Link Aware Routing Protocol for Landslide Monitoring Using Efficient Data Gathering and Handling System

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ONLINE FIRST

Wireless Personal Communications
An International Journal

ISSN 0929-6212

Wireless Pers Commun
DOI 10.1007/s11277-020-07169-6

Springer

Wireless Personal Communications
https://doi.org/10.1007/s11277-020-07169-6

Link Aware Routing Protocol for Landslide Monitoring Using Efficient Data Gathering and Handling System

M. S. Sumathi[1] · Gowda Sheshadri Anitha[2]

Abstract
The landslide phenomenon's has become a serious problem in Himalayan regions to killed many people and also thrashed their whole living areas. All these tragedies triggered by environment changes and gathered by sensor nodes. Due to some reasons, sensor nodes are not possible to transfer sensed data to base station. The link failure is a major problem which creates data losses in the wireless sensor networks. In this paper, we propose an efficient lossless landslide monitoring (LLM) system. The proposed system consists of two phase, such as data gathering and handling phase. In data gathering phase, we use modified gray wolf optimization algorithm for clustering technique, which provides link aware routing. In data handling phase, we use an iterative dichotomize-3 (ID-3) based decision making algorithm for landslide prediction. The proposed system tested with the five different environmental sensors, such as rain gauge, incline meter, crack meter, tilt meter, and piezo meter for gathering environmental information's. The simulation result shows that the delivery ratio of proposed LLM system is 30% higher, drop ratio is 27.5% lower, energy consumption is 11.25% lower, routing overhead is 13% lower and throughput is 19% higher than existing systems.

Keywords Link aware routing (LAR) · Modified gray wolf optimization · Iterative dichotomiser-3 (ID-3) · Lossless landslide monitoring (LLM)

1 Introduction

Wireless sensor networks (WSNs) invigorate a wide assembling of occupations, for instance, target following, home computerization and trademark checking [1]. A space of these applications may be administered or connected with the transmission of talented media data over WSNs [2]. Existing WSNs, in any case, have objectives in supporting these video/sound spilling applications in light of the contraption, for instance, cameras enough little to be showed up on sensor centers, information exchange cutoff of the structure, and

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Published online: 10 February 2020

power supplies of sensor centers [3]. The impelling advances of remote advances, indicated structures, sight and sound source coding procedures and unpalatable mechanical social event, for instance, CMOS cameras, enhancers, et cetera have pulled in the refinement in sensor frameworks, over which blended media data streams are transmitted [4]. In like way, new applications are made, for instance, sharp media perception [5], most remote inspiration driving conceivably immense activities [6], propel keeping up a key segment from [7], began restorative affiliations transport [8], modernized help for the elderly and family screens [9], and so forth.

Organization together quality is required for an unrivaled impression of the conditions, more especially, an awe inspiring thankfulness on the connection oversee plans mind blowing affiliation quality. Everything considered, an unthinkable relationship for directing needs to guarantee low centrality use, a high throughput, a low engineering overhead, and time endeavored ways when retransmissions are open [10]. Clearly, it should be responsive, figured out how to imagine short and whole approach interface threats, stable in time, extremely far affiliation quality, should rely on key estimation, or to have change predefined cutoff centers to isolate conflicting neighbors. Particular strikes [11] concentrating on the administering framework to partake in the structure, it can hurt the controlling procedure by fundamentally dropping the packs it gets for sending, i.e. denying to genuinely empower in the arranging structure. Another easily implementable strike is package change [12]. Careful ask for of controlling strikes screen the direct of their neighbors taking a gander at the good fashioned objective to audit their undaunted quality, with respect to specific lead edges called trust estimations [13]. Those sort of masterminding traditions not fitting for the profitable application like huge slide checking structure.

Flooding slides are gravitational improvements of soil or shake down affinities that can affect astounding capacity essential to structure. Particular fatalities and dire frustrated need caused by structures for lavish slides have been tended to in the midst of the time [14]. It achieved by the geotechnical instrumentations, for instance, inclinometers, extensometers, and piezometers. The instruments are once in a while showed up on the survey and wired to PC structures band together with data examination programming. Regardless, interface based looking are over the best, require dependable help, and are obliged in their correspondence flexibility [15]. To beat these detainments, remote sensor structures are an achievable elective change [16]. Front line remote flooding slide checking structures amass trademark data from the blueprint and forward it to related PC systems for picked keep [17]. The shielded information recuperation from any subset of sensors, at an optional blueprint of time, should be guaranteed and excitedly resources the merging condition, while understanding among its obsessions is meanwhile observed [18]. The remote inductor-capacitor (LC) full circuits [19] used to screen the water-content in head building material. An alternating direction of multipliers (ADMM) and a heuristic distributed linear programming (DLP) enable check [20] are other than used for relentless review. A trademark watching structure using WSN made by centrality getting, quality concerning clearing class of disturbs and unending change as showed up by the framework topology [21, 22]. A computational data count [23] used to move the goliath use in a trademark watching structure to the degree water level estimations in overpowered zones.

1.1 Our Contributions

An efficient lossless landslide monitoring (LLM) system consists of data gathering and handling phase. In data gathering, the efficient clustering technique designed by the modified gray wolf optimization algorithm, which maximize the link quality. An Iterative Dichotomize-3 (ID-3) based decision making algorithm used to improve the data handling phase.

The rest of this paper is organized as follows: Sect. 2 describes the recent works related to our contributions; Sect. 3 summarizes the problems and system model of proposed LLM system; Sect. 4 describes the detailed explanation of proposed LLM system. Simulation results are discussed in Sect. 5. Finally, the paper concludes in Sect. 6.

2 Related Works

Prabakaran et al. [24] have analyzed inside point perplexity and center thickness issues in prop indicated checking structure. The conviction joining remote and physical contraptions related with minor sensor center obsessions share with each other to plot the gatherings and the most clear obsession point go about as cluster head (CH). The party head began in light of its battery quality whose beating impacts rest of the trades. This structure obliging the errand of CH using exchange centers, for instance, participatory contraptions and the broken obsessions are seen over Poisson undertaking which watches the bobble probability without impacting correspondence and lessened resource use.

Jiang et al. [25] have proposed a dynamic converge cast tree algorithm (DCTA) in light of a tree-like topology for watching structure. The WSN estimation using the information of the got hail quality sign and skip check to really change the building structure for each sensor center point. This estimation joins a flexible booking based approach for the medium access control custom to guarantee higher transmission consistency of the sensor data. This figuring dependably gather trademark data, focal strong data move rates of the entire tried structures with various flexible obsession centers are refined. This checking structure furnished with the DCTA and outfits the standard estimations with better spatio-transient resolutions.

Reducing et al. [26] have proposed the head watching structure, which redesigned comfort and submitted quality. The social occasion of information into a specific zone was a standard errand and computerization can diminish work stray pieces. This setup approach for the thing structure required specific decisions to be made in light of commitment and data. The weighty reasons why there are a wide anchoring of ways to deal with oversee manage sort out manage engineer coordinate control complete a required driving forward quality with programming, each execution having certain focal obsessions and weights.

