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Wireless Sensor Networks to Implement Smart Elevator System

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Abstract: In modern day world, time has become a precious resource. Therefore, different strategies and techniques are constantly being employed in all fields of life to save every bit of time. Increasingly many of such applications involve wireless sensor networks. A highly potential system that can be made significantly more efficient using WSNs is an elevator system. There have been numerous attempts to improve the serving efficiency of the elevator system over the course of time. This paper proposes to utilize the elevator system in a more productive manner so that more number of people can be served in a lesser time. Hence, people will be able to spend this valuable time on other important and crucial matters rather than waiting for the elevator and wasting their time in vain. In the smart elevator systems, there are a number of wireless sensors that detect and transmit information on a number of people requesting elevator transport. The smart elevator system uses that information to select or determine one or more transport paths for one or more elevators to follow and, therefore, can be beneficial in enhancing efficient use of one or more elevators in an elevator system to service persons awaiting elevator service.

Keywords: smart systems; elevator system; wireless sensor networks; wireless adhoc networks.

I. INTRODUCTION

Smart Elevators are advanced systems that allow automated vertical transportation of goods or passengers. As this system utilizes automation, it reduces the waiting time and increases traffic management efficiency in residential, commercial and other buildings. Smart Elevator systems consist of new-age digital security system controls, i.e., biometrics, touch screen, destination dispatching & access control systems, which make them advanced. Since the elevators provide automated features and consume less energy, these elevators are labeled as “Smart Elevators”. Moreover, reduced waiting time of passengers, enhanced spending capabilities of customers in emerging markets and overall improvement in global economies are some of the major driving factors for the Smart elevators market. In spite of various advantages and driving factors, substantial initial investment in the installation of smart elevators would limit its presence, which in turn would adversely impact the global market growth.

The global smart elevators market is segmented on the basis of solutions, applications and geography. Solutions segment provides detailed information on different devices, which are used in smart elevators such as card based systems, biometrics, touch screens and keypads, security and access control systems, visitor management systems, sensors, motor drives and controllers building managements systems and many more. Historically, when the first passenger elevators were introduced in the 1890’s, each car was individually controlled by an attendant riding the car. As building heights rose, however, so did the number and speed of the cars and it soon become impossible for the attendants to provide effective coordination and control.

The application segment focuses on residential, commercial, industrial, institutional and others. Further, the market is segmented according to different geographies. The global market is closely examined by conducting research across various geographies such as North America, Europe, Asia Pacific and LAMEA.

Automated or smart elevators make use of artificial intelligence (AI) to enable vertical transportation of commodities and passengers. Smart or connected elevators are increasingly being used in buildings such as hotels, residences, arenas, hospitals, sports facilities, offices and airports among others. These are designed so as to minimize overall energy consumption and manage passenger traffic efficiently within a building. Smart elevators make use of automation technology and minimize waiting time by efficient traffic management in commercial, residential and various other buildings. Technologies incorporated in these units include biometrics, destination access and dispatching control systems, digital security control system and touch screen control among others.

However, substantial initial costs of installation for smart elevators limit their use worldwide. Battery backup, alarm, door interlocks, levelling device, brake system with speed sensor, evacuation latch and fire and earthquake emergency return and many more are all a part of the elevator control system. With the advancement and innovation of technology and changing building infrastructure these control systems are becoming all the more versatile in order to securely manage building traffic.

The deployment of automation to the elevator systems reduces the wait time, increases efficient management of the traffic in residential, commercial and institutional buildings. The improvement in management at these facilities with the incorporation of automated solutions has driven the elevator automation market. As these elevators are employed with automated features and consume less power they have been widely adopted by contractors worldwide. The restriction imposed by the government on construction projects to reduce operational cost by introduction of automated facilities within the elevator has increased the demand for this market. The increased concern for development and security of the building premises has led to the rise in demand for the elevator automation market.

Urbanization and increased expenditure on constructional projects has driven the smart and connected elevators and elevators control systems market. The incorporation of latest technologies namely personal occupant requirement terminal (PORT) and dispatch destination has substantially increased the demand for this market.

Modernization of traditional building structures in countries such as UK, the U.S., Canada and France has contributed majorly to the growth of smart elevator market. Moreover, expanding building infrastructure across developing economies especially in Asia Pacific has escalated need for comfortable, secure, efficient and quick vertical transportation. The numerous companies operating within the market strive to remain competitive by expansion and innovation of their product line offering. Companies are working towards enriching the customer experience through fabrication of smart elevator components which include doors, interior and entrance. Technologies enabling functioning of these elevators are of optimum level thus cost of entire elevator unit is high. All the above factors prove to be a barrier for the growth of smart elevator market. Technological breakthrough for the smart elevator market is emergence elevator control system which provides increased safety, comfort, enhanced infrastructure and operation control through voice commands, sensors and more.

In recent years, the elevator becomes more and more important in the intelligent building as a vertical transport accompanied by increase of domestic high-rise buildings, office buildings and residential areas. As the large number of elevators, busy action, frequent failure, and little maintenance personnel, which will bring the personal and property hazards, the elevator's safe issue has become a common concern. To improve the safety of elevator, regular maintenance is of particular importance.

The current electrical adjustment focuses on the machine room, and the existing elevator cable adjustment mode has a long debug cycle on the adjustment of flat floor, running curves and involving running part for the car. On the other hand, it usually requires the close coordination between two adjustors, one stays in the car to judge if the elevator works well and the other stays in the machine room to adjust the elevator. Besides, it is a wired connection and needs hot-swappable interfaces. However, this method is convenient for adjustor to adjust the elevator in the machine room, and inconvenient to adjust the parameter of elevator car.

