Context-Aware Indoor Environment Monitoring and Plant Prediction Using Wireless Sensor Network

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Abstract. Remote sensor networks are a flexible innovation that deals the capacity to observe thorough actual occurrences as well as a wide-range environment where physical frameworks are considered unsuitable and costly. This study presents the context-aware based remote sensing network (remote or wireless sensor networks or WSN uses alternatively in this paper) for indoor ecological observing at home. Indoor environs atmosphere as well as stability among occupant's well-being and predicting plants are the principles of this proposed framework. The introduced framework comprises of various sensor gadgets simultaneously evaluating temperature, relative humidity via mobile sensors, illumination, carbon dioxide CO_2, oxygen O_2 and benzene C_6H_6 levels in separate spaces. This study also exhibits the framework structure, the context-aware lifecycle and the context modeling and reasoning architectures for observing the environment.

Keywords: Pervasive · Context-aware · Wireless sensor networks (WSN) · Remote sensor · Acquisition · Reasoning · Schema · Node · Air quality monitoring (AQM)

1 Introduction

In 1988, the main innovation officer of Xerox's Palo Alto Research Center, Mark Weiser, has initially instituted the frame of ubiquitous computing. At that time, the advancements in this domain have proceeded for more than 25 years. In the middle of

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this duration, one term in the IT industry has turned into the fundamental style, i.e., "Pervasive Computing," that has the aim of computing gadgets being accessible everywhere at any time. These gadgets, as a feature of our day-to-day lives, enable us to associate with overall systems without any limits and also aims to furnish us with fastening as well as a safe and secure approach to an abundance of data and its directions [1].

An innovation that develops from its sources as scholastic research to a market reality is term as pervasive or ubiquitous computing. This term is not a smooth one and still means distinctive things to various individuals. Pervasive computing, for instance, is about portable information and facilitate the users with providing such networks that allow roaming possibilities. More of it, a space of context-aware environments where humans communicate with their everyday devices to make the environment contextual [2]. All these territories are centered in one Pervasive computing but for sure, pervasive computing in about three core ideas. First, it concerns the portable gadgets from an individual's point of view and perception for utilizing them to act on the environment. Second, it concerns how applications are made and conveyed and to empower the achievement of such undertakings. Third, it relates to the surroundings and how it is upgraded by the development and the fact of appearing everywhere at any time with multi-functionalities. Currently, pervasive computing is more a virtual imagination than the recent innovations. This imagination remains so far as humans keep on viewing handy computing gadgets as smaller than normal work areas, applications as expert programs that keep running on these gadgets and their surroundings as a virtual galaxy that a client enters to implement an action and leaves when the action is done.

Away from the large fixed screen displays and consoles, the interaction between the physical and electronic world through original correspondence has become advanced and embodied along with regular objects such as dresses, rooms, furniture, artistries and so on so forth with the transformation of "invisibility." The artifact is to facilitate these interconnected daily objects to weave them into surroundings even deprived of knowing the existence. Every one of these perceptions presents genuine difficulties to the applied designs of processing, and the related building disciplines in software engineering. Pervasive computing adapts all these circumstances [3].

Even so, Weiser's article evoked genuine emotion that depicted another model for communication between computer and human with having modern difficulties as well as give inspiration for new prototype and designing actions [4]. It opened up new doors by demonstrating how little, specific gadgets could assume a job in more prominent frameworks for individuals who work in equipment structuring. For analysts working in distributed structures, it made new difficulties of scale and revolving the focus on the reciprocal concerns of choosing strategies. At that point, an energizing vision for an extensive variety of software engineering has stepped into research zones famously termed as "Ubiquitous computing" instead of another subject in itself, it provided another way to deal with an extensive variety of research areas with new or old ones.

1.1 Technology Review

A phenomenal chance for bringing up pervasive computing is due to the astonishing progress of portable, distributed computing, wearable, and smart gadgets. Lately, we have envisioned a massive intensification in smartphones, tabs, pads and so forth [1]. While these gadgets are outfitted with numerous CPUs, storages and connectivity gears as well as embedment of GPS or any other sensors.

The third trend in computing [5] which is alluded to as "Ubiquitous Computing" or "Pervasive Computing" has the tendency of turning up the developments, for example on-going shrinking of every object, the expansion of capabilities as well as execution speed [6], lessen the power request and reduction of creation and implementation expenses of innovations, has been portrayed by this no ending trend [7].

