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Development of WARKS for Accessing Supply-Chain Management

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Abstract: ***In our modern society, the demand of wireless communications increases exponentially. All the indoor and outdoor everything converting from wire to wireless. Even the newly invented devices, cars, TV, refrigerator, washing machine all the advanced things uses wireless technology. Because of the reason, there are more fields to do research in this area. WiFi is one of the important technology in wireless communications. In this work, we have developed a device which will useful to build an wireless network. The device used to monitor and to control supply-chain management of any organization. We have used WiFi which works as two different modes; one is AP (Access Point) and another is STA (STAtion). In this paper, AP acts as a Server where STA act as a Client. We have developed a wireless network system using self organized sensor nodes (each node has one AP, one STA and one Controller) to communicated each other serially to exchange data and request task accordingly. Because of its serial distributed formation the WiFi range is also be increased with different topology. All the command and request can be done using computer or smartphone. This system (we named it WARKS) can be implemented in home, industrial, hospital, farms, forest, agriculture and many more. To verify the system capabilities and work performance, we do the experiment in indoor and outdoor using required hardware and software.***

Keywords: ***Access Point, Arduino, NodeMCU, STAtion, WARKS, WiFi, Wireless Sensor Networks.***

I. INTRODUCTION

Wireless devices have grown tremendously within recent few years due to the appearance of global adoption, various functionality and wide applications. Future WiFi probably dedicate broadband speeds. Wireless access is consider to both indoor and outdoor environments. For high quality of service (QoS), WiFi enabled devices (i.e., smartphones, tablets, laptops, smart TVs, cameras, sensors etc.) improve user experience and attract them to this technologies. The communication technologies currently used in D2D (device-to-device) communications, to interconnect multiple sensor nodes spread into a particular area. Access to communication technology can play a pivotal role in social and economic development.

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The choice of technology to achieve this a significant aspect [1]. If the network has to cover a larger area than router is not capable of transmitting to, or if signals have to penetrate through obstacles, performance will take a hit. Interference is also a big issue, signals from other wireless networks and electronics can impact speeds. The goal of this work is to analyse WiFi feasibility and evaluate its performance and applications in different fields by using a WiFi network with sensors, kits and multimedia support. This work improve D2D communications in a significant way, appointing intermediate multi hop WiFi nodes with different network topology. The objective of this work to retain the WiFi communications without boosting the signals for both static and dynamic cases (maintaining the order and range of WiFi nodes).

For static purpose this network is usable in house, colony, factory, hospital, office, hostel, restaurant, forest etc. Also for dynamic purpose this network is usable in agriculture, animal monitoring, mountain, train, army and rivers etc. Authors intention to establish a online/offline data processing enable network for communication [2]. WiFi deals with the specification of an unlicensed bands worldwide use in wireless local area network supporting a set of scenarios based on number of devices, range, and energy constraints. WiFi offers a simple, robust, and efficient solution in the industrial, scientific, and medical radio band (ISM band) compared with other existing technologies. WiFi technology enables devices to exchange information and perform actions without human intervention. Due to their short wireless range and high obstruction losses, current WiFi require the use of intermediate nodes, to reduce complexity of the network. This paper upsurge our experiences, should create a revolution in offline WiFi network and keep the impression at peoples mind [3]. In the following sections we describe four different perspective relevant to the WiFi networks,

- Introduction
- Network Models
- Network Applications
- Conclusion and Future Plan
- Acknowledgment
- Reference

This network will be adoptable for future communication technologies to establish a convenient environment.

II. NETWORK MODELS

Authors intention to construct a network which can be use in different field and for different purpose with various functionality. Which produce a secure, reliable, energy shaven, portable and simple local area network, that favor in both cellular and ad hoc compositions.

