Swarm Based Effort Distribution System for Industry Automation.

Nayan Kabra, Sanket Karnik
Student, Department of Computer Engineering,
Sinhgad Institute of Technology and Science,
University of Pune.
Pune, India

Akshay Pasalkar, Ketki Nivangune
Student, Department of Computer Engineering,
Sinhgad Institute of Technology and Science,
University of Pune.
Pune, India

***Abstract*-- In this paper major focus would be on collaborative work distribution in swarm capable system, highlighting the emergence of novel effort in the world of distributed systems. Here we would be devising techniques for enhancement in Automation of industries where employment of humans to do hazardous jobs may prove fatal. The protocol suite and algorithm for the working model of the system is being devised in a way to detect and avoid collision conditions and to overcome deadlocks. The said system would consist of few autonomous swarm robots that would synchronize with each other by establishing ad-hoc network amongst them. At any instant of time, the system would assure task completion. Appropriate implementation of concepts like global data share policy and local communications between the robots as an when required has facilitated revision of drawbacks of legacy swarm systems. At the concluding end merits and demerits of current system are penned. Also a glimpse of what new fields of research would open up in this direction in near future are discussed.**

***Keywords*- Collaborative tasks in distributed systems, Swarm Robotics, ad-hoc networks.**

I. INTRODUCTION

The concept of swarm robotics traces back its foundation to the concept of swarm intelligence where a number of autonomous individuals (specifically robots) coordinate with each other to carry out a specific set of tasks. The desired collective behaviour emerges from the interactions between the robot and interaction of robot with the environment. Synchronization is the basis of modelling such swarm behaviour. These robots are also known as Ant robots, as they exhibit collective action as a swarm of ants.
Few concepts that drove attention in this field were biological inspiration, control approach, communication, mapping and localization, object movement and manipulation, motion coordination, etc. [2]

IJERT

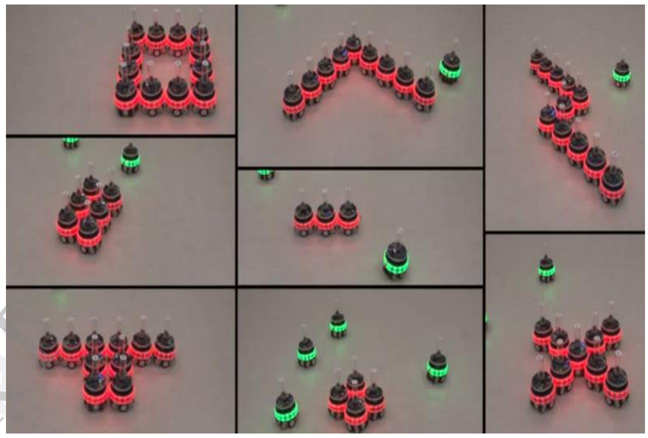

Fig. 1 Swarm Robotic System

Ad hoc Networks:

An ad hoc network is a local area network (LAN) that is built spontaneously as devices connect. Instead of relying on a base station to coordinate the flow of messages to each node in the network, the individual network nodes forward packets to and from each other. In Latin, *ad hoc* literally means "for this," meaning "for this special purpose".

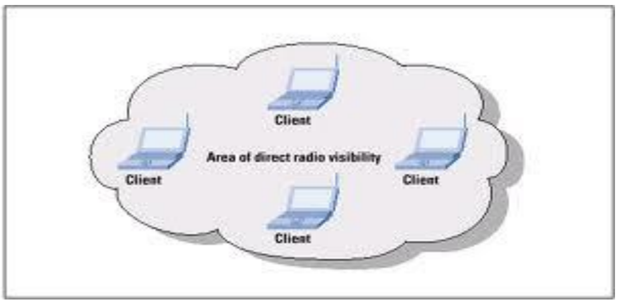

Fig. 2 Multiple Devices in Wireless Network

An ad hoc network is made up of multiple “nodes” connected by links, which are influenced by the node's resources (e.g., transmitter power, computing power and memory) and behavioral properties (e.g., reliability), as well as link properties (e.g. length-of-link and signal loss, interference and noise). Since links can be connected or disconnected at any time, a functioning network must be able to cope with this dynamic restructuring, preferably in a way that is timely, efficient, reliable, robust, and scalable. The network must allow any two nodes to communicate by relaying the information via other nodes. A "path" is a series of links that connects two nodes. Various routing methods use one or two paths between any two nodes; flooding methods use all or most of the available paths.

