A Comparative Study of Single VS Cluster Verification Approaches for Crowd Management: A Pilgrimage Case Study

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Summary
The verification of massive crowd has become an important factor to avoid or to stop the entry of illegal and un-authorized people without compromising the speed or efficiency. The crowd is required to verified in a short specific time but as we make a tough verification criterion, it increases the crowd verification time. If we go without verification or random verification, increase the percentage of illegal entries. Therefore, to handle a massive crowd with verification during specific time period (Hajj and Umrah) became a big challenge. The advance and new methods are used to make the verification process fast especially in case of massive crowd. To make the verification process fast at public places, advance technologies such as WSN, IoT, Cloud Computing etc. are used. In the same way different methods of verification are used such as biometric, face recognition, voice recognition, scanning etc. In this paper, we collected data to calculate minimum, maximum, average verification time by well planned interviews and observations for the existing approach. We have presented a cluster verification approach that leads to optimal verification time in cluster form. A preliminary analysis is done in between current verification approach and cluster verification approach. Simulation results shows that cluster verification along with proactive support has minimized the verification time that will increase the performance for crowd verification.

Keywords:
Wireless Sensor Network, Crowd Management, Massive Crowd, Cluster member, Cluster Verification, Verification Time

1. Introduction

Crowd has a sense of press, push, or hurry therefore if there are enough people, they feel pushed together that is called crowd. To avoid crowd at public places there must be enough space, so the people do not face the problem. At public places density of the crowd is increased if there is a need of verification and identification. We cannot stop the people, but we can reduce the crowd by fulfilling the requirements of verification in short time so that people move to their next destination. Different automated methods are used to verify document, face recognition, or database checks, but these are not enough if there is a massive crowd. Verification becomes a tough job if verification is done at airport for massive Hajj crowd as it required a number of steps (to verify document, face recognition by immigration, database checks, pasting of sticker and border number are written) in limited time frame. In such public places if verification is not performed quickly then crowd will increase with the passage of time. To reduce the verification time at public places different technologies and approaches have been used. We have studied the existing verification approach and we have taken the Hajj as use case. As usually at public places verification is done in the queue form such as during the vote casting, getting into stadium, at checkpoints etc. Especially during the Hajj verification of the pilgrims is different than other airports as sticker is pasted and border number are written run time on the passports which is a time-consuming process. At airport, passports of pilgrims are taken by the company that is responsible for the pilgrims. In short there are multiple challenges, owned by such packed events, which can be focused by state-of-the-art technologies. In this research, we calculated time for the existing approach by conducting the well plan survey (interview) and observation for three countries. We intent to use of available technologies according to the nature of the problem and we proposed a cluster verification approach to verify the pilgrims at airport in the form of group. Our results show that by using this approach verification time can be optimized.

2. Theoretical Consideration

Overcrowding normally occurs in the public areas like a train station, airport, stadium and the pilgrimage zones. Such gatherings may cause injury or loss of life. Therefore, in [1] it has been discussed essentials for mob to maintain the safety. Moreover, it has always been an important concern to enhance the performance of buildings and structures, in order to monitor and manage the crowd. The crowd, crowd density, crowd issues, and crowd management are defined. An area representing more than one person having a homogeneous and coherent motion is called crowd element [2]. The two ways have been defined by [3] for safety limit with crowd density, primarily for moving crowd, secondly for standing or static crowd. Density for a mobile crowd is defined as 40 individuals per 10 square meters and for standing or static areas 47

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individuals. The authors in [4] estimated time for stoning for each pillar to observe the temporal and spatial movement within Jamrart area. In research and industry, dynamic crowd management has significant focus of researchers. In [5] authors have discussed the main objective to control large public places to manage large scale events where massive crowd of people at high densities are existing.