The previous term is utilized when the prominence is on the chance of people to approach computing and to use various processing gadgets from anyplace, whenever, and in any shape, additionally nomadically, on the other hand the last term is utilized to direct that computing is undetectably inserted in the whole thing in a comprehensive network. These are considering as making: (a) a sort of computational reasoning, (b) another connection concerning with people, data as well as properties [8], (c) not at all comprehended financial effects, societal or single influences and (d) another circumstance for framework, element and administration engineers and creators.

2 Background Study

A networked of all home electronic apparatuses yet to come soon like phones, coolers, clothe washer as well as computers. Beforehand ACs/heaters were commanded by an on its own, settled or manual indoor regulator would now be able to be overseen by a smart, intellectual command via distant competences [9]. In recent times, the utilization of inhabited atmosphere with expanding expectations for affording mental comforts is growing pervasive. Regulating and observing such indoor atmospheric environments signifies an essential undertaking with the objective of guaranteed appropriate operations and living spaces to individuals.

The thoroughly perceiving of indoor atmospheric conditions that comprise on temperature, CO_2, humidity, pressure, and all others are not being easily examined or measured. A genuine danger to our wellbeing and personal satisfaction is none the other than toxic air. Estimating such toxic atmosphere is indeed noticeable all around the globe for what we inhale and offering the outcomes to our associates is a vital phase in expanding communal attentiveness for making a perfect surrounding. Generally, toxic air estimations are directed utilizing costly observers at settled areas. These estimations are somewhere deficient in giving exact ongoing toxic air data in the vast majority of the profoundly contaminated streets [10]. It is an alluring approach for ongoing estimations to have the capacity to examine and recognize worrying levels of toxins rapidly. The pervasiveness of advanced mobile phones with web network and expanded accessibility of individual air monitoring sensors give a one of a kind chance to create toxic air sensible network of clients for gathering and sharing constant air contamination information.

2.1 Context-Aware in Ubiquitous Computing

To upgrade the urban effective working or timely mannered administration to provide effectiveness, and supportability, the context-aware systems have incredibly fulfilled personal satisfaction. For sure, context-aware applications possess numerous urban applications that are capable of implementing such technologies.

Such areas may be associated via wire, or remote systems are capable of gathering, practicing, and investigating around real-time information. Concerning urban life in connection to the basic frameworks and procedures to cause interpretations, e.g., ecological conditions, 4-D or 3-D locomotion, areas or occasions for taking of predictions step towards implementation of them are needed to appear in a group of context-aware structures, podiums, and applications over a few spatial meters.

One of the significant part to build frameworks for such savvy or urban ecological areas comes under the term of "Context-Aware Computing." Its vital role [11, 12] in assisting decision making is to approach context data in such smart urban applications/structures. It seems progressive that urban conditions dependent on context-aware mechanisms will be typical in urban communities soon to help urban standards from numerous points of view [13].

Paper [14] spoke to the idea of existing WSN devices, gas devices, and soil monitoring screens were utilized for air pollutants observing based on real-time measurements. Java and a toolbox module were used for obtaining sensor information. It gathers the non-meaningful sensor information, explain, excerpt the IAQ data and places them in the sensor data center. The goal that HVAC regulator can access the data by reading daily basis to intrigued IAQ considerations via IAQ factors that are distributed in Context-Aware Framework. Air pollutant Quality directory was computed to realize the wellbeing effect of air contamination on the natural surroundings. Trials were done by utilizing the created indoor air toxins quality observing framework under various ecological conditions. The framework carried on according to the real circumstance and sufficiently gathered measures of continuous air quality information. With the end, the goal is to keep up great indoor air quality record; we mean to build up a DCV framework for occupants in which HVAC regulator algorithm will keep air contaminations inbound. It is required to build a tenant's wellbeing level with vitality investment funds.