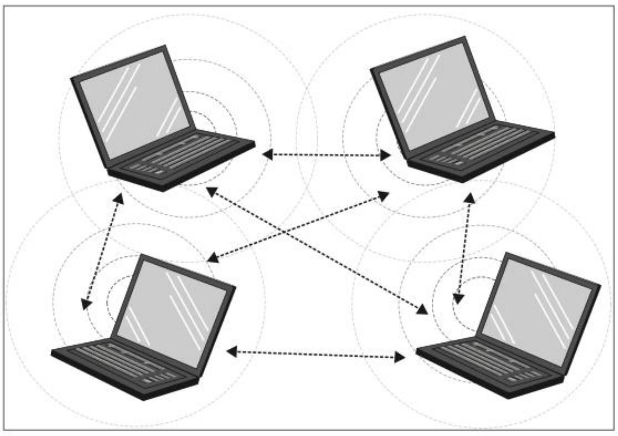

Fig. 3 Wireless ad-hoc network

Concepts implemented in Legacy Swarm Systems:

In some of the accomplished project works, behaviour control algorithm for maintaining network connectivity is proposed the local path planning using the virtual force and the global path planning using the Delaunay triangulation, respectively , where Global path planning uses centre of gravity of Delaunay triangle to maintain network connectivity of swarm robot uniformly. Delaunay triangle is formed by first connecting the base robot and search robot to neighbour relay robot, then each relay robot has single pair of connection between base robot and search robot, respectively. Local path planning method makes robot to avoid collision with obstacles, and to move to target point. Virtual force is used to realize a local path planning. Virtual force can be divided as attractive force and repulsive force and summation of these two forces indicates where the robots have to move. [1] Some of the protocols used in legacy systems were, **Sender-Receiver Protocols,** for the time synchronization
in wired systems where the node is communicating with a reference node to synchronize with it. The delay of sending and receiving time messages is very less in wired systems as compared to wireless systems. **Receiver-Receiver Protocols,** which has broadcasting facility are useful strategy for finding the moving direction of the robots is to divide the communication area of the reference robot into six regions having an angular separation of 60. [3] Some systems are based on sense limited, interact locally strategies, which uses local communication policy instead of global, used in case of rescue missions. [4]
The drawbacks of the legacy robotic systems are as given below:

- Previously developed systems did not assure task completion in case of failure of all but one robot.
- Centralized Controller is the controlling head in many of the old systems, which governs the action of entire system working under its guidance, here, failure of this controller, crashes the working of entire system.
- Either of Local or global path planning algorithms are used by old systems, which may not address dynamic time path change requirements.

Local Path Planning: The path planner only provides the next step on a possible path. No complete path is calculated prior to initiation of robot movement.

Global Path Planning: The path planner computes the complete path before providing a solution. Its major disadvantages are, no robot movement is possible prior to complete path calculation, and in case of deviation of a robot or a failure, entire path has to be recalculated.

- Most of systems use implicit communication strategy, even when transmission delay across a noiseless, infinite-capacity external channel is smaller in explicit communication than the propagation delay of implicit communication. Such implicit communication is required to provide robustness only if the channel is noisy, but in such ideal conditions it is not expected.

II. REFINEMENT PROVIDED BY PROPOSED SYSTEM.

Objective of the proposed system is to develop economical, reliable, flexible, fully scalable swarm capable distributed robotic system, which can be easily produced at domestic level. As this is a distributed system, there is no central controller responsible for coordination amongst the robots, and unlike those systems, this system assures more safety with regards to system crashes and run-time failures. Also, system assures task completion even if single robot is loaded with entire responsibility of carrying out work, which is not possible with most of other swarm systems, which can produce work only by combining their strengths together. It uses explicit communication among the robots, as the amount of data to be shared is very limited. The system that is proposed in this paper uses a blend of both local and global path planning strategies, as and when required. Thus, overcoming the drawbacks of the legacy systems, this system outstands itself by delivering high performance and exhibiting enhanced efficiency in reduced time span.

III.SYSTEM DESIGN

A. *Strategy:* This system is mainly towards developing swarm robotic system for completing given set of tasks optimally and efficiently. Task distribution will be done, depending upon the proximity of objects and time constraint of the task. As the networking among the robots is completely Ad-Hoc, the distributed system facilitates that robots can join or leave arena at any given time. In case of failure of any of the robot s, the system will confirm its

IJERT

failure and will again strategize the policy of working. In case of any instability about the presence or absence of any robot, other robots will share their updated information with each other and its regain stable state of the system to resume its work.