Very few crowd behaviors models have been used practically among the many models in order to assist crowd management. This practical limitation is partially due to a variety of circumstances that involved to management crowd such as capabilities in forestalling, sense-making, observing and acting [6]. Research has been done by [7] to develop an application to find out the locations of Hajj rituals for pilgrims. The application has been developed in perspective of the management authorities not for the pilgrims. The research has worked in [8] for the collaboration of the organizers and the research so that researchers understand the Hajj events and different scenario and provide efficient and reliable solutions for different scenarios. A work has been done by [9] using sparse-scale convolutional neural network (SS-CNN) to detect human heads and dense-scale convolutional neural network (DS-CNN) to generates dense scalemap. The dense scalemap is used to generating scale-aware proposals by using exceptional property that it captures all scale variations in image. A divergence localization method has been introduced in [10] that identify the divergence point along with its size of divergence in the moving crowd. A multi-scale and multi-level features aggregation network (MFANet) has been represented in [11] to count the crowd in accurate and efficient way. Research has been done by authors in [12] to compare static and dynamic exit selection models for crowd evacuation. They have studied the dynamic exit selection model and its effects on group size and group shape on the evacuation time. An abnormal crowd behavior has been studied by [13] from online Hajj footage by using the computer vision and machine learning. The adaptive co-training technique has been used to adapt to scene changes in Hajj crowd. An investigated has been done by authors in [14] for billions of devices that can collect, disseminate, calculate, and potentially trigger.

The clustering algorithm is a series of steps used to make the cluster or group of the objects or sensor nodes to do the task efficiently. Research has been done by authors in [15] to measure the pedestrian by capturing the image from surveillance cameras. Machine Learning technique of the Boosted Regression Trees has been used to estimate the density of the pedestrian at crowded areas. WSN will be beneficial when sensor data will be added to blogs, social network applications and virtual communities. Before shifting data into the cloud, traditional high-performance computing approach may be substituted or find a place in the manipulation of data. Requests from the users will be entertained via three layers of service Infrastructure-as-a-Service (IaaS), Platform-as-a-Service (PaaS), Software-as-a-Service (SaaS). Primarily, either by creating a live query to the accompanying network of the sensor or secondly, from the archive which is made from WSN to Data Centers (DC) by collecting data periodically [16]. A large-scale concurrent data anonymous batch verification scheme has been used that verified the data in [17] batch that is generated by different users. Authors have investigated in [18] that there is no relation between the exit width, obstacle size, obstacle shape and obstacle distance in the evacuation of the crowd. A concurrent residual neural network (ResNet) technique in [19] has been used to identify the person without determine the true identity with the help of multivariate kernel density estimation matching algorithm. From crowd images, a specific identity of an individual face has done in [20] by using face detection and verification phases. Vehicle reidentification and abnormal event detection has been discussed in [21] to solve the traffic flow problem by using spatial verification and vehicle detectors for anomaly. A streak line-based fluid mechanics has been used in [22] with high accurate variational optical flow model to identify the crowd behavior in different types of scenes and scenarios. The deep-rooted learning technique has been used in [23] to detect the violence detection in crowd movement by using object recognition, action recognition and crowd analysis. Traditional approaches to data management will be challenged by streams of data coming from billions of devices. These include Sensor data and related context capturing techniques, federating sensor networks, archiving, storing, and processing of received data from sensors. Previous work focused on the use of new devices and methods mostly, but the comprehensive and structured approach is seldom focused by them with the purpose of increasing efficiency and safety [24]. In Mobile Crowd Sensing (MCS), cross validation mechanism has been used in [25] that just required the lightweight “plug-in” for practical adoption.

As the number of devices are increasing on the net, the huge amount of data that can be sensed, communicated, computed and stored that issue is investigated in [26]. Adaptive clustering protocol is used in CDC approach, in this approach cluster head (CH) has main responsibility to handle the data. To solve the storage problem one of the algorithms named as distributed data collection algorithm is presented by [27]. Apart from the positive economic and social merits of drawing people together, there are negative effects of massive crowd. Basic needs of humans should be considered by health authorities, including sufficient public toilets, potable water, adequate refrigeration for the preservation of perishable foodstuff, the supply of bulk foodstuff by approved and recognized suppliers to the food providers, management and disposal

of liquid and solid waste and curb of insects and rodents affecting health [28]. A cluster verification technique has been used in [29] to discuss different scenarios to calculate the verification time in a group.

