, Mumbai and Department of Computer Science and Engineering, Walchand College of Engineering. The work is original and has not been submitted earlier as a whole or in part for the award of any degree/diploma at this or any other Institute/University.

Swarup Babaso Fule

Date:

Certificate

This is to certify that the dissertation work entitled “Software simulator for Orbit60 Development” submitted by **Swarup Babaso Fule (2019MTECSCO003)**¹ in partial fulfillment of the requirement for the degree of “Master of Technology (Computer Science and Engineering)” is a record of his own work carried out under my supervision during the year 2020-21.

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Dr. N. L. Gavankar

Guide,

Department of Computer Science and Engineering,
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The candidate has completed all the required phases of evaluation and he has performed satisfactorily. Hence, recommended for the partial fulfillment of the requirement for the said degree.

¹⁶
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Mantor**

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**Prof. S. S. Rokade
Panel Member 2, DEC**

**Mrs. Dr. M. A. Shah
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External Examiner

**Dr V.B Dharmadikari
Dean Academics**

Acknowledgements

Firstly,² I would like to express my sincere gratitude to my advisor Dr. N.L. Gavankar for the continuous support, for his patience, motivation, and immense knowledge. His guidance has helped me all the time for research and writing of this dissertation report. I could not have imagined having a better advisor and mentor for my M.Tech studies.

¹¹ I would like to express my gratitude towards my industrial guide Mr. Pankaj Timase (Staff technical manager) for their constant guidance and making⁵ facilities available to me. I would also like to thank our former H.O.D Dr. M. A. Shah for her continuous encouragement.

I take this opportunity to express my sincere thanks to Miss. Maithili Kondurkar (Senior Manager) and all the staff members of Baker Hughes, Mumbai for their help whenever required. Finally I express my sincere thanks to all those who helped me directly or indirectly in this seminar.

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Abstract

Keeping track of industrial machinery is important to ensure efficient working operation and to avoid future downtime of machine. The data which is collected from machines is highly complex and huge in size. For such data providing holistic view of machines is important. One web based application is proposed to resolve this issue under tag Enterprise Insight, Which is web based application which collects data from condition monitoring software. This document elaborate about EI software simulator. Which is used by developers of Enterprise insight to test this cloud, Web based application for real world scenarios. This software simulator is make to simulate 200 big enterprises which pushed to Enterprise Insight, also by using simulator developers can simulate real world and complex scenarios on which Enterprise insight will be tested. The simulator is made be online all the time which also simulate important concept called as continues integration and continues deployment(CI/CD). So simulator itself cooks the data and send it to enterprise insight.

Keywords: Condition monitoring, Azure cloud, CICD pipelines, micro-services , Data processing hubs.

A
Dissertation Proposal
On
Software simulator for Orbit60 Development
For the Degree of
Master of Technology
In
Computer Science and Engineering

Submitted by

Swarup Babaso Fule
(2019MTECSCO003)

Under the Guidance of

DR N . L Gavankar

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Department of Computer Science and Engineering,

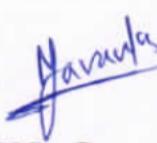
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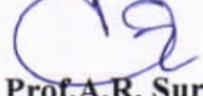
2020-21

CERTIFICATE

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Dr. N.L. Gavankar
Guide

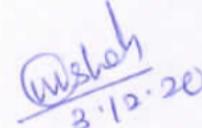


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- 3. Name of Industrial Guide** : Mr. Rahul Joshi
- 4. Broad Area** : Asset Monitoring System
- 5. Title of the proposed dissertation**

"Software simulator for Orbit60 Development "

6. Introduction



Fig- Orbit 60 firmware

An Orbit 60 is next generation machine monitoring and diagnostic system. with highly secure data transmission over channels. which supports over 6 million types of sensors that can easily configured with Orbit Studio. Orbit studio comes with following features.

1. Security and data isolation – built in data diode technology
2. More data handling for better decision making
3. High processing power
4. Distributed architecture
5. Has backward compatibility – Ie with ancestors System 1 and 3500 series
6. Provides firmware and software simulators for developers

Data in oil and gas industry –

Oil and gas industry provide huge amount of data. It will be nothing wrong to say data is more expensive than oil and gas itself. Following is some mainly focusable fields in oil and gas industry they are not complete list but this element has more significance.

1. Speed
 2. Thrust
 3. Vibration
 4. Torque
 5. Temperature
 6. Operating time
 7. Last Maintenance
- and many more.

This data must be handled with care. because this data not only needed for better decision making but also to reduce redundant cost.

Built in Data diode technology

There is possibility that system may encounter malicious data. this data may be harmful to software which manages machines. hence new technology comes in picture data diode technology which will allow data flow in only one direction

7. Problem Statement

To add software simulator in system which generate similar data as original machinery does and provide it with highly secure channels to Orbit Studio System.

8. Significance

1. In order to modify system features the developer need machine data to work with. however, it is not always possible to get access of machinery because huge team is working on same problem.
2. If something went wrong it may damage machinery which cost millions and billions.
3. In some cases, developer may need to work only with small portion of data. i.e., like only temperature data
4. May cost you more

9. Literature Survey

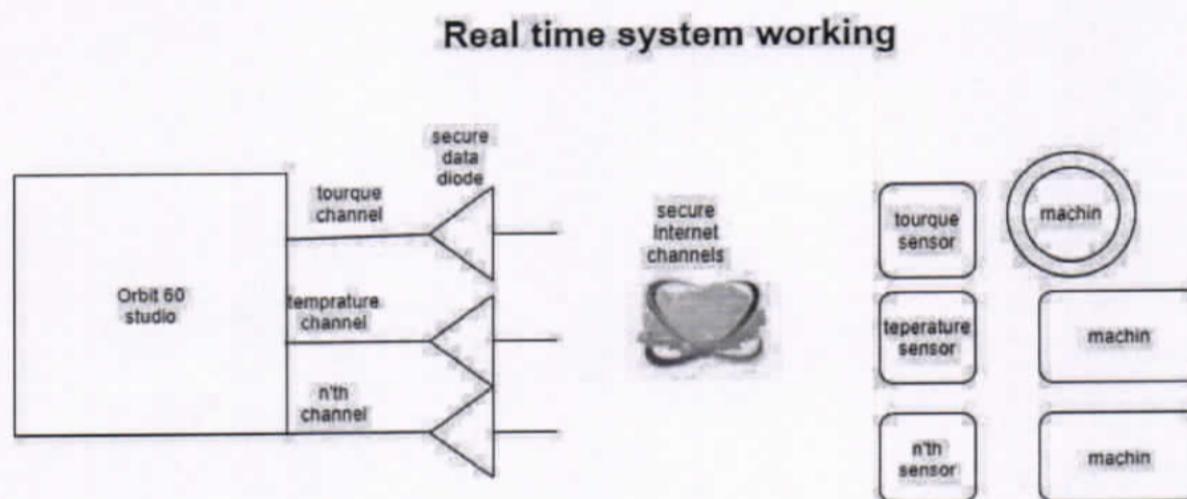


Fig: Realtime system working

Above shown the Realtime working of orbit 60 system. availability of sensor data is limited because few powerful orbits 60 system can able to handle huge amount of data. but in development phase each programmer may working on different data. hance it is not possible to provide sensor access to huge Orbit 60 developer community.

