Support System For Decision Making in Emergency Evacuation

Prashant Ahlawat

Department of Computer Science, Gurgaon Institute of Technology & Management, Gurgaon (India)
Ahlawatprashant2@gmail.com

Abstract— The evacuation of a building is a challenging problem, since the evacuees most of the days don't grasp or do not follow the optimum evacuation route particularly throughout an current hazard present in the building, finding the best evacuation route becomes tougher as the conditions on the paths amendment within the course of the evacuation procedure. In this paper we tend to propose a distributed system that can reckon the best evacuation routes in period, whereas a hazard is spreading inside the building. The system is composed of a network of call nodes and detector nodes, positioned in specific locations inside the building. The recommendations of the decision nodes ar computed during a distributed manner, at eachof the decision nodes, that then communicate them to evacuees or rescue personnel set in their neighborhood. we tend to value our proposed system in numerous emergency eventualities, employing a multi-agent simulation platform for Building Evacuation. Our results indicate that the presence of the system improves the end result of the evacuation with respect to the evacuation time and the injury level of the evacuees.

I. INTRODUCTION

Decision making throughout associate emergency response procedure has to be created in a very timely manner so as to minimize the evacuation time and avoid injuries connected with the continued hazard. It is, however, terribly troublesome for the evacuees to create the best choices throughout associate evacuation. Most of the times they do not grasp that is the best path that they ought to follow so as to succeed in associate exit since they're unfamiliar the overall architectural design of the building. Moreover, the conditions within the building could change due to the presence of a hazard that's spreading [1], like a fireplace or a hazardous gas. This renders the task of finding a secure route to associate exit even a lot of troublesome. A call support system that provides directions to the evacuees throughout associate emergency situation would prove helpful to the outcome of the evacuation, since it may recommend the best obtainable ways at any given time, avoiding the exposure of evacuees to unnecessary risk.

Our approach focuses on the style and analysis of a decision support system that will be used throughout associate emergency scenario within a building. The system should be able to function in period of time, adapt to the changes of the setting and offer reliable suggestions to the evacuees concerning the direction of the best available exit. This approach has been inspired by [4] wherever vehicles, modelled as good agents, square measure traversing a dangerous urban grid. The agents,

who use data returning from the setting and from other agents, square measure able to adapt so as to go and safely. Our system operates in a very building setting, where civilians square measure participating in associate evacuation within the presence of a spreading hazard. By following the directions provided by the decision network, they'll evacuate the building using the best obtainable methods and avoiding the dangerous areas. we have a tendency to appraise the prosposed system by the use of a multi-agent Building Evacuation machine that models the evacuation procedure. This approach provides a practical environment during which our projected methodology will be tested.

The rest of the paper is union as follows: Section II offers the details of the modelling approach we have a tendency to followed for the style of the system. In Section III we have a tendency to gift the distributed algorithm that is used by the call support system, whereas the evaluation of the system along with simulation results for various scenarios is the subject of Section IV. Finally in Section V we have a tendency to gift our conclusions and describe our future work.

II. DESCRIPTION OF THE SYSTEM

We begin by giving the style details of the call support system. we tend to gift the assumptions we tend to created and the modelling approach we tend to adopted.

A. Assumptions

Our initial assumption is that the layout of the building is known. This is valid for the case of a call support system that has been pre-installed within the building before the evacuation method is initiated. Since such a system are part of a building's safety infrastructure, it should have already been deployed once the emergency scenario happens. Another assumption is the existence of a variety of Decision Nodes (DN), put in in specific locations within the building. These devices don't have to be compelled to have high process power or storage. Their job is to figure the direction that ought to be followed by every migrant, towards the best available exit. the recommendation of a DN is communicated to folks in its locality. The interaction between the evacuees and also the DNs will be accomplished by the employment of a visible indicator (such as a wise panel) or by a wireless communication device (i.e. a PDA) that is carried by the evacuees or the emergency personnel and receives the suggestions from the DNs.