1) Concepts: Multiple walkie talkies use a single radio channel, and only one radio on the channel can transmit at a time, and others walkie talkies receive it. The goal of authors

Table I. Comparison with Existing Technologies

Technology	WiFi	Bluetooth LE	ZigBee	WiMAX	LoRa	LTE	4G
Standard	IEEE 802.11	IEEE 802.15.1	IEEE 802.15.4a	IEEE 802.16a	IEEE 802.15.4g	IEEE 802.16	IEEE 802.16m
Frequency	2.4 GHz, 5 GHz	2.4 GHz	2.4 GHz, 868 MHz, 915 MHz	2.5−5.8 GHz	433, 868, 780, 915 MHz	824−1990 MHz	1.8−2.5 GHz
Bandwidth	20−40 MHz	1 MHz	1 MHz	1.25−20 MHz	125−500 KHz	1.4 MHz	5−20 MHz
Range	10−150 m	10−50 m	10−100 m	5−30 km	2−15 km	10−30 km	10−30 km
Protocol	CSMA/CA	BR/EDR	CSMA	CSMA/CA	ALOHA	TCP/IP	TCP/IP
Modulation	BPSK, QPSK, QAM	GFSK	BPSK, QPSK	CSK	CSS	QPSK, QAM	PSK, QAM
Data Rate	54 Mb/s, 6.75 Gb/s	1 Mb/s	20−250 Kb/s	30−40 Mb/s	50 Kb/s	50−100 Mb/s	50−100 Mb/s
Network Topology	Star	Star, P2P	Star, Tree, Mesh	Star, Tree, Mesh	Star	Cellular	Cellular
Band	ISM	ISM	Wireless	Wireless	Wireless	Wireless	Wireless
Duplex	Half	Half	Half	Full	Half	Full	Full
Spectrum	Unlicense	Unlicense	Unlicense	License	Unlicense	License	License
Transmission Technique	OFDM	FHSS	DSSS	CDMA	OFDM	OFDMA	OFDMA
Latency	3 ms	6 ms	20 ms	5 ms	2 ms	2 ms	2 ms
Power Use	6 W	0.01−0.5 W	Low	High	Low	High	High
Battery Life	Months to Years	Days to Weeks	Months to Years	Months to Years	Months to Years	Days to Weeks	Days to Weeks
Transmit Power	1−100 mW	1−10 mW	1−100 mW	200−20000 mW	10−2000 mW	200−20000 mW	200−20000 mW
Sensitivity	-95 dBm	-97 dBm	-100 dBm	-100 dBm	-149 dBm	-120 dBm	-122 dBm
Packet Length	100 bytes	200 bytes	100 bytes	100 bytes	200 bytes	1200 bytes	1240 bytes
Security	WEP, WPA, WPS	128 bit AES with counter mode CBC MAC	Low	Low	Low	Low	Low
Module Price	$10	$10	$40	$50	$60	$70	$80

is to build a network, which can work as both cellular and ad hoc, with multi hop connection. Which can use in home for static network and in outdoor dynamic network for natural disaster. By walkie talkie the voice data can transfer, but this WiFi network must include various sensors, kits and enable multimedia support. So the concepts are increase the capability of network with different functions. Such that it is possible to form different topology by this network.

2) Opportunities: This technique implement for various field of applications. By this network it is possible multi hop nodes communication. If any person control a device/machine of 7th node with mobile connection from 1st node Fig. 1, then it is also possible to monitor another device/machine of 4th node with mobile connection from 8th node, and so on simultaneously. In this way multiple device can be control by one clients. WiFi devices are easily portable, so they are use in both static and dynamic purpose. This technique increase the range and the number of connections. Also both short and long range WiFi connection may use to provide good services.

3) Hardware: In this network an AP, a STA, a Controller, various sensors and kits have been used to model the WiFi network. AP and STA are connected each other with wire connections, STA/Master connected to a Controller and a display with wire. At each nodes different type of sensors and kits have used, which are connected with wire to Controller. AP, STA and Controller are connected with power bank by USB (Universal Serial Bus). In each node same type of WiFi device have been used for AP and STA, AP works as Server and STA as Client.

4) Duplex: Four type of half-duplex protocol have been used in this network. WiFi communication between AP and STA is half-duplex, UART communication between AP and STA is half-duplex, I2C communication between STA and Controller is half-duplex and HTTP communication between AP and Client (mobile) is also half-duplex. This means no device can send and receive, or upload and download, simultaneously.

5) Mapping: By mathematics, since 'STAs' and 'APs' are two sets and by some given rule, element of STAs corresponds to a unique element of APs, so the rule is called a mapping of 'STAs' into 'APs'. Here 'STAs/ Clients' set include mobile, laptop, wireless sensors etc. and 'APs' set include all Servers/APs in the network. Mapping are two types "one one" and "many one". Since many STAs can connect with one Server therefore the map are many one mapping. And STAs/Clients connected to a Server/AP of a node with wire connection is a many one mapping, Similarly Controllers connected to a STA with wire in this node also a many one mapping, Sensors/Kits are connected to a Controller with wire is also form a many one mapping.