The implementations of many smart systems are increasingly depending upon wireless ad-hoc sensor networks. Lack of need for centralized and dedicated infrastructure in wireless ad-hoc sensor networks and comparatively lower power consumption of the wireless sensor nodes make it more ample to be applied in many situations [1].An implementation of a smart elevator system based on a wireless multi-hop ad-hoc sensor network is demonstrated. For experimental simplicity, a single elevator in a five storey building is considered. Each floor is equipped with a sensor and the traffic conditions of every floor are communicated to all other floors in a direct or multi-hop fashion.

In the proposed system, the elevator serves the floor with greater traffic and hence achieving the objective of serving more people within a given time. The most striking feature of our proposed system is that of avoiding unnecessary stops at floors by sensing the departure of the requesters before the elevator reached there.

Wireless ad-hoc sensor networks are those that comprise of entities (sensor nodes) that can connect, communicate and coordinate with each other with neither a centralized server no many pre-existing infrastructure [1][6]. Evaluating the performance of Mobile ad-hoc wireless networks is important because it allows determining the types of applications that can be supported on such networks. BER (Bit Error Rate) of an average multi-hop route directly affects the ability of an ad hoc wireless network to support applications requiring a specific BER, for a given no de-transmission power and node spatial density.

Given this feature, destination node can estimate stability of routes and can select the best and more stable route. Therefore we can reduce the delay and jitter of sending data packets. The network performance metrics evaluated in these studies are usually network layer related parameters such as packet delivery ratio, average end-to-end delay, and average hop count, and control packet overhead. Such Wireless sensor networks have been successfully deployed and have numerous applications in several fields such as

- Medicine [7], a typical wireless node is equipped with at least one sensor that could be as simple as a small thermistor or as complicated as miniature video capturing system;
- Military [8], the security checkpoints are set up on the international roads where all vehicle traffic is stopped to detect and apprehend illegal aliens, drugs, and other illegal activity. Each border troop watches and controls a specific section of the border. The troops patrol the border according to predetermined route and time interval. Under the conventional border patrol system, even modest-sized areas require extensive human resources if manual patrolling is considered alone;
- Environment monitoring [9], Recently natural disasters such as earthquake, seismic sea wave, typhoon, hurricane in addition to annual disaster have frequently happened at many places around the world. When disaster occurs,

information networks infrastructure performs very important role as the resident's communication means. However, once a disaster occurred, failures of network equipment, cutoff of communication lines and traffic congestion cannot be avoided. More reliable and robust network environment is required even though the serious damaged by disaster occurred.

Another application of wireless sensor networks is our elevator system. As our proposed elevator system communicates in a multi-hop manner, this means that every node (floor) can only communicate with its adjacent nodes (floors) only. All nodes are capable of being informed of each other's traffic through this technique of wireless multi-hop communication [2]. The challenge in ad-hoc networks are the development of dynamic routing protocols that can efficiently finds routes between two communicating nodes. The routing protocols must be able to keep up with the high degree of node mobility, which effects rapid and unpredictable topology changes.
We propose this multi-hop nature of interacting between sensors keeping in mind the inter-floor distance and the floor thickness that could affect communication if each floor was to be connected to every other node. To integrate our WSN in controlling the elevator, a study on traditional elevator systems was made. The two basic algorithms that make the decision to stop the elevator car at a particular floor, called the dispatching algorithms, are
(a) Based on the current direction of the elevator.
(b) Based on the time of request from each floor [3].

These revolve around the objectives of either minimizing the consumption of power or minimizing the average waiting time for passengers [4]. In the first approach, if the elevator is currently moving in a certain direction, it will stop at floors in its way that have requests in that direction only and will change direction once it serves them and if there are requests in the opposite direction. On the other hand, in the time-based approach, the requests are stored in a queue and ordered according to their time of arrival [3]. The elevator then would serve the floors according to this queue. Though there are quite a few elevator dispatching algorithms being commonly implemented and used, like those above, there are several problems concerning the passengers and requesters. Firstly, considering the direction-based approach, if the elevator is moving in a particular direction(up/down), and the number of people requesting to go in that direction is less than those requesting to go the opposite way, a majority will be kept waiting.
Secondly, in the time-based approach, if the queue of requests is haphazard, the elevator would waste a lot of power and trips. The elevator would be moving up and down the building and passing other requesting floors without serving them. Eventually it will return to them at some later point in time. So, in such cases, the elevator would be consuming more power and time than it would have to if it served the intermediate floors when it passed across them previously.
In addition, the dispatching algorithms like those above and many more improvised ones fail to consider the cases when the passengers push the request button and leave the elevator-area due to some reason. In such cases where the elevator will have no mechanism to be aware of this update, it will have wasted trips to such floors where the requesters have left. We present a solution to such problems through the use of real-time wireless sensor networks connected together in a multi-hop ad-hoc manner including the network design of the system and the communication protocols. Then our main elevator dispatching algorithm has been explained along with some test cases and their analysis.
A good elevator service is important to improve the users comfort. However, this comfort is directly related with large energy consumption and therefore implies high functional operational cost. In modern buildings the vertical transport of passengers is implemented by an Elevator Group Control System (EGCS) and many micro processed sub-systems implementing local control for each elevator.
Advances in EGCSs have been developed at the same time that IA techniques began to be explored in real situations. The performance of an EGCS is measured by means of several metrics such as the power consumption, average waiting time of passengers, among others.

