# Feasibility Report

## For

# Coal Mining Safety Monitoring and Alerting System

**Version <2.0>**

**Prepared by**

**Group No.: 02**

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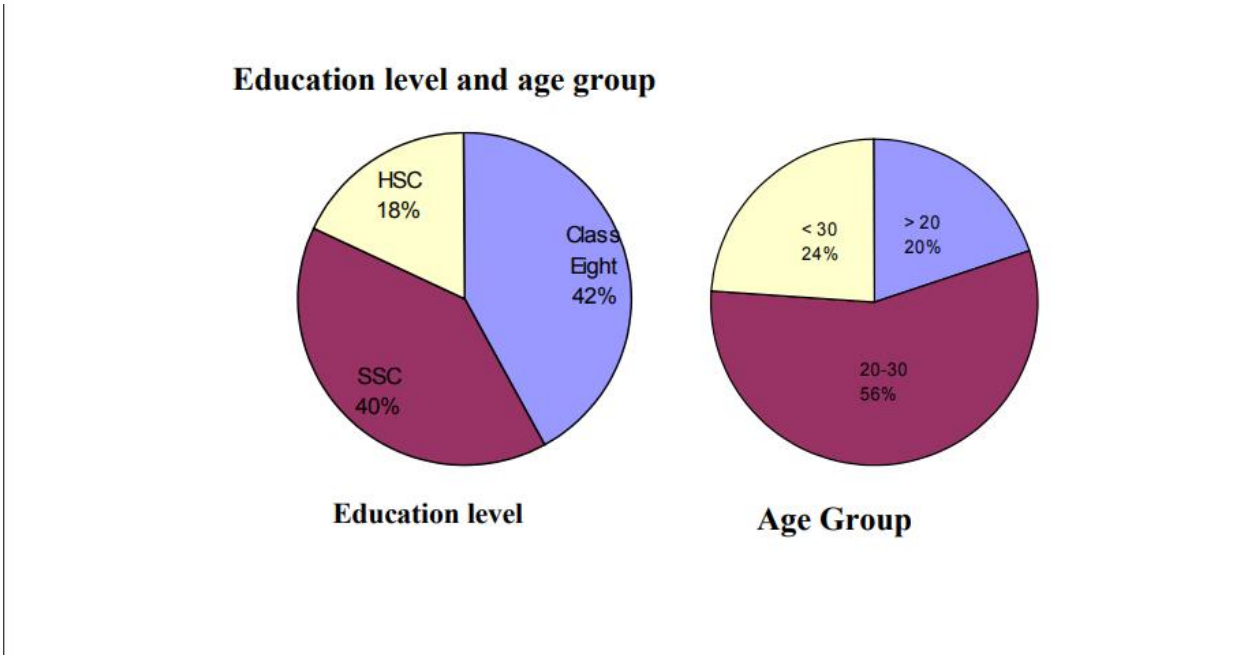
# ABSTRACT/EXECUTIVE SUMMARY

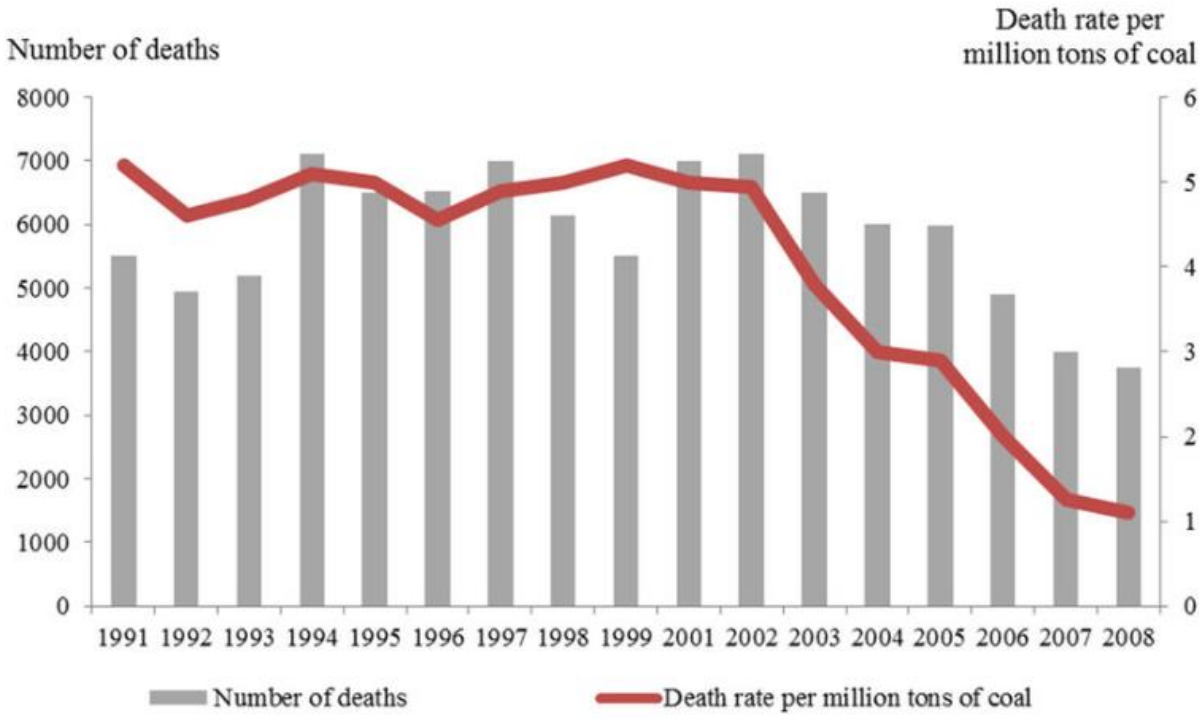
In this feasibility study, we have explored the idea of implementing a coal mining safety monitoring system for the betterment of workers and for ensuring welfare and productivity of workers. First we have looked upon the existing system and the potential problems regarding safety issues in the mining area. We have also studied the most common accidents occurring frequently in the mining site. Then we have proposed two potential candidate systems and described their characteristics in terms of economical, technical and operational feasibility. Finally we have chosen our best candidate system and described its specifications.