Simulation tools are playing their important role to study sensor webs and to test new protocols and their applications for wireless sensor networks in this developing research field. Most of the verification approaches are using a number of verification steps along with single or queue form verification therefore existing approaches are incapable to verify the crowd in limited time period. To reduce the verification time, we proposed cluster verification approach to solve the above problem.

3. Current Approach for Crowd Verification

Fig. 1 represent the current approach for verification of the pilgrims at their arrival at airport. The crowd verification is also in queue form at different checkpoints. As we know the religious crowd has a time constraint after that these events or prayers cannot be performed.

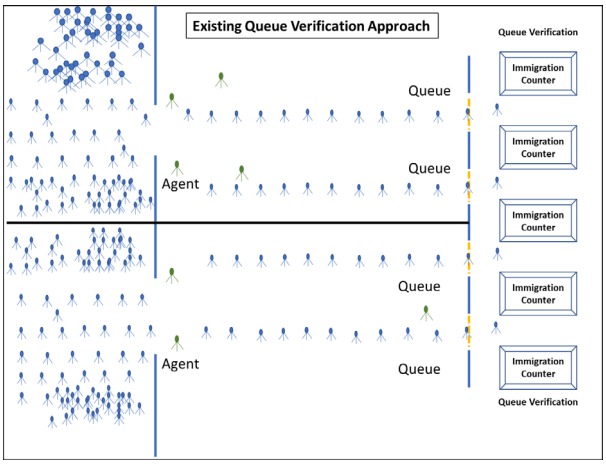

Figure 1: Existing verification approach

For example, event of Hajj once in a year in a specific date but Umrah can be performed almost in the whole year. At some points we cannot let the pilgrims go without verification such as airport or crossing the border of a country. But in some cases, we can do random verification or let the people go without verification such as crossing the city border random checking but crossing the places of Hajj places (Al-Mushier) without checking. But in the case of checkpoints the verification is done randomly, which is a tiresome job and increases the chances for unverified (unregistered) pilgrims to cross the checkpoints. The random verification is done because it takes a lot of time to verify Hajj crowd individually. In case of the huge crowd, it is difficult to perform verification according to the existing approach. To overcome the problem of crowd verification, cluster verification approach is proposed which supports crowd verification in cluster form and has the CMs, CH, servers with pre-stored data. As we experience many times the process of verification at the airport. Long queues and long waiting time and disorder perhaps cause more pain for elderly people, female and children. Although scanner and biometric machines are used for verification process that provides the maximum surety of verification. But on the other side this verification process takes more time specially when there are large crowds, the efficiency of the immigration staff become slow with the passage of time being a human they need rest and cannot work as fast as machine. Sometimes scanner is unable to read the barcode for document and as well biometric machine unable to identify the fingerprints. In queue verification processing, all the group members not sure that they are in one queue. If they are in different queues, they worried about their group fellows not visible to them. A high percentage of Hajj crowd is uneducated, untrained, travelling first time, or health condition is not good specially in case of three countries Pakistan, India and Bangladesh. These reasons also causing delay in the crowd verification process. To overcome such problem, we think about cluster verification approach.

4. Proposed Cluster Verification Approach

The proposed cluster verification approach is an idea to optimize verification time for a crowd by dividing the crowd in cluster or group form. This approach feature with the capability of the collect the data before verification and perform the verification in the cluster form.

I. In Fig. 2, the proposed crowd cluster verification is shown. The proposed crowd verification processing steps at the airports as use case are:

a) On the arrival of the pilgrims, already indexed CM devices will be hand overed to the pilgrims and passport will be taken with respect to schedule of flights.

b) Verification of pilgrims from CMs to CH

c) In the next step, verification of pilgrim in group or cluster form from CH to server

II. According to the Tab. 1, steps vi and viii will be done at step v in the proposed approach. Steps vii, ix, and x will be done because of prestored data. Steps xi, xii and xiii will provide help because of verification is already done and record is updated on the system.

