Intelligent Automation And Soft Computing, 2020
Vol. 26, no. 3, 597–607
DOI: 10.32604/iasc.2020.013938

# Research on the Advanced Prediction Model of the Tunnel Geological Radar Based on Cluster Computing

**Meng Wei*, Ningxin Zhang, Yuan Tong, Yu Song**

Chengdu University of Technology, College of the Environment and Civil Engineering, Chengdu, Sichuan,610059
Mailing address: No. 1, East Third Road, Erxianqiao, Chenghua District, Chengdu city, Sichuan Province

ABSTRACT
The traditional radar signal detection mode of the analog digital converter (ADC) has a low prediction efficiency. Therefore, the advanced prediction model of the tunnel geological radar based on the cluster computing was designed. The completeness factor of the detection radar signal was calculated by the computer cluster effect, and then the information extraction and information integration of the radar pulse for the radar detection signal was determined. Moreover, the multi-order nonlinear regression forecasting model restructured the received signal. Thus, the prediction of the radar detection signal was achieved. In order to ensure the effectiveness of the design, the simulation experiment was carried out. Experimental results show that the ahead prediction model of the geological radar is 25% higher than that of the traditional model, which proves the effectiveness of the designed prediction model.

KEY WORDS:Advanced prediction; cluster computing; computer technology; continuous wave radar; tunnel engineering; geological survey; pulse radar.

## 1 INTRODUCTIONS

THE cluster is a parallel or distributed processing system [1], which is a computer group that connects a lot of isomorphic or heterogeneous computers and completes the specific task cooperatively through a high-performance network. Meanwhile, it provides a single system image to the user and application. In the cluster system, computing nodes may be part of a single processor system or multiprocessor system. Each node has a CPU, memory, I/O device and independent operating system. The cluster system provides high performance, extendibility, flexibility, high throughput and high availability with low cost. The cluster computing method is used to forecast the radar signal. The detection intensity of the cluster computing the radar signal is researched through analyzing the different radar detection signals of the different elements of their source points, and then the radar signal detection effect is obtained under the same conditions of other factors. This achievement is applied to the radar signal prediction. The results show that the radar signal intensity in the middle section of the tunnel will raise half the level compared with the auxiliary equipment under the condition that other resources are similar in the same position. During the radar signal detection, the cluster computing radar prediction model detects the sequence of the cement paste, sealing liquid and drilling fluid, and includes several detection interfaces. Each detection interface will have an important influence on the detection of the tunnel quality. At present, the research about the tunnel geological radar advanced prediction mainly contains: the theoretical analysis of the ahead prediction of the geological radar, the experiment of the ahead prediction of the geological radar and the numerical experiment of the ahead prediction of the geological radar.

Special contributions of this paper include:

(1) The algorithm flow analysis of the clustering algorithm and its advantages are introduced.

(2) The parameter setting and prediction criteria for the geological radar prediction.

(3) The analysis and application of the clustering algorithm in a geological prediction.

The rest of this paper is organized as follows: Section 2 introduces the correlation prediction model of the geological radar. Section 3 introduces the

CONTACT Meng Wei ✉ se7019@163.com

clustering algorithm model and its application in a geological prediction, and Section 4 summarizes the paper.

## 2 DESIGN OF THE RADAR AHEAD PREDICTION MODEL

FROM the point of the third dimension, the numerical simulation method based on the cluster computing uses the multiphase flow equation as the control equation. Through the computer, the development process of the interface in the tunnel is numerically simulated, and then the formation and development characteristics of the three-dimensional detection interface can be truly reappeared. Based on the national super large-scale cluster computing platform [3], the influence of the cluster computing mode on the ahead prediction of the tunnel geological radar is researched, which provides a theoretical basis for the reasonable design of the construction scheme of the tunnel. For the advanced prediction method of the tunnel geological radar, the geological survey of the tunnel is designed by the cluster computing. The cluster computing mode is used to calculate and analyze the signal received by the radar, which arrives at the sensor in the form of a direct wave and the reflected wave along different paths. The reflection wave needs long propagation time compared with the direct wave. The first step of cluster computing is to convert the longitudinal wave propagation time measured from the radar detection point to the sensor into the propagation velocity $V_p$ of the seismic wave.

$$V_p = \frac{X_1}{T_1} \tag{1}$$

where, $X_1$ denotes the distance (m)between the blasting hole and sensor. $T_1$ denotes the propagation time (s) of the direct longitudinal wave. If the propagation velocity of the radar detection wave is known, we can derive the distance among the reflection interface and the sensor and the tunnel section through the measured reflection propagation time. The whole derivation is derived by Formula(1).

$$T_2 = \frac{X_3 + X_2}{V_p} = \frac{X_1 + 2X_2}{V_p} \tag{2}$$

where, $T_2$ denotes the propagation time (S)of reflected wave. $X_3$ denotes and represents the distance (m) from the blasting hole to the reflection interface. $X_2$ denotes the distance (m) between the sensor and the reflection interface.