1.1 Objective of Study and Scope
In this project, smart elevator system is going to be implemented using wireless sensor network. Thus, the main objectives for this project is to design and construct a wireless sensor based smart elevator system.
There are some scopes which needed to achieve the objective for this project:
a) To design a smart elevator system using wireless sensor network.
b) To design the program (software) for the overall system according to the elevator dispatching algorithm.
c) To integrate the hardware and software in order to simulate the functions of a basic lift system.

II. REVIEW OF LITERATURE

2.1 History and Influence
Elevators began as simple rope or chain hoists. An elevator is essentially a platform that is either pulled or pushed up by a mechanical means. A modern day elevator consists of a cab (also called a "cage" or "car") mounted on a platform within an enclosed space called a shaft or more correctly a hoist way.

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In the past elevator drive mechanisms were powered by steam and water hydraulic pistons.
Today, there are intricate governors and switching schemes to carefully control cab speeds in any situation. Buttons have been giving way to keypads. Virtually all 5commercial elevators operate automatically and the computer age has brought the microchip-based capability to operate vast banks of elevators with precise scheduling, maximized efficiency and extreme safety. Elevators have become a medium of architectural expression as compelling as the buildings, in which they are installed, and new technologies and designs regularly allow the human spirit.
The first concept of moving vertically an object or a person appeared in 3rd century B. C as a form of hoist. They were operated by animal and human power or by water-driven mechanisms. However, the elevator, as one knows it today, is first developed during the 1800s. They mostly used hydraulic plunger or steam for lifting capability. Then, with the great invention of electricity, the modern concept of elevator began to evolve.
Otis promoted elevators to businesses to move freights from one floor to other, maintained and operated with the help of lift boys. Until then, there was no clear distinction between passenger and freight elevators. However, in 1857, first commercial elevator for passengers was installed in a department store of New York City. The advancing electronic systems during World War II has brought many changes in elevator design and installation such as the automatic programming that eliminated operators at the ground level or morning and evening peak scheduling, etc.

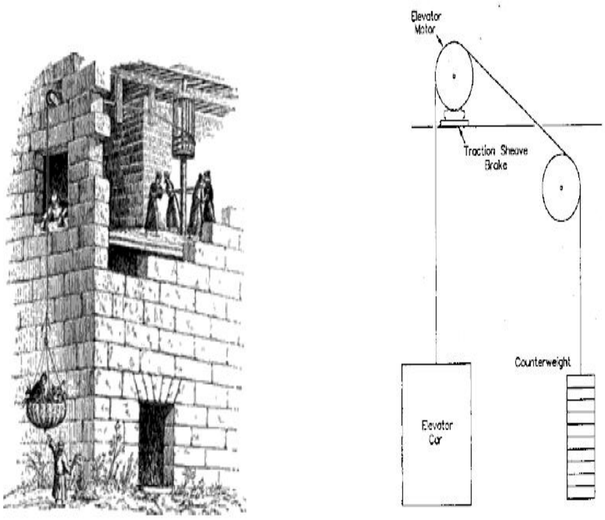

Fig. 2.1 Historical (Hoists) and Present (Traction) elevator concepts

Accordingly, the development of modern elevator deeply affected practically and aesthetically in both architecture and urban development by allowing high rise commercial and residential buildings, as well as skyscrapers. With the recurrent use of lifts in buildings, standards have been formed by types of buildings, number of passengers, and their traffic pattern for planning and for service quality. In fact, the centralized main core that one often can notice in multilevel building is a consequence of lifts. In most cases, lifts are placed together (when there is more than one elevator) near the entry point of the building to reduce the walking distance and to reduce the congestion of users.
Moreover, the introduction of elevator has also affected in localization of different functional space in a building. For example, in mixed-use buildings, it is common to place commercials on the lower, offices in the middle and residential on top floors. On the other hand, not only passengers elevator has evolved, but also way to deliver goods within a building has diversified through years. Namely, dumbwaiters have been invented around 1800 by Thomas Jefferson and pneumatic capsule transportation, a cylindrical container that is propelled through a network of tubes travelling by compressed air, was first conceived in 1860’s. Moreover, autonomous logistics, a system of unmanned equipment that transfers goods; and automated guided vehicles, a mobile robot that follows navigation guides often located on the floor have developed in recent years. These systems are widely used in present days, particularly in libraries, hospitals, warehouse etc. to deliver documents and packages.

Fig. 2.2 Rail system, Pneumatic Tube System and Automated Guided Vehicle

More specific to delivery system, recently, parcel keeping lockers are widely being installed in the lobbies of apartments. Deliveryman puts the parcel into the locker, also known as “Ubi-lockers”, without delivering them door-to-door. This prevents the deliveryman from taking the elevator and to use the related energy as he/she only needs to put the parcel in the locker usually located on the first floor of the building.
The Ubi-lockers keep the goods until someone picks up the parcel. Actually, these systems are common in Japan, where 95% of apartments have this kind of parcel lockers already in use. These recent systems show how much the number of parcel deliveries is being increased, and how it has become an essential part of daily lives.