III. Although much more improvement has been done in the field of WSN but still there is a need of improvement. But WSN devices have limitations because of economic and technology reasons, such as communication capabilities storage, processing power, and efficiency. The various industries have shown the interest to development multifunctional sensor for different applications considering low-cost and low power. To develop organizational structure among such low cost, low power and multifunctional WSN devices is one of the

researches [30].

IV. Telecommunication, Internet and other network devices along with WSN can play vibrant role to sense, collect and process massive amount of data globally to get required results [11].

V. If proposed approach is unable to verify the whole crowd in a specific time period, then it can be implemented at the part or nature of the crowd where it is compulsory or more helpful.

4.1 Use Case and Operational Phases

The Companies inside the kingdom are responsible to make correspondence with companies of different countries to complete the applications process for Hajj, Umrah or visit. Each company will make the correspondence to their country fellows (pilgrims) to complete visa or permit, tickets and booking plan for hotels. The companies will provide the documents to the concern government department or authority for pilgrims under their supervision. The concern government department or authority will register the sensor device for each approved applicant.

The phases involved are given below:

- Senor Registration
- Sensor Dispatching

i. Dispatching to Ministry of Hajj in the concern country OR

ii. Dispatching to the city offices defined by different Hajj companies OR

iii. Dispatching on arrival at airport by passport and sensor device interchange

- Clustering or Group Formation
- Cluster Sensing and Verification.

In the first phase, after the application has been approved, a sensor device will be registered against each successful applicant (pilgrim). This registration of sensor device will be done by the concern government department or authority. These sensor devices can be dispatched to the pilgrims by using different options. For Example, on arrival at pilgrims' camp or departure airport from their country of origin, in ministry of Hajj or on arrival of destination airport or at their hotels. On arrival at airport of destination, each pilgrim will be verified, and passport are replacing with sensor device. The pilgrim is forwarded to the group formation area. In the group formation area, the data for each CM (pilgrim) will be collected by the CH or GH device. If any pilgrim's sensor device is unverified then that pilgrim will be forwarded to the special dedicated immigration counter for existing verification approach. As all CMs (pilgrims) are verified by the cluster or group head (CH or GH) device. Now in the next step under the supervision of CH, all CMs will be taken to the immigration counter. The verification will be done by the immigration in the form of cluster or group from CH or GH at once. Next at any checkpoint data will verify and updated by CH, as CH head is responsible for CMs.