For the vibration measurement, the biggest difficulty is not the above mathematical operation but rather the propagation time of the reflected waves based on the accurate determination of the reflection interface. The premise of accurately determining the reflection interface is to clearly separate the reflected wave from the overall mixing signal including the direct wave and other interference signals in some manner. Compared with the direct wave, the amplitude of the reflected wave is very small. On one hand, it depends on the distance between the reflection interface and the sensor and on the other hand it depends on the reflection coefficient of the radar detection wave on the reflecting surface. The definition of the reflection coefficient is as follows:

$$R = \frac{\rho_2 V_{\rho 2} - \rho_1 V_{\rho 1}}{\rho_2 V_{\rho 2} + \rho_1 V_{\rho 1}} \tag{3}$$

where, $\rho_1$ and $\rho_2$ denote the propagation velocity of the wave. $V_{\rho 1}$ and $V_{\rho 2}$ denote the density of rock outside the reflection interface. For the spherical wave, the amplitude of the earthquake wave also reduces with the increase of the propagation distance. In conclusion, the ratio between the amplitude of the reflected wave and the amplitude of the direct wave can be expressed by the following formula:

$$A_r / A_d = RX_1 / (X_2 + X_3) \tag{4}$$

Through the analysis for cluster computing of the detection information of the tunnel, the nature, position and scale of the geological conditions of the surrounding rock engineering in the tunnel front can be calculated. The new model is designed through combing the above cluster computing model with the traditional method. The specific operation and function of the new model are shown in Figure 1.

From Figure 1, we can see that the radar signal detection model designed by the cluster computing method has a very powerful function. The combination of many techniques is used to closely monitor the advanced prediction of the tunnel geological radar. Combined with the task division strategy of the cluster system in the new model of the tunnel geological radar prediction model, the specific computing task is divided into several continuous task blocks. Each calculation node in the cluster system is responsible for the calculation of a piece of data. The computing task of the cluster system is to process the massive tunnel image data based on the existing image processing algorithm of the tunnel. It is assumed that the number of tunnel images in a computing task is Pic-num, and the number of computing nodes is m, and the number of pavement images, which are assigned to each computing node is Avg-num. In order to achieve the parallel computation of the image information, first we need to calculate the Aver num, that is:

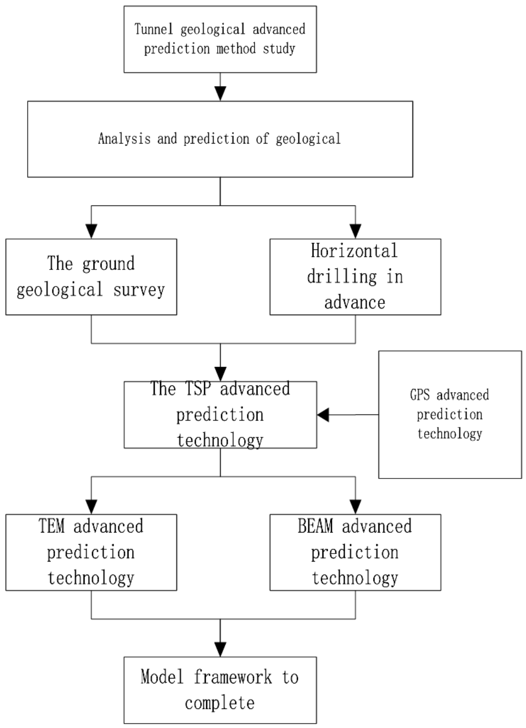


**Figure 1. The Technical Operation Flow Chart of the New Model.**

$$\text{Avg-num}=\frac{\text{Pic-num}}{\text{m}} \tag{5}$$

If the number of sub-computing nodes of m cannot be divisible by Pic-num, then the remainder number of Mod-num can be obtained, namely:

$$\text{Mod-num}=\text{Pic-num}\%\text{m} \tag{6}$$

Therefore, the number of pavement images assigned by each computing node is Node-num. If the remainder Mod num! =0, the remainder is allocated to the computing node with the lightest load in the cluster system, that is:

$$\text{Node-num}=\text{Avg-num}=\frac{\text{Pic-num}}{\text{m}} \tag{7}$$

$$\text{Node n} \neq \text{m} \;\; \text{Avg+num-Mod}\frac{\text{Pic-num}}{\text{m}}\text{+p} \tag{8}$$

Thus, the initial task allocation of each computing node is obtained, and the node is dispatched and managed according to this task. In general, the dynamic load balancing algorithm needs to solve three main problems: The monitoring of the load, the task migration strategy and the migration realization. Therefore, the dynamic load balancing algorithm also includes the specific methods of the load monitoring, the task migration strategy and the migration realization. The three parts are not independent of each other. The cluster system takes the load monitoring information of each node as the basis and is combined with the task migration strategy. The computing task can reasonably migrate between various computing nodes, and the load of each computing node should be balanced as much as possible. Thus, the computing rate and the parallel computing ability of the cluster system are effectively improved, which ensures the detection accuracy of the tunnel radar signal.