Fig. 2.3 Ubi-locker System

2.2 Elevator Design
The two most popular types of elevators are: traction and hydraulic elevators. The way they operate and their purposes are different one from other. Hydraulic elevators use fluid in a tank, which is pumped and released by the electric motor to move the car. Whereas, traction elevator possesses a counterweight (weight of elevator + 40% of its maximum rated load) that balances in the reverse direction to displace the car. Hydraulic elevators are used in lower buildings compared to traction, as higher the building is, it needs more fluid and power to move the car.
Also, the installation fee and maintenance cost reaches higher. However, it has advantage in space saving and initial installation cost. On the other hand, the cable and pulley systems considered more energy efficient, safer and eco-friendly as they do not use hydraulic fluid. Moreover, they are widely used in high-rise buildings and skyscrapers.
In case of traction type, there are many other parameters that have to be considered: gear, drive, roping, programming and motor. These can be decided upon many perspectives; the installer’s budget, the quality service targeted to its users and quantity of energy consumption reviewed by the building owner.
The freight elevator is comparatively a recent product due to the substantial increase in its need. In fact, the freight elevator first existed in form of dumbwaiter. By definition, dumbwaiter is a smaller elevator that can have all the performance characteristics of an elevator.
Furthermore, the word freight elevator represents elevator that can handle heavier mass and greater volume of an object, mainly for the purpose of its delivery, not designed for passengers. Therefore, it doesn’t need to satisfy lift standards. Consequently, it has looser safety regulation.
On the other hand, the service elevator stands for an elevator that can transport passengers, as well as goods. The elevator integrated delivery system plays a part in latter category of elevator as it is first foreseen to respect passenger elevator standards and then to play an additional role as a delivery system.
Smart elevators are designed to transform the simple act of traveling between floors. Instead of pushing a button to go up or down, passengers first select the floor they want. Then they are directed to the elevator that will take them to their destination with the fewest number of stops.
Manufacturers say smart elevators are faster, easier and even more energy efficient than older elevators. But they can also take a little getting used to, if you live or work in a big city like New York; you end up taking a lot of elevators. At certain times of day, like lunchtime or 6 p.m., when everyone's coming and going at once, you can feel like you've spent half your life waiting for the floor number on that little digital screen to change.
Hearst's elevator is called the Miconic 10. It's made by the Schindler Corp., though other manufacturers including Otis Elevator and ThyssenKrupp Elevator have similar models. The first thing you notice about the Miconic 10 is that it has no up and down buttons. Instead, a single square column with a keypad stands in the middle of the lobby. Enter the floor number and the keypad directs you to a particular elevator.
The elevator closes almost noiselessly and speeds to its floor. The Miconic 10 is called a smart elevator for its ability to move people around more efficiently. By stopping at fewer floors, the elevator cars can return to pick up people more often. And because smart elevators make fewer stops, they use less energy. Building owners like them because they mean fewer large crowds forming in lobbies waiting for the next car.
Smart elevators can also calculate the weight of their passengers to prevent too many people from getting on. It can also slow down if a disabled person is boarding. Smart elevators can be tough for users to figure out.

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That can be confusing at a place like a hotel, where users are inexperienced. But Hearst's Brian Schwagerl says people quickly adjust.
Manufacturers concede that smart elevators aren't practical in buildings that are less than 10 stories. They're also more expensive. For those reasons, their use is spreading slowly. Schindler has installed about 600 of the systems in North America. But with more and more buildings looking for ways to move people around faster, the market for smart elevators is expected to grow.

2.3 Research trends
Most of researches related to elevators are done in practical fields, largely by companies and organizations rather than academic association. The researchers can be divided into two general categories: hardware or software analysis. Technical researches include physical replacement of motor type, elimination gear and addition of safety equipment to increase service quality to its users. The second category has been productive in the beginning of the electric elevator apparition. First, to serve as basis of elevating in the building, calculation methods of round trip time, waiting time, and transit time have been investigated and expressed in mathematical equations in terms of many other components of the physical lift and demand specification. Then, automatic scheduling, various programs controlling the elevators have been investigated to increase elevator efficiency in terms of passenger's waiting and transit time. Currently with the increase of interest in sustainability, research on observation of energy consumption and ways to reduce electricity usage in lifts are one of the new lift related research fields.

2.4 Passenger Traffic Pattern in Elevator
A. Passenger Traffic Demand
In the late 1960's, researchers such as Hall and Fruin took interest in pedestrians movement in buildings. Also, lift's appropriate service profile has begun to be actively researched in the 1970's namely by Barney, Santos, Peters and Strakosch. In European and North- American countries, where vertical transportation system is considerably studied, the designation of a specific elevator size and number depends on the passengers' demand and pattern. Actually, peak hour passengers are usually expressed as a percentage of total building population per five minutes. Moreover, the traffic can be categorized into four types:

I. Incoming
II. Outgoing
III. Two-way
IV. Inter-floor

Where incoming traffic consists up of passengers that take the elevator from the home floor (usually first floor) to the other floor (upper floors). In opposition, outgoing traffic denotes passengers going out of the building through the home floor from a certain floor. For example, in office buildings, incoming traffic mostly happens in the morning, whereas the outgoing traffic is observed during the afternoon. However, in some buildings such as apartments, the incoming and outgoing traffic is not very clear; this situation belongs to two-way traffic; where both, incoming and outgoing happen in the same time. Finally, the inter-floor traffic designates trips that happen in the same building, between floors that are not home floors.