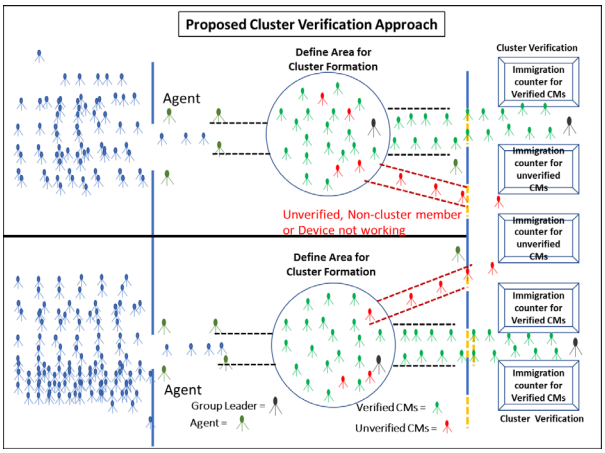

Figure 2: Proposed cluster verification approach

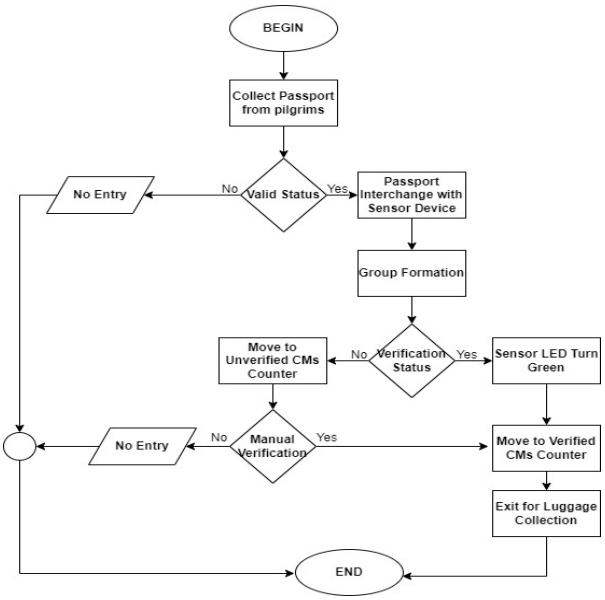

Figure 3: Flowchart for proposed cluster verification approach at airport

4.2 Preliminary Analysis

In the preliminary analysis, we discuss the different aspects of both of existing single (queue) verification and proposed (cluster verification) approaches. In the existing approach, each person filled up (Optional) the form for personal information but in our cluster verification approach, a CM device has pre-stored personal information. In the existing and proposed approach, queues are made for vaccination. In the existing approach, crowd is moved from waiting area to verification counter in queue form but in proposed approach, crowd is moved from waiting area to group formation area. In case of

existing approach biometric is done and passport is check for visa verification but in case of proposed approach on the base of biometric passport is interchanged with CM device that is keep in rack according to serial number. CM device is handover to the person for further verification. In the existing approach, passport is checked for visa, scanning of passport or entering of visa number to verify the visa but in case of proposed approach data is pre-stored on CM device. In the existing approach, face identification, printing and pasting of the stickers for each pilgrim is done one by one but in case of proposed approach it can be done in group form after releasing the pilgrims. In existing approach, reference number is written, entry stamp and passports are handover to each pilgrim. But in case of proposed approach reference number can be burnt or store on the device, entry stamp and passports handover to the company later. In existing approach, pilgrims move one by one in queue form that will increase the frequency of human delay because of long time duty of officers but in proposed approach the pilgrims move in group and make fast processing that reduce verification time hence human delay reduced. In existing approach, if one-person cause verification problem whole queue will be blocked but in case of proposed approach person has verification problem can be forwarded to a separate dedicated counter for manual verification. In existing approach, it is difficult to do verification for multiple time at each checkpoint but in case of proposed approach multiple verifications can be done on multiple checkpoints on the base of CH and CMs. In the existing approach, queue or single verification is done but in case of the proposed approach, cluster verification is done. A preliminary analysis is given in Tab. 1.

Table 1: Comparison between two approaches (Single and cluster)

S No.	Single Approach	Cluster Approach
i.	Fill up the entry form (can be skipped)	No need data are pre-stored on the CMs device
ii.	Making of Queue	Making of Queue
iii.	Vaccination	Vaccination
iv.	Moving from waiting area to counter in the queue	Moving from waiting area to group formation area
v.	Biometric	Biometric & Passport interchange
vi.	Show the passport and visa (Time to find out visa on a specific page)	Already done in step (v).
vii.	Scanning of the passport or to enter visa number to verify visa	Data is prestored on the CMs device
viii.	Identification of the face by the officer	Already done in step (v).
ix.	Printing and pasting of sticker schedule for each pilgrim	Printing and pasting of sticker can be done in group form later on
x.	Writing reference number, entry stamp and hand over the passport to each pilgrim	Handover to the company in group form after releasing the pilgrims
xi.	Pilgrims moving one by one (in queue) will increase the frequency of human delay (officer on duty), for example, drinking, eating and chatting with colleagues. Because single verification will take more time as compared to cluster verification	Cluster or Group verification will decrease time and hence decrease the frequency of human delay, for example, drinking, eating and chatting with colleagues. Because cluster verification will be done quickly.
xii.	If one person caused verification problem, whole queue will be blocked	If one or two persons caused verification problem, they can forward to the separate dedicated counter for manual verification.
xiii.	It is difficult to do verification for multiple time at different places	Multiple verification can be done on different places on the base of CM device
xiv.	Queue or single verification is done	Cluster or group verification is done

5. Verification by Existing Approach

In current verification approach there are multiple steps which are done in queue form. This queue form verification causes a long queue and delay.

In case of an existing approach, data is entered manually, writing of reference number, printing of the tags for schedule take more time for verification. But in our case study, we focus on the concept of pre-stored data that minimized the redundancy because data are already stored. Storing of data on the CMs, CH and on the server is done with human control. Verification of CMs is done in cluster form so that time for crowd verification can be minimized.