## 2.1 The Cluster Computing of the Radar Detection Signal

In the use of the continuous wave radar and pulse radar for the geological detection [5], a method using the cluster calculation model to observe the tunnel displacement and the time observation curve predicts the accuracy of the radar signal receiving rate. The turning point of the time observation curve of the wall displacement is the time of instability of the surrounding rock. Thus, the multi-order nonlinear regression forecasting model is built, and the mathematical expression of the detection time of the radar signal is obtained. Moreover, the least square method is used to fit the monitoring data and obtain the parameters of the forecast model. Thus, the time of the radar signal detection can be predicted. Generally, this method is suitable for the short prediction of the radar signal detection, and its reliability depends on the continuity of the displacement-timer observation curve. The new cluster system uses the design idea of modularization. The main structure of system is described by the main program, the sub-program and the sub-process. According to the relationship between the input and the output, the algorithm is described as the function block unit, and the program is designed. The calculation method is as follows:

$$\begin{vmatrix} 0 & 0 & 0 & 1 & 0 & 0 \\ 0 & 0 & 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 0 & 0 & 1 \\ 3.3089 & 11.6932 & -22.0632 & 0 & 0 & 0 \\ -37.2547 & -112\,3976 & 44.8306 & 0 & 0 & 0 \\ 4\,2986 & 182.9873 & 0.7907 & 0 & 0 & \end{vmatrix} = \begin{vmatrix} x1 \\ x2 \\ x3 \\ x4 \\ x5 \\ x6 \end{vmatrix} + \begin{vmatrix} 0 & 0 \\ 0 & 0 \\ 0 & 0 \\ 2.6897 & 5.6391 \\ -13.7438 & 19.1921 \\ 19.1921 & -126600 \end{vmatrix} \begin{vmatrix} u1 \\ u2 \end{vmatrix}$$

$$y = \dot{x} = \begin{vmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \end{vmatrix} \begin{vmatrix} x1 \\ x2 \\ x3 \\ x4 \\ x5 \\ x6 \end{vmatrix} + \begin{vmatrix} 0 \\ 0 \\ 0 \\ 1 \\ 0 \\ 0 \end{vmatrix} |u| \tag{9}$$

From Formula (9), we can see that the cluster computing model is a typical nonlinear multivariable system with multi-input of $(x_1, x_2, x_3)$ and the multi-output of $(u_1, u_2)$. From the motion model of the system, we can see that there is a strong interaction between variable $(x_1, x_2, x_3)$, and this interaction will change with the continuous survey of the continuous wave radar for the receiving frequency of the image. The specific operation method is shown in Figure 2.

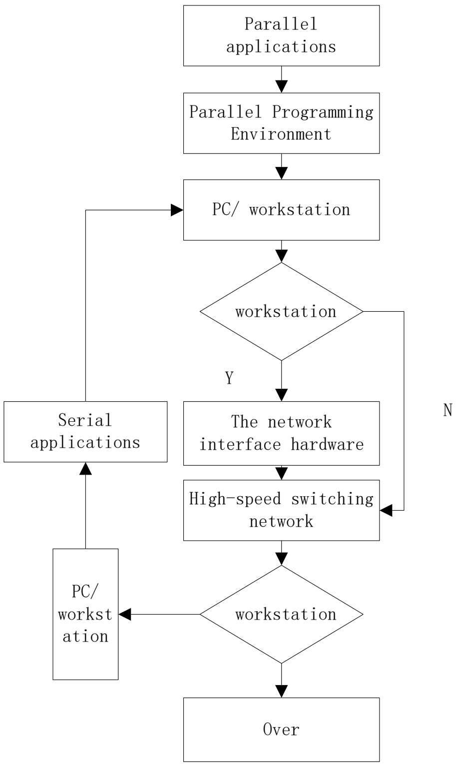


**Figure 2.** **The Structure of the Cluster System.**

Based on the target of the radar signal detection, the cluster computing method can be divided into two categories: The cluster detection radar signal with high-availability and the cluster detection radar signal with high-performance. The cluster with high availability runs on two nodes or more, thus the system can continue to provide service when the system fails. The design idea of the high-available cluster is to reduce the interruption time of service as much as possible, and to automatically detect the failure. Once we find the failure of the computer, we should transfer all the tasks on the computer to other computers, to provide uninterrupted service for the geological survey of the tunnel radar. Based on the configuration of the processor, the cluster can be divided into the isomorphic cluster and the non-isomorphic cluster. The isomorphic cluster is that all nodes have an approximate structure and the same operating system. The non-isomorphic cluster is that all nodes have different structures or different operating systems [6]. The technical basis of the cluster system contains the microprocessor technology, the network technology, the cluster system middleware technology, the resource management and scheduling system (RMS, and the Resource Management and Scheduling). The research on the middleware technology of the cluster system mainly includes a single system image SSI, system availability infrastructure, resource management and scheduling system. The single system image shields the specific physical structure of cluster system through the software and hardware. The cluster computing mode processed by using the computer is shown in Figure 3.