10. Objectives

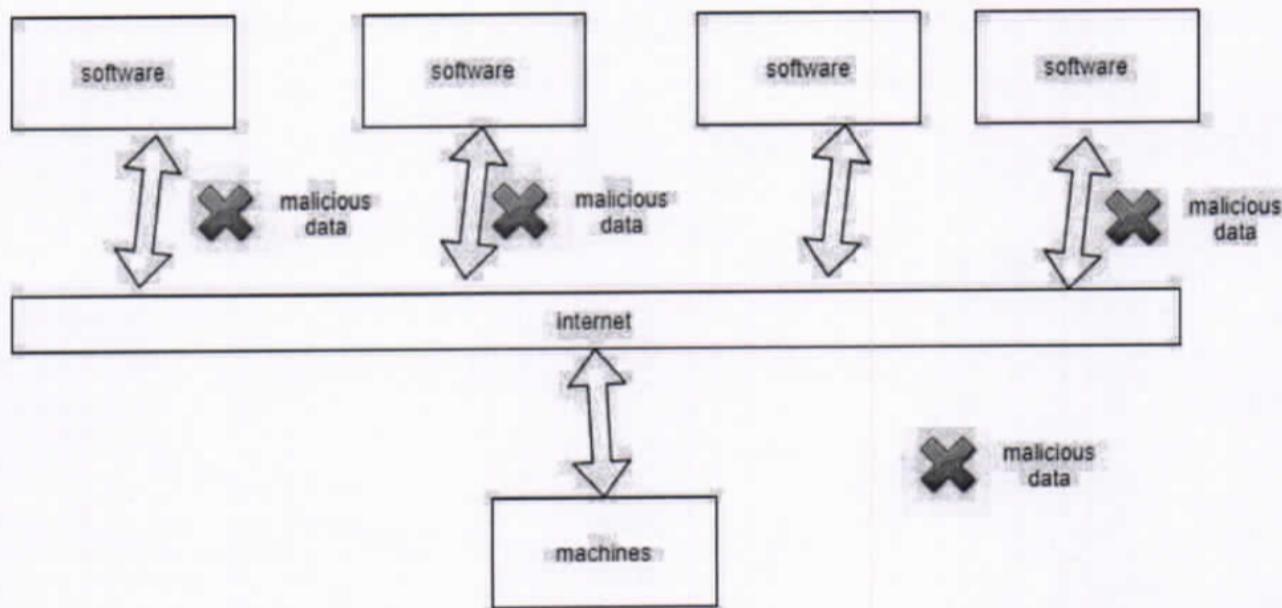
Following are the objectives of the proposed dissertation work:

1. To understand oil and gas industry data sets.
2. To design or develop System which generate similar data as original machines does.
3. To implement secure channel based on data diode technology
4. To analyze and evaluate type of data.

11. Methodology

Data diode technology-

When malicious data enter into system it can flow back to the control system because there are two-way channels. can cause huge data as well as financial loss to organization



Above shown system without data diode technology.