5.1 Verification Time Taken by Existing Approach

This interview or survey is done in Hajj buildings in Makkah Al-Mukarmah and observation is done at the King Abdul-Aziz Airport Jeddah, Saudi Arabia to compute the crowd verification time by the existing approach. A well-planned interview or survey is done by requesting to the young male and female pilgrims to calculate the verification time. They noted the start and end verification time by using stopwatch. The data collection was conducted for pilgrims of three different countries (Pakistan, India and Bangladesh). We do not have access to other countries such as European countries, therefore, we did not include the other countries, but the verification process is the same for all pilgrims. There are different packages of Hajj that are available for pilgrims.

The male (74%) and female (26%) pilgrims from Pakistan, Bangladesh and India were included into data collection to see the effect on verification time. Because female pilgrims are travelling with their “Mahram”, therefore, we also included young females in the data collection. A Mahram (Arabic محرم) is a man who must go with a woman during the time period of Hajj or Umrah. according to Islamic law, A Mahram is the man must be

the husband or another relative who cannot legally marry with the woman. The data collection was done for a single pilgrim (person by person) in queue form at the airport. For person-by-person data collection, young male pilgrims from Pakistan were requested to report the start and end time of the immigration verification process. We also visited the airport and use the stopwatch to calculate the verification time per pilgrim. At the airport data collection is done by observation for not all young male and female pilgrims but also aged pilgrims because they were travelling with young pilgrims as a group fellow. The data were collected in a table having pilgrim name, age-group, time and gender. We also collected the passport number and flight time, but we did not consider it because not all people like to share all personal information. On the base of 724 total Pakistani pilgrims, having 518 male pilgrims and 206 female pilgrims, we calculated the minimum, maximum, total and average time for verification. The minimum time per pilgrim is 3 minutes, the maximum time is 10 minutes without human delay and the average time is 5.4 minutes. The Tab. 2 represents the data collected by data collection and its evaluation according to the existing approach.

In Tab. 2, data for Pakistani pilgrims are collected. The Tab. 2 represents the information of pilgrims according to the number of pilgrims and verification time in minutes has been taken during immigration at the airport. Further information about total number of pilgrims, the total time for verification, average time per pilgrim, minimum time and the maximum time is calculated. The important verification time is average verification time per pilgrims on the base of which we will calculate the performance of the proposed verification approach.

Table 2: Pilgrims data for Pakistan

No. of Pilgrim	Time Taken per Pilgrim in Minutes	Total Time for Each Category
100	3	300
208	4	832
148	5	740
79	6	474
52	7	364
72	8	576
37	9	333
28	10	280
724		3899
	Total no. of Pilgrims	724
	Total Time for Verification	3899
	Average Time Per Pilgrims	5.4
	Minimum Time	3
	Maximum Time	10

In Tab. 3, data for 151 Bangladeshi pilgrims are collected by observation at the airport. The Tab. 3 represents the information of pilgrims according to number of pilgrims and observational verification time in minutes at the airport. Further information about the total number of pilgrims, the total time for verification, average time per pilgrim, minimum time and the maximum time is calculated and also given in Tab. 3. Average verification time per pilgrim for Bangladeshi pilgrims is 5.5 Minutes.

TABLE 3: Pilgrims data for Bangladesh

Number of Pilgrims	Time Taken per Pilgrim in Minutes	Total Time for Each Category
31	3	93
27	4	108
28	5	140
19	6	114
14	7	98
12	8	96
12	9	108
8	10	80
151		837
	Total No. of Pilgrims	151
	Total Time for Verification	837
	Average Time Per Pilgrims	5.5
	Minimum Time	3
	Maximum Time	10

In Tab. 4, data for 154 Indian pilgrims are collected by observation at the airport. The Tab. 4 represents the information of pilgrims according to number of pilgrims and observational verification time in minutes at the airport. Further information about total number of pilgrims, total time for verification, average time per pilgrim, minimum time and the maximum time is calculated and also given in Tab. 4. Average verification time per pilgrim for Indian pilgrims is 5.4 minutes.