# 1 Introduction

Coal mining industry is one of the most important industry in the energy sector since most of our energy demand are met by fossil fuels like oil, coal and natural gas etc. But the environment of the coal mining area is hazardous. Coal mining workers have to work several meters underground. So getting injury in the coal mine occurs very often.




The pie charts above are showing the average literacy of the coal mine workers and their age group. Here we can see that maximum workers are only class eight or SSC passed. So since they are young and not very well educated, they are not well aware of their health or safety issues. As a result, many severe accidents occur frequently in the coal mining area for the unawareness of the workers and for the hazardous environment.




The figure above shows a global statistics about the no of deaths in coal mining area against year and also death rate per million tons of coal. From this graph, we can deduce that the situation has improved since year 2006 for taking certain measures but still the no of deaths per year is moderately high.

The existing coal mining safety system evolves around providing training to the workers and taking better measures in administrator level but our project aims to solve these problems by introducing technology into the picture. Recent technological advancements have led us to a position where we can use various equipment like sensors and other monitoring devices to prevent coal mining deaths.

So our purpose is to introduce technological innovations into coal mining sector to improve the overall safety system.

# 2 EXISTING SYSTEMS

## 2.1 Information Gathering and Analysis

### 2.1.1 Information required for system analysis:

As we want to develop a system to ensure workers safety in the coal mining area and to improve the overall environment of coal mining, we first have to know about the current situation of the coal mining area and the rate of death in recent years. By doing this analysis we will be able to understand the current status of the safety measurements.

Moreover, we want to know if our system will be able to improve current situation. For this, we have to study our candidate systems robustly.

### 2.1.2 The sources of information:

We have used following sources to gather our information about current system-

1. Scientific articles
2. Most recent research papers on this topic
3. People's answers to interview questions.

During interview, we have asked the questions to know what people think about current system and what type of system they want most.

### 2.1.3 Information gathering methodology:

We have used two types of information gathering tools-

1. Review of literature, procedures and forms
2. Interview

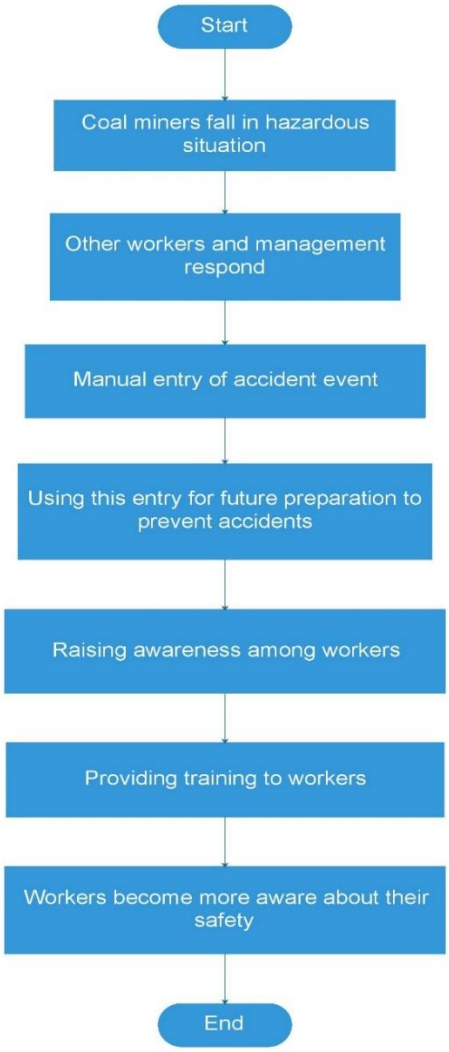
A literature review is a comprehensive summary of previous research on a topic, including comparative discussion as well as pros and cons which helps the analyst to provide an overview of what features exists and how they can be enhanced to meet present requirements.