2.5 Microprocessor, Microcomputer and Microcontroller
Microprocessor is a CPU (Central Processing Unit) that is compacted into asingle chip semiconductor device [1]. It is a general-purpose device, suitable to perform many kinds of applications. When the microprocessor is combined with input or output and memory devices, it is called microcomputer [1]. The choice of these devices that are combined depends on the specific application. For example, most personal computers contain a keyboard and monitor as standard input and output devices. The major difference of a microcontroller compared to a microprocessor and microcomputer is that microcontroller consists of central processing unit (CPU), memory devices (ROM and RAM), input and output ports and timer embedded into a single chip [2].
They also have many on-chip facilities such as serial port, counters, analog to digital converter and interrupt control so that they can be interfaced with hardware and control functions of many kinds of application. It is ideal for many applications in which cost and space are critical.
Microcontroller has a wide range of applications in many control-oriented activities. For example, they are used as engine controllers in automobiles and as exposure and focus controllers in cameras as well as they are used in a lift control system.

2.6 Description of the Proposed System
The proposed smart elevator system utilizes a wireless multi-hop ad-hoc sensor network and will be simulated and prototyped depicting a building comprising of five floors. We emulate each floor using a single laptop to ease simulation and implement a graphical view of the system at work. Therefore, five floors will be connected together in

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Vol. 6, Issue 7, July 2017

an ad-hoc multi-hop manner such that the nth floor will be connected only to(n-1)th floor and (n+1)th floor with the exception of 1st and 5th floors respectively where 1st floor will only be connected to 2nd floor whereas 5th floor will be only connected to 4th floor.

The proposed idea is to have two separate areas (boxes) at every floor's elevator lobby/area:

(1) For the people wanting to go up, and

(2) For the people wanting to go down

Each floor could be equipped with some external sensor/camera connected to them which could then feed a people counting algorithm (for example, based on Image Processing) and know the number of people waiting in that floor to go upwards and downwards. The floor will then communicate and pass this information to the next connected floor (multi-hop). In this way, the information will be shared among all the floors. However, the final decision will only be made by that floor where the elevator is currently present. This decision will only be made by this floor after running some algorithm.

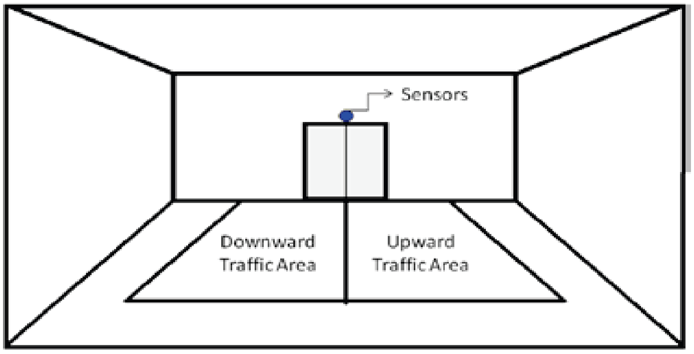

Fig. 2.4 View of the elevator-lobby with upward/downward traffic areas

III. SYSTEM DESIGN

3.1 System Architecture

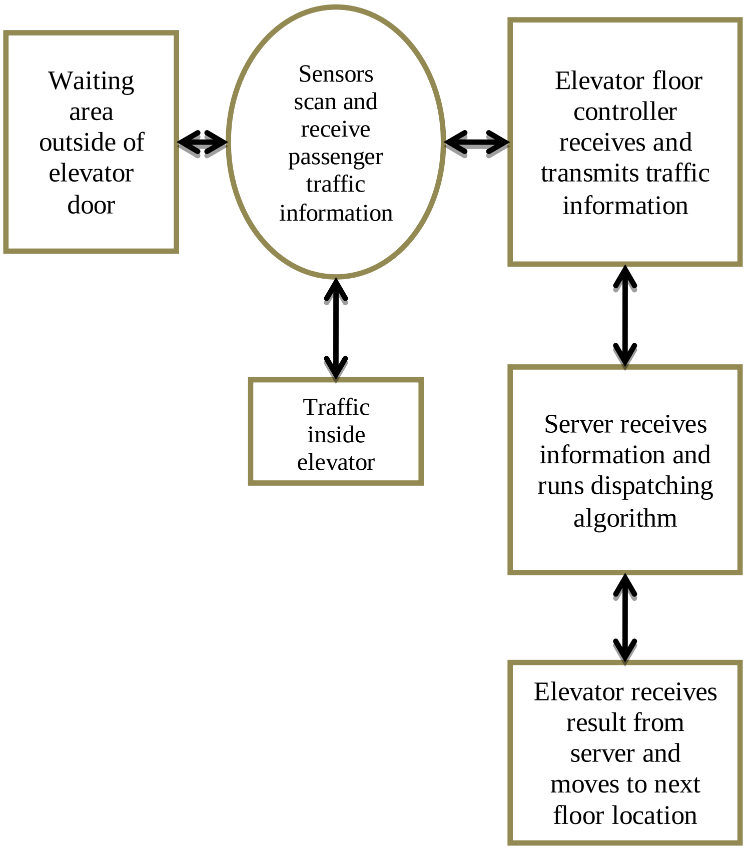

Fig. 3.1 System Architecture

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Figure has the following claims:

1. A smart elevator system including one or more elevator cars, comprising: a plurality of sensors, at least one of the plurality of sensors associated with a floor elevator door of a corresponding elevator car on a floor of a structure or associated with the corresponding elevator car, wherein the sensors detect a number of persons awaiting elevator service at one or more corresponding floors in the structure or receiving elevator service of a corresponding elevator car and transmit data signals of the number of persons detected; one or more receiving processors associated with one or more floor elevator doors or associated with one or more corresponding elevator cars, wherein the one or more receiving processors receive the data signals transmitted from one or more corresponding sensors and determine passenger traffic data corresponding to data signals; and at least one master processor associated with a corresponding one or more elevator cars in the structure, wherein the at least one master processor receives the passenger traffic data from the one or more receiving processors or from one or more corresponding sensors in the smart elevator system and determines at least one transport path to at least one floor location for corresponding one or more elevator cars, based on the received passenger traffic data.