6) Topology: The topology of this network can form tree, star, bus, line, chain or combination of them. But that nodes of this network should not form ring or mesh topology.

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Because the data will forward from one node to all others nodes. Since each node forward data to all others nodes, which nodes are connected to it. Therefore if some nodes form a ring or mesh topology of this network then the data will turn around in, which happen continuously and will hang this network. For n nodes network, total $2n$ numbers of AP and STA are need.

7) Security: For establish a connection to a node of this network by mobile or computer, peoples should go through some authentication password. After network authentication, users also should go through Second password for access specific node of this network. A web server has been design for receive/request instruction of specific node of this network from mobile/computer. By this web server peoples can control or monitor specific node's relay, sensors, devices and also can do, multimedia communications online/offline.

8) Experiment: The experiment has done in the Hostel and in the Department of Jadavpur University. Which cover different floors of building with distributed rooms for indoor purpose. This experiment also has done in the playground of University for outdoor purpose, where each node placed at 20 meters distance from others. All external clients (mobile) *Fig.*1 are connect to the AP/Server of a node of this network for monitoring or controlling any sensor/kits of other nodes. AP of any node receive and request the instruction from clients and forward to all STA and AP (both wire and wireless) by these Serial and WiFi connections. Total eight nodes are used, each node have one AP, one STA and one Controller. STA work like a Client, one display and one controller are connected to it. Controller works like a Slave of STA/Master. Various sensors/kits are connected to the Slave by wire. Seven mobile are used as an external clients. Both command and request are done simultaneously. Message of any client flash to the screen of display. In case of connection lost of any node to this network, this also flash to all nodes display that which node lost the connection. The connection speed was approximately 112kbps for using seven mobiles to receive/request instructions of eight nodes network. The receive/request instruction also work if maximum three STA/Clients connected to one AP and access to other different nodes.

9) Challenges: For static/dynamic situation, if some nodes lost connection, then it automatically reconnect to its previous node, that it was connected to in this network. Since STA can connect only one AP and many station can connected to a AP *Fig.*1. If some cases, connection is not define (i.e STA can randomly select an AP). In this type of cases if connection lost, STA of any node search random AP within its range. If it get another node (not previously connected node) and connect it's AP. Then the network may form two or more disconnected sub network with different topology. Same node STA and AP can connect each other. This is a great challenge to this network. Since one STA can connect only one AP wirelessly therefore the whole system will suffer for it. So for random connection, should make a manual connection configuration.

Table II Comparison of different board we used for this system

Specs/Board	ESP32	ESP8266	Arduino Uno
Number of Cores	2	1	1
Architecture	32 Bit	32 Bit	8 Bit
CPU Frequency	160 MHz	80 MHz	16 MHz
WiFi	Yes	Yes	No
Bluetooth	Yes	No	No
RAM	512 Kb	160 Kb	2 Kb
Flash	16 Mb	16 Mb	32 Mb
GPIO Pins	36	17	14
Busses	SPI, I2C, UART, I2S, CAN	SPI, I2C, UART, I2S	SPI, I2C, UART
ADC Pines	18	1	6
DAC Pines	2	0	0

String Processing					
DNID	SNID	CMD	REQ	MSG	TERM
16 bits	16 bits	32 bits	32 bits	N bits	8 bits