Following is general data diode technology diagram which provide more security

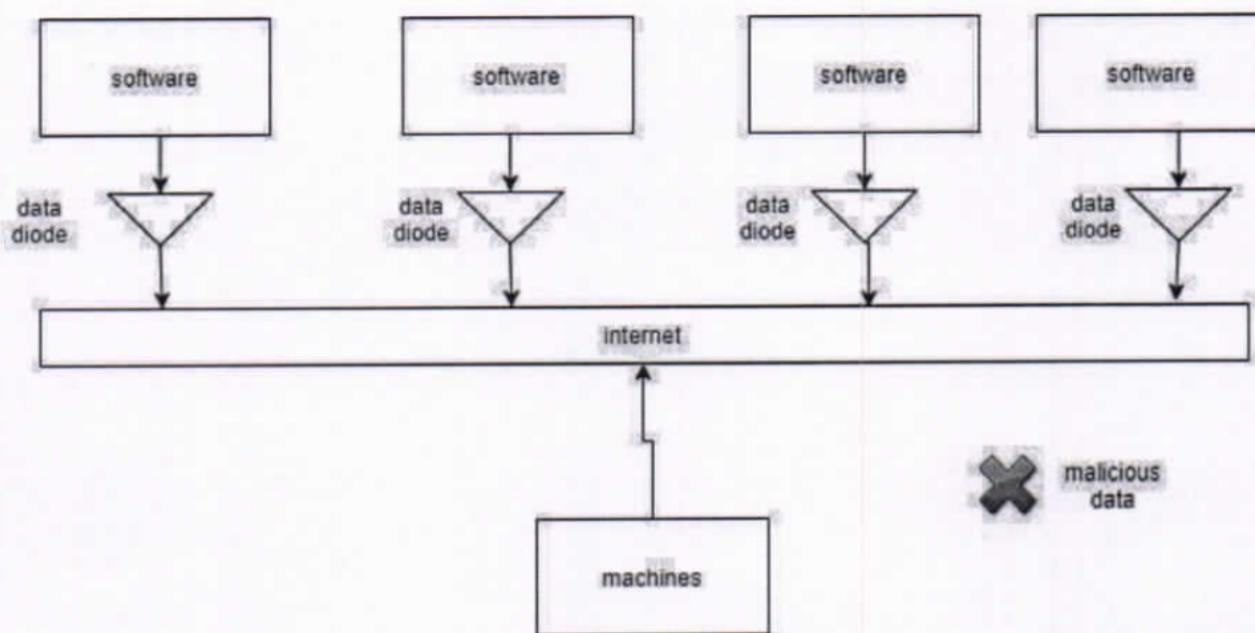


Fig: general data diode technology

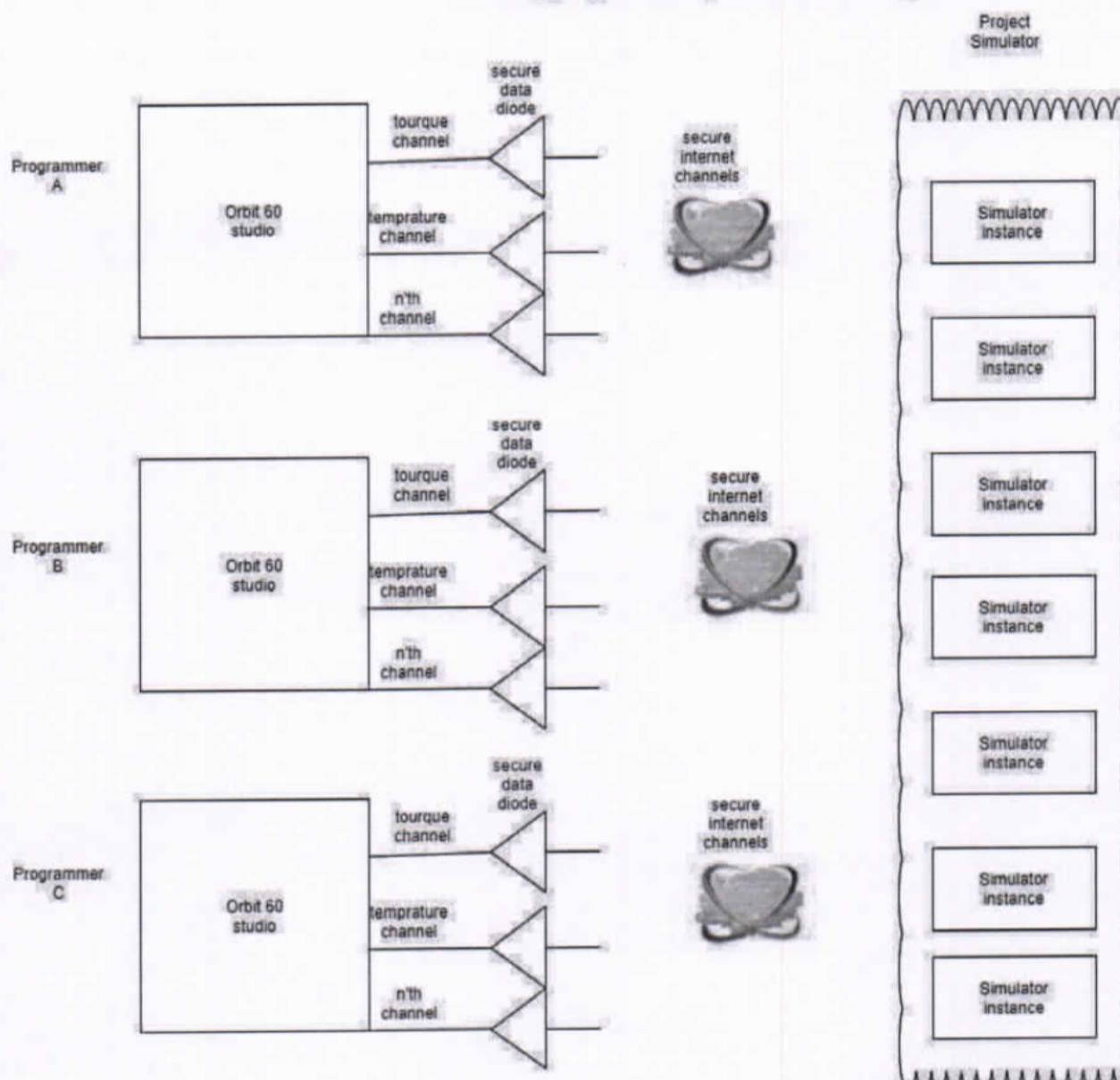
Simulators-

Simulator need to provide following features to programmers/ developers

1. Infinite instance of machine data
2. Provide data which must be useful to specific area. i.e., if programmer is working on temperature module then simulator must generate more temperature specific data.
3. Should support wide range of sensor modules.
4. Provide secure channel to work with.
5. Generate data that can test every aspect of system.

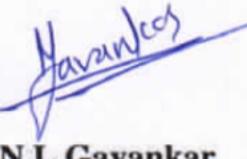
Follow is sample scenario when system is in development phase

Staging time system working



12. Place of Work:

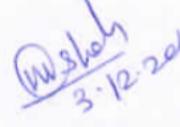
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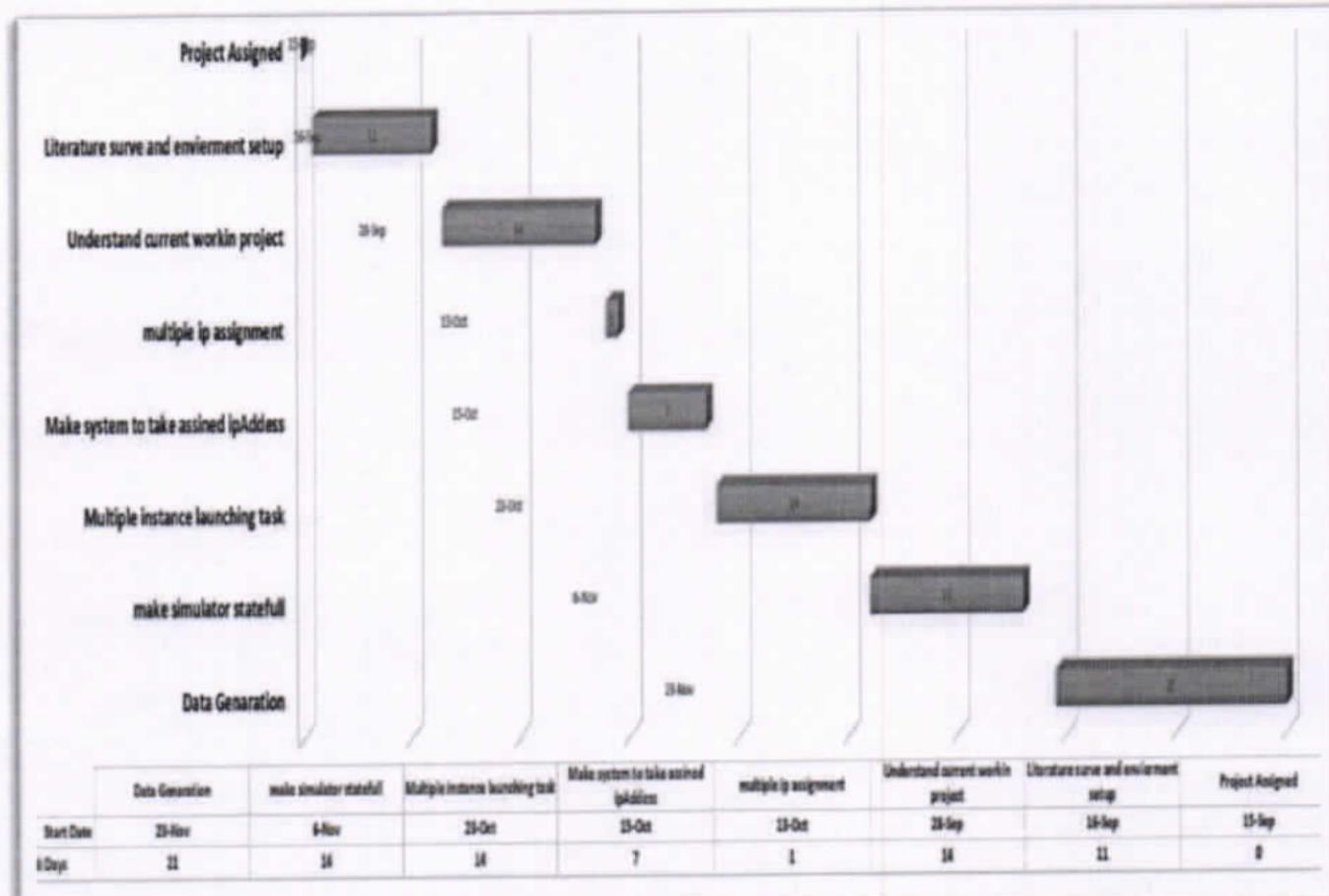