Literature review is appropriate for our system because it provides us a detailed overview of present system and research direction on this topic.

In case of interview, we have interviewed the students of PME department since they have a good amount of knowledge about the coal mining industry. In this case, we have followed the unstructured method. In other words, we have allowed the participants to answer freely in their own words.

## 2.2 Presenting the Existing System:

The existing system does not provide any special advantage to the workers because the existing system does not incorporate any technological innovation.



### 2.2.1 Characteristics of the Existing System:

We will now present the existing system in tabular format to describe its efficiency, effectiveness and operating costs.

| Characteristic Criteria | Short Description |
|---|---|
| Effectiveness | The effectiveness of the current system relies on the awareness of the workers and the capability of management committee. Since most of the workers are illiterate, raising awareness is hard in this context. |
| Efficiency | Efficiency of the existing safety system is poor because it depends on human actions rather than technological innovation |
| Technical aspect | Technical aspect is also poor because current system doesn't incorporate any technological innovation to enhance safety measures |
| Weaknesses | There are many weaknesses of the existing system. The existing system relies on awareness and training but there is no analysis if this method really reduces coal mining accidents. Even if the workers become aware about safety issues, there is no guarantee that it will reduce the number of deaths due to accidents. Many problems persist even if awareness increases. |

| | **Type of cost** | **Qualitative measurement** |
|---|---|---|
| Operating cost | Maintenance cost | High |
| | Training cost | Very high |
| | Cost for manual entry | Moderately high |
| | Other costs | High |

# 3 Proposed Candidate Systems

The recommended proposals are solely concerned with the safety of the miners. Both consists of alerting systems for hazardous situations.

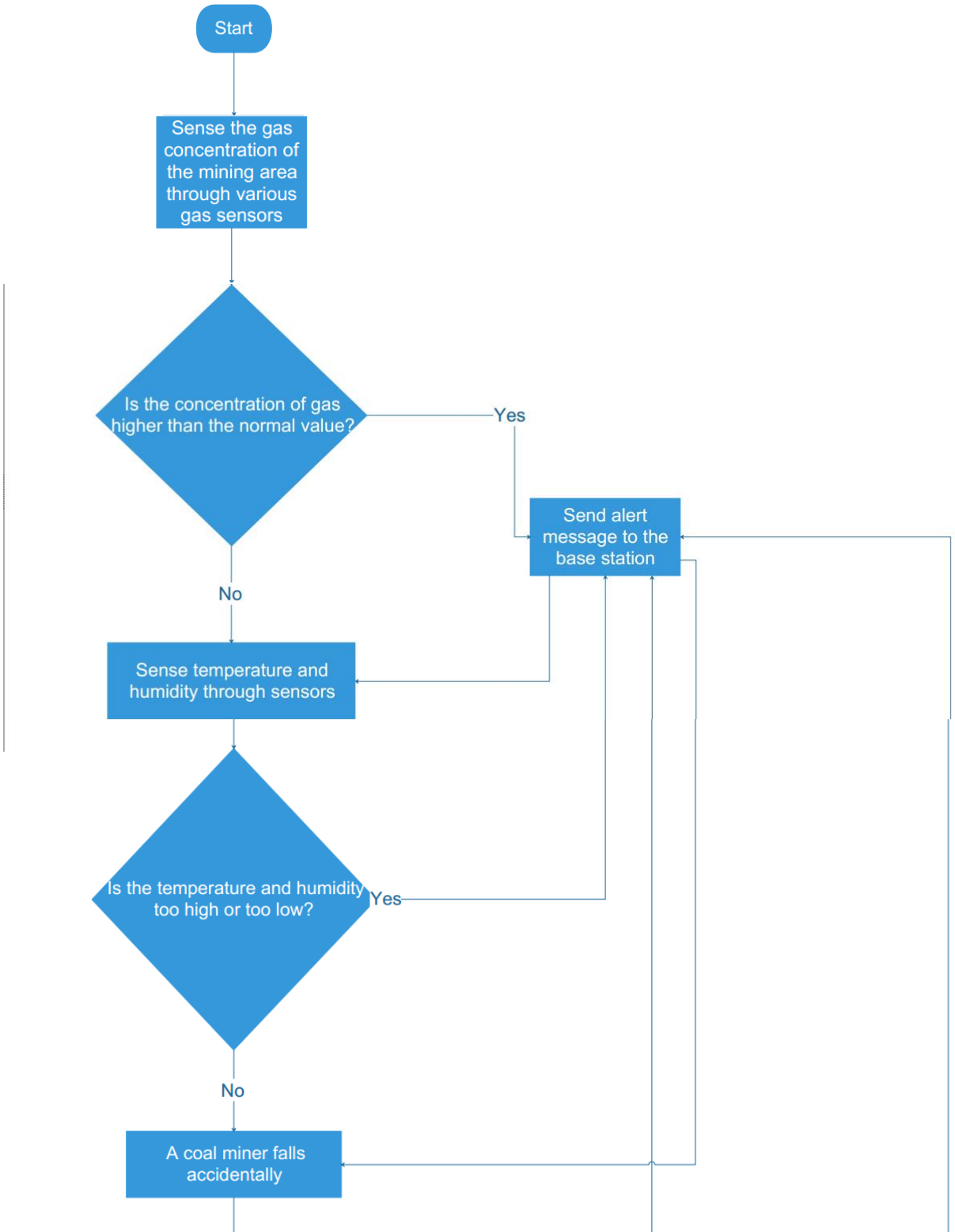
**3.1 Potential Candidate Systems:** Our proposed candidate systems are:

1. Wireless Sensor Network
2. Fuzzy Neural Network System

| Candidate System | Features | Process Flow |
|---|---|---|
| . Wireless Sensors | 1. Based on Internet of Things.<br>2. Wireless sensors are used to collect data and determine the amount of harmful gases<br>3. A fall detector sensor to detect if a coal miner falls accidentally and a limit switch as a helmet removal sensor to detect whether a worker is currently wearing his helmet.<br>4. If a dangerous environment is detected, this will be stored on cloud and transmitted wirelessly to the base station.<br>5. We can also report event using outlier detection algorithm and track the position of workers using localization algorithm. | 1. A number of sensors, hardware and connector will be installed in the several places of mine.<br>2. Each and every moment these sensors read data from surrounding environment and send to base station.<br>3. A controller in the base station will process all the data and generate a warning signal if find something accidental<br>4. After the warning, authority will take safety measurement. |

| | | |
|---|---|---|
| Fuzzy Neural Network | 1. Fuzzy theory and neural network will be combined to develop an intelligent fuzzy neural network system.<br><br>2. If the intelligent fuzzy theory will be combined with neural network then we will get intelligent fuzzy sensor system which will sense the surrounding environment.<br><br>3. Based on some input samples or datasets, it can calculate if the amount of gas in the air is hazardous or not, if the temperature is OK and wind speed etc. | 1. A system with AI and Fuzzy Login will be implemented here.<br><br>2. Some information of previously occurred accidents will be given to this system.<br><br>3. Some sensors will be installed in the mine and send data to the base station.<br><br>4. In the base station, Using AI and Fuzzy logic, the system will process current situation's data and compare with previous data.<br><br>5. Then if possiblity of accident, system will generate a warning signal. |