2. The smart elevator system according to claim 1, wherein at least one floor elevator door on a corresponding floor is associated with at least one corresponding waiting area for passenger transport on the floor, and the at least one corresponding waiting area is associated with at least one sensor that detects a number of persons awaiting elevator service in at least one downward elevator transport zone and in at least one upward elevator transport zone.

3. The smart elevator system according to claim 2, wherein the at least one downward elevator transport zone is indicated on a corresponding floor except a lowest floor serviced by a corresponding elevator car and the at least one upward elevator transport zone is indicated on a corresponding floor except a highest floor serviced by a corresponding elevator car.

4. The smart elevator system according to claim 1, further comprising: at least one display for a corresponding elevator car located on a corresponding at least one floor of the structure to selectively display elevator service information, the elevator service information including one or more of: a number of persons in an inner area of the corresponding elevator car, a current capacity of the corresponding elevator car, and a time of arrival of the corresponding elevator car at a corresponding floor, wherein the elevator service information displayed is based on information transmitted by at least one of a corresponding at least one master processor or a corresponding receiving processor.

5. The smart elevator system according to claim 1, wherein the sensors are wireless sensors to wirelessly communicate the data signals of the number of persons detected.

6. The smart elevator system according to claim 1, wherein the one or more receiving processors transmit the passenger traffic data to one or more other receiving processors.

7. The smart elevator system according to claim 1, wherein at least one master processor is associated with at least one elevator car and receives the passenger traffic data from one or more receiving processors and determines the transport path to a floor location for the at least one elevator car.

8. The smart elevator system according to claim 1, wherein the at least one master processor is distinct and separate from at least one elevator car and receives the passenger traffic data from one or more receiving processors and determines the transport path to the floor location for the at least one elevator car.

9. The smart elevator system according to claim 1, wherein the at least one master processor transmits at least one selection decision as to the determined at least one transport path to a floor location to corresponding one or more elevator cars directing the one or more elevator cars to a corresponding floor elevator door on a floor in the structure.

10. The smart elevator system according to claim 9, wherein the at least one master processor is distinct and separate from at least one elevator car and receives the passenger traffic data from one or more receiving processors and determines the transport path to the floor location for the at least one elevator car.

11. The smart elevator system according to claim 1, wherein at least one master processor is a central master processor distinct and separate from one or more other master processors and receives the passenger traffic data from the one or more other master processors and determines at least one transport path to at least one floor location for the one or more elevator cars in the structure, based on the received passenger traffic data.

12. A method for operating an elevator system, the method comprising the steps of: scanning by one or more sensors an area on at least one floor outside of at least one floor elevator door on one or more corresponding floors to detect a number of persons awaiting elevator service; receiving by the one or more sensors scanning the at least one floor outside of at least one floor elevator door on the one or more corresponding floors data regarding the number of persons awaiting elevator service; transmitting data signals corresponding to the number of persons awaiting elevator service detected by the one or more sensors to at least one receiving processor; determining by at least one receiving processor passenger traffic data corresponding to the transmitted data signals; transmitting the determined passenger traffic data regarding the number of persons awaiting elevator service to at least one master processor; and determining by at least one master processor at least one transport path to at least one floor location for one or more elevator cars, based on the received passenger traffic data.

13. The method of claim 12, further comprising the steps of: scanning by at least one sensor an inner area of a corresponding elevator car to detect the number of persons in the inner area inside the elevator car; receiving by the at least one sensor scanning the inner area of the corresponding elevator car data regarding the number of persons in the inner area of the elevator car; transmitting data signals corresponding to the number of persons in the inner area of the corresponding elevator car detected by the at least one sensor to at least one receiving processor or at least one master processor; determining by at least one receiving processor or at least one master processor the number of persons in the inner area inside the corresponding elevator car based on the transmitted data signals corresponding to the number of persons in the inner area of the corresponding elevator car; and displaying on a display for the corresponding elevator car elevator service information, the elevator service information including one or more of: a number of persons in the inner area of the corresponding elevator car, a current capacity of the corresponding elevator car, and a time of arrival of the corresponding elevator car at a corresponding floor.

14. The method of claim 12, further comprising the step of: receiving by at least one master processor the determined passenger traffic data from at least one receiving processor; and directing by at least one master processor at least one elevator car to a respective destination corresponding to the determined transport path to the corresponding floor location.

15. The method of claim 12, further comprising the step of: directing by at least one master processor one or more elevator cars to respective one or more destinations corresponding to the at least one determined transport path to at least one corresponding floor location.

16. The method of claim 12, further comprising the step of: receiving the determined passenger traffic data from one or more receiving processors by at least one master processor, the at least one master processor being distinct and separate from the one or more elevators cars.

17. The method of claim 16, further comprising the step of: directing by the at least one master processor one or more elevator cars to respective one or more destinations corresponding to the at least one determined transport path to at least one corresponding floor location.

18. The method of claim 12, wherein the one or more sensors are wireless sensors to wirelessly communicate the data signals of the number of persons detected.