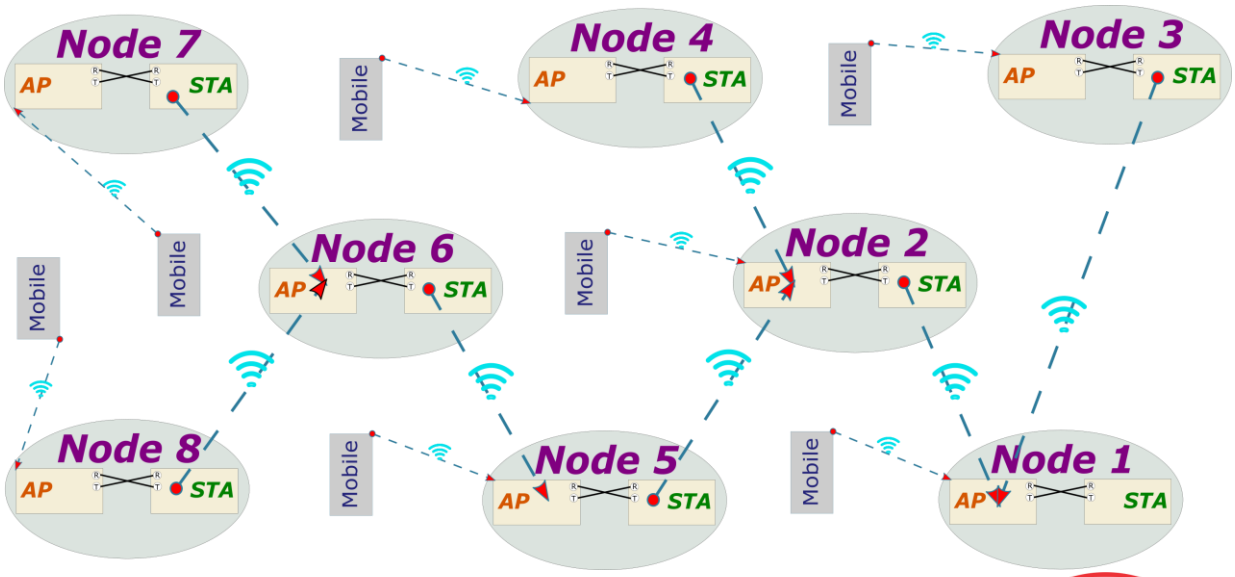

Fig. 1. Wi Fi Communications using WARKS

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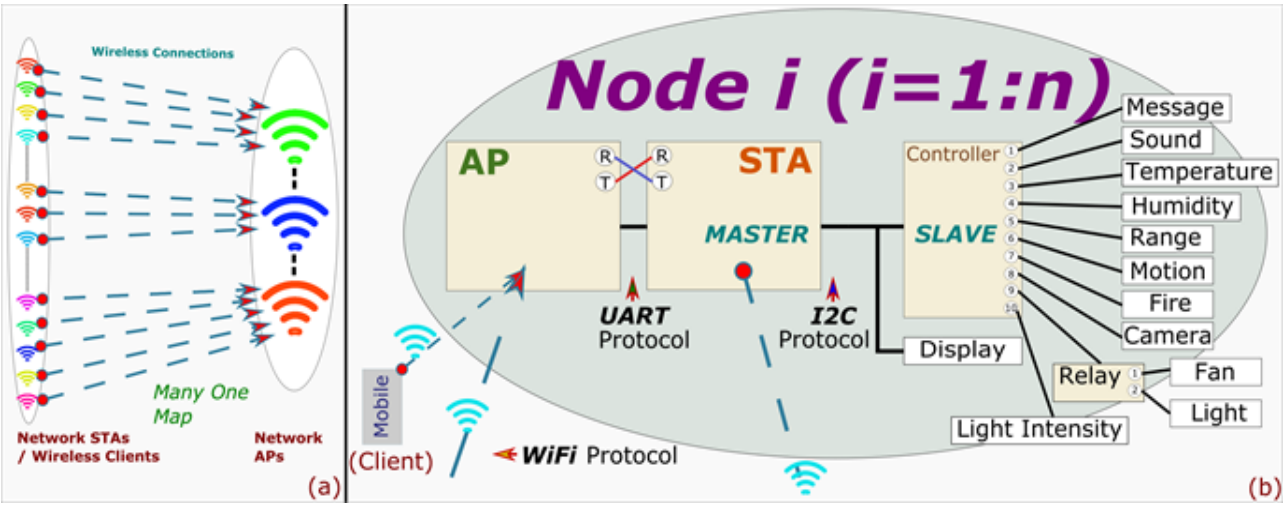

Fig. 2. (a) STA/Clients map into APs/Servers, (b) Hardware design of *i*th Node with communication protocol and sensors/kits of the Network

Command	Descriptions
RLY[number]	It will control the relay board
FAN[O/F]	Control Fan On/ofF
Li [O/F]	Light
WIN[O/F]	Windows close or open
DOR[O/F]	Door close or open
Ref[O/F]	Refrigerator On/oFf
ALL[O/F]	All control on or off
MSG	Message from requested node to source node