### 3.1.1 System Flowchart for Wireless Sensor Network System:



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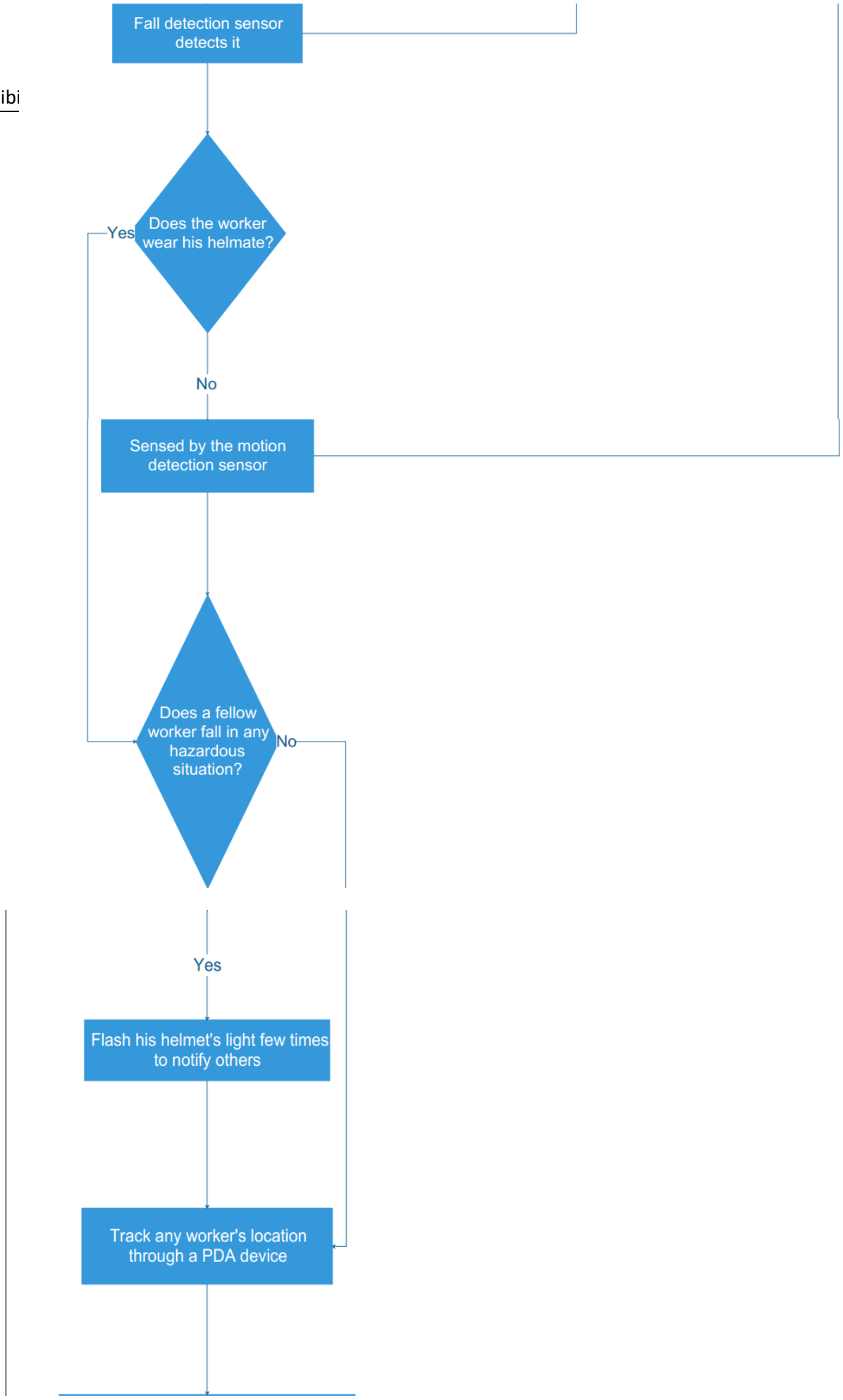
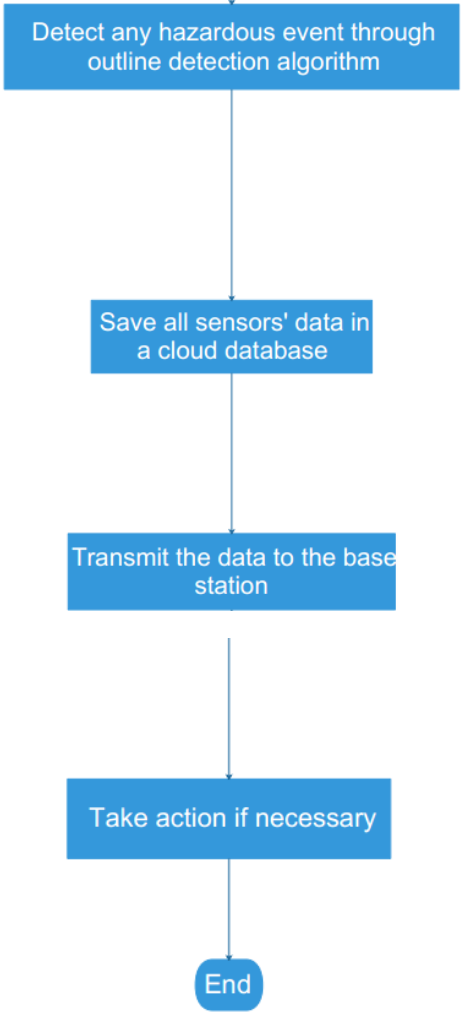
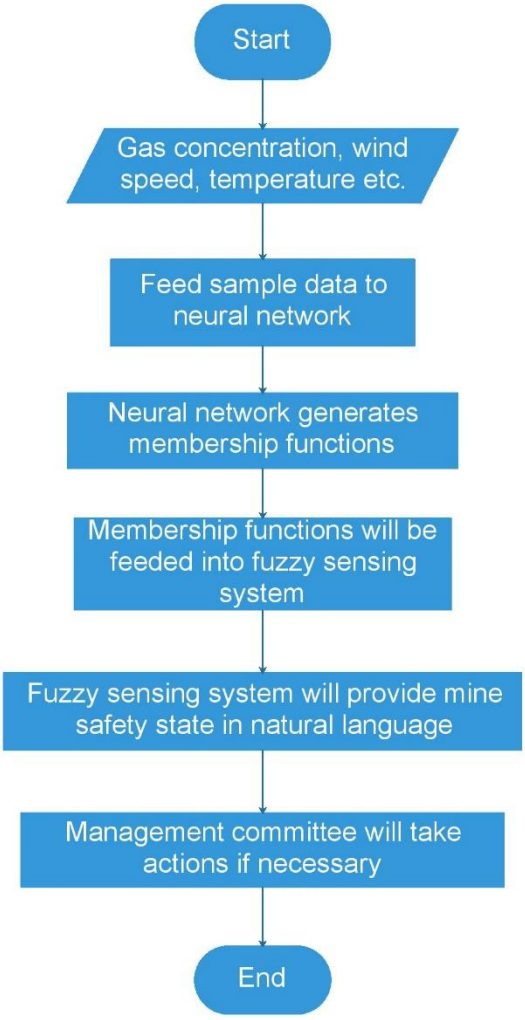