Wu et al. [27] have proposed a trademark checking with the data require achieved by the least mean square (LMS) twofold measure count with hail start measure by impacting the mean-square difference (MSD). An amassed principal component analysis (PCA) structure used to play out the weight and recovery for the anticipated data on the CHs and the sink. This framework reestablished the correspondence cost and looks mean square shocking and this present reality data show up and this structure focal and persevering. In like way, the measure check gives better execution concerning need exactness, alliance together speed and correspondence diminishment.

Lesta et al. [28] have proposed a ZIGBEE WSN with perpetual motes for terrestrial snail activity monitoring. The approach has been made with WSN test structure which pays staggering identity to honest to goodness conditions as an uneven space of bits clear streams amassed by the sun energized cells of the bits. An up-scaling to more fundamental living structures is conceivable to the degree hugeness and more clear houses would oblige to weave more power figuring and fittingly more apparent batteries and sun made cells in the base/facilitator bit to administer more information.

Ueyama et al. [29] proposed an adaptable and reliable wsn based system for flood monitoring system. The key issues and necessities for ensuring that an exhibited WSN system bolstered by and large fitted concentrated on structure application and contraption make. The key issues and necessities are given through the remote standard that orchestrated in the wake of sending a WSN-based stream checking structure for quite a while. The versatile approach clear by the nonexclusive structure that got with a wide remains of programming, for instance, phones and WSN center focus interests.

Muduli et al. [30] have proposed a WSN deployment scheme for environmental monitoring in long-wall coal mines. The working most remote compasses of this technique in setting of the probabilistic event zone approach for complete level of the checking zones in long-divider coal mines. The virtual power thinking related with keep the having a go at covering zones of the sensor center obsessions by gets straightforwardness of the structure. Likewise, the having effect can be settled by the probabilistic event presentation approach.

Bar et al. [31] have proposed a binary tree-based data aggregation and routing for real time monitoring system. This protocol reduces the packet loss and energy dissipation which occurs due to unsuccessful packet delivery. The joined tree based data mix out performs concerning the parameters end to end delay, sensible degree and total centrality use. This spreading out headings sensor lively, remote, zone and cloud benefits as a specific unit for solid indoor condition seeing did in the school get a couple of information about office to consider the execution concerning time and centrality utilize.

3 Problem Methodology and Network Model

3.1 Problem Methodology

Ju et al. [32] have shown a real-time monitoring network with a computer-aided early warning system (EWS) for titanic slide seeing. A four-level incited criteria structure has been joined into the changed endeavor process, and a period of star judgment is in like way included to keep up a key bundle from false alarm. The rich slide had been picked as a case application for the gave practicality. It ought to be seen that several containments should be considered in proceeding on use. To a stunning degree far unavoidably pays unprecedented identity to degrees of progress of the connection between checking information and overpowering slide event. The structure was should have been a versatile, if focal, purposes behind control can be changed by the sensible condition. The request game plan of sensible sensors for the checking structure is focal issues, which are everything considered managed by the accuracy, lifetime and bit of transmission. The notice structure messages are on a to an awesome degree critical level seen as a potential risk, not an advancing toward reliability. From exiting works [24–32], authors have mainly focused on data handling systems as well as corresponding warning system, not the data gathering phase. A real-time monitoring system according to the modern WSN is mainly affected by the data gathering phase [24, 25]. The security is a main problem, which affects the link between sensors. For this reason, a lossless landslide monitoring (LLM) system will required, so we concentrate on both data gathering and handling phase. Additionally, security is an important factor for WSNs, which breaks the link between sensor nodes when sensor nodes have limited power, computational capability, and transmission range. The limited resources nature of WSN posts a great challenge to any proposed security solution.

The proposed LLM system combines the Link aware routing (LAR) and efficient decision making algorithm. In data gathering phase, we use new constraints such as received signal strength, cooperation, and vacant rate used to compute the quality of Link. The modified gray wolf optimization algorithm used to perform clustering process. This algorithm inspired from the conventional gray wolf optimization (GWO) algorithm [33]. The clustering consists of two processes such as cluster formation, and cluster head (CH) selection. In data handling phase, we use an Iterative Dichotomize-3 (ID-3) based decision making algorithm for landslide detection with false-less results. Similar to real-time monitoring network [32], the proposed LLM system describes warning levels as 1, 2, 3, and 4. Finally, the proposed LLM system with LAR protocol based data gathering is simulated in Network Simulator (NS-2) tool and gather environmental factors such as rainfall, horizontal angle strata, vertical angle strata, displacement of strata, and the pore water pressure. Then, the gathered information's are analyzed to predict the landslide using the efficient decision making i.e. iterative dichotomize-3 (ID-3) algorithm.

3.2 Network Model of Proposed Lossless Landslide Monitoring (LLM) System

The data gathering phase performed with the different sensors such as rain gauge, incline meter, tilt-meter, crack meter, and piezometer for gathers the rainfall, horizontal, vertical angle strata, displacement of strata, and the pore water pressure respectively. The link aware routing (LAR) protocol is designed by cluster formation and CH selection. The network of proposed system consists of higher density sensors and each node embedded with real time sensors like [34]. First, frame the cluster using position and velocity. Then, compute the CH using new constraints such as received signal strength, cooperation, and path vacant rate. The proposed LAR protocol guaranteed to forward gathered environment data to the Base station (BS). Figure 1 shows the network model of proposed work.

The gathered environment factors further handled in an Iterative Dichotomize-3 (ID-3) algorithm for detect the landslides in network. The gathered factors are rainfall (mm), horizontal angle strata (degree), vertical angle strata (degree), displacement of strata (mm), and the pore water pressure (Kg/cm^2) using rain gauge, inclinometer, tilt meter, crack meter, and piezometer respectively. The gathered information from sensors is forward to the base station (BS) by the proposed LAR protocol. The gathered environment factors are effectively handled in data handling phase using ID-3 algorithm, which computes the situation of network in terms of four different levels. The level 1 describes the normal safe situation; level 2 defines the seasonal variations caused by human activity; level 3 mentions the landslide activity due to prolonged rainfalls; and level 4 defines the seasonal fluctuation, it is final/danger level. For each detection, our proposed system gives the reply like warning mark-1 for level 1; warning mark-2 for level 2; warning mark-3 for level 3; warning mark-4 and warning mail to authorized person for level 4.

4 Proposed Lossless Landslide Monitoring (LLM) System

The proposed lossless landslide monitoring (LLM) system consists of two phase, first the data gathering phase describes in Sect. 4.1 and the data gathering phase discuses in Sect. 4.2.