Table 4: Pilgrims data for India

Number of Pilgrims	Time Taken per Pilgrim in Minutes	Total Time for Each Category
35	3	105
29	4	116
27	5	135
20	6	120
15	7	105
10	8	80
9	9	81

9	10	90
154		832
	Total No. of Pilgrims	154
	Total Time for Verification	832
	Average Time Per Pilgrims	5.4
	Minimum Time	3
	Maximum Time	10

In Tab. 5, we made a comparison among the three countries based on number of pilgrims and the average time taken by each pilgrim. The average verification time taken by Pakistani pilgrims is 5.4, for Indian, it is 5.4 and for Bangladesh, it is 5.5 minutes. Further Tables can be created to provide information of pilgrims according to the verification time with different age groups and with different time groups.

Table 5: Pilgrims data for 3-Countries

Country	Number of Pilgrims	Average Time
Pakistan	724	5.4
India	154	5.4
Bangladesh	151	5.5

5.2 Time Verification by Proposed vs. Existing Approach (Verified &Unverified CMs)

In this section, we compared the existing and proposed time verification approaches as given in Tab. 6 and Fig. 5. In Tab. 6, first column represents the number of CMs in cluster, second column represents the no. of verified CMs, third column represents the verification time (VT) for verified CMs and has been calculated on the bases of the log file by using Contiki/Cooja tool [29]. Forth column represents the VT for unverified CMs (pilgrims) by existing approach. This time is calculated by the multiplication of number of unverified numbers by average time to verify one pilgrim that is approximately 5 minutes (No. of unverified CMs * 5). Fifth column represents the sum of the verified CMs (by proposed approach) and unverified CMs having some problem (by existing approach). Sixth column represents VT for all CMs in group by existing approach. A comparison between fifth and sixth columns has been made to check the performance and time difference of both approaches. Fig. 5 represents the summary of the difference of both approaches. When the CMs are 20 all CMs are verified, and total time taken by proposed approach is 3.3 minutes. In case of existing approach 100 minutes (i-e 1 hour and 40 minutes) for 20 CMs (pilgrims) that shows a huge difference. Maximum time is 189.7 minutes when 13 out of 50 CMs are verified and 37 remains unverified in a cluster or group. It has been observed from Fig. 4 that 3 CMs remain unverified when there are 25 CMs in a cluster i.e 22 out of 25 are verified. As CMs increase in the group the number of unverified CMs also increase. Unverified CMs affect the performance and VT increases. Reasons for this increase in VT are discussed in the discussion section.

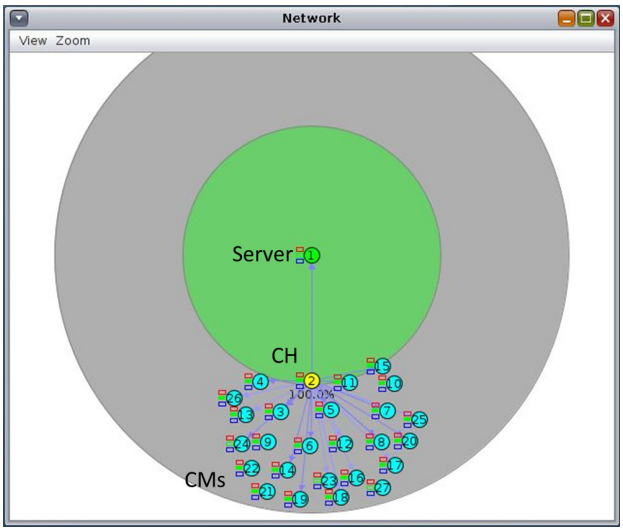

Figure 4: 22 CMs out of 25 verified but 3 remain unverified

Table 6: Time Chart for Verification by proposed VS Existing Approach (Verified & Unverified CMs) [29]