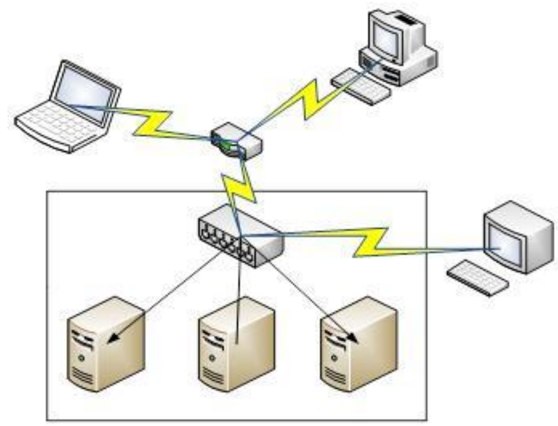

**Figure 3.** **The Cluster Computing Technology of the Tunnel Geological Exploration Processing System.**

The two problems that the resource management and scheduling system needs to solve is to shorten the response time of the task and improve the resource utilization of the cluster system. The average response time of the task is an important index for users to evaluate the performance of the cluster system. The resource sharing is the basic point of the cluster system. The higher the utilization rate of system resources is [8], the larger the throughput of the system is, and the better the effect of the resource sharing is. Under the premise of sharing, effective management and scheduling for the resource within the cluster scope has an important role in improving the throughput and performance of the cluster system. The occurrence of the tunnel geological disaster is a complex geological process. When judging the possibility of the geological disaster, the decision-maker faces massive and complex data. How to effectively arrange and scientifically analyze this data is difficult and time-consuming. It is necessary to use the computer to research and calculate the research object according to the cluster computing methods. To develop the auxiliary decision system of the geological advanced prediction is to provide support for decision makers. Some foreign products such as the Beam forecasting method and its software system in Germany have been formed in the aspect of advanced intelligent technology and computer-aided decision.

The geological condition of a tunnel is surveyed and evaluated. Meanwhile, the rock sample is extracted without delay. The cluster computing is used to calculate the radar detection model in the field. The point load intensity $I_{s(50)}$ of the radar signal is measured and the resist compression of the rock $R_b$ and tensile strength $\sigma_t$ are obtained to quantify the strength grade of the rock. According to the point load instrument, the formulas for the resist compression $R_b$ of the rock and tensile strength $\sigma_t$ are as follows:

$$P = I_p \times S_p \quad (10)$$

$$I_s = \frac{P}{D^2} \quad (11)$$

$$\sigma = 2.15 \times I_{s(50)} . \quad (12)$$

$$R_b = 22 \times \sigma \quad (13)$$

$$PLS = R_b \frac{P}{D \times Lf} \quad (14)$$

$$\sigma_t = 1.92 \times PLS \quad (15)$$

$$R_b = 17.86 \times PLS \quad (16)$$

where, $P$ denotes the breaking load of ($MN$); $S_p$ denotes the piston area of the lifting jack. Constant 15 $cm^2$ ; Ip denotes the pressure gauge reading of ($MPa$). $I_s$ denotes the point load strength index of ($MPa$); D denotes the distance between the loading points ($cm$); PLS denotes the point load strength of ($MPa$). $I_{s(50)}$ denotes the corrected $I_s$ ($MPa$); $Lf$ denotes the average length ( $cm$ )of the vertical loading axis on the failure surface. $R_b$ denotes the uniaxial compression strength of the rock ($MPa$)and $\sigma_t$ indicates the tensile strength of rock ($MPa$).Based on the above geological survey and test, the ahead detection of the geological radar can be carried out near the tunnel. According to the detection result and the rock mass strength feature of the tunnel survey, the variation characteristics of the indexes such as the earthquake wave, S wave, and P wave velocity. The poison ratio, and elastic modulus in the cluster computing radar detection results can be analyzed comprehensively. Compared with the strength of the rock mass in the tunnel, the strength of the rock mass in the front surrounding the rock is comprehensively predicted. Meanwhile, we can judge the effect of the cluster computing technology for the radar signal prediction.

The static load balancing method in the cluster computing gets the best prediction of the radar signal under the condition of accurately predicting the task execution. The control program contains the request scheduling module, the access control module, the algorithm management module, the algorithm module, the control management module, the control module and the key management module. The request scheduling module completes the distribution of the requests and the scheduling of task threads. The algorithm management module and the control management module are respectively responsible for the installation and the uninstall of the algorithm modules and control modules, and the entry provided by them is used to complete the specific operation. The $Kv$ method of the integrality and the coefficient in the cluster computing is used to calculate the radar detection signal.

$$Kv = \left( \frac{V_{Pm}}{V_{pr}} \right)^2 \quad (17)$$

$V_{pm}$ denotes the longitudinal wave velocity of the rock test specimen. $V_{pr}$ denotes the longitudinal wave velocity of the rock mass. The radar wave velocity of the rock mass is measured by the cluster computing. The integrity coefficient is obtained to evaluate the integrity of the radar signal. The new model will integrate data through the precision operating system, to accurately predict the continuous wave radar detection.

### 2.2 The Information Extraction and Information Integration of the Radar Detection Signal

In the cluster computing technology, the image segmentation is an image processing technique that divides an image into several regions. Essentially, it is the process to classify the pixel of each image, which is good preparation for the feature extraction and the parameter measurement of the pulse radar. It is necessary to segment the image. Therefore, the new cluster system uses image segmentation to process the pulse radar image, which makes clear judgments for the analysis result [10]. The difference between the fact and operation of the radar prediction system in receiving image frequency is clearly expressed in

Figure 4, and thus to determine the effect of the ahead prediction of the pulse radar.