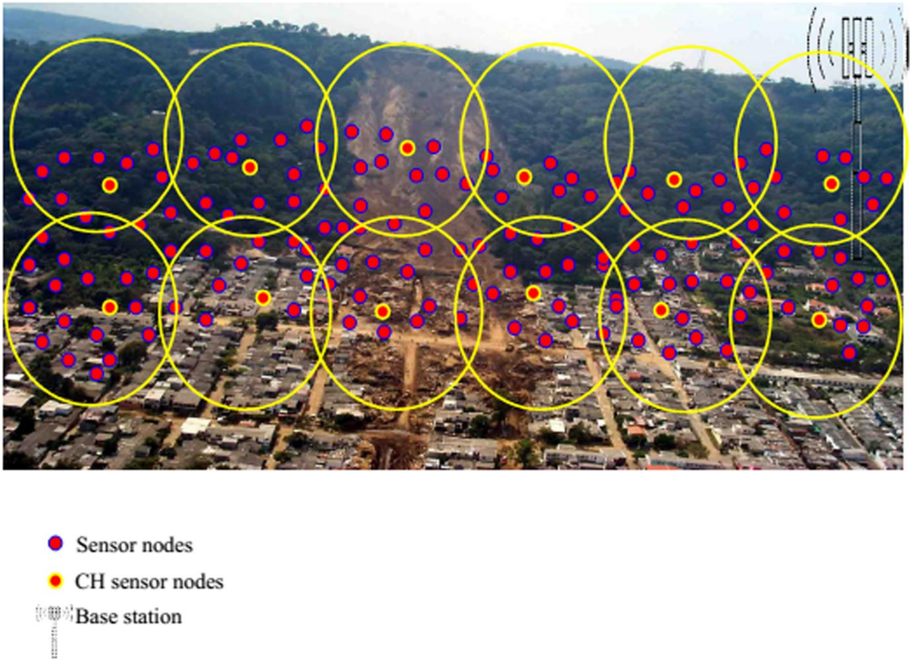


Fig. 1 The network model of LLM system with LAR protocol

4.1 Data Gathering Using LAR Protocol

The data gathering in possible networks done by the five different sensors are rain gauge, inclinometer, tilt meter, crack meter, and piezometer. The sensors equipped with the each nodes in our testing network. The data gathering will mostly affected by the link failure, which caused by the unwanted attacks. Here, we improve the data gathering process by proposing the new protocol named as link aware routing (LAR) protocol. The protocol consists of cluster formation and CH selection process. The clustering will performed by the modified gray wolf optimization algorithm, and collect performance metrics from each node such as received signal strength, cooperation, and vacant rate for compute the CHs. The path between the sensed nodes to BS is done via the CH nodes only, which defends against the attacks to reduce the data losses.

4.1.1 Clustering Using Modified Gray Wolf Optimization Algorithm

Grey wolf optimizer (GWO) [33] is another metaheuristic vivified by the drive rise structure, what's constantly the looking for after down after part found in reduce wolves. The decreasing wolf confining for after direct is general maneuvers again into three phases: following, circumnavigating and striking the prey. The balanced dull wolf streamlining virtuoso pushed from the general GWO estimation and the wolves consider the prey a zone, through an iterative structure. The figuring starts with a people of shockingly made wolves. The measure of tenants in self–self-unequivocally made wolves tends to plots. Like the lessening wolves' prompt, the measure of tenants in wolves thinks about the perfect approach through an iterative structure. The three best compass for after expert, for instance, alpha, beta and delta are used to pull in whatever is left of the cautious structure's zone. Solution tracking represents the exploration phase by attacking the prey. The wrapping conduct is numerically showed up as takes after:

$$\vec{\chi} = \left| \left(2\vec{r}_1\right) \vec{X}_p(t) - \vec{X}(t) \right| \tag{1}$$

$$\vec{X}(t+1) = \left| \vec{X}_p(t) - 4\vec{a}\,\vec{r}_1\,\vec{r}_2 - 2\vec{a}\,\vec{r}_1 \right| \tag{2}$$

where $\vec{\chi}$ pays special mind to the package between the position vector of both the prey $\vec{X}_p$ and a wolf $\vec{X}$, $\vec{r}_1$ and $\vec{r}_2$ are sporadic vectors between 0, 1 and t addresses the present cycle number. The conditions (1) and (2), a wolf can self–self-no uncertainty on the planet restore the situation in the space around the prey. The three best plans are figures as takes after:

$$\vec{\chi}_\alpha = \left| \left(2\vec{r}_1\right) \vec{X}_\alpha(t) - \vec{X} \right| \tag{3}$$

$$\vec{\chi}_\beta = \left| \left(2\vec{r}_1\right) \vec{X}_\beta(t) - \vec{X} \right| \tag{4}$$

$$\vec{\chi}_\delta = \left| \left(2\vec{r}_1\right) \vec{X}_\delta(t) - \vec{X} \right| \tag{5}$$

The other search agents are computes as follows:

$$\vec{X}_1 = \vec{X}_\alpha - \vec{A}_\alpha\left(\vec{\chi}_\alpha\right) \tag{6}$$

$$\vec{X}_2 = \vec{X}_\beta - \vec{A}_\beta\left(\vec{\chi}_\beta\right) \tag{7}$$

$$\vec{X}_3 = \vec{X}_\delta - \vec{A}_\delta\left(\vec{\chi}_\delta\right) \tag{8}$$

Then

$$\vec{X}(t+1) = \frac{\vec{X}_1 + \vec{X}_2 + \vec{X}_3}{3} \tag{9}$$

The conditions (3)–(9) can be seen that the situation $\vec{X}$ of any wolf is controlled by the condition of the three best structures. The breaking down for after down after closes by ambushing the prey, this change pays unmistakable character to the abuse makes. It is performed by lessening the estimation of $\vec{a}$, straightly from 2 to 0. This in like way diminishes the estimation of $\vec{A}$. To keep up a key district from neighboring stagnation, sporadic estimations of more massive than 1 are utilized to oblige the wolf far from the prey. This change pays astonishing identity to the examination shape. Utilizing versatile estimations of a and subsequently $\vec{A}$, which is portrayed by no absence of insurance on the planet diminishing the estimations of from 2 to 0, ensures an accreditation among examination and manhandle. This change is fit since half of the emphasess depend upon examination when $|A| \cdot 1$, while the straggling remains of the cycles is given for mishandle when $|A| < 1$. This change is one of these estimation qualities. To whole up, estimations of

|A| < 1 oblige the intrigue stars to move towards the prey while estimations of |A| > 1 oblige them to bend from it. In this check, each wolf holds an approach of N focuses that moving out of N parties. Each inside is a D dimensional vector. In like way, each wolf is tended to by a $N \times D$ vector. A people of N wolves charmingly investigate for after for the best chart of the packs. The best chart of social gatherings is reflected by the ideal spots of inside interests. These fixations are in this way used to make packs demonstrates are traded the package with closest focus. The objective function defined as follows:

$$F = \sum_{i=1}^{N} \sum_{j=1}^{M} \left\| x_{i,j} - c_j \right\|^2 \tag{10}$$

where N is the number of nodes in the cluster, M represents the number of clusters, the i-th node belongs to the j-th cluster, and c_j is the center of the cluster. For each interest head pays huge character to a method of M centers and it gives a sign on how fit this master. The fittest compass for after expert is the one related with the base estimation of F. In get-together, inside obsessions are spread to their relating parties. The standard sensibility for undertaking is performed by scarcest bundle to center. Inside obsessions are exchanged to packs make just in light of scarcest division to center; infeasible social events might be blended. The one possible approach is to fight the Euclidean bits between each inside point and the entire obsession is figured. The obsessions are scattered to the social affair in light of humblest division until the minute that the moment that cutoff control is come to. At this stage, the remaining non-clustered customers are left of the non-amassed customers will discharge necessities if allotted to any bundle. For each non-amassed customer, we figure the measure of cutoff encroachment if the customer is doled out to every party. Each non-stuffed customer is then moved to the get-together having past what clear would think about conceivable encroachment.