Fall detection sensor detects it
Does the worker wear his helmate?
Yes
No
Sensed by the motion detection sensor
Does a fellow worker fall in any hazardous situation?
No
Yes
Flash his helmet's light few times to notify others
Track any worker's location through a PDA device


Detect any hazardous event through outline detection algorithm
Save all sensors' data in a cloud database
Transmit the data to the base station
Take action if necessary
End

## 3.1.2 System Flowchart for Fuzzy Neural Network System:



## 3.1.3 Hardware and Software Requirements for Candidate Systems:

| Candidate Systems | Hardware | Software |
|---|---|---|
| Wireless Sensor | Gas sensor | A real time monitoring system |
| | Fall detection accelerometer | Different types of algorithm implementation for event detection and location detection |
| | Helmet removal sensor(limit switch) | |
| | Microcontroller | |
| | Different types of nodes such as SNs, RNs and MNs | |
| Fuzzy Neural Network | Computer System | Cloud database |
| | | Neural network |
| | | Training dataset |

## 3.2 Characteristics of the Candidate Systems:

| Characteristics | Wireless Sensor | Fuzzy Neural Network |
|---|---|---|
| Technical Feasibility | 1. Various sensors will read data from surrounding environment<br><br>2. Data collected by the sensors from environment will be processed by a controller.<br><br>3. Analyzing these information, sufficient steps will be taken to ensure the safety.<br><br>4.There will be different types of sophisticated algorithms for event detection and worker's location detection. | 1. Data of previous accidents, previously taken measurement, situation before hazards will be given to the system.<br><br>2.Using advanced technology, such as Artificial Intelligence, Data Mining, Neural Network etc all these information will be analyzed and a warning as possibility of hazard will be generated.<br><br>2. According to the warning, necessary steps will be taken to ensure the safety of workers and minimize the loss. |
| Economic Feasibility | 1. This system requires a lot of hardware to be implemented. So hardware cost is more.<br><br>2. As we aren't using any advanced technology here, sophisticated software cost will be less. | **1.** Hardware cost will be less because we are implementing neural network which is purely software based.<br><br>2. As advanced technologies are used, sophisticated software system will be required.<br><br>3. This system's maintenance cost is high because of advanced technology and technically more efficient people is required. |

## 3.3 Performance and Cost Effectiveness of Candidate Systems:

### 3.3.1 Candidate Qualitative Evaluation Matrix:

| Criteria | | Candidate System 1 (Wireless Sensor) | Candidate System 2 (Fuzzy Neural Network) |
|---|---|---|---|
| Performance | System accuracy | Excellent | Good |
| | Scalability | Excellent | Excellent |
| | Response time | Excellent | Very good |
| | User friendliness | Very good | Good |
| | Complexity | Good | Very good |
| Cost | System development | Good | Very good |
| | User training | Very good | Very good |
| | Maintenance | Good | Very good |
| | Payback | Excellent | Excellent |