The new development in remote sensor equipment made great feasibility to observe the indoor as well as outdoor surroundings of a premises [15]. The article also presents the three distinct goals: (i) the processing and transmission of signals generated from sensors are being customized by these remote sensors and are proficiently fulfilled by a freely available OS, and via particularly remote sensor equipment based computing language, (ii) next, it includes the handling of indicators generated by remote sensor peripherals. At this point by the help of java coding, the remote recipient's conveyed notifications were decoded and sent via PC's sequential ports for keeping them in a record. This may provide the recognition of the vital data sections that are expected to utilize the information, and (iii) last but not the least; the information needs a smooth

surface for the assessment is also provided by this observing framework. A client can extract some particular records by providing basic factors, for example, a spatial sensor or correct time of information. It is foreseen that this exploration will show the capability of utilizing remote sensor systems for checking different premises.

A study in [16] portrayed different ecological conditions like humidity, temperature or light is quantified based on TinyOS by implementing nesC language along with SHT 15 remote component as well as photovaristor sensor. This framework gathers, sends and naturally command the information. It also showed the proficient execution of the framework as the client can collect accurate information about the atmosphere with no ambiguity.

ZigBee remote sensor system is posed in [17] for observing the greenhouse atmosphere while conducting the measurements of air moist, CO_2 and temperature values via oretical exploration and exploratory test technique to guarantee framework proficiency. It also facilitates the interconnection of connected nodes with the system, arranges system maintenance as well as a facilitator of hypothetical information and real-time conditions. The framework is turned out to be strong, dependable, and simple for client formation. These days the environmental difference on the planet provoked numerous impacts, for example, ice breaking over the ocean, warm winds, and the heated temperature of lakes or other factors.

Paper [18] proposed a framework that supports in observing such environmental changes that gather real-time information and provide provision of location inquiry based on collected data. They manufactured a framework for climate observing and organizing the location-based demands to deal with keeping remote information. They reserved the received information in different portions by scheming them via timestamp method based on variations in the assisted values. It also shows the updated information if any occurs. They control the portion based strategy to retain the information stream and diminishing the spared dataset with no damaging information. From the question result, the precision of the framework is enhanced, and the strategy that utilized can diminish expense.

3 Challenges of Pervasive System

The “innovation that vanishes” nearly and effortlessly coordinated with consumers, having immersion abilities into computing and in communication has been entitled as “Pervasive or Ubiquitous Computing.” Such kind of innovations fundamentally provide portability; as roaming is a basic feature in our daily life span or else, a consumer will be intensely conscious of the innovation by its nonexistence while on the go. Henceforth, Pervasive or Ubiquitous Computing incorporates portable computing with a lot of advances as outlined in the Fig. 1, a couple of challenges standing up to the structure of pervasive computing are mentioned below:

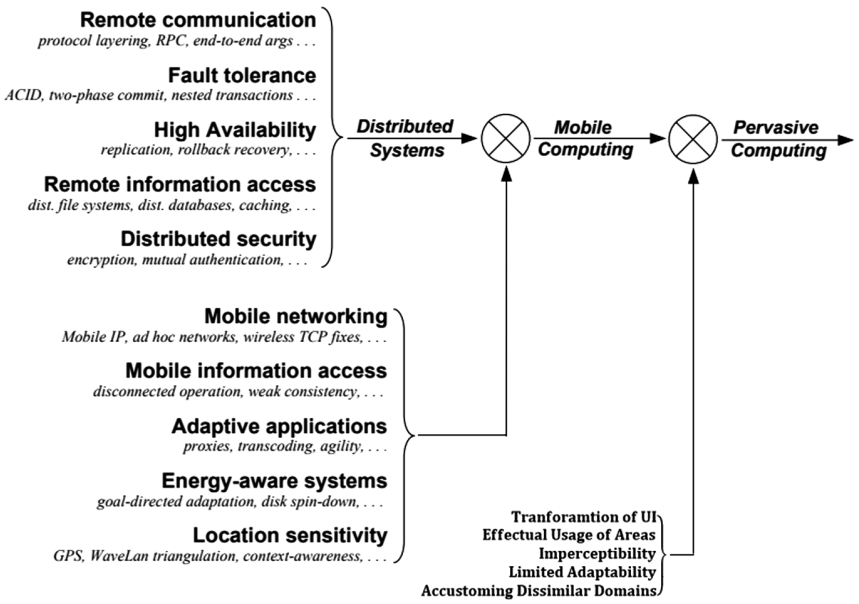


Fig. 1. Taxonomy of computer systems research problems in pervasive computing [19]