Mr.Swarup Fule
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DR.M.A Shah
H.O.D
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Gantt Chart



13. References

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Abbreviations

CM:	Condition Monitoring
CI:	Continues Integration
CD:	Continues Deployment
DAQ:	Data acquisition layer
DHP:	Data processing Hub
EI:	Enterprise Insight

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Chapter 1

INTRODUCTION

Monitoring parameters and estimating condition of object is done by humans since while. To monitor health of machine GE provided software package name System1 which monitors the parameters of machine. Based on the parameters administrators have to take appropriate action, actions may include stopping rotating-moving part, switch on other mechanisms such as cooling, reporting to someone specific and many more.

Oil and oil gas industry also generate huge amount of data. In oil and gas industry following parameter may be observed

Vibration - Vibration of machines can provide very vast information of machine state. Vibration monitoring itself is a different area of study

Temperature - Not only in oil and gas industry monitoring a temperature of any phenomena gives important aspects of that phenomena. Take example of human body temperature, the doctors can predict what's wrong in body just by checking temperature of body. In oil and gas industry also lots of temperature sensors are used in various parts of machines that can give you meaningful insights.

Sound - Another important parameter is sound, it is also one of the oldest parameters by which we can interpret machine state without doing any further observations

Viscosity of oil - In any big machines the oil played very important role hence measuring Viscosity of oil can give you meaningful insights

Speed of rotating parts - In machines if the objects are well synchronised then the speed of that object should not exceed parameters. hence measuring speed of machine also important.

The system 1 is condition monitoring software which is standalone application need to install on consumer's machines. Condition monitoring data is complex and were hard to interpret for common user. also because of being standalone application(System 1) availability of condition of machine is big concern. To resolve this issue one web based solution is proposed under tag Enterprise insight. The complex data is now pushed to cloud and Enterprise insight is responsible to make this data available to consumers in more holistic way. Because Enterprise insight pulls data from System 1 DAQ layer which internally gets data from sensors which located on actual machines, Simulating real-word scenarios was complex. The software simulator is cloud based solution which takes small portion of data from actual system 1 and simulate 200 enterprises which will serve to Enterprise insight to test EI as real-world entity.

Light weight - In-concern with data storage and all software simulator only runs logic on cloud pods and required files is fetched from azure file share hence running simulator won't cost more because it does not need to increase resource.

Less time consuming - Simulator is online azure cloud all the time so pushing real enterprises to respected environments is as easy as changing connection string, then simulator will start pushing data to that particular environment.

Infinite instance - Horizontal as well as vertical scaling is possible for simulator. By using single machine any numbers of simulators can be generated also each simulator can able to simulate different different scenarios as well.

1.0.1 Comparison between various tools used in Oil and Gas Industry

The tools used in oil and Gas industry fall under following three main categories

- Pure Condition Monitoring software
- Machine configuration Software
- Data representation Software

Each tool has different responsibilities. The comparison between these tools is shown in figure

Machine configuration software (e.g.: - Orbit studio)	Condition monitoring software (System 1)	Fleet management and presentation tools (Enterprise insight)
Configures the machines	Collects data from machines	Present collected data from multiple systems
Need condition monitor software to monitor data	Many numbers of machines can be added to such software	Many number of systems can be registered to such tools to provide insight
Less costly compared to System 1	Costly as it supports whole lot many devices	Less costly
Made for technicians	Made for data scientist	Made for end users

Figure 1.1: Tools used in Oil And Gas Industry.

1.1 Problem formulation

Software simulator improves productivity by mimicking the actual working of System, hence developers and testers now can work independently without waiting for machines to be allocated.

Before software simulator introduced, developers of Enterprise insight, test their application on actual machines and System 1. This was time consuming and simulating real-word scenarios is near to impossible.

Enterprise insight when launch, will deal with large number of huge real enterprises. Any application which deal with such huge data are now implemented using micro service architecture. For web based application each micro service need to be validate properly and sometimes isolated.

1.2 Objectives

1. To understand oil and gas industry data sets .
2. To design and develop System which simulate data.
3. To reproduce the System 1 real-time scenarios.
4. To understand type of data which affects system most.

Chapter 2

LITERATURE SURVEY

2.1 The traditional System 1 and Enterprise insight scenario

System 1 condition monitoring software by using its DAQ layer senses and represent condition of machine to users. The Enterprise insight on other hand pulls data from System 1 DAQ at specific time called as heartbeat. By using system 1 with real machine in several type of testings of Enterprise insight is very time consuming and lengthy task.