19. A computer implemented smart elevator system, the system comprising: a plurality of sensors, at least one of the plurality of sensors associated with a floor elevator door of a corresponding floor associated with a corresponding elevator car, wherein the plurality of sensors detect a number of persons awaiting elevator service at one or more corresponding floors and transmit data signals of the number of persons detected; at least one first computer implemented device, the at least one first computer device including a processor and a program stored in a memory, the program directing the at least one first computer implemented device to perform the following including: determining passenger traffic data corresponding to the transmitted data signals; and transmitting the determined passenger traffic data to at least one second computer implemented device; and the at least one second computer implemented device, the at least one second computer device including a processor and a program stored in a memory, the program directing the at least one second computer implemented device to perform the following including: receiving the passenger traffic data from at least one corresponding first computer implemented device; determining at least one transport path to a corresponding floor location for corresponding one or more elevator cars, based on the received passenger traffic data; and directing one or more elevator cars to respective one or more destinations corresponding to the one or more determined transport paths.

20. The computer implemented smart elevator system of claim 19, wherein the plurality of sensors are wireless sensors to wirelessly communicate the data signals of the number of persons detected.

IV. METHODOLOGY

4.1 Wireless Sensor Networks

Wireless Sensor Networks is sometimes called Wireless Sensor and Actuator Networks (WSAN) are spatially distributed autonomous sensors to monitor physical or environmental conditions such as temperature, sound, pressure etc. and to cooperatively pass their data through the network to a main location. The WSN is built of Nodes from a few to several hundred or even thousands, where each node is connected to one sensor. The development of wireless sensor networks was motivated by military application such as battlefield surveillance; today such networks are used in many industrial and consumer applications, such as industrial process monitoring and control etc. Each such sensor network node has typically several parts:

- A radio transceiver with an internal or external antenna
- Microcontroller

A. Characteristics

The main characteristics of a WSN include:

- Power consumption constraints for nodes using batteries or energy harvesting

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Vol. 6, Issue 7, July 2017

- Ability to cope with node failures (resilience)
- Some mobility of nodes (for highly mobile nodes see MWSNs)
- Heterogeneity of nodes
- Scalability to large scale of deployment
- Ability to withstand harsh environmental conditions
- Ease of use
- Cross-layer design

4.2 IR Sensor
IR sensor is an electronic instrument which is used to sense certain characteristics of its surroundings by either emitting and/or detecting infrared radiations. IR is also capable of measuring the heat being emitted by an object and detecting the motion.
IR Sensor is an elevator device that detects a passenger or an object on the doorway which prevents the doors from closing. If a person or an object blocks the doorway and the sensors detects the person or object, the door will reopen then stays open and will not closed until the person moves away or the object is removed from the doorway.

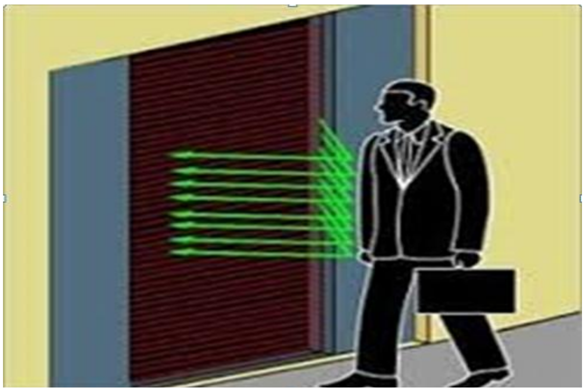

Fig. 4.1 IR SENSOR

4.3 Image Sensor
An image sensor is a sensor that detects and conveys the information that constitutes an image. It does so by converting the variable attenuation of waves into signals, the small bursts of current that convey the information. The waves can be light or other electromagnetic radiation. Image sensors are used in electronic imaging devices of both analog and digital types, which includes digital cameras, medical imaging equipment etc.

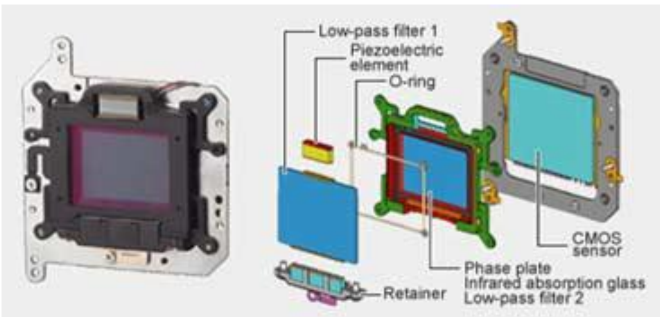

Fig. 4.2 Image sensor

4.4 The Network Design
In our implementation of the elevator system, floors are represented and simulated by a laptop with the Java based application to run the simulations. The floors are connected with each other in a multi-hop ad-hoc fashion such that each can communicate only with its immediate neighbouring floor (the floor above, and the floor below).
For example, Floor3 can communicate with Floor1 and Floor2 only.

4.5 The Inter-Communication Procedure
A. Updating other Floors
Depending on the input by the sensor/camera (or from the user in our simulations) about the traffic at a certain floor, its traffic/no-traffic info is sent as a packet to the floor above it and the floor below it (i.e., its immediate neighbours only). A sending thread is created whenever there is change (increase/decrease) in traffic.

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B. Listening to other Floors
To be aware of the traffic conditions of other floors, two threads of codes run simultaneously on each floor (sensor):
(1) To receive information from the floor(s) above, and
(2) To receive information from the floor(s) below.
C. Conveying floors' traffic information
In our design, as soon as a floor receives the information from its immediate neighbours, it passes it on immediately upwards or downwards.