Request	Descriptions
TEM	Temperature
HUM	Humidity RSS Received Signal strength
LDR	Light intensity measurement
DIS	Ultra-Sonic range finder
SMK	Smoke Sensor MOS Motion Sensor

III. NETWORK APPLICATIONS

Several scope of applications [4] of this network are present in multiple fields Fig.3, some of them are describe as follows,

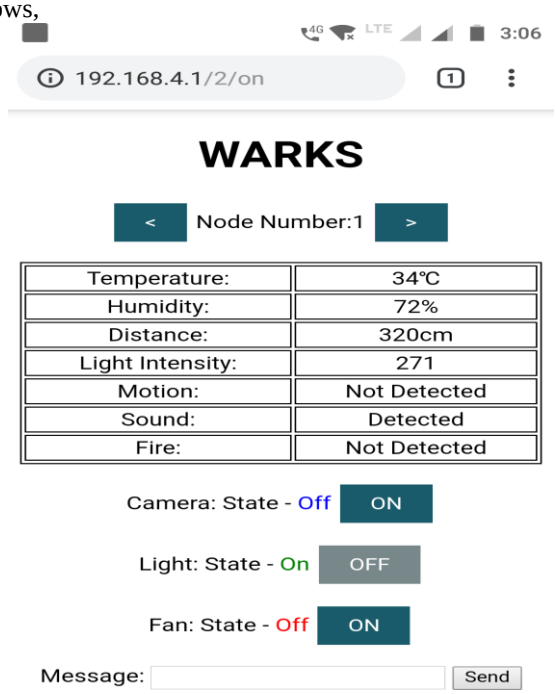

Fig. 3. WARKS user interface

A. Industry

Automatic control has played a vital role in the advance of engineering and science and it has become an important and integral part of modern manufacturing and industrial processes. It makes the process easier and time shaven. One of the main ingredients of automation is undoubtedly control, which means information being collected, processed and delivered back to each sensors. Workers of a factory can easily control various machine with their mobile, using WiFi connections. Also they can receive real time temperature, humidity, gas, radio frequency, fire, smoke, alarm etc., to their mobile app. Moving robots or vehicles can be control. Workers can get access to this network by connecting moving robots or vehicles, they act as multi hop nodes of WiFi network. From first WiFi connection from mobile, workers can control a robot and by second connection from mobile to robot's node (this time robot's node work as multi hop node) can monitor/control another device or machine. All data will store to the servers through multi hop connections.

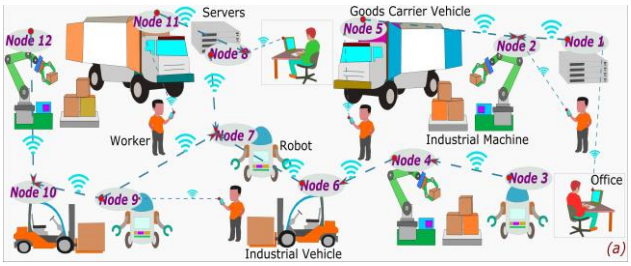

Fig. 4. Applications in Industry

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A. Train

WiFi network connections enable operators to manage car-riage to carriage and train to ground communications with increased efficiency and create attractive onboard multimedia services that give passengers safe and environmentally friendly transportation. At each carriage of a train should have some WiFi nodes which have some sensors. Passengers can access this network using mobile by connecting to a single node of the network. They can receive information about temperature, humidity, fire, smoke, alcohol etc., can access movie, music to their mobile from the network servers. Passenger can do, chat to other coaches passengers, order foods, complaints, take necessary helps from other passengers or securities. This network should distributed among authority, security, kitchen and coaches. Train authority can control air conditioner, doors, send massage, alarms to passengers. The authority can collect all information to server by this multi hop nodes. In this way restaurants, shopping mall can provide services to their customers.

Fig. 5. Applications in Train

C. Hospital

In a hospital constant health care monitoring system is necessary for the patient's physiological parameters. In case of emergency patient should need medical treatment or shifted to other hospital. For this purpose a communication network need among patient, doctors, patient relatives, nurses, inquiry, pharmacy, ambulances and offices. This WiFi network full fill all functionality and take care about hospital emergency man- agement. Patients are placed in different ward, it is difficult to look after all patients if lack of doctors or nurses in hospital. So by WiFi sensors, camera and various devices, it is easy to monitoring to all patients physical conditions from different places with mobile or computer by this network. Using real time data this system will be faster.