4.1.2 CH Selection Using New Constraints

After the cluster formation, BS collects the constraints from each node such as received signal strength, cooperation rate, and vacant rate. Then, BS computes the quality for every node, which used to fine the CH in the cluster. The sensed information's are forward to the BS via the elected CH nodes that are avoids unwanted link failure. Additionally, the higher quality nodes not easily affected by network attacks. The detailed function of new constraints as follows:

The received signal strength (R_0) is controlled by the division and transmission tremendousness, if inside point transmits data with hugeness $E\,(n,\ d)$, the middle fixations got hail quality, with the unit of D, can be passed on as takes after:

$$R_0 = \frac{E\,(n,\ d)}{4\pi D_i^2} + T_{a,a_1/a_2} \tag{11}$$

where $E\,(n,\ d)$ addresses the importance usage of a center point, which is diverging from square of section $\left(D^2\right)$ when the spread division (D) not as much as the edge void $\left(D_0\right)$, else it is with respect to $\left(D^2\right)$.

$$E(n,\ d) = \begin{cases} n \times E_{elec} + n \times \varepsilon_{fs} \times D^2; & if\ D < D_0 \\ n \times E_{elec} + n \times \varepsilon_{mp} \times D^4; & if\ D \geq D_0 \end{cases} \tag{12}$$

The distance and relative speed determine the speed accurately according to the current sampled signal strength, sample points are selected which meet constrain $\Delta t_1 = \Delta t_2 = \Delta t$, but the sample domain may have no such points. Different reference points are used to approximate nodes' actual received signal strength. The distance parameters are D_{i1}, D_{i2} and D_{i3} obtained from Eq. (4), and the modified distance is computed from the cosines laws as follows:

$$D_{i1}^2 = D_{i2}^2 + a_1a_2^2 - 2D_{i2} \cdot a_1a_2 \cdot \cos(\alpha) \tag{13}$$

$$D_{i3}^2 = D_{i2}^2 + a_1a_2^2 - 2D_{i2} \cdot a_1a_2 \cdot \cos(\beta) \tag{14}$$

The present position of center point a, is and can move to a_1 and a_2 in two reference thinks respectively. Consider $\cos(\alpha) = -\cos(\beta)$ and simply above condition to choose speed (v) as takes after:

$$2a_1a_2^2 = D_{i1}^2 + D_{i3}^2 - 2D_{i2}^2 \tag{15}$$

$$v = \sqrt{\frac{\left(D_{i1}^2 + D_{i3}^2 - 2D_{i2}^2\right)}{2\Delta t}} \tag{16}$$

The change term for versatile concentration point from current position a to the moved position a_1 or a_2 is passed on as the division $T_{a,a_1/a_2}$ secluded within point's speed and it can get by sign law as takes after:

$$T_{a,a_1/a_2} = \frac{R \cdot \sin\vartheta}{\sin\beta \cdot v} \tag{17}$$

Use Eqs. (8) into (9) and compute R_0 as,

$$T_{a,a_1/a_2} = \frac{\Delta t \cdot R \cdot \sin\vartheta}{\sin\beta \cdot \sqrt{\frac{(D_{i1}^2+D_{i3}^2-2D_{i2}^2)}{2}}} \tag{18}$$

The cooperation rate (R_1) of an inside its neighbors set is brisk enlisted from an impression of each middle point which has a place with the neighbors set of the inside point. The cooperation rate, at time between time , is gotten the hang of utilizing a weighted customary of the attestation rating factors gave by focus fixations having a place with the neighbors set of the middle. Likewise, to fulfill a certain examination of focus point practices, keep up a key section from mixed up zone in light of affiliation breaks, and certification that the fixations which are changed non-strong due to their obliged assets are not rejected from the structure, with a thought of immaterial effect on the evaluation of the last intrigue respect. The condition that enrichments finding the joint exertion rate of focus point (i) at time interim (t) and in light of a structure operation (F) as takes after:

$$R_1(i, t, F) = \sum \left(x_1(t) + x_2(t)\right) \tag{19}$$

The vacant rate (R_2) is used to compute the store of sensor center, which is gotten from investigating center point stack, basic obsession point, and enormity of focus premiums. Here, the each for the most part enchanting concentration can adaptively observe the occasion of stop up and after that exhortation the parent center obsessions to lessen the package transport rate as demonstrated by the blockage level. The vacant rate of each center is figured as takes after:

$$R_2 = v_i = \frac{\sum_{i=1}^{N} PI(P_i) - PI(P_i)}{\sum_{i=1}^{N} PI(P_i)} \tag{20}$$

where the bare rate of the node i is v_i and $V = \{v_i, 1 \le i \le m\}$ and $PI(P_i)$ is the node importance index, which computes a quantitative indicator. It can be defined by

$$PI(P_i) = \sum_{n_i \in L_{ij}^m} C(n_i) \tag{21}$$

where $C(n_i)$ looks out for the straightforwardness degree takes after how closed inside point is to its neighbors. Here, we use an expanding probability to address the transparency degree. It can be gotten by

$$C(n_i) = \left|\sigma_{ij}(n_k)\right| \tag{22}$$

where $\sigma_{ij}(n_k)$ represents the edge number from n_i to n_k on node L_{ij}. The Eqs. (11), (19), and (20) used to compute the quality of each node. The maximum quality owned node selected as CH in the cluster. In this paper, the Rosenbrock function used to compute the quality (F_q) of sensor nodes as follows:

$$F_q = \sum_{R=0}^{3} \left[100\left(x_{R+1} - x_R^2\right) + \left(x_R - 1\right)^2\right] \tag{23}$$

Then, select the CH by

$$CH = \max\{F_q\} \tag{24}$$

The sensed environmental information's forwarded only via the CH node to reach the BS, and it forward to the data handling system.

4.2 Data Handling Using ID-3 Based Decision Making Algorithm

The gathered environment factors are effectively handled here to compute the critical situation in network. For every second, the system updates the results in terms of warning levels 1, 2, 3, and 4.

The level 1 traces the standard safe condition; level 2 portrays the general mixes caused by human progress; level 3 says the rich slide action due to surrendered rainfalls; and level 4 delineates the wide insecurity (risk level). Iterative Dichotomiser 3 (ID-3) tally is the information depiction estimation. In this paper, we utilize ID-3 for essential affiliation reason. The probability of the ID-3 is to disperse dataset into a picked number of subsets that are practically identical to the measure of above delineated levels. Each level has one of the subsets as an information subset; the ID-3 tally is then connected with all subsets in the interim. Each datum subset is inspected against the related level. The figuring produces two yields are one yield is a diagram of cases, I1 that really has a place with the related level, and the second yield is an approach of occasions, I2 that does not have a place with the related level. I2 is then moved to another level as another data dataset, and an in every way that really matters unclear structure is rehashed until all occasions that have a place with I2 are checked on against all levels. At last, an ensuing association believing is associated with the subsets I1 for each level, which passed in each steps. Let see the yield of estimation is a strategy of levels depicted as takes after:

$$L = \{l_1, l_2, l_3, l_4\} \tag{25}$$

where l_1, l_2, l_3, l_4 represents the defined warning levels. Assume that the input test data (T) for this decision making algorithm. The data set consists of gathered environment factors are

$$T = \{t_1, t_2, t_3, t_4, t_5\} \tag{26}$$

where t_1, t_2, t_3, t_4, t_5 is the testing factors rainfall, horizontal/vertical angle strata, displacement of strata, and pore-water pressure. Test data (T) is decomposed into several subsets as follows:

$$T(s_i) = T(s_1) \cup T(s_2) \cup T(s_3) \cdots \cup T(s_n) \tag{27}$$

where s_i is the test sets for verify the system model with a group of input factors.