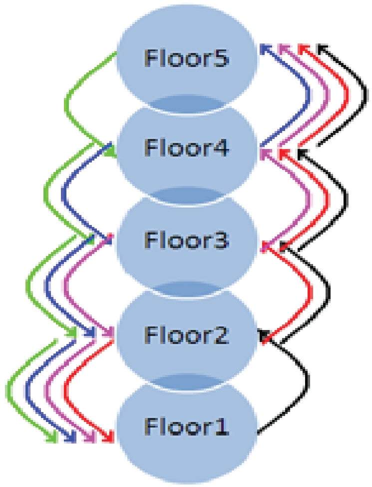

Fig. 4.3 Multi-hop FIPs transfer

4.6 Elevator Dispatching Algorithm
Although our basic idea of integrating a WSN to an elevator system can be coupled with any elevator dispatching techniques, we implemented the elevator system based on developing an approach to serving the denser areas first, i.e. serving the floors with greater traffic intelligently sensed, which is a quite unique idea and very different from traditional elevator systems. Thus, we had to come up with our own design of the system and redefine the basic elevator decision algorithm. The following points summarize and highlight the most basic and fundamental components of our elevator dispatching algorithm.
Initially (During the start-up of the elevator system program), elevator is always present at Floor-1. The floors intermittently communicate with each other in order to keep each other updated about the latest traffic information as well as the current location of the elevator. Each floor (sensor) that receives the Elevator (EIP) is entitled to take the decision about where to send it next based on the following criteria:

- Let n be the floor which currently has the elevator. If the sum of the traffic (number of people) requesting from above floors and the up traffic (people requesting to go up) in the nth floor is greater than the sum of the traffic (number of people) requesting from down floors and the down traffic (people requesting to go up) in the nth floor, the result will be that the elevator will be sent to the above floor i.e. to Floor (n+1).
- However, If the sum of the traffic (number of people) requesting from above floors and the up traffic (people requesting to go up) in the nth floor is lesser than the sum of the traffic (number of people) requesting from down floors and the down traffic (people requesting to go up) in the nth floor then the elevator will be sent downwards to Floor.
- In the same way, the new floor which receives the elevator will then make the decision.
- If the traffic above equals the traffic below, the elevator will continue to move in the same direction that it was previously travelling in, according to predefined default elevator dispatching algorithm(s).
- If the total traffic in all floors is zero (i.e. there are no requests), the elevator will eventually return back to Floor 1 (the default stop). After the elevator serves any floor, the traffic in that floor is updated to '0' and communicated across other floors. The stopping case for the elevator is Floor-1. In other words, after serving all the requests, the elevator will always return back to Floor-1.If there are any new requests or changes in traffic conditions at any floor, the system would be capable of accommodating these changes dynamically and would responding to them as per the algorithm.

For example:
(1) If there is increase/decrease in number of people waiting at a floor, then change the priority of serving based on the new traffic conditions;
(2) If the people at a floor requested the elevator but left before it arrived, cancel stopping at that floor so as to save a considerable amount of time of other passengers.

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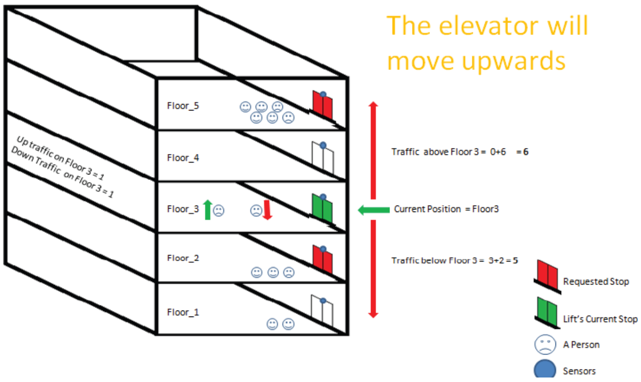

Fig. 4.4 Proposed Elevator Dispatching Algorithm

The Figure explains the concept with greater detail, considering the example of a five floor building with a single elevator. As depicted in the figure below, since traffic above Floor_3 + up-traffic at Floor_3 (i.e., 0+6=6) is greater than traffic below Floor_3 + down-traffic at Floor_3 (i.e., 3+2=5), the elevator is sent upwards to Floor_4 (to be sent to Floor_5).

V. CONCLUSION

Elevator plays an increasingly significant role in today's smart buildings. Their capacity for communication and integration with other building systems improves building performance, sustainability and efficiency. Developments in elevator technology that load passengers according to their destination, move people faster, reduce energy consumption. A smart elevator system has been designed utilizing wireless sensor nodes that are connected in multi-hop fashion and sense passenger-traffic in real-time. Furthermore an algorithm is developed to implement and prioritize the elevator system based on the traffic inflow such that all the floors communicate with each other and share their traffic information to optimize and control the movement/stopping of the elevator.

VI. FUTURE ENHANCEMENT

The smart elevator should be equipped with some mechanism to keep track of people inside it at any given time and also of people going in/out as there are certain situations when the proposed algorithm could face bottlenecks when it has reached its passenger limit. Other issues such as those related to security of wireless ad-hoc network of sensors, failure of nodes, information update delays in case of high-rise buildings, enabling emergency or manual interruption and controls etc. also need to be researched and analysed in order to come up with a completely robust and applicable solution of the smart elevator system.

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