No. of CMs in Group (cluster)	No. of Verified CMs	VT for Verified CMs (Min)	VT for Unverified CMs (Min)	VT by Proposed Approach for Verified and Unverified CMs (Min)	VT by Existing Approach (Min)
5	5	0.4	0	0.4	25
10	10	0.9	0	0.9	50
15	15	2.5	0	2.5	75
20	20	3.3	0	3.3	100
25	22	3.9	15	18.9	125
30	17	4.2	65	69.2	150
35	15	4.7	100	104.7	175
40	15	4.7	125	129.7	200
45	14	4.7	155	159.7	225
50	13	4.7	185	189.7	250

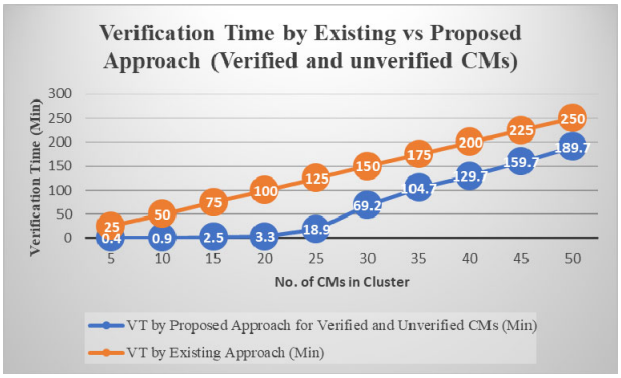

Figure 5: Time chart for verification by proposed vs existing approach (Verified & Unverified CMs)

6. Discussion

The reasons the VT is reduce because in our proposed scenario many steps are done as proactive approach such as the store the personal information on the sensor device on completion of visa process. The second reason is that the process of writing of boarder number and collection of the passport will be done by the immigration and passports will be handover to the responsible company that is bringing the pilgrims. It is worth noting that the immigration process of the pilgrims in KSA is different than the other countries immigration process. As the verification is done by the immigration the pilgrims' handover their passports to the responsible company on airport. Therefore, in our proposed model pilgrims do not need to wait for the collection of passports. As an alternate the pilgrims have the sensor device and a passport photocopy or ID cards given by the company. Further detail is given in Tab. 1. Third reason, by using the sensor devices along with other technologies and verification in the form of group will play a major role to reduce the VT. The reason with the increase of CMs in group the VT is increasing as mentioned the Tab. 6. Multi hop protocol is used in the simulation therefore each CM maintain the record of its neighbors. As CMs are increase in the group the number of the records for neighbors also increased and because of low memory some records are deleted to manage the new records. The deletion of the neighbor records causes the imperfect route to destination and hence drop the packet as maximum time is out. In the same way on exceeding of the maximum number of neighbors the packet is also drop. Further as we increase the CMs in the group the number of collisions also increases. Because of collisions more packets will drop and the CSMA Contiki has to retransmit more packets and it will cause increase in VT.

7. Conclusion and Future Directions

This paper represents an overview of the cluster verification approach, preliminary analysis between single and cluster verification approach. We discussed the approach from perspective of currently available single verification approach and proposed cluster verification approach by using CMs. We examined how the proposed cluster verification approach works by using clustering. A Cooja/Contiki tool is used to verify and compare the VT with existing approach. Discussion is given in the previous section. Explanation is done by airport use-case for cluster verification.

If cluster verification approach is commercially applied it will support in different application, such as:

i. Creation of plan for routes for each group.
ii. In case of emergency, to calculate resources such as ambulances required according to the crowd density and situation.
iii. To distribute the crowd according to the estimated cluster VT.
iv. Manage the transport according to the verified crowd and time.
v. To identify the group and location of CMs.
vi. Provide the food demand according to the crowd density and location.

This research provides results for VT on the bases of the proposed and existing approaches by using interviews, observations and simulation. There is no such real implementation of proposed approach to compare it with existing approach. This is one of the limitations. If some of the CMs cause verification problem, then detail plan for such CMs is required to handle them. WSN has low memory low energy and less processing capability, such issues are required to discuss to improve the efficiency of the verification. An algorithm can be designed to maintain the social distance among the CMs in a group. Estimation of the space that is required for optimized number of CMs in a group to take a prevention from COVID-19 attack.

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