Finally, we tend to assume the existence of a network of detector nodes, that gives the choice Nodes with time period info concerning the conditions within the building. This info will be associated with the temperature of a location or the presence of smoke.

B. Graph illustration of the Building

We have used the celebrated building layout to construct a graph G. Figure one shows the ground of a building and also the corresponding graph. The vertices of the graph correspond to locations wherever folks will congregate (e.g. rooms, corridors, doorways or hallways). A link between 2 vertices of the graph represents a path that may be followed by the evacuees.

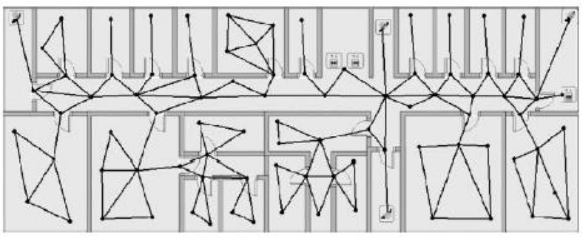

Figure two depicts AN example topology wherever call Nodes and sensing element nodes ar positioned in specific locations within a space of a building. every DN is placed at every of the vertices of the graph G. In observe, however, there may be fewer call nodes than vertices in G, with every DN being answerable of providing selections for a collection of contiguous locations of G.

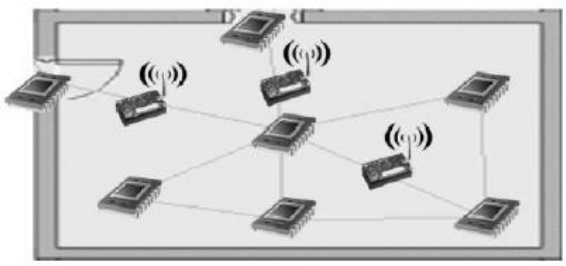

Fig. 2. Decision Nodes and Sensors Nodes Positioned in specific building locations

III. A DISTRIBUTED ALGORITHMIC PROGRAM FOR DECISION SUPPORT

Instead of employing a centralised system to figure the worth of the effective length of the methods to AN exit, we tend to propose a distributed design. we tend to make a case for the benefits [5] of this approach and provides the main points of the distributed algorithmic program employed by every call node.

A. benefits of a Distributed Approach

The projected call network may be imple-mented during a centralised manner. in this case, the algorithmic program runs in one central process centre. The centre is re-sponsible for gathering data from the detector nodes, corporal punishment the algorithmic program and act the ensuing choices to the several call nodes. This approach, however, has varied drawbacks that have a negative impact on the practicality of the system and might impair the results of AN evacuation procedure.

A centralised approach isn't fault tolerant, since it depends on one purpose of knowledge assortment, process and retrans-mission. within the case of a failure within the process centre, the choice system cannot operate. what is more, there may additionally be failures within the overall communication system throughout AN emergency. victimization native communications to tell evacuees victimization the choice Nodes is a lot of strong compared to a centralised answer that depends on being perpetually ready to communicate with the process centre.

Moreover, the process needs for an outsized scale system might not be met by one process centre. because the size of the building and therefore the range of floors will increase, the specified range of call nodes will increase consequently. This encompasses a direct impact on the number of knowledge that must be processed by the centre, so as to figure the most effective path towards the exit. In our distributed system, each call Node executes the choice support algorithmic program domestically and depends solely on its own process resources. Thus, the dimensions of the system doesn't have an effect on the dimensions of knowledge that ought to be processed.

A distributed approach conjointly facilitates AN extensile and ascendable style method. In alternative words, the planning principles of the distributed system for a given size of building will be scaled up or down, to deal with larger or smaller buildings victimization constant principles and building blocks.

B. Description of the Distributed rule

The rule that we tend to propose is galvanized by the distributed shortest path downside [6], [7], [8] and from reconciling routing techniques like psychological feature Packet Networks [9]. it's dead by every call Node, in a very distributed manner, associated its output is that the next call Node that's on the most effective on the market path towards an exit.