## 3.3.2 Candidate System Performance/Cost Evaluation Matrix:

| Criteria | | Candidate System 1 (Wireless Sensor) | Candidate System 2 (Fuzzy Neural Network) |
|---|---|---|---|
| Performance | System accuracy | 99% | 90% |
| | Scalability | 100% | 100% |
| | Response time | Less than 1 second | Less than 3 seconds |
| | User friendliness | Menu driven, interactive | Sample data and command driven |
| | Complexity | More complex | Less complex |
| Cost | System development | 3,00,000 tk. | 2,00,000 tk. |
| | User training | 1 – 2 days | 1 – 2 days |
| | Maintenance | 50, 000 tk. / month | 20, 000 tk. / month |
| | Payback | 6 months | 6 months |

## 3.3.3 Weighted Candidate Evaluation Matrix:

| Evaluation Criteria | Weighting Factor | Candidate System 1 (Wireless Sensor) | | Candidate System 2 (Fuzzy Neural Network) | |
|---|---|---|---|---|---|
| | | Rating | Score | Rating | Score |
| **Performance** | | | | | |
| System accuracy | 5 | 5 | 25 | 3 | 15 |
| Scalability | 4 | 5 | 20 | 5 | 20 |
| Response time | 5 | 5 | 25 | 4 | 20 |
| User friendliness | 5 | 4 | 20 | 3 | 15 |
| Complexity | 3 | 3 | 9 | 4 | 12 |
| **Costs** | | | | | |
| System development | 5 | 3 | 15 | 4 | 20 |
| User training | 4 | 4 | 16 | 4 | 16 |
| Maintenance | 4 | 3 | 12 | 3 | 12 |
| Payback | 4 | 5 | 20 | 5 | 20 |
| **Total** | | | 162 | | 150 |

## 3.4 Selection of the Best Candidate System:

The system with the highest total score is judged the best system. According to our analysis, the wireless sensor network is the best system for ensuring coal mining safety. System accuracy and response time are the criterions that have the greatest effect on the total score.

# 4 Specification of the Selected Candidate Systems

## 4.1 Functional requirements:

1. If any worker falls in any dangerous situation, then the fellow workers should be notified so that they can provide help.

2. If any undesirable event occurs in the coal mining area, then there should be an alert system that will notify the base station so that the authority can take immediate action.

3. Various environmental parameters of the coal mining area such as concentration of harmful gas in the air, temperature, humidity etc. should be measured in regular basis.

4. If the concentration of harmful gas is too high or the temperature and humidity is beyond the acceptable level then immediate action should be taken

5. The worker's location should be tracked during working hour so that when a worker falls in danger, the authority can track down his location.

6. The data about environment of coal mining area should be collected and transmitted wirelessly to the base station so that the authority can observe these through a web interface.

## 4.2 Non-functional requirements:

1. The response time of the system should be minimized.

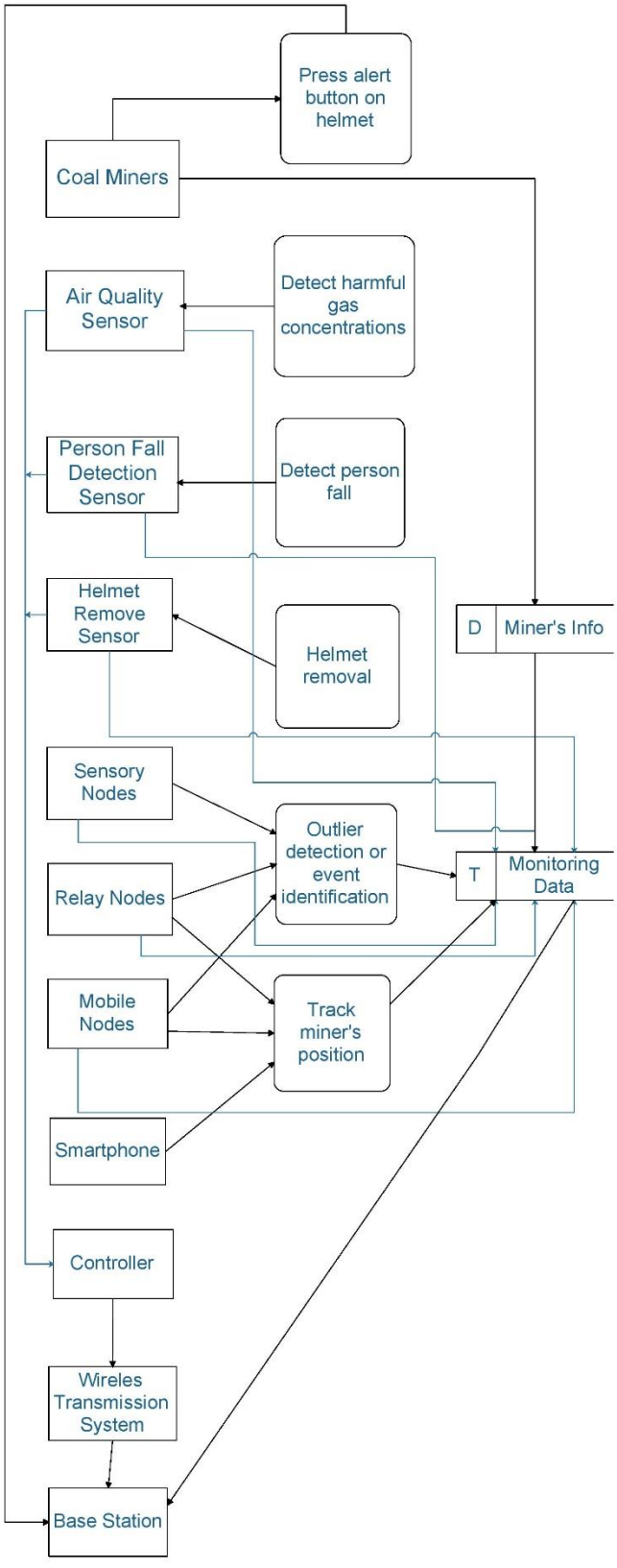
2. The system should be secured so that the worker's personal information or location could not be leaked online.