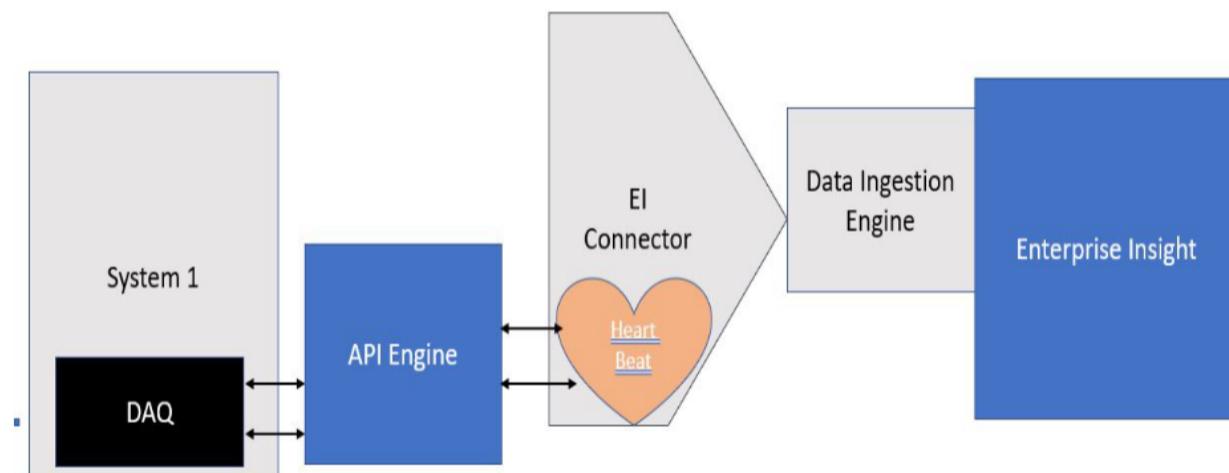


Figure 2.1: Enterprise Ingestion with connector.

As shown in figure 2.1 System 1 is software which consist of Data Acquisition layer the DAQ is made up of firmware plus software which means it is nothing but combination

of various sensor interfaces as well as complex software coding, Hence DAQ or Data Acquisition layer in any condition monitoring system play vital role. In other word the state of DAQ is nothing but soft representation of industrial machine which it monitors.

DAQ is also consist of component called as Data Processing HUB (DHP) few DHPs which present in all condition monitoring softwares are **Enterprise DAQ** - This DAQ is responsible for holistic parameter management.

Configuration DAQ - This DAQs are responsible to perform configuration related activities. Lets take example of Adding new machine in firm, This task leads to adding connection to many other existing machine. such task is done by Configuration DHP.

Event DHP - When something went wrong in machine it exceeds the parameter in that case then several types of alerts get generated this alters in oil and gas industry called as Events. there are lot many types of events some events are very severe and need to take action immediately and some events are not which can be simply ignored. For some events the severity is reduced but event is not cleared this phenomena is called as Latching of events.

The Software which is under development needs to depend of such complex DAQ from here the problem starts. Using real DAQ for software development has following problems,

Simulating real load is impossible - In this scenario developer can only follow testing with happy path. .

Can not get specific data - As original machines working on high cost and human resources interrupting machines to just get specific data is unrealistic .

Costly - Working with actual machines may result into high cost.

Time consuming - Making handshake with actual machine taking too much time

2.2 A new approach - Software simulator

One way to tackle above problems is to buy new set of machines which mimic original machine set, which is not realistic and easy. Another approach is create software implantation which mimic the actual machine working.

Simulation of real load - Software simulator let create as many as 200 enterprises with more than 5000 of assets and more than 5,00,000 alarm and system event each.

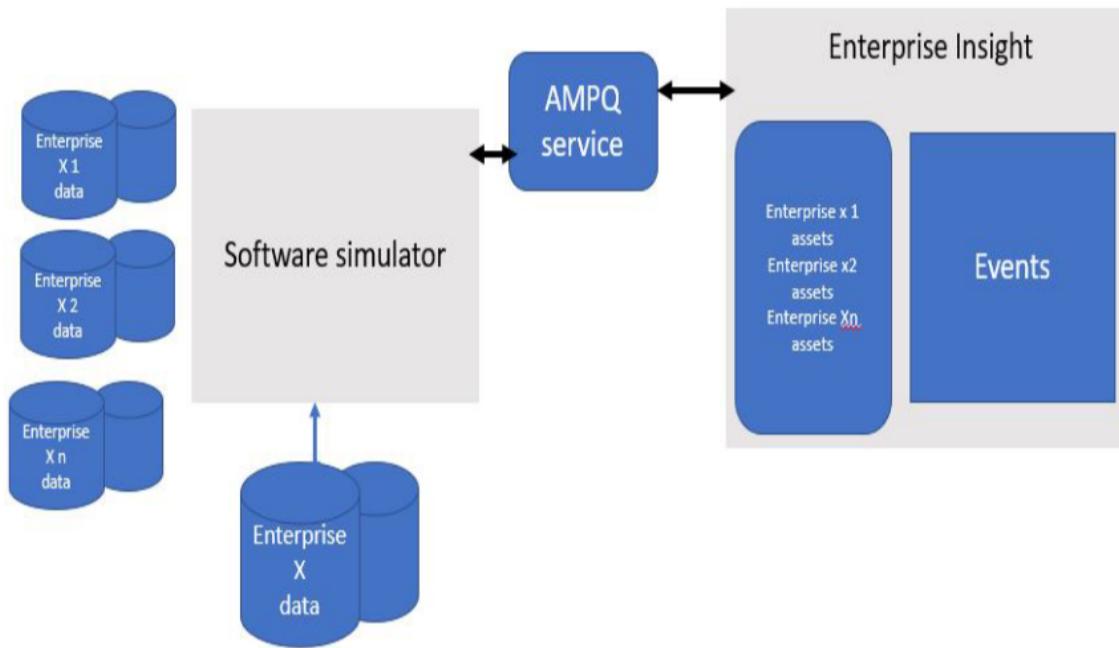


Figure 2.2: Software simulator scenario.

As shown in figure 2.2 The software simulator which will work as mocked DAQ has simulated DHPs and the communication with the software under development is done by using Asynchronous Queuing Messaging Protocol or AMQP. The AMQP is widely used protocol in scenarios where the acknowledgments of messages is not relabel or the processing of message by other entity will take lots of time. In such scenario the callback mechanism is used.