Transformation of UI. The coordination of wide-ranging gadgets; including tiny sensors to hand-held, pads or even computer units, altogether with distinct VDUs sizes, is counted as one of the features of ubiquitous computing framework. In the perception of framework engineer's, they pursue such kind of applications that work adequately within the mixed environs, and every element could be governed by consumers having no physical troublesome forced by dimensions. For instance, modest gadgets suggest small demonstrations as well as the finest user interface structure on such a miniature unit necessitates the consumers to explore a sequence of the brisk set of menus. Normal involvements outline such kind of issues with PDAs, frequently stacked with highlights however not once be used, for the reason that they are covered with the unpredictable interface.

To create user interfaces depend on dynamic nature as well as adaptive capabilities of the desired VDUs dimensions, would enable application novelists a much adaptable methodology. Four parts: UI detail dialect, shared device protocol [20], apparatus connectors and the realistic UI generator are expected to fabricate such a framework being extracted by Personal Universal Controller toolbox.

In Ubiquitous Computing conditions, the scope of desire display sizes is more projecting as compare to ordinarily personal computers; subsequently, if the product items keep working on in such situations, the marketplace and possible incomes will be extensively bigger. Though, critical programming obstacles are static in making models as well as essential instruments to create or demonstrate material to the consumer.

Effectual Usage of Smart Areas. The viable utilization of smart areas that might be an encased region like conference area, hallway or might be a clear wide region like plaza or enclosure. A smart area ties two present-awaited disconnected universes by implanting computing structure into building structure [19]. The combination of these universes empowers detecting and being regulated by each other. For instance, in a room dependent on a tenant's electronic profile, a change of warming, freezing as well as illumination levels can be programmed. Additionally, conceivable impact on others is—programming on a consumer's PC may act diversely relying upon where the consumer is presently positioned. Savvy may likewise spread out to singular articles, regardless of wherever positioned in a keen area or not.

Imperceptibility. The Weiser's model is ample vanishing of pervasive technology at the end of the consumer's perception. A sensible guess to this model is insignificant consumer diversion. If pervasive environs constantly encounter consumer desires and once in a while gives him wonders, it enables him to communicate nearly at an intuitive stage [21]. In the meantime, a small portion of expectation might be fundamental to evading huge, repulsive wonders far ahead.

Limited Adaptability. The force of communication between consumers' PC domain and their environments increases due to the complex evolution of smart areas. All these have serious data transfer capacity, vitality and diversion suggestions for a versatile remote consumer. This issue additionally obscure due to the existence of extensive consumers [22]. Therefore, adaptability in the widest think, in pervasive systems is considered a serious issue. Physical separation has been overlooked in past adaptability experiments – a document server should deal with as numerous consumers as expected under the circumstances of though the consumers are positioned nearby or far away.

In pervasive computing the circumstances are quite distinct in manner, the firmly united connections need to decrease as a single step ahead, on the other hand, together the consumer as well as their system will be overpowered via faraway collaborations, assumed to be somehow significant for them [23]. Despite it, a remote gadget consumer not at all near to home will, in any case, produce approximately faraway collaborations accompanied by significant to them, the prevalence of his communications will be a neighborhood.

Accustoming Dissimilar Domains. The speedy of pervasive development into the foundation will fluctuate significantly upon numerous non-specialized aspects, for example, administrative foundation, financial terms, and industrial impacts. A constant entrance is only be accomplished in past eras. In the meantime, there will endure enormous contrasts in the smartness of various conditions. What is accessible in a very much prepared summit room, workplace, or lecture hall might be more advanced as compared to different areas.

This extensive unique scope of smartness can be shocking to a consumer, bringing down the objective of making pervasive innovation undetectable. One approach to decreasing the measure of variety perceived by a consumer is to, let his individualized system area reward for imbecilic surroundings. As a slightly model, a framework that is fit for a separated task can veil the nonappearance of remote inclusion in its condition.

4 Proposed Methodology

The proposed framework comprises of two sections. The initial section controls the environment of the indoor territories including the light, temperature, pressure, and humidity that identifies air toxins and sends cautions to the person. The second section is to predict several indoor plants that are capable of decreasing pollutions present in the indoor air at some degree. This will enable us to connect with indoor atmospheric situations and living space comfort.