3. The system should be reliable so that the failure of one part doesn't affect other parts.

4. The system should be less bulky in case it includes many hardware components.

5. There should be some authentication system so that the workers of the coal mine can authenticate themselves.

## 4.3 Data Flow Diagram (DFD):



## 4.4 Decision Table:

| | | Condition Entry | | | | |
|---|---|---|---|---|---|---|
| | **Condition Stub** | | | | | |
| IF (condition) | A worker falls in danger? | **Y** | | | | |
| | The harmful gas concentration is too high? | | **Y** | | | |
| | A worker falls from the ground? | | | **Y** | | |
| | A worker removes his helmet? | | | | **Y** | |
| | A hazardous event occurs in the coal mine area? | | | | | **Y** |
| THEN (action) | Press alert button on helmet | **x** | | | | |
| | Detect it and send alert to the base station | | **x** | **x** | **x** | |
| | Detect the event and send alert | | | | | **x** |
| | **Action Stub** | **Action Entry** | | | | |

# 5 Conclusions

As we have discussed so far, we have learned all the characteristics and features of the proposed candidate systems. We also have measured the weight of candidate systems. From this study, we came to know that the second proposed candidate system is the the best according to weight. So we suggest the management to select the second candidate system as solution.

First Candidate system, wireless system, takes information after or during accidents and hazards. When an accident occurs, this system can identifies a risky incidents but not before an accident. So, most of the time, if the accident is very dangerous, authority don't get enough time to take steps to save that/those person in the risk.

Here the second proposed solution, Fuzzy Neural Network, gives better approach. Based on its analysis of previous data, this candidate system generates a warning of possible danger. According to this danger, authority can take necessary steps. As this warning is generated before the danger, there is enough time to get prepared.

If we consider the economical factors, second solution is better. This system requires less hardware and technically less person to handle the equipment. On the other hand, considering the software side, this system is more complicated as advanced technologies are used here. But economically considering both hardware and software costing, second proposal is less expensive.

As first candidate system consists of so many hardware, these needs to be kept in maintenance and often hardware requires repairing. But the second system needs less maintenance of hardware.

Repairing hardware is more dangerous than maintaining the software. While repairing, repairer must go to the underground surface, that is too dangerous. On the other hand, maintenance of software is very easy and free of risk.

# Appendix A – References

## References

[1] A. Zhao, "The analysis of coal safety production monitoring data based on deep learning," 2017 13th International Conference on Natural Computation, Fuzzy Systems and Knowledge Discovery (ICNC-FSKD), Guilin, 2017, pp. 1053-1057.

[2] S. R. Deokar and J. S. Wakode, “Coal Mine Safety Monitoring and Alerting System”, *International Research Journal of Engineering and Technology,* vol: 4, issue: 3, pp. 2146-2149, 2017

# Appendix B – Mapping of Information to Sources

| Information | Source | Methodology |
|---|---|---|
| Current system lacks implementation of technology | Interviewee | Unstructured interview |
| The death rate of coal mining area | Internet | Literature review |
| Average literacy of coal mining workers and their age group | Internet | Literature review |
| Few technological innovation have recently been used | Internet | Literature review |