Chapter 3

METHODOLOGY

A software simulator is heavily micro-service based implantation which act as System 1 for Enterprise insight a web base asset management portal. In micro services the term called as heartbeat used here. In human body each heartbeat generated by heart provide important entities to each cell in other words heartbeat is also important to synchronize all cells. In same in micro service based architecture the artificial heartbeat can be generated. following is a simple heartbeat generation code

```
// HeartBeatGeneration.cs
using System;
using Time;

public class HeartBeat {
    public int _heartBeatInterval = 30;
    public event _HeartbeatReciver;
    public void RaiseHeartBeat() {
        while(true) {
            _HeartbeatReciver.Invoke(this, null);
            Thread.Sleep(heartBeatInterval);
        }
    }
}
```

As shown in above code heartbeat will be generated each 30 seconds and other components which subscribed to heartbeat receiver event will synchronize itself based on the events.

3.1 Pillars of simulator

following are some key pillars for simulator working simulator

- Micro service architecture
- asynchronous message queuing protocol (AMQP)
- Azure fileshare

Above are tools and technique are heavily used in design and development of simulator.

The micro service

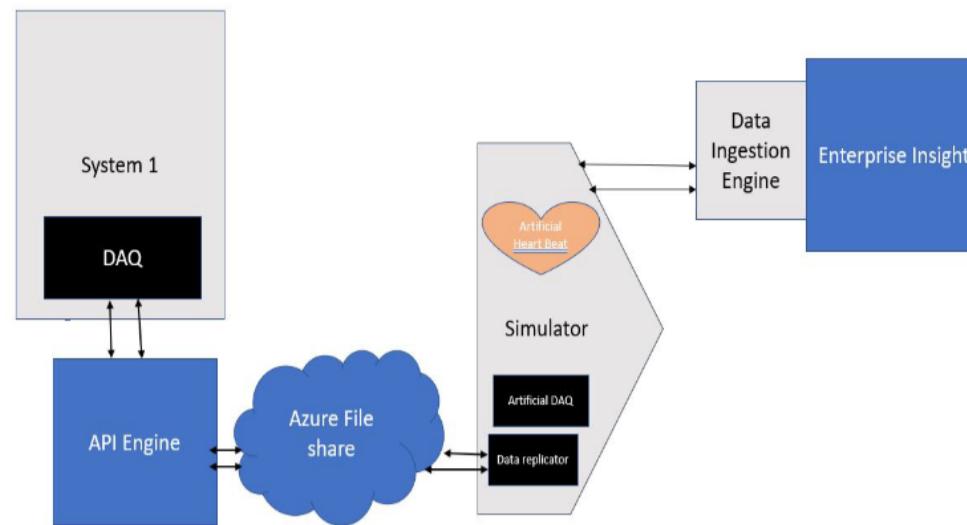


Figure 3.1: Proposed design.

Figure 3.3 elaborate software simulator as a System 1 for enterprise insight. Simulator stores and retrieves files from azure file share which is collected from System 1 DAQ. The files are consist from various DHPs as discussed previously. the following file type each DHP can generate

- ¹⁴ JavaScript object notation (JSON)
- Extensible markup language (XML)

Fallowing is example of Enterprise JSON

```
// EnterpriseMinden.json
Enterprise: {
    name: "Enterprise Minden",
    ID : "45ttbdbd88-77373bb-99093838-98388"
    Location: "minden"

    Extra Properties : {
        Connected Devises : {
            fan:{ 
                type : Centrifugal
            },
            Motor:{ 
                type: AC
            }
            Chember,
            Belt:{ 
                Lenght : 44 mm
            }
        }
    }
}
```

```
        }
    }
}

EventDHP :{
    Connection Type: SSL,
    Session Timeout: 40min,
    Event Target: Alarm Events
    Target Machine : Centrifugal Fan
    Event Setpoints:{  

        Green : >400
        Yellow : 400mph,
        Red : 300mps
    }
}
}
```

Above shown the enterprise DHP json.

3.1.1 Micro service architecture

There are two types of architecture any commercial software follows

- monolithic
- Micro service based

both service has its own advantages and disadvantages, In monolithic architecture there is no separation between the services it provide. the code base is also same. following are some disadvantages of Monolithic architecture⁸

Single point of failure - This is one of the biggest failure of monolithic architecture that is single point of failure. This happens because the monolithic architecture the models are tightly coupled and because of this if any single components fail then this can leads to whole system failure.

Difficult for Unit testing - Providing code coverage is essential when it comes to quality of product. because of tight coupling it is not possible to test and validate each module separately .

Operation speed - because of complex call stack the speed of monolithic architecture differs. but in some cases specially if call stack es are simple and well organised the Monolithic architecture can outperform micro service architecture.

Increased chances of bug - As standard thumb rule more number of lines is directly proportional to coding mistakes and bugs

as compare to Monolithic architecture the micro service architecture provides following benefits

Single responsibility - ¹² In Micro service architecture each module has its own responsibility.

Quality of code - Because of Micro service the developers can focus on just single functionality of code this leads to improved quality of code and eventually the quality of software.

Unit testing - Because each module is separate providing 100 percent code coverage is possible and because of this developers have more confidence on product before its realise.

Because of above the micro service based architecture were used. In this particular scenario simulator use 3 service namely

- Asset service
- Event service
- Update event service (running 24/7)
- Updated asset service (running 24/7)

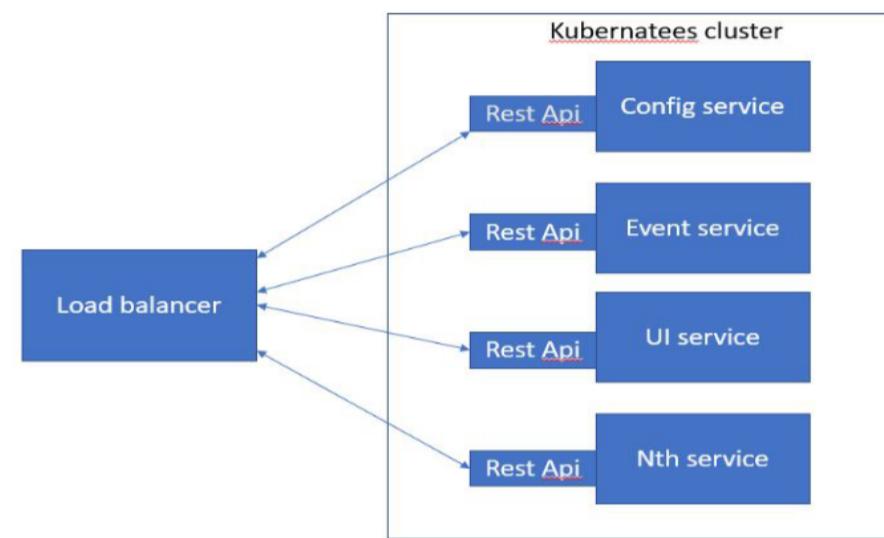


Figure 3.2: Simulator micro services.