The defined levels and a determined test data when applying the ID-3 algorithm, the functional model of each constraint is depends on the time varying function T as follows:

$$\forall\, v, \text{ constriant } (x_v) \tag{28}$$

where x_y is a standard occasion on the off chance that it has a place with the picked levels. The yield of ID-3 check will be an approach of sets (x_y, L); where L is between [1, 4], the level 1 looks out for the necessities are standard, level 2 watches out for the standard strategies caused by human progress, level 3 passes on advancement saw due to surrendered rainfalls, and level 4 is the last risk one. The yield of the ID-3 test information can also be described as follows:

$$T_{output} = T(l_1) \cup T(l_2) \cup T(l_3) \cup T(l_4) \tag{29}$$

where $T(l_1)$ represents the normal environmental factors denoted as level-1, $T(l_2)$ represents the pair of variations in small and denotes as level-2, $T(l_3)$ represents the pair of variations in defining vectors and denotes as level-3. $T(l_4)$ represents the pair of variations with the all determined network belongs to level-4. The test data can be defined as follows:

$$T(l_1) = \{\langle x_v, 1\rangle \mid \langle x_v, 1\rangle \in T_{output}\} \tag{30}$$

$$T(l_2) = \{\langle x_v, 2\rangle \mid \langle x_v, 2\rangle \in T_{output}\} \tag{31}$$

$$T(l_3) = \{\langle x_v, 3\rangle \mid \langle x_v, 3\rangle \in T_{output}\} \tag{32}$$

$$T(l_4) = \{\langle x_v, 4\rangle \mid \langle x_v, 4\rangle \in T_{output}\} \tag{33}$$

The classification of each testing factor x_v, whether it is a level 1, 2, 3, or 4, performed using a threshold rule. Here, we follow the threshold value of sensor nodes as per in [34] and forward the reply as warning messages in terms of one punctuation mark for Level-1, two punctuation mark for Level-2, three punctuation mark for Level-3, four punctuation mark for Level-4 with the warning mail to the authorized person. The working function of LLM algorithm is given in Algorithm 1.

Algorithm 1: Lossless landslide monitoring (LLM) system	
Input: Number of populations, control variables, and Population size **Output:** Set of clusters, CH, and level detection	
1.	Initialize the position of node.
2.	for each search agent
3.	Calculate the distance between every node and all centers.
4.	while the node not assigned
5.	Assign node to it is nearest center
6.	end while
7.	end for
8.	for i =1 to n
9.	for j = 1 to k
10.	R_0 (P_i, C_j) = Compute (Received signal strength between node i and j)
11.	R_1 (P_i, C_j) = Compute (Correlation rate between node i and j)
12.	R_2 (P_i, C_j) = Compute (Vacant rate between node i and j)
13.	Calculate quality (q) of node using Rosenbrock function (23).
14.	end for
15.	end for
16.	CH=max (q)
17.	Define the set of input test data T, and element of test set t_1, t_2, t_3, t_4, t_5
18.	for each (N, x_v)
19.	apply ID-3 using equations (30)-(33)
20.	Level= T_{output}
Return: Cluster, CH, and Level	

Table 1 Simulation parameters

Parameter	Value
Network size	1000×1000
Number of nodes	50, 100, 150, 200, and 250
Number of attacks	2, 4, 6, 8, and 10
Traffic source	CBR
Radio range	50 m
Radio mode	First order
Deployment type	Random model
Data rate of node	512 bits/s
Data packet size	64 bytes
Simulation time	1000 s

Table 2 Simulation scenarios

Scenarios	Number of nodes	Number of attack	Attack name/count
1	50, 100, 150, 200, 250	–	–
2	100	2, 4, 6, 8, 10	
		2	DoS-1, Blockhole-1
		4	Block hole-2
		6	Wormhole-2
		8	DoS-2, Block hole-2,
		10	Grayhole-2
			DoS-2, Block hole-2, Wormhole-2, Grayhole-2
			Block hole-4,
			Wormhole-3, Grayhole-3

5 Simulation Results

The proposed LLM structure joins two phases, the data gathering stage repeated in Network Simulator (NS-2) instrument and data controlling method made in Net Beans IDE 8.2. We consider the five particular sensors are set up in an inside point. The sensor revolves are passed around in a framework with a size of 1000×1000 m^2. The measure of center obsessions in the given structure is changed by 50, 100, 150, 200, and 250. The radio level of sensor center point is 50 m with the key deal with radio model. The BS is created in the left side corner of the sensor field. The data rate of each inside point is 512 bits/s. The concealed centrality level of each inside point is 10 J. The data package size of each inside is 64 bytes. The reenacted movement is constant bit rate (CBR). The reenactment parameters and states of proposed LLM structure is given in Tables 1 and 2. The essential testing circumstance we move the measure of center obsessions by 20, 40, 60, 80, and 100. In second, we disengage the measure of ambushes by 2, 4, 6, 8, and 10 with settled number of center obsessions as 100. The total redirection will take the season of 1000 s. The execution of proposed LAR custom is separated and the present traditions in terms of delivery ratio, energy consumption, routing overhead, and throughput.