A Decision Node, at vertex u, stores the subsequent information:
• The effective length L of all the links that are incident to u

• For each neighbour n of u, the effective length of the path y from n to associate exit e : L(n, e, y)

• The effective length of the shortest path x , from u to associate exit e: L(u, e, x)

• The next steered call Node

The initial conditions for the rule ar set as follows:

L(u, e, x) = ❑ ∞0 ,, otherwise if u∈E (2) where E is that the set of accessible building exits. Since the decision support system is already installed in the building once the hazard starts spreading, we are able to take into account that the initial condition for every call Node, at that point, is that the actual physical length l(u, e, x) of the shortest path from a call node u to associate exit e. this can be a consequence of the very fact that the system are already operative before the hazard happens, so every call Node can have designated a path that minimises the effective length once no hazard is gift.

We should conjointly signifies that it's not necessary for a call Node to stay data concerning the effective length L of the ways towards all the on the market exits. because the rule is dead, this data is propagated from all the exits to all or any the choice Nodes. every call Node can eventually choose the exit that minimises the worth of the chosen metric, that in our case is that the effective length of the trail from the node to the exit. the choice of associate exit depends on the situation of the choice Node, the locations of the exits and therefore the spreading of the hazard.

When the choice web is operating, every call Node at u sporadically executes rule one and provides a suggestion to the evacuees that ar in its locality.

IV. ANALYSIS OF THE CHOICE

SUPPORT SYSTEM

We appraise our planned call network within a Building Evacuation machine we've developed. an outline of the machine and its characteristics is first of all given, followed by simulation results of evacuation pro-cedures that use our system.

A. The Building Evacuation machine

We have enforced the planned call support sys-tem within the Building Evacuation machine (BES) [10], [11], so as to guage its performance throughout associate emer-gency state of affairs within a building. The BES is associate agent-based machine for building evacuation. The actors that participate within the simulation square measure sculptural as agents. every one has its own health model and movement model that rely on the individual characteristics of the actors and on the setting. The implementation of the agents was done mistreatment the JADE framework [12]. The physical world of a building is viewed as a group of "Points of Interest" (PoI) and accessible links between them, that type a directed graph. every dish is appointed to a bunch in keeping with its location, for instance, a space or section of a passageway. The links represent the walking access between adjacent dish. The BES conjointly simulates congestion and therefore the unfold of a hazard within the building [13], [14] (such as hearth or venturesome gas). the most reasons for selecting to guage the choice system mistreatment the BES are:

• Realism: The BES consists of actors that move and act within the simulated world, whereas the environ-ment is dynamical owing to the spreading hazard. differing kinds of actors, like civilians, rescuers and medical personnel, will participate within the simulation whereas the choice network is employed to supply them with directions relating to the most effective accessible exit route. Thus, we will investigate the potency of our system below realistic conditions and appraise its performance by analysing the result of diverse simulated eventualities.

• World Model Structure: the choice network we tend to prospose relies on a graph, that is analogous to the one employed by the BES. This structural homogeneity was helpful to the mixing of the choice network with the BES. we tend to were able to develop the choice model while not the requirement for major modifications within the organisation of the machine, which might have resulted in excess complexness and problem.

• Extensibility: The standard, agent-based structure of the BES allowed for a comparatively simple addition of the entities that square measure a part of the choice network, like call Nodes and sensors. This contributed to the fast development and implementation of the choice network.

B. Migrant - System Interaction

The evacuation eventualities within which our planned system is employed, involve a multi-storey building and a hazard spreading within it. Civilians area unit settled within every floor of the building. once the simulation begins, every civilian tries to evacuate Associate in Nursing starts moving towards an exit.

In the case wherever the choice web is employed, every civilian decides its next destination supported the recommendation of the various call Node. Figure four illustrates the ground of a building, because it is portrayed through the BES interface. we will conjointly note the presence of a fireplace, that is spreading within the ground. The arrows represent the directions that Associate in Nursing migrant receives from a choice Node that is found in its neighborhood. The interaction between Associate in Nursing migrant and a choice Node are often accomplished by either a visible indicator (such as a sensible panel) or a wireless communication device (such as a PDA) that is carried by the evacuees and is ready to to receive the directions from the choice Nodes. every call Node directs the evacuees towards one in every of its neighbour call Nodes, on the most effective path that ends up in the exit and avoids exposure to the hazard.