3.1.2 AMQP protocol

Asynchronous messaging is another key concept used in simulator. To make any code usable now day asynchronous calls are getting popular. in AMQP the message is pushed to queue and then simulator only subscribe for that queue and it is free to do other stuffs. when some events occurs on that queue then simulator do appropriate actions this gives feel as simulator is working as real machine.

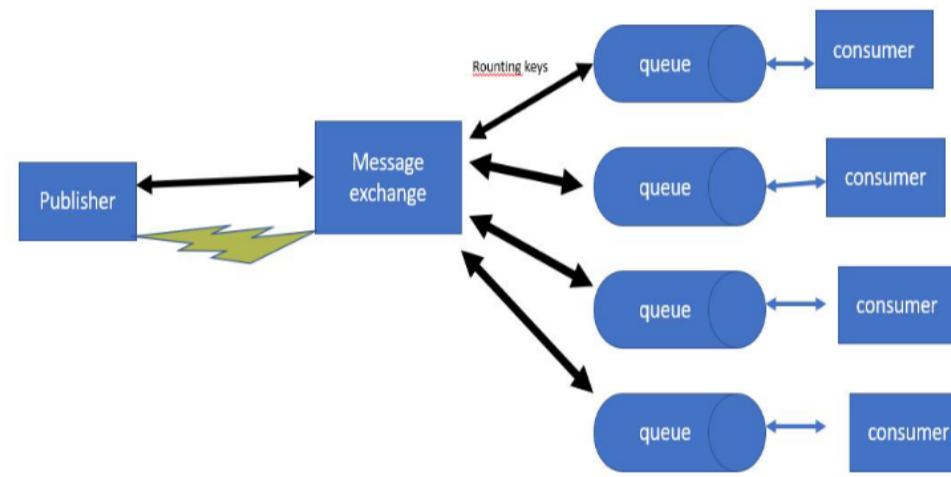


Figure 3.3: Proposed design.

3.1.3 Azure Fileshare

Simulator tackle large number of files and data which including asset data, events data, re-guided data. which need to be store somewhere which should provide reasonable write and read time. A azure fileshare one such solution. Another reson to use azure fileshare is that simulator is running on cloud cluster so from cloud to cloud communication speed is very high.

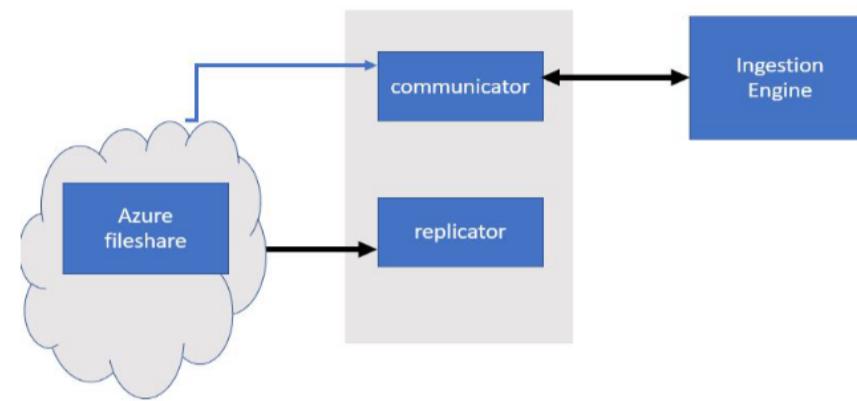


Figure 3.4: Azure fileshare with simulator.

As shown in figure 3.4. The simulator is dependent on coloud based azure fileshare solution. There are handles simulator used one for getting the data but other is for updating old data.

4 Chapter 4

RESULT AND ANALYSIS

4.1 Hardware configuration used in experimentation

1. Laptop/ Desktop

4.2 Software packages used in experimentation

1. Visual Studio 2019 professional
2. GE's System 1
3. Proxyfier tool if running in Virtual machine
4. Azure storage explorer
5. Virtual machines (if very huge Enterprise begin senf)
6. API Dhp communicator tool resources

4.3 Dataset

1. Asset files collected from System 1 DAQ
2. Event files collected from System 1 DAQ

4.4 Simulator pushed 10 Enterprises (Scaling)

BumbleBee is huge database with more than 5 Lakh events and around 2050 asset. This database is benchmark to test many successful running software. If any software able to successfully perform this huge database then it drastically improves the reliability confidence of software.

The simulator successfully pushed such 10 replications to enterprise insight.



Figure 4.1: simulator 10 bumbleBee simulation.

As shown in figure 4.1 the 10 bumble bee pushed to Enterprise Insight web portal. In the diagram some more words are attached to the Enterprise name which is nothing but machine name from which simulator is launched. Appending this machine has following benefits

1. Horizontal scaling
2. Tracibility between each enterprise

4.5 Leaf level expansion of simulated Enterprise(accuracy)

To validate if enterprise is simulated properly we need to expand till its leaf node level hierarchy of assets. If hierarchy is expanded till leaf node level then it is considered as sign of proper ingestion.