The proposed system comprises of different sensor gadgets set in the indoor territories such as a terrace, lounge, and kitchen and resting regions. In this framework, the system uses a set of sensors that enable us to analyze multiple parameters. The demonstrated arrangement gives checking of surrounding humidity, temperature, pressure (gathered from mobile sensors), illumination, and carbon dioxide (CO_2), benzene (C_6H_6) and oxygen (O_2) gas levels.

The inspiration driving creating such a system is that the situation of the present atmosphere portrayed by its dehydrated and exceptionally warm weather conditions, which leads to an increase in the level of global warming. This way, there is a need to give a cutting edge framework that is rapidly adaptable, user-friendly and effortlessly saving executing time. The principal objectives of the proposed concept are to give an appropriate and pleasurable indoor atmosphere, lessen the air toxins, increment the indoor air quality, and to simplify the process of preserving the air conditions. These objectives were put into activities by accomplishing the targets of the concept that includes; building a smooth indoor atmosphere, structuring an independent or intuitive nurturing plants framework, actualizing sensors that screen the plants, adjusting the indoor environment, and installing a notification scheme (Fig. 2).

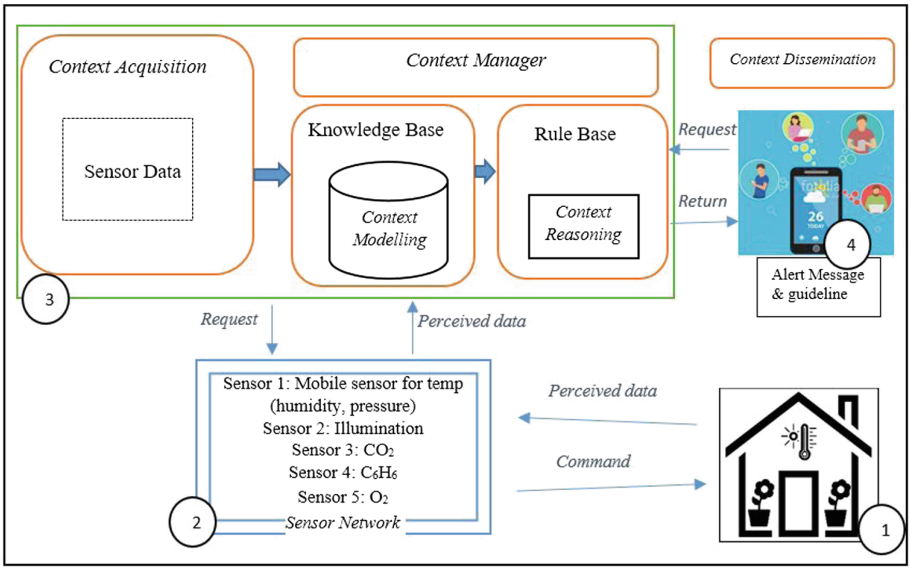


Fig. 2. System architecture

5 Implementation

Sensory information commencing the physical domain is the prime as well as note able dependencies of any smart atmosphere. Such information is being originated by using numerous sensors depending on a particular method or procedures in different spreader areas [24]. Small miniature devices that are used to take ecological parameters like temperature, moisture, sunlight, pressure, CO_2, C_6H_6, O_2 gases and so forth, comprises of numerous cheap, moderate message passing small remote gadgets that team up to construct a remote system.

To gather information about various circumstances from the environment such type of remote sensors are installed into the real domain by providing compact detecting near real environs.

A centralized node is responsible for information analysis as well as decision making on the gathered information from numerous sensors. A typical design of a wireless sensor network is exhibited in the below Fig. 3, through which information is being provided to the consumers. On the other hand, sensor devices may experience numerous confines, and the most commons are infrequent power points, insufficient memory or constrained execution capacities.

Sensors are extensively installed in numerous WSN systems. Therefore numerous different concerns with them, for example, versatility, information consistency, robustness or significant controlling, as well as effective many routing methods. Regardless of all these restrictions, for numerous ecological observing systems, WSN is still considered as the fundamental framework. In this proposed work, the implementation part is further divided into sub-parts, to have the thoroughly understanding of its execution.