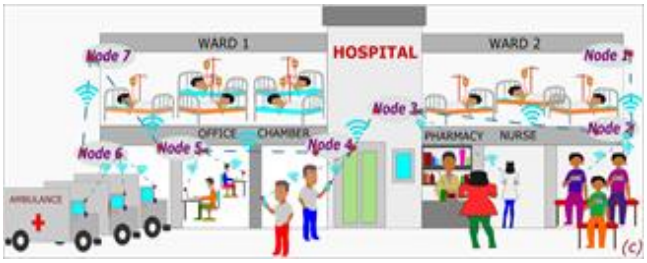

Fig. 6. Applications in Hospital

D. Agriculture

WiFi reduce effort and time for monitoring agricultural environment [5]. The utilization of WiFi technology allow for remote measurement of temperature, humidity, crop condition, atmospheric pressure, soil moisture, water level and insects detection, observation etc. The WiFi system will reduce the cost. Sensor location can easily repositioning. Also enhance the flexibility and mobility of sensing points. Greenhouse farming growth, germination, sprouting, flowering and fruit de- velopment monitoring with WiFi reduce the labor of farmers. This proposed idea introduce together a controlling and moni- toring system which activate or deactivate automatic irrigation, reaper, seed planter and agricultural vehicles of an agricultural fields with short and long range multi hop WiFi nodes. A farmer can fly a drone by mobile, together with drone node WiFi (i.e. three hop connection) the farmer can communicate with other farmers. Any animals, birds or human activity to the crop field can easily identify from any corner or share data to each other by multi hop WiFi network. Dairy farming easily look after with deploying various WiFi sensors. For short of connection farmers can access to network with moving agricultural vehicles. Fishermen can communicate each other by this WiFi network from fishing boats.

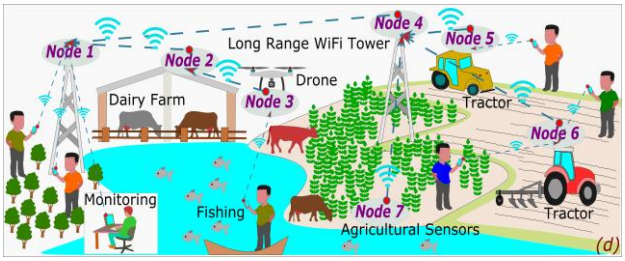

Fig. 7. Applications in Agriculture

E. Mountain

Mountaineering is the set of activities which involves as-cending mountains. Mountaineering related activities include traditional outdoor climbing (rock and ice), hiking, backpack- ing, skiing, and traversing via ferratas. Mountaineer are travel long distance for climb up to horn of the mountain. Sometime they leave behind their accompany or needs to medical helps. As there is no network coverage, so it is impossible to communicate each other. For this purpose they should need both short and long range WiFi communication networks. Long range WiFi [6] are deploy like mobile tower (base station) and short range WiFi communicate among the group of mountaineer. If any group want to communicate another group to whom they leave behind, simply connect to long range WiFi network, by mobile WiFi and can communicate with each other. In case of medical emergency, can get help from administrator or rescue camp by connecting to long range WiFi network. Administrator or mountaineer can share any problem with others by connecting one node of this network such that rest of group can avoid this difficulties. Since each and everyone are connected to the long range WiFi network.

So by RSSI values [7] one group can find other groups node location to the mountain and how far away this group traveling from a WiFi tower can be identify. In the same way, this technology can be use in desert.