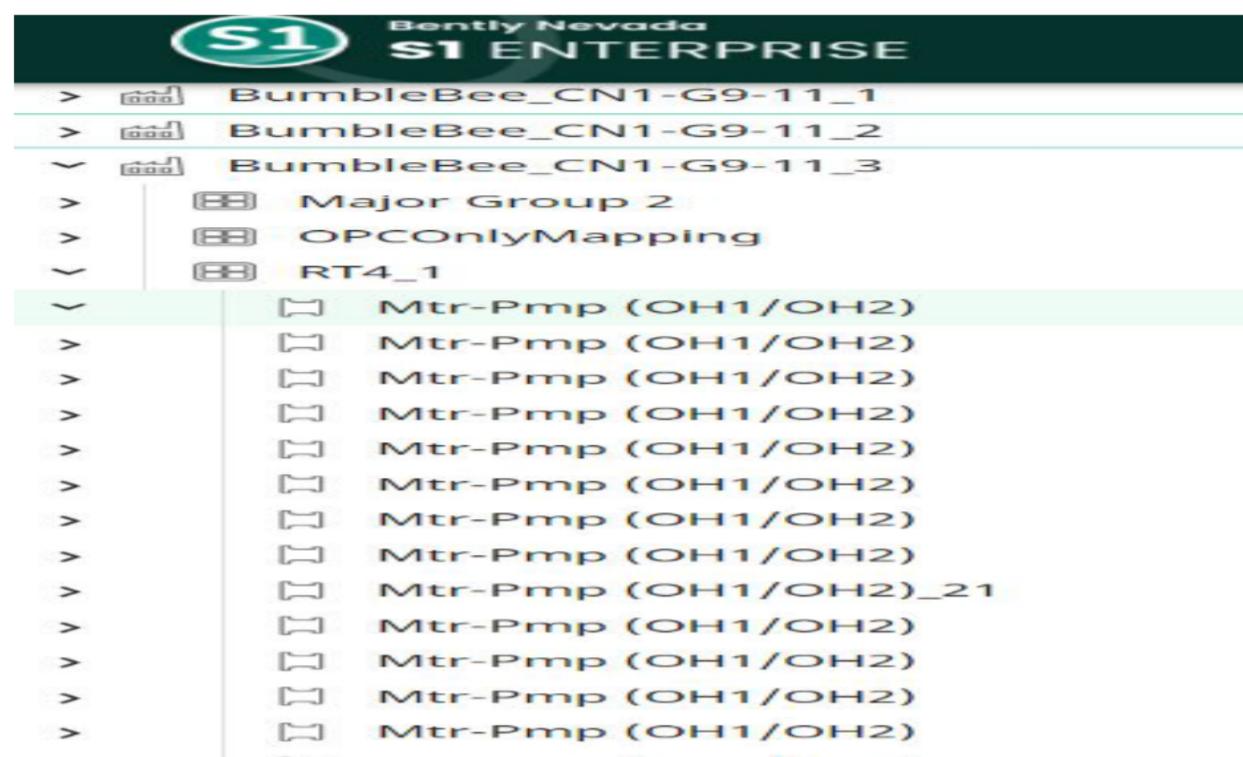


Figure 4.2: Leaf level expansion of simulated enterprise.

above figure show the configuration is retrieved after reloading of System

4.6 Simulator pushed Events

The simulator can also mimic the Event DHP, hence by using software simulator as many as ten lakh events can be mocked

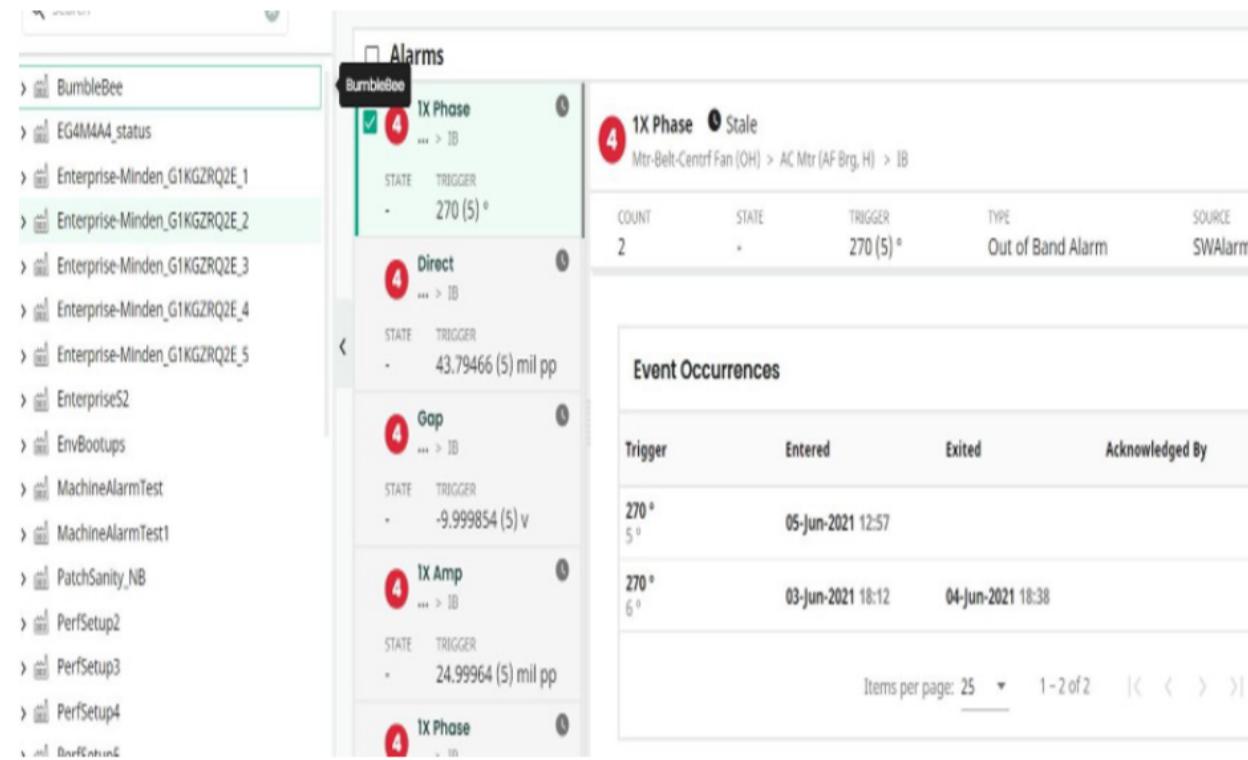


Figure 4.3: Simulator pushed events.

As shown in Figure the events are being pushed and displayed on Fleet management system

Chapter 5

CONCLUSION

Monitoring and interpreting machine condition has always been a great challenge. In this study, we proposed and demonstrated software simulator which can work as system 1 DAQ which will serve to Enterprise insight. The simulator is made to simulate as much as 200 enterprises to test real world scenarios with Enterprise insight. Because of simulator dealing with real-world scenarios which will face by enterprise insight in future is tested and rectified with help of simulator before Enterprise insight becomes live. Simulator simulated 3 most important DHP's of system 1 viz. Asset DHP, Event DHP, Updated event and config DHP's and that is noted that simulator is properly pushing whole enterprises with connection between each asset is preserved and its validate by using real System 1. Generation update for sent enterprise gives feel to enterprise insight that it is receiving data from real system 1. This made possible by argocd pods. which generate update at interval of 10 percent of total number of assets in enterprise.

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