The mounting of the sensor is dependable on the indoor structure. For instance, the space is separated by segment dividers from floor-to-ceiling with an average extension of 1.2 to 2.4 m then the analysis zone is just that of the space or room.

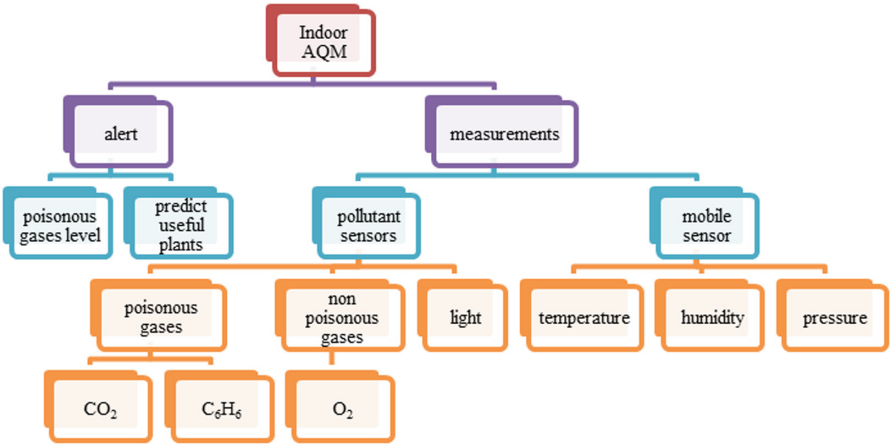


Fig. 3. Hierarchical view of indoor AQM

5.1 Architecture

The proposed system incorporates the following components as multiple sensors are equipped in different spaces for monitoring of humidity, air toxic, gases and temperature values: (i) central node, (ii) multiple air toxic measuring sensors and (iii) information acquiring and preparing and a communication component.

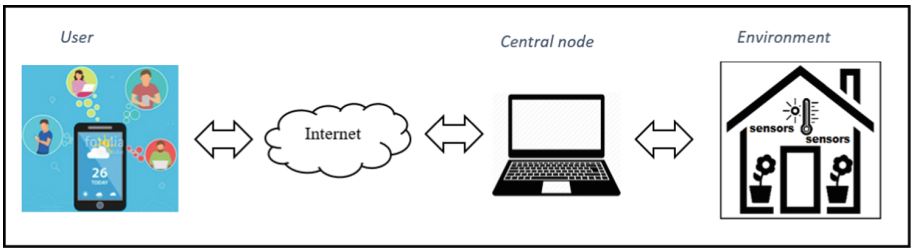


Fig. 4. Atmosphere observing via WSN

Detecting Nodes: Multiple nodes are deliberated and executed to achieve pollutant detection via cheap hazardous gas sensors along with acquiring of temperature, pressure and humidity data. Gas detectors are utilized to guarantee the contamination discovery, C_6H_6 detection, CO_2 and O_2 detections. In the meantime, temperature, pressure and humidity data are attained by using consumer's mobile phones. Self-contained sensors like illumination, temperature, pressure, and humidity are equipped within a large system with additional equipment of gas detectors, e.g., C_6H_6, CO_2 or O_2.

- *CO_2*: We used BME680 for estimating CO_2 levels that use dispersion valuation of range, from 0–2000 ppm with a precision of 50 ppm or three percent of sensing or either greater.

350–1,000 ppm	Concentrations involved indoor spaces with great air interchange
1,000–2,000 ppm	Illnesses of tiredness as well as bad air
2,000–5,000 ppm	Nuisances, drowsiness, and motionless, smelly air. Bad concentration, carelessness, amplified ECG and minor motion sickness possibly be existed

- *Surrounding Temperature:* The temperature sensor is a silicon bandgap type having the scope of −20 ºC–60 ºC with the precision of ±0.5 ºC (±1 ºC close lower/upper closures of scope).
- *Comparative Moisture:* The moistness sensor is having a scope of 0–100% relative humidity with an exactness of ±2% humidity from 20–80% relative humidity (±4% outer this scope).