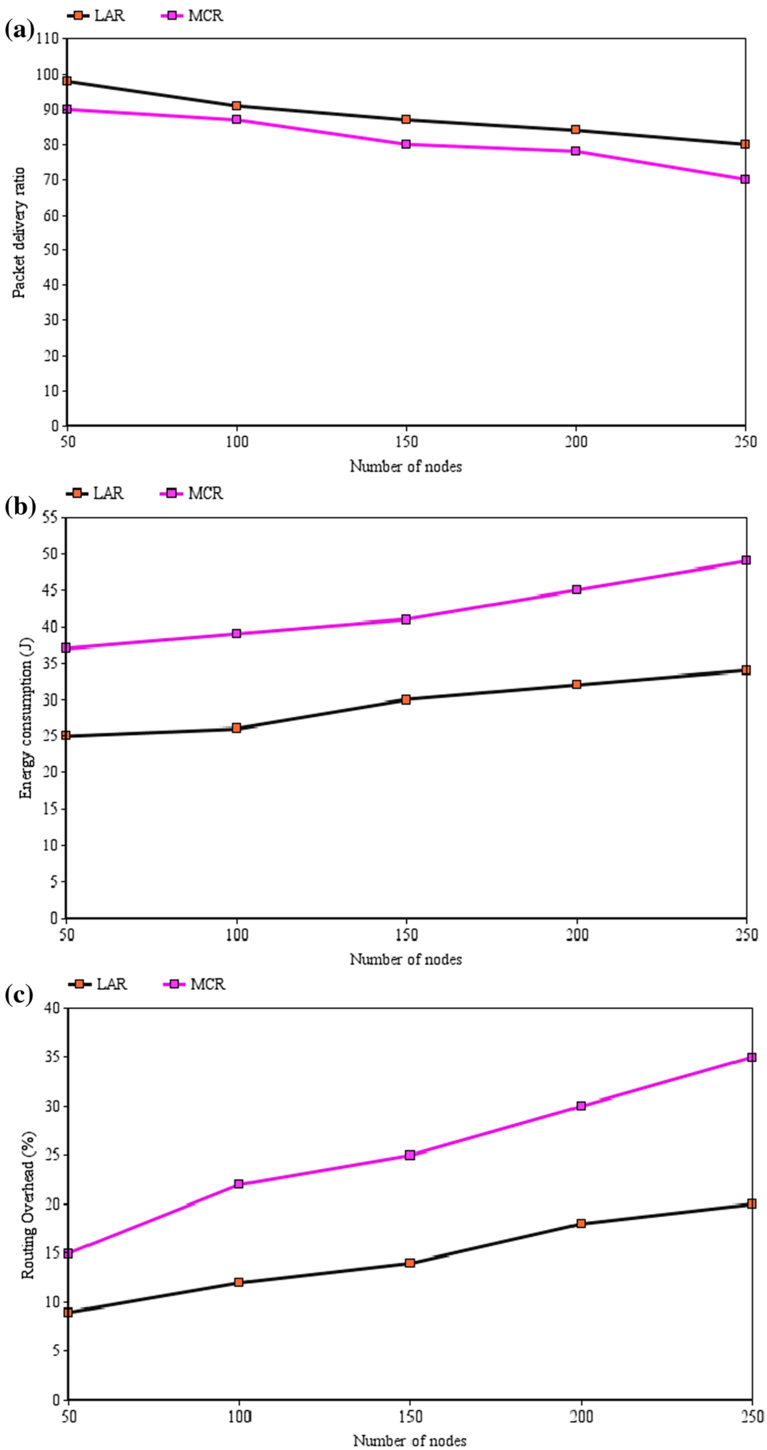


Fig. 2 Performance analysis with varying the number of sensors **a** delivery ratio, **b** energy consumption, **c** routing overhead, and **d** throughput

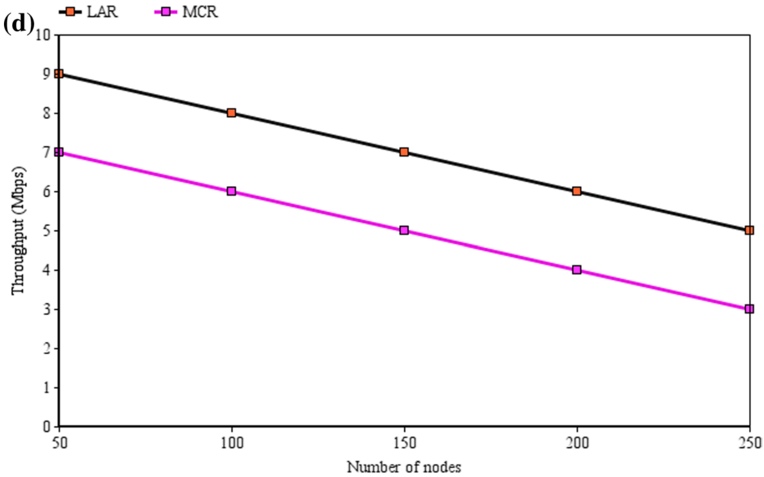


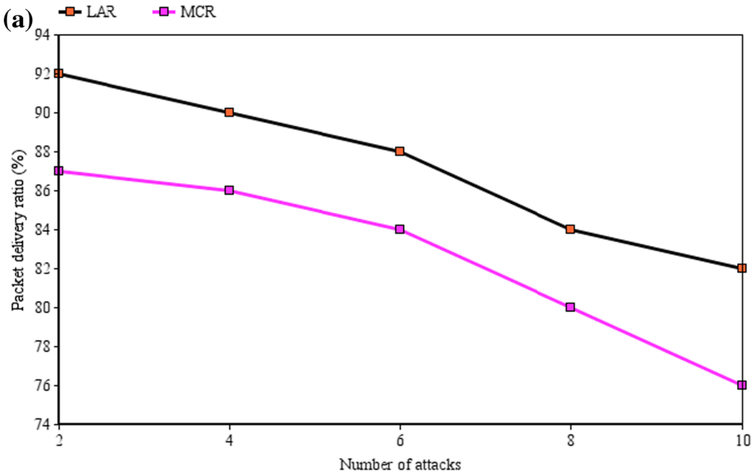
Fig. 2 (continued)

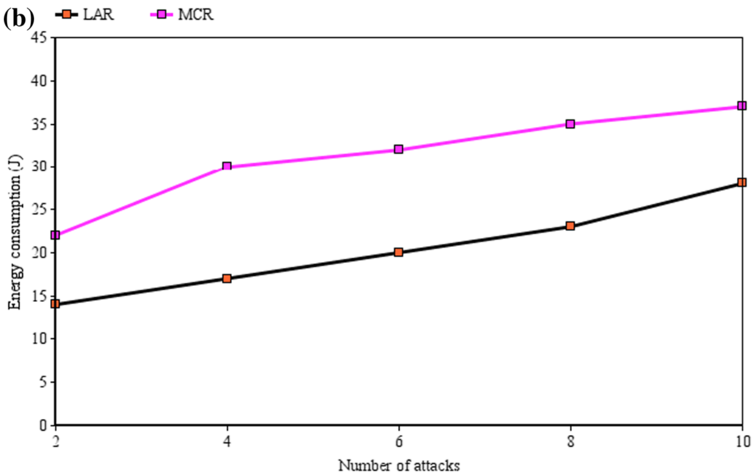
5.1 Varying Number of Sensor Nodes

In this condition, we enlist execution estimations with settled structure study as 1000 × 1000 m^2 area. We are moving the measure of nodes as 50, 100, 150, 200, and 250. Figure 2a demonstrates the delivery ratio of proposed LAR custom and existing MCR sorting out [35]. The plot plainly charts the delivery ratio of the proposed LAR convention is superior to anything existing custom for various number of sensors working in the system topology. Figure 2b demonstrates the energy consumption of proposed LAR custom and existing MCR masterminding [35]. The plot verifiably depicts the energy consumption of the proposed LAR convention is superior to anything existing custom for various number of sensors working in the structure topology. Figure 2c shows the routing overhead of proposed LAR convention and existing MCR dealing with [35]. The plot undeniably depicts the routing overhead of the proposed LAR custom is superior to anything existing convention for various number of sensors working in the structure topology. Figure 2d displays the Throughput of proposed LAR custom and existing MCR controlling [35]. The plot unmistakably portrays the Throughput of the proposed LAR convention is superior to anything existing custom for various number of sensors working in the structure topology.