B. *System Specifications:* For communication between the robots, Ad-Hoc networking is used, which will help share information for synchronization. For implementing this project, we are considering a group of autonomous robots, with a microcontroller, transmitter receiver pair embedded on each of them. Specifically we are using Transmitter Receiver modules for wireless communication. Emitter Collector pair sensors are provided on the robots circuit to help them identify their position and other nodes while traversing through the arena.

C. *Mathematical Representation of the system:*

Deciding the Block based on Proximity:

We will be representing position of robot and objects using 2-D geometry. Objects position will be represented as (X,Y). We will use Manhattan Distance function to determine distance between block and the robot. Manhattan Distance function is defined as,

Distance = **Horizontal distance + Vertical distance**
Hence,
Distance =|BOTX-BLOCKX| + | BOTY-BLOCKY|.

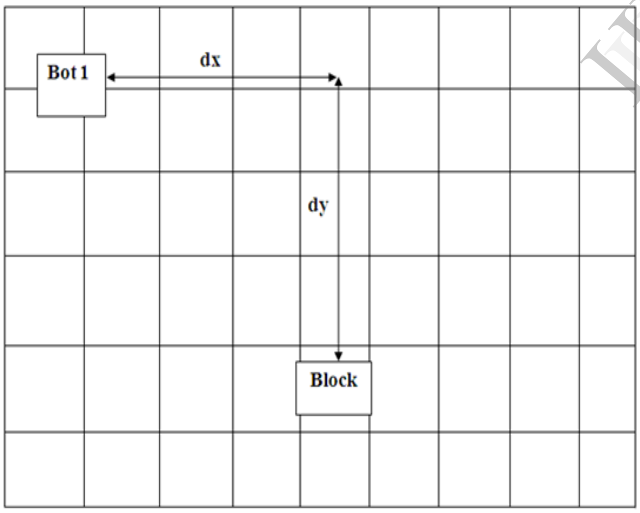

Fig. 4 Calculating Distance between bot and block

The distance between nearest robot and block could be calculated as:

F (distmin) = min (d1,d2,d3,d4,…..,dn).
Where, d1 is distance between block1 and robot and d2 is distance between block2 and robot and so on.
If there are n blocks in the arena then the time required for choosing the block with minimum distance will be n. The nearest block would be the block having minimum distance from the robot.

Deciding Path:

The path from position (x,y) to (X,Y) would be decided as sequence of nodes ((x1,y1) ,(x2,y2) ,(x3,y3)….(xn,yn),(X,Y)). The function of planning path would determine the position (x,y) of robot at time instance tn. The function could be represented f(id,t,dest).

Where, id -> unique id of the bot
t ->time instance
dest -> final destination of the bot

The main task of the function is to keep the system in the stable state. System is said to be in stable state if path robot paths are not conflicting. Hence the most important condition of our project is:

∀ t, ∀id1, id2 ∈ ID ∀ dest1, dest2, such that,
dest(id1)=dest1 and …where dest1 is the planned destination of bot1
dest(id2)=dest2 …where dest2 is the planned destination of bot2
pathplanner(id1,t,dest1) ≠ pathplanner(id2,t,dest2)

i.e., at same time instance no two robots should reach at same co-ordinate (x, y) so as to avoid the collision. For this purpose we will be using a function called detect collision which will take input from 2 robots which will include current position and final destination of the robot.

IJERT

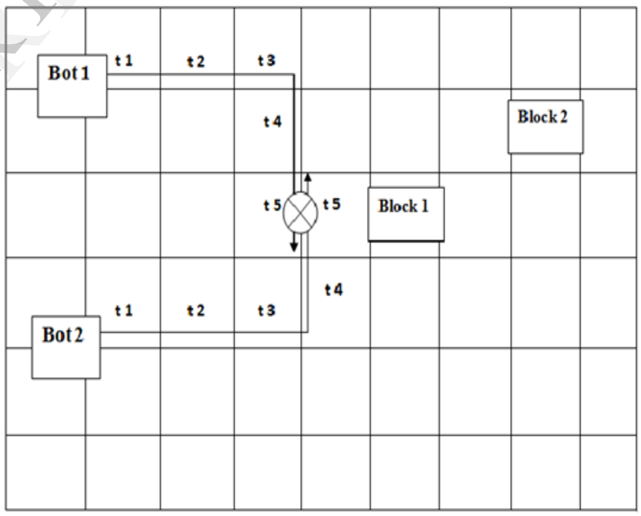

Fig. 5 Collision Detection

The function could be represented as
collisionDetect(c1,d1,c2,d2).