- *Oxygen:* Typical O_2 is roughly 75–100 mm of mercury (Hg). Qualities below 60 mmHg typically show the requirement for additional O_2. Ordinary heartbeat analyses more often than not go from 95–100%. Qualities below 90% are observed as low.
- *Benzene:* Indoor dimensions of benzene in a home environment and workplaces without solid indoor bases like; oil cookery, warming ovens are commonly under 15 μg/m^3 every 24-h, which are thriving under the most minimal stages demonstrating a sign of unfriendly wellbeing impacts. Rising high peak in the scope of 100–200 μg/m^3 is due to the usage of either fragrance scorching or food preparation without vents with twenty-four-hour heights having 10–50 μg/m^3 scope. Benzene has been connected to unsteadiness, shocks, faintness, retching, cerebral pain as well as laziness subsequently to abnormal states in the scope of 700–3000 ppm [25]. Impacts after sub-constant to unending experiences at very low; i.e., <1 ppm incorporate dynamic worsening including bone marrow harm, variations in flowing platelets and modified invulnerable reaction.

This particular structural design enables us to design separate sensor devices, depend on the specific area. The proposed application is being accessed via a local API system that uses different algorithms for numerous sensors. All the parameters are estimated once at regular intervals.

This paper also tries to notice different hacks and splits that may run periodic interrupts, however security remains a bit of hindsight in an obvious set of applications that make it worse as a result of installing tiny gadgets. Hence, middle ware is a solution that helps to reduce such intrusions and protect the gadgets as well as system while preventing them from such interpolations that turns into the form of great obstruction to originality is among the core challenges (Table 1).

Table 1. Components of context acquisition process in context-aware application

Context acquisition process			
Based on responsibility	Based on frequency	Based on acquisition	Process based on source
Push	Instant (for poisonous gases)	Direct sense	Middle ware
	Interval (for non-poisonous gas and mobile sensors)		

Disposition of Sensors: The proposed system consist of multiple sensors (of each gas) are dispersed on the single story of the building (3 to 5 ft above the floor). Set of sensors are positioned in different areas, e.g., lounge, living room, kitchen, and restrooms. Ad-hoc based sharing is structured to accomplish an effective information passing mechanism. Information passing among the sensors is empowered amidst small scale of span at the standard period of interims. The disposition range for the placement of sensors varies from 5 to 10 m relying upon the closeness of wireless LAN that affect or degenerate sensors motion.

The center node is constantly assembling every information that is being generated by all sensors. All physically generated information by every single sensor is accessible by a collaborative User Interface simultaneously.

Data Analysis: The essential purpose of the proposed system starts with the observing of air pollutants. The excessive energy consuming sensors are typically considered tricky while monitoring toxic in the air and therefore have undesirably influence on sensor duration. This article tries to solve such issues by using implanted BME680 ecological sensor technologically advanced for portable applications as well as wearables having functionalities of size and low energy consumption [26] for the evaluation of indoor air pollutants.

They are dynamic, thin, extensive battery life without repairing (for a short time) capabilities that are persuasive characteristics of any wireless sensor network applications. The article also possesses the concept of delivering immediate information of temperature, pressure, and humidity by using mobile sensors which helps assess the indoor air observing proficiency after some time.

5.2 Context Modelling and Reasoning

After the context acquisition described in Sect. 5, the acquired data afterward will be modeled using database schema with SQL-Query by applying rule-based reasoning. In this paper, the context reasoning is implanted via particular as well as a complete context reasoner at the server side, whose vital role is to execute cognitive jobs because of the distinct areas of sensory devices. The requisition of rule-based thinking methodologies for preparation of context information or knowledgeable rules is required. All the information and rules are explicit to specific areas with separate environments. The provisioning of such thinking over a spread area, there is a need to prototype a model as well as deduce the information and logic associated with overall areas.

This paper proposed a hierarchical structure for context thinking that provides adaptability as well as expandability. A middleware as an individual context medium – at a low level, is implemented to realize the noticeable actions that are taking place in the relating areas. Then the context manager as a high-level reasoner concludes the actions identified with numerous factual areas in particular or distinct spaces. In this manner, the purpose of context thinking is being circulated in the overall system with an increase of adaptability of the framework and reduce the centralized breakdown, and extra load as the amount of cognitive work is divided among numerous reasoner inside various framework portions dependent on their specific logic. The context elements or particular actions generated by any sensor in a specific area becomes the input of high-level reasoner. Sometimes the outcomes generated from top level would become inputs of low level to enhance their thinking condition. The term “circumstance” in this proposed study is a type of realized context element outcome via any two of reasoner in our thinking structure. For example, the high concentration level of toxic gases inside the house is an individual area circumstance (Fig. 5).