5.2 Varying Number of Attacks

In this condition, we process execution estimations with fixed network size as 1000 × 1000 m^2 zone. Figure 3a demonstrates the delivery ratio of proposed LAR custom and existing MCR orchestrating [35]. The plot certainly charts the delivery ratio of the proposed LAR custom is superior to anything existing convention for various number of sensors working in the structure topology. Figure 3b demonstrates the energy consumption of proposed LAR custom and existing MCR masterminding [35]. The plot certainly portrays the energy consumption of the proposed LAR custom is superior to anything existing convention for various number of sensors working in the structure topology. Figure 3c shows the routing overhead of proposed LAR convention and existing MCR designing [35]. The plot unquestionably diagrams the routing overhead of the proposed LAR custom





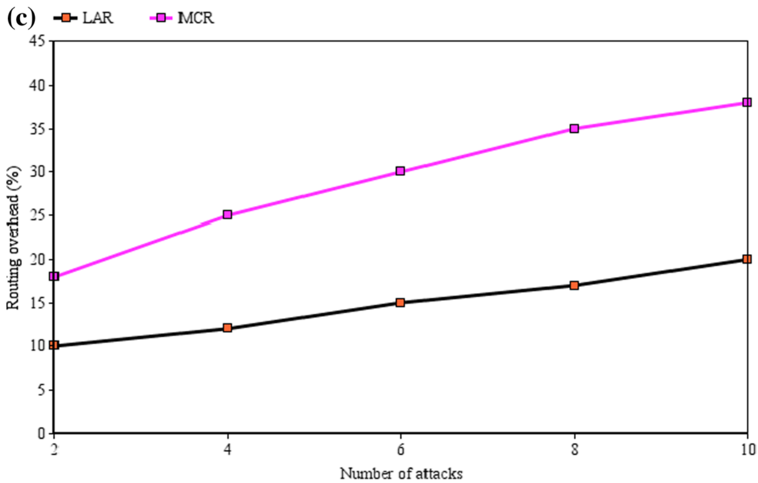


Fig. 3 Performance analysis with varying the number of attacks **a** delivery ratio, **b** energy consumption, **c** routing overhead, and **d** throughput

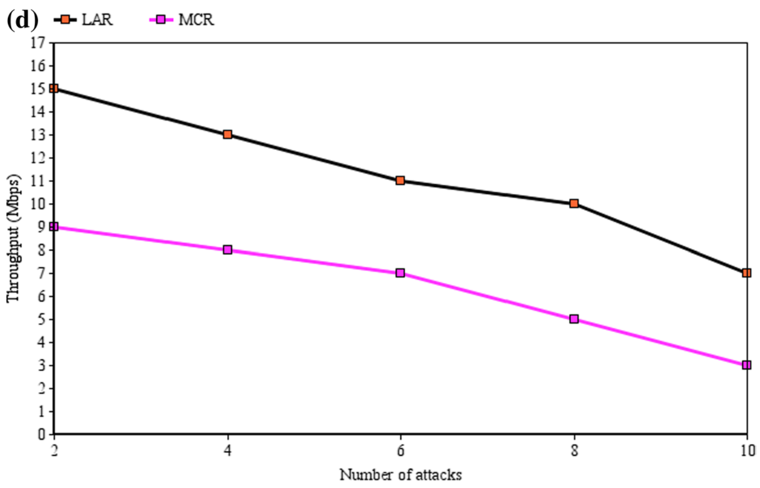


Fig. 3 (continued)

Table 3 Test data of a single sensor node

Time (s)	Rain gauge (mm)	Tilt meter (degree)	Inclinometer (degree)	Crack meter (mm)	Piezometer (kg/cm^2)
11:54:00	9.5	−0.3102	−0.10709	5.451275	0.2770603
11:54:10	9.8	−0.31094	−0.10644	5.430,952	0.2710104
11:54:20	9.5	−0.31145	−0.10452	5.483812	0.2725643
11:54:30	9.8	−0.3122	−0.10608	5.452247	0.2766139
11:54:40	9.5	−0.31023	−0.10529	5.492191	0.2799158
11:54:50	9.2	−0.31099	−0.10877	5.436885	0.2713724
11:55:00	9.4	−0.31241	−0.10708	5.447316	0.2753404

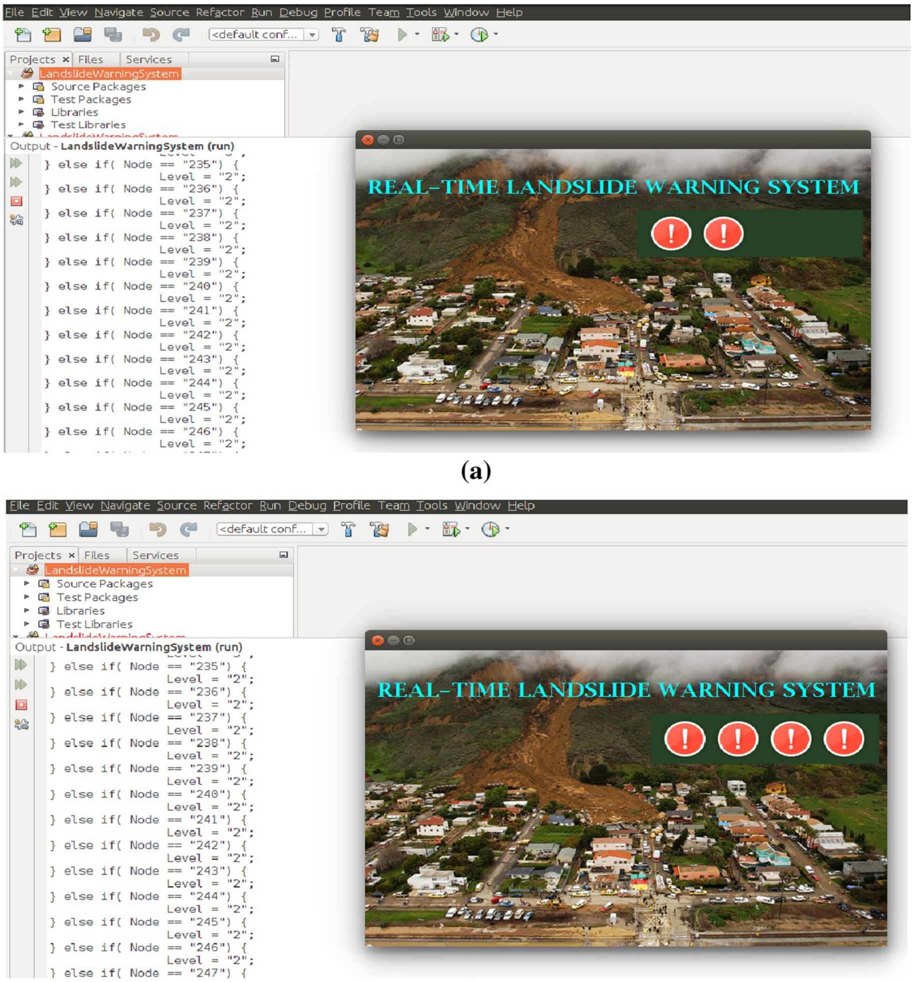
is superior to anything existing convention for various number of sensors working in the structure topology. Figure 3d demonstrates the Throughput of proposed LAR custom and existing MCR planning [35]. The plot clearly delineates the Throughput of the proposed LAR convention is superior to anything existing custom for various number of sensors working in the system topology.