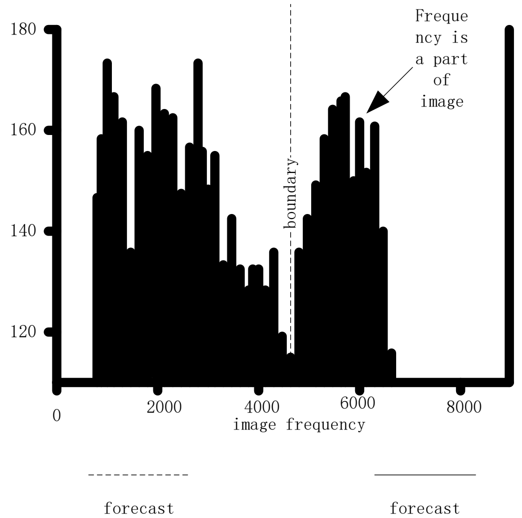


**Figure 4. The New Model of Receiving Image Processing.**

From Figure 4, the image mode received by the new model shows little difference with the actual image mode, which shows that the effect of the cluster technology for the prediction of the pulse radar being very good. The application of the image segmentation technique is extremely advantageous in the pulse radar detection. Because the image segmentation is the primary task and to realize the automatic analysis of the image, it is very important in image processing. First, the original tunnel image is transformed into a more abstract tunnel image through the image segmentation. Second, the image segmentation can separate the cracks from the background.

In the aspect of the radar signal prediction, the cluster computing mode puts forward a method to predict the emission time of the signal based on the time observation curve of the tunnel wall displacement. It is considered that the inflexion point of the time observation curve of the tunnel wall displacement is the emission time of the radar signal. Thus, the multi-order nonlinear regression forecasting model is established, and the formulas are as follows:

$$y = b_0 + b_1 t + b_2 t^2 + b_3 t^3 \tag{18}$$

$$t^* = -b_2 / (3 \times b_3) \tag{19}$$

$$\alpha = Log_{10}[(A1 \times A2)/(B1 \times B2)] \tag{20}$$

where, t is the time variable, b is the pressure value of the tunnel measured by the new model. $\alpha$ indicates a coefficient without the unit. A1 is thickness of the rock wall. A2 is the strength of the rock wall. B1 is the water abundance andB2 is the water pressure condition. Based on the geological indexes such as the stratigraphic lithology and the geological structure and the geophysical prospecting parameters such as the TSP, geological radar, transient electromagnet, and the enriching condition of the groundwater is judged synthetically. According to the above formula, the launching time of the radar signal is solved. The monitoring data is fitted by the least square method. The parameters of this forecast model are obtained. The launching time of the radar signal can be obtained through the time series conversion. This method is generally suitable for the short prediction of the radar signal detection. Its reliability depends on the continuity of the displacement- time observation curve [11].

At present, the common load balancing strategies for the prediction methods of the radar signal include the central task scheduling strategy, the gradient model strategy, the sender start-up strategy, the receiver start-up strategy, the symmetric start strategy and the adaptive strategy. The comparison is shown in Table 1.

**Table 1. The Common Load Balancing Strategy.**

| Policy Name | Advantage | Disadvantage |
|---|---|---|
| Central task scheduling strategy | Can the comprehensive each center scheduling nodes Can the comprehensive each center scheduling nodes Can the comprehensive each center scheduling nodes | In a lot of computing nodes, the scheduling node In a lot of computing nodes, the scheduling node |
| The gradient model strategy | Don't set up center scheduling node, does not exist Don't set up center scheduling node, does not exist | May lead to too much computing tasks |
| The sender launch strategy | No center scheduling nodes, the system light load No center scheduling nodes, the system light load | The system is overloaded, the sender is not easy to find |
| The receiver launch strategy | No center scheduling node, heavy load system | Under light load conditions, the receiver starts |

In order to improve the usability of the radar signal detection system, we can use the redundancy, failover and recovery technology in the cluster computing. In another words, we continue to use the redundant components to provide services by maintaining some redundant components in the system when the working parts lose their effectiveness. The failover is to monitor the running state of multiple machines in the cluster system by the software. When a machine fails, we start the auxiliary machine to take over the machine and continue to provide service, then the failure machine can be recovered itself in certain conditions. The process placement and process migration are to transfer a running job process from one node of the system to the other. The process can continue from the breaking point of the original process, and its behavior and results are the same as that before the migration. According to this feature, the cluster system can transfer the process of the heavy load node to the light load node, which dynamically changes the load distribution of the system and efficiently completes the calculation with a large throughput. The process migration has become one of the key technologies to improve the overall performance of the cluster system and enhance the fault-tolerant ability of the system [12]. The $LZG$ formula for forecasting the radar location detection of the tunnel fault based on the cluster computing mode is as follows:

The hanging side of Formula 1:

$$B_1 = 37.7379N - 4.8501$$

$$B_2 = 17.5536N - 2.8272 \quad (21)$$

$$B_{1-2} = 20.1843N - 2.0229$$

The hanging side formula 2:

$$B_1 = 34.9943N$$

$$B_3 = 16.2157N \quad (22)$$

$$B_{1-3} = 18.7786N$$

The hanging side formula 3:

$$B_1 = 34.3692N$$

$$B_3 = 14.8677N\ . \quad (23)$$

$$B_{1-3} = 19.5051N$$

where $B_1$ denotes the first band initial point station number of $I_1$ jointing (minor fault). $B_3$ denotes the third band initial point station number of $I_1$ jointing (minor fault). $B_{1-3}$ denotes the distance between the first band and the third band of the $I_1$ jointing (minor fault). $N$ denotes the fault throw. For the radar signal prediction, the thickness of the fault fracture zone is one of the important data and is the main purpose of the cluster computing .It is the main geological factor causing the construction to collapse and the position of the radar signal emission point.