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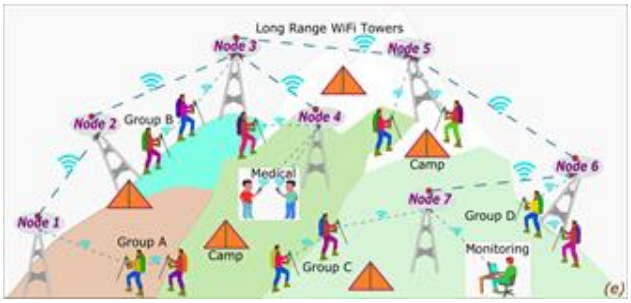

Fig. 8. Applications in Mountain

F. Forest

The forest is a complex ecosystem consisting mainly of trees that buffer the earth and support a myriad of life form. Wild animals graze in forest, sometime herd of several wild animals or birds migrate together one forest to another. They are need monitoring from different place of forest. Also the forest needs security from poaching, forest fire etc. To get away from this problem this WiFi network is a good solution. Each node of this WiFi network should have camera, fire detector, motion sensors, sound detector etc., and will be a combination of short and long range WiFi network. By this network, animal, birds or any unauthorized human activity can easily track for taking necessary steps.

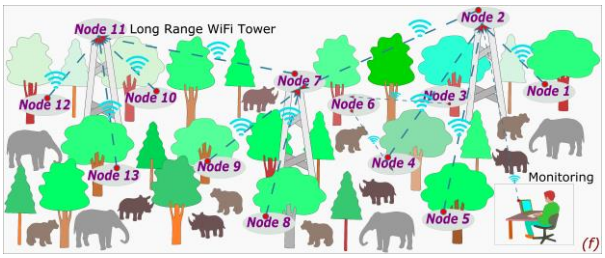

Fig. 9. Applications in Forest

G. Army

Military automation has changed the face of battle, and WiFi devices have played a key role. The air force, the army and the navy all get benefit and improve their function. Army communicate each other for battlefield operations. It may be take place in forest, hill, sea, urban or rural areas. Army can communicate among them, using drone or vehicles to aerial vehicles by WiFi network. Even inside the army camp this technology may use. In case of natural disaster, i.e. earthquake, flood, fire etc. this technology will use. The advantage of this network is, it can use dynamic, static and both together.

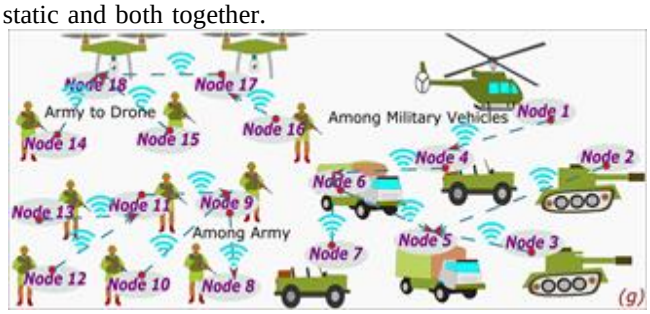

Fig. 10. Applications in Army

H. Home

A home automation system will control TV, light, fan, door, window, climate, entertainment etc [8]. It may also include home security, such as alarm, motion, gas, fire, smoke, baby care systems.

All of this sensor devices can control and monitor connecting with one node by mobile, present in any place of network coverage area. Use this multi hop WiFi connection people can communicate among multi floors with multi buildings. Any person can send message to any people or a group of people by this WiFi networks. Also can control their cars from multi floor building using this network. The same technique may use in office buildings.

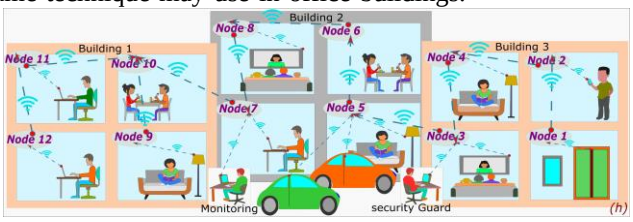

Fig. 11. Applications in Home

IV. CONCLUSION AND FUTURE PLAN

This work is done to make the living environment easier for controlling and monitoring remotely using mobile or computer. The proposed system can be used in agriculture, home automation, industrial automation, smart cities, army, fishing, mountain tracking etc. Distance can be find using RSSI technique [7], [9], [10], [11], [12], [17]. In this model all the AP has variant SSID but unique IP address and port number. Making unique SSID for all AP and variant IP address is under process.

Our future plan is to implement this system into swarm robotics to create dynamic formation using wireless commu- nication to solve the complex problem which can be finding shortest path of path following robot [3], [13], [14], [16] rescue people from danger, battle field fighting technique and many more. To improve the hardwares, we have to use the LiFi or future technology to create a super speed wireless data transfer. To improve softwares, we plan to develop a new programming language to configure required wireless network hardwares easily.

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