5.3 Result of Data Handling Phase

Initially data were received at an interval of 10 s and subsequently it changed to a minute to reduce the storage capacity. Rainfall, vertical angel, horizontal angel, slope displacement and pore pressure have gathered by rain gauge, tilt meter, in-place inclinometer, crack meter, and piezometer, respectively. Example test data of a single sensor node with 11:54:00 to 11:55:00 is given in Table 3. The proposed LLM system detects the landslide for test data from Table 1 and produces the result as given in Table 4. The proposed LLM system forward the messages in terms of one punctuation mark for Level-1, two

Table 4 Landslide detection for test data form Table 3

Time (s)	Rain gauge (mm)	Tilt meter (degree)	Inclinometer (degree)	Crack meter (mm)	Piezometer (kg/cm^2)	Levels
11:54:00	9.5	−0.3102	−0.10709	5.451275	0.2770603	3
11:54:10	9.8	−0.31094	−0.10644	5.430952	0.2710104	2
11:54:20	9.5	−0.31145	−0.10452	5.483812	0.2725643	2
11:54:30	9.8	−0.3122	−0.10608	5.452247	0.2766139	3
11:54:40	9.5	−0.31023	−0.10529	5.492191	0.2799158	3
11:54:50	9.2	−0.31099	−0.10877	5.436885	0.2713724	2
11:55:00	9.4	−0.31241	−0.10708	5.447316	0.2753404	2



(a)

(b)

Fig. 4 Screenshots of warning signal **a** Level-2 detected **b** Level-4 detected

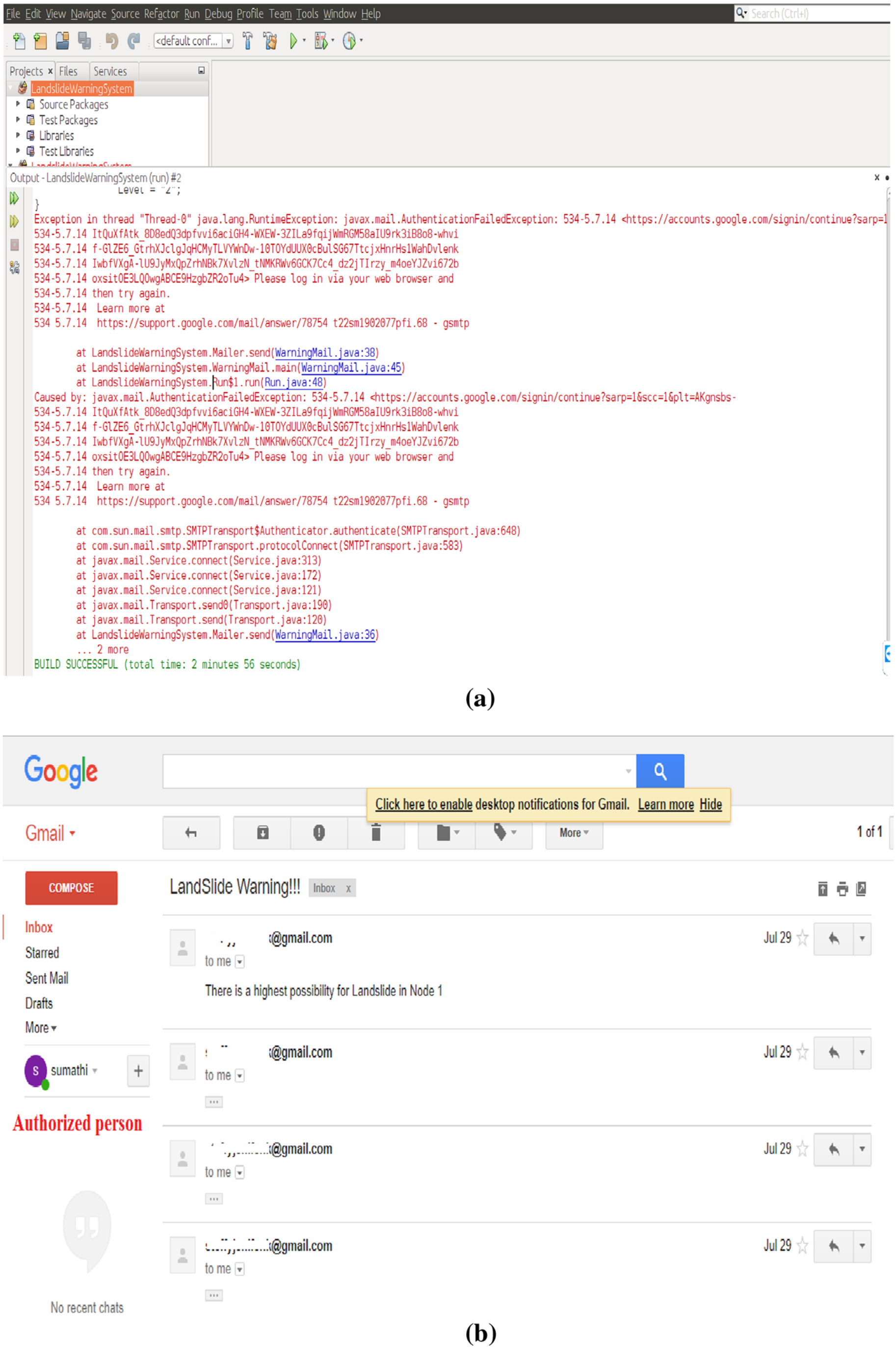


Fig. 5 Warning mail **a** mail forward from sender **b** mail received at receiver

punctuation mark for Level-2, three punctuation mark for Level-3, four punctuation mark for Level-4 with the warning mail to the authorized person. The screenshot of warning signals are taken from Net Beans IDE 8.2 and shown in Fig. 4.

Due to increase in pore water pressure, the landmass starts displacing from its original location and in turn triggers the landslide. When other triggering factor i.e. displacement of masses/inclination of natural slopes reaches or exceeds the threshold of crack meter, threshold of Tilt meter or in-place inclinometer, respectively along with threshold of rain gauge and piezometer, the system shows a red punctuation symbol representing a greater chance of occurrence of landslide. During this level, local people to be alerted about the occurrence of landslide by alert emails to concerned authorities. The resultant Net Beans IDE 8.2 screenshots of warning mail transmission form sender and the received by receiver is shown in Fig. 5.

6 Conclusion

In this paper, we have proposed a lossless landslide monitoring (LLM) system using efficient data gathering and handling process. The modified gray wolf optimization algorithm used to form the clusters and the new constraints used to compute the cluster head (CH) node, which provides the link aware routing (LAR). The Iterative Dichotomize-3 (ID-3) based decision making algorithm used to predict the landslides in gathered information's. For the simulation setup, five different sensors such as rain gauge incline meter, crack meter, tilt meter, and piezo meter are embedded with each node. The simulation result shows our proposed LLM system performs very better than existing system. In future, we enhance our data gathering phase by optimization algorithm to enhance the quality of data collection to ensure the landslide monitoring system.

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