### 2.3 The Realization of the Radar Detection Signal Prediction

There are some special module functions in the radar signal prediction model based on the cluster computing, which undertakes the specific data operation. Its processing of the performance influences the overall performance of the service system. The performance of the dedicated module depends on the performance of the hardware and the software. For the hardware, we choose the hardware development board taking the high-performance embedded processor as the core, and the operating system uses the cluster computing system. The particularity of the cluster computing system requires that the security is first. Therefore, all the requests received by the radar signal must be strictly checked. We can consider a master control node to receive working requests from the outside. After the filtering, the job is assigned to other operation nodes. When the operation node receives the job request from the secure channel, it does not judge the validity and source of the job request, but the main control node is easy to be the performance bottleneck. We need to further weigh the scale and communication traffic of the system [13]. It should be limited to the prediction of the basic geological condition and harmful geologic body in the tunnel. There is less disaster research on geological disasters with complex formation mechanism such as rock burst and large deformation, which may not be included in the advanced prediction [14].It must be noted that the measured dip angle of the formation interface in the pilot tunnel is the true dip angle. If the true dip angle projects the formation interface in the pilot tunnel to the main hole, there will be a great error. Because the stratum is the intersection between the apparent dip angle and the main hole, in order to determine the accurate position of the formation interface in the main hole, the projection should be carried out, and the true dip angle is converted into the apparent dip angle of the tunnel section plane. The projection formula is:

$$\tan\beta 1 = \tan\beta \sin\omega \quad (24)$$

In the formula, $\beta$ 1 denotes the apparent dip angle of the stratum interface. $\beta$ denotes the true dip angle.

$\omega$ denotes the angle between the stratum interface and the profile azimuth of the tunnel. Based on the above investigation of the stratum lithology, the geological radar forward probe based on the cluster computing can be carried out near the tunnel. According to the probe result, the stratum lithology, the attitude of rock and the rock thickness investigated around the tunnel environment are combined to analyze the results of the geophysical exploration [15]and predict the lithology of the front surrounding rock. According to the new cluster computing system, the angle value of the tunnel is measured. The curve is shown in Figure 5.

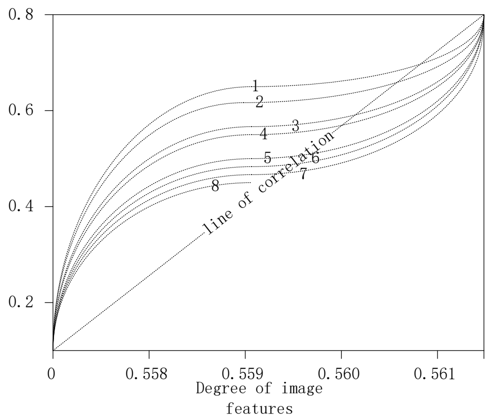


**Figure 5. The Linux Network Protocol Stack Frame.**

According to Figure 5, we can see that there is a critical angle value. The angle is constantly changing with the radar detection. Thus, we can determine the difference with the actual angle. The difference between the surrounding rock and the lithology of the tunnel stratum is compared. The rock outburst is mainly researched from the ground stress condition, the stratum lithology, the rock mass structure [16], the embedded depth and topography, the geological structure, hydrogeological condition, excavation and other factors. The research of the tunnel advanced comprehensive prediction system has received some achievements [17], but some of the system frameworks are simple and some systems have not incorporated new geophysical prediction technology into the prediction method system. Some systems have not incorporated some major engineering geological disasters during the tunnel construction into the prediction system. In general, a comprehensive and reasonable and perfect forecasting system of the tunnel combining with the geophysical prospecting has not been formed, which uses the geological analysis as the core [18].

## 3 EXPERIMENTAL ARGUMENTATION ANALYSIS

IN order to verify the practical value of the advanced prediction model of the tunnel geological radar based on the cluster computing, the following contrast experiment was designed. Taking a mine system as the sample, we took the radar signal prediction as the experimental object. One of them took the model based on the cluster computing technology as the experimental group, and the other analog digital converter was used as the control group, which was recorded in fixed time.

### *3.1 The Experimental Parameter Setting*

In order to obtain stable data contrast results from the experiment, the relevant parameters were set according to Table 2.