Finally, the movement of the evacuees within the absence of the system is modelled exploitation Associate in Nursing optimistic approach, since every migrant is assumed to possess a full data of the building's structure before the hazard starts spreading. we have a tendency to think about that the evacuees area unit accustomed to all the accessible exits and area unit able to follow the shortest methods that cause them. In terms of modelling, this can be translated in a very full data of the building graph and a calculation of the shortest methods by exploitation Dijkstra's rule. Associate in Nursing migrant becomes tuned in to a venturous space once it reaches a location near it. This triggers Associate in Nursing update in its data of the building graph and a re-calculation of the shortest path.

C. Experimental Setting

In order to guage the planned system in a very big selection of conditions, we've got chosen to randomize the subsequent state of affairs parameters:

• Initial civilian locations: For every simulation run, the initial locations of the civilians area unit chosen from a uniform distribution over the graph vertices of a floor. This allows on check our call system's performance under completely different building occupancy patterns, including cases wherever civilians area unit settled close to the hazard once it starts spreading.

• Hazard spreading: The spreading rate of the hazard also differs between consecutive simulation runs. It is primarily based on the probabilistic hazard model used by the Building Evacuation machine [10], [13]. This increases the realism of the simulation, since it guarantees that the spreading of the hazard won't be identical for all the simulation eventualities.

D. Simulation Results

We evaluated the planned call web mistreatment the subsequent metrics:

• Share of evacuees that have exited the building versus the evacuation time. This metric reflects the efficiency of the system in directive the civilians towards the exits, with reference to the speed of the evacuation procedure. the upper the slope of a curve, the quicker the evacuees exit the building.

• Average remaining health of the evacuees. It denotes the degree of exposure to the hazard. an occasional worth indicates that the system has succeeded in directive the evacuees on safe methods, avoiding the venturous locations.

• Percentage of fatally contusioned evacuees. this can be a straight-forward metric and it denotes the quantity of evacuees that weren't able to exit the building thanks to excessive exposure to the continued hazard.

We have evaluated totally different cases were the choice sys-tem is employed, by corporal punishment 200 simulation runs for every case. The distinction between them is however oftentimes every call Node executes the algorithmic rule. this may have an effect on the speed of propagation of knowledge among the choice nodes and also the adaptivity of the system to the dynamic surroundings. we've conjointly enclosed a case wherever there's no call web within the building.

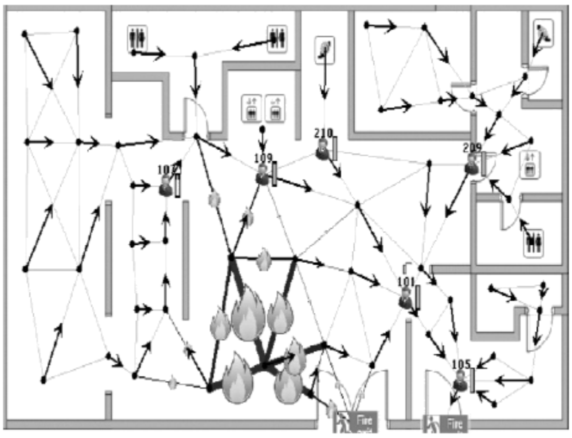

Fig. 4. The decision support system inside the BES. The arrows correspond to directions from the Decision Nodes

1) state of affairs 1: the primary evacuation state of affairs involves the 3 level building illustrated in Figure four. The broken arrows represent the staircases on that the evacuees will move from one floor to a different. The building occupancy level is thirty civilians in total (ten civilians per floor) and there area unit 2 exits situated on the bottom floor. a fireplace starts on the bottom floor of the building. Figure half dozen illustrates the proportion of evacuees that have excited the building , versus the evacuation time. we tend to notice that within the cases wherever the choice web is employed, the evacuation procedure finishes quicker and with the next share of civilians exiting the building.