Where, c1 -> current position of bot1
d1-> destination of bot1
c2 -> current position of bot2
d2 -> destination of bot2

The function will give output as 1 if there is collision, 0 if both robots have reached their destination, -1 otherwise.

International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 3 Issue 3, March - 2014

collisionDetect(c1,d1,c2,d2) will be given as:

f(c1,d1,c2,d2) =
- **1 for ((new1=nextnode(c1,d1))= (new2=nextnode(c2,d2)))**
- **0 for c1=d1 and c2= d2**
- **-1 otherwise**

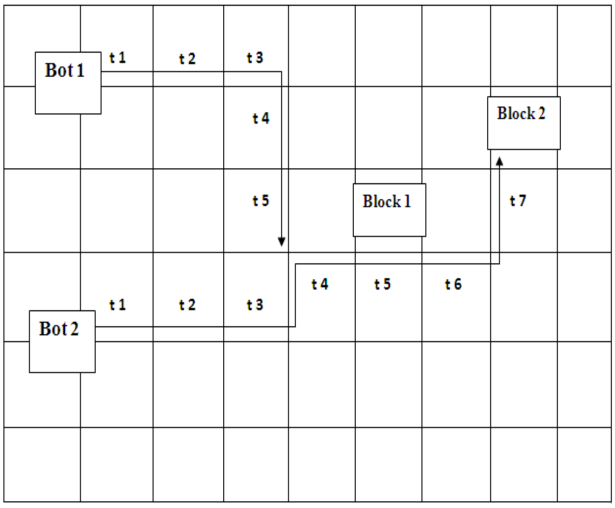

Fig. 6 Collision Avoidance

Deciding Next Node:

Function nextNode is used to find the next node selected by the robot to reach given destination. This function will take current position of the bot, Δ x, Δ y of the bot and will tell robot which will be his next node. The function could be represented as :

nextNode(x ,y, Δ x, Δ y)

Where,

X -> x co-ordinate of the bot

Y-> y co-ordinate of the bot

ΔX -> difference between x co-ordinate of bot and x co-ordinate of the destination

ΔY ->difference between y co-ordinate of bot and y co-ordinate of the destination.

The function will be given as:

F(x, y, Δ x, Δ y) =
- **x=x+1 for $\Delta x > 0$**
- **x=x-1 for $\Delta x < 0$**
- **y=y+1 for $\Delta y > 0$**
- **y=y-1 for $\Delta y < 0$**

IV. MERITS OF THIS SYSTEM.

This system is robust enough to deal with the traps like collision and deadlocks as the message transfer and bots movement will be working in sync even for a single node move. Also due to the perfect blend of local and global path planning policies efficiently this system assures better performance as compared to many of the legacy systems. This system is definitely scalable, reliable and flexible enough to meet the future needs.

V. FUTURE SCOPE.

Few things that can be extended to enhance the features of current system can be the use of internet, helping the bots to cover a wider range of area. Also this system can be modified to be used for swarm activities like surveys, rescue missions, spying systems, etc.

VI. CONCLUSION

We have chosen this inquisitive and emerging field of technology i.e. Swarm Robotics, with a view to bring about automation in industries where hazardous and laborious tasks are carried out by humans at present. With this social orientation, efforts are being taken by us to extract the hidden potential of distributed systems. Also we would like to revise the old notion in the minds of people that robots are luxury elements in today's society and are only affordable to the higher class, by providing a cost effective working robotic model that can help many of us in day to day life.

REFERENCES

[1] Jong Sun Kim , "Behavior Control for the Swarm Robots with Network Connectivity", 2012 9th International Conference on Ubiquitous Robots and Ambient Intelligence (URAI) ,Pp. no 337-340,November 2012.

[2] Yogeswaran Mohan, "An Extensive Review of Research in Swarm Robotics", "Nature & Biologically Inspired Computing, 2009. NaBIC 2009. World Congress", Pp. No. 140-145.,Dec 2009.

[3] Yara Khaluf," Self-organized Cooperation in Swarm Robotics", "Object/Component/Service-Oriented Real-Time Distributed Computing Workshops (ISORCW)",PP no 217-226, March 2011.

[4] Xue Songdong, "Sense Limitedly, Interact Locally: the Control Strategy for Swarm Robots Search", "Networking, sensing and control, 2008. ICNSC 2008. IEEE Inernational Conference", 402-407,April 2008.

IJERT