**Table 2. Experimental Parameters Set to the Table.**

| Parameter name | Experience group | Control group |
|---|---|---|
| MSD /（%） | 86.75 | 86.75 |
| DCF /（%） | 94.32 | 94.32 |
| CBC /（%） | 95.18 | 95.18 |
| TID /（T） | $4.65\times10^{11}$ | $4.65\times10^{11}$ |
| MSI | 0.83 | 0.83 |

In above table, the MSD parameter denoted that the detection signal of the tunnel section received by the radar. The DCF parameter denoted the detection signal of the tunnel face received by the radar. The CBC parameter denoted the detection signal of the rock received by the radar. The TID parameter denoted the detection signal of the soil structure received by the radar. The MSI parameter denoted the simulation index of the model. In order to ensure the fairness of the experiment, the parameters in the experimental group and the control group were always consistent.

Without changing the other conditions, 10minuteswas used as the experimental time, and the changes of the internal detection and signal reception in the tunnel were recorded in the cluster computing radar prediction design model and the analog digital detection system. The specific experimental data was shown in Table 3.

**Table 3.** The Tunnel Reception Table.

| Experimental time /min） | Degree of clarity of cloth fold in experimental group /%） | Degree of clarity of cloth folds in the control group /%） |
|---|---|---|
| 0 | 53.28 | 17.85 |
| 1 | 56.77 | 18.43 |
| 2 | 61.09 | 19.61 |
| 3 | 64.35 | 21.32 |
| 4 | 70.21 | 22.47 |
| 5 | 70.21 | 24.68 |
| 6 | 70.21 | 28.53 |
| 7 | 70.21 | 32.76 |
| 8 | 77.46 | 37.29 |
| 9 | 82.58 | 40.72 |
| 10 | 89.54 | 45.60 |

Comparing Table 1 with Table 2, when the cluster computing radar forecast design model and the analog digital detection system kept running, and with the increase of the running time, the signal reception ability of the experimental group showed a tendency of rising first, then stabilizing, and rising again. When the experiment time was 10minutes, the radar signal reception of the internal structure of the tunnel reached the maximum value of 69.54%, which did not reach the expected value. The radar signal reception of the tunnels internal structure in the control group showed a rising trend. When the experimental time was 10minutes, the radar signal reception of the internal structure of the tunnel reached the maximum value of 45.60%, which was lower than 23.94% of the experimental group. We used the data obtained from the above control group to draw the curve's statistic stable, and then used the frequency as the constant value to measure the ability of the analog digital detector and the cluster computing radar forecast model for receiving the mineral element signal at different times, see Figure 6:

According to the position of the element point of the radar detection in Figure 6, the comparison between the analog digital detector and the cluster computing radar prediction model was performed. The comparison of the experimental conclusion is shown in Figure 7.

From Figure 7, the advanced prediction model of the tunnel geological radar based on the cluster computing in the same time can centralize the position where the elements could exist, and the location was more accurate. The traditional analog digital detector had some deviations for the element detection. in the same time, the survey of the element points had some differences. From the comparison result of the experiment, the radar prediction model based on the cluster computing was better than the traditional model during the radar detection, which was closer to reality.

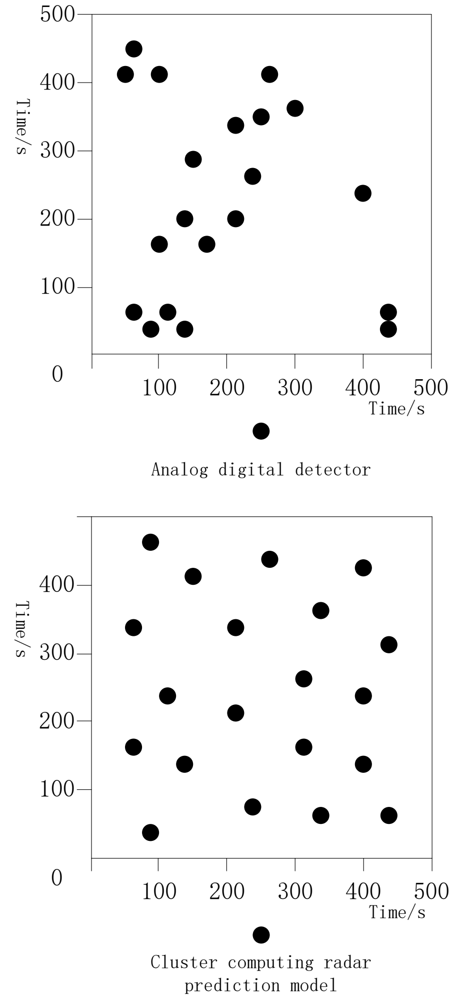


**Figure 6.** The Mineral Element Radar Signal the Receiving Contrast Figure.

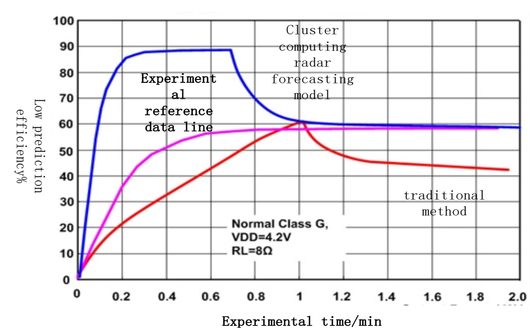


**Figure 7.** The Curve Comparison Chart.

## 4 CONCLUSION

THE new model of the radar prediction based on the computer cluster technology has made great progress in the construction of the laboratory experiment system, the configuration of the similar liquid, display and observation of tunnel interface. Through the numerical simulation of the development process of the interface in the tunnel and the receiving and detection of the radar signal, the formation and development characteristics of the radar signal can be truly reproduced. Meanwhile, it describes the development tendency of tunnel geological radar advanced prediction, which has good research prospect.