V. CONCLUSIONS AND FUTURE WORK

We have conferred a choice network that aims at providing directions to evacuees throughout Associate in Nursing emergency situation. The system consists of call Nodes, positioned in specific locations within the building, and sensor nodes that give data concerning the intensity of the spreading hazard. every call node computes the simplest direction towards the exit in a very distributed manner, using only local data. The directions of the choice Nodes area unit communicated to the evacuees via good Panel Indicators or Wireless

Devices that they carry. The planned system is evaluated employing a multi-agent Building Evacuation machine that we've developed. The actors participating within the simulation follow the directions of the choice network as they move within the building. Our study includes simulation scenarios for multiple floors, totally different buildings and numerous building occupancy levels. The simulation results illustrate that the presence of the choice network improves the outcome of the evacuation procedure by leading the evacuees towards safe methods, that avoid the spreading hazard and minimise the evacuation time and injuries.

REFERENCES

[1] R. R. M. Gershon, “The world trade center evacuation study: Lessons for alternative high rise workplace buildings,” in NFPA World Safety Conference & Exposition, June 2006.

[2] Q. Li, M. D. Rosa, and D. Rus, “Distributed algorithms for guiding navigation across a sensing element network,” in MobiCom ’03: Proceedings of the ninth annual international conference on Mobile computing and networking. New York, NY, USA: ACM, 2003, pp. 313–325.

[3] Y.-C. Tseng, M.-S. Pan, and Y.-Y. Tsai, “Wireless sensing element networks for emergency navigation,” Computer, vol. 39, no. 7, pp. 55–62, 2006.

[4] E. Gelenbe, E. Seref, and Z. Xu, “Simulation with learning agents,” Proceedings of the IEEE, vol. 89, no. 2, pp. 148–157, Feb 2001.

[5] D. P. Bertsekas and J. N. Tsitsiklis, Parallel and distributed computation: numerical strategies. higher Saddle watercourse, NJ, USA: Prentice-Hall, Inc., 1989.

[6] D. Bertsekas and R. Gallager, information networks. higher Saddle watercourse, NJ, USA: Prentice-Hall, Inc., 1987.

[7] P. A. Humblet, “Another adaptational distributed shortest path formula,” IEEE Transactions on Communications, vol. 39, pp. 995–1003, 1991.

[8] T. H. Cormen, C. E. Leiserson, R. L. Rivest, and C. Stein, Introduction to Algorithms, Second Edition. The Massachusetts Institute of Technology Press, Sept 2001.

[9] E. Gelenbe, R. Lent, and Z. Xu, “Measurement and performance of a psychological feature packet network,” Journal of pc Networks, vol. 37, no. 6, pp. 691–701, Dec. 2001.

[10] A. Filippoupolitis, L. Hey, G. Loukas, E. Gelenbe, and S. Timotheou, “Emergency response simulation mistreatment wireless sensing element networks,” in Ambi-Sys ’08: Proceedings of the first international conference on Ambient media and systems, 2008.

[11] A. Filippoupolitis, E. Gelenbe, D. Gianni, L. Hey, G. Loukas, and S. Timotheou, “Distributed agent-based building evacuation machine,” in Summer theoretical account Conference (SCSC ’08), 2008.

[12] F. L. Bellifemine, G. Caire, and D. Greenwood, Developing Multi- Agent Systems with JADE (Wiley Series in Agent Technology). Wiley, April 2007.

[13] D. G. Elms, A. H. Buchanan, and J. W. Dusing, “Modeling hearth unfold in buildings,” hearth Technology, vol. 20, no. 1, pp. 11–19, 1984.

[14] A. M. Hasofer and D. O. Odigie, “Stochastic modelling for dweller safety during a building hearth,” hearth Safety Journal, vol. 36, pp. 269–289,2001

◈◈◈