## 5 REFERENCES


Bai Hongfen, Zhu Jingwei, Qin Junfeng. Rotor position estimation algorithm of dual winding permanent magnet fault tolerant motor based on variable structure model reference adaptive control[J]. Control and decision, 2018, 33(1):27-36.

Hu Ying, Zhuang Lei, Lan Julong. Research on energy saving mapping of virtual network based on adaptive co evolution particle swarm optimization algorithm[J]. Journal of electronics and information, 2016, 38(10):2660-2666.

Li Hongmei, Yao Hongyang, Wang Ping. Online fault diagnosis and adaptive fault-tolerant control of position sensor for PMSM drive system[J]. Transactions of China Electrotechnical Society, 2016, 31(2):228-235.

Li Wei, Zhai Pengfei, Li Yajie. NCS new discrete event triggered communication and less conservative robust H_ infinity fault tolerant co design[J]. Journal of system simulation, 2017, 29(4):740-751.

Liu Zhicheng, Wang Dianwei, Liu Ying. Adaptive illumination correction algorithm based on two-dimensional gamma function[J]. Journal of Beijing Institute of Technology, 2016, 36(2):191-196.

Pei-qin fan, Liang-long da, Lu Xiaoting. For underwater acoustic field calculation of PC cluster building [J]. Computer simulation, 2007 (12): 16-19 + 44.

Ren Xiaoyu. [1] of the job management system analysis and design [J]. Computer simulation, 2003 (10): 92-93 + 136-137.

Shao Gang Jinhao, Yang Peizhong, Xian-long Jin. Visual tunnel fire simulation system development [J]. Computer simulation, 2007 (03): 198-201 + 206.

Tao Hongfeng, Zou Wei, Yang Huizhong. Robust dissipative iterative learning fault-tolerant control for multi-rate sampling process with actuator failures[J]. Control theory and Application, 2016, 33(3):329-335.

Wang Guodong, Ying Liming, Chang Yong. An improved anti-jamming adaptive algorithm and its application in active noise control of transformer[J]. Power grid technology, 2017, 41(2):656-662.

Wang Jun, Li Shuzhen, Li Wei. NCS event triggered communication mechanism and design of active and passive hybrid robust fault-tolerant control[J]. Journal of Lanzhou University of Technology, 2016, 42(6):79-86.

Wang Yufei, Tian Jingcheng, Zhuo Keqiong. Identification of PMSM moment of inertia based on improved model reference adaptive algorithm[J]. Application of motor and control, 2016, 43(8):63-67.

Wei Shurong, Huang Surong, Fu Yang. Review on fault handling and fault tolerance mechanism of permanent magnet synchronous motor and its drive system[J]. Power automation equipment, 2016, 36(10):100-107.

Xie Bin, Yang Liqing, Chen Qin. Adaptive LMMSE channel estimation algorithm in DWT domain based on EMD-SVD differential spectrum[J]. Computer application, 2016, 36(11):3033-3038.

Xie Xiaolong, Jiang Bin, Liu Jianwei. Visual tunnel fire simulation system development [J]. Computer simulation, 2008(06): 221-231+ 159.

Xu Xiangpeng, Huang Hai, Huang Zhou. Research on low frequency excitation control of micro vibration for Stewart platform based on adaptive algorithm[J]. Space control technology and Application, 2017, 43(1):36-41.

Yang Jiawei, Xu Bugong, Yang Jiawei. Distributed intelligent lighting control based on single neuron adaptive PSD algorithm[J]. Computer application research, 2016, 33(6):1834-1838.

Zhang Hongwei, Wang Xinhuan, Jing Penghui. Fault diagnosis and fault tolerant control of switched position sensor for segmented permanent magnet linear motor[J]. Journal of electronic measurement and instrument, 2017, 22(11):1745-1752.

Zhang Wei, Guowang, Yang society. Based on the cluster computing middleware RTI [J]. Computer simulation, 2006 (8): 142-145.

Zhou Kailai, Chen Hong, Sun Hui. ALFHJ: an adaptive lock free hash join algorithm for many core coprocessors[J]. Journal of Computer Science, 2017, 40(10):2404-2420.


## 6 DISCLOSURE STATEMENT

NO potential conflict of interest was reported by the authors.

## 7 NOTES ON CONTRIBUTORS

**Meng, Wei,** Doctor. Specialties; research direction: disaster prevention and control technology of tunnel and underground engineering,

**Ningxin Zhang**, A postgraduate student studying at Chengdu University of Technology. Specialties; direction: geotechnical stability evaluation.

**Yuan Tong**, Graduate student studying at Chengdu University of Technology. Specialties; disaster prevention and control technology of tunnel and underground engineering.

**Yu Song**, Postgraduate, studying at Chengdu University of Technology. Specialties; tunnel engineering disaster prevention technology.