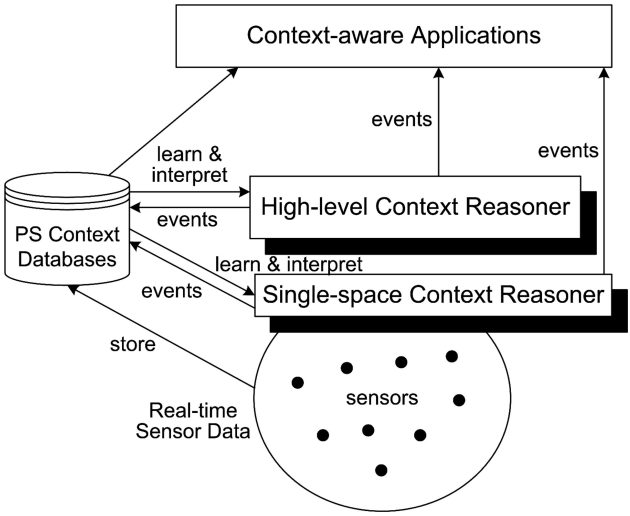
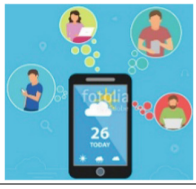


Fig. 5. Structure of context reasoning [27]

The practical illustration of this thinking structure shown in Fig. 4. Every reasoner depicts and executes rule-based prototype and devices. A single circumstance can be followed or anticipated via one single thinking prototype or their mixture specified the particular circumstance delivered by the application. Concurrent information is gathered from overall factual places employing the context information facilities in the indoor environment. The explicitly generated information is stored in the context data-center for further processing by the thinking model at any stage. The unstructured information is first tested and then kept in the data-center for any specific prototype, and afterward utilized to develop as well as periodically upgrade prototype measurable factors. The outcome circumstances of thinking prototype are openly stated to applications at any time or kept in unusual circumstance product stacks in the context data-center for further inquiries. Context data-center presented in Fig. 4 is typically organized in a distributed fashion. The presented framework depicts the execution of rule-based thinking mechanism for the top level reasoner [28]. This dimension of thinking is acknowledged as judgment rules, a vital role of the application semantic (Table 2).

Table 2. Mapping of context life cycle for developing context-aware application

Context acquisition	Context modeling	Context reasoning	Context dissemination
Based on responsibility – "push"	Database schema	Query and rule-based techniques	Ubicomp User Interface (UUI) subscription 
Based on frequency – "instant" (for poisonous gases) and "interval" (for non-poisonous and mobile sensors)			
Based on acquisition process – "Direct Sense"			
Based on source– "Middleware"			

6 Conclusion

In this paper, we introduced a simultaneously working remote sensor network establishment for indoor atmosphere checking. The introduced system incorporates diverse sensors situated in rooms, living areas, and kitchen and resting regions. Fully supported sensors are integrated to evaluate the effectiveness of the proposed framework, realize inhabitant well-being. The future work incorporates the expansion of the system with new hubs to cover more space in the house or vicinity.

References

1. Lu, H., et al.: Pervasive computing. Pervasive Comput. **6696**, 188–205 (2011). https://doi.org/10.1007/b96922
2. Godara, V.: Strategic Pervasive Computing Applications. IGI Global, Sydney (2010)
3. Bao, L., Intille, Stephen S.: Activity recognition from user-annotated acceleration data. In: Ferscha, A., Mattern, F. (eds.) Pervasive 2004. LNCS, vol. 3001, pp. 1–17. Springer, Heidelberg (2004). https://doi.org/10.1007/978-3-540-24646-6_1. https://link.springer.com/content/pdf/10.1007%2Fb96922.pdf
4. Dourish, P., Bell, G.: Divining a digital future: mess and mythology in ubiquitous computing (2011)
5. Bell, G., Dourish, P.: Yesterday's tomorrows: notes on ubiquitous computing's dominant vision. Pers. Ubiquit. Comput. **11**, 133–143 (2007)
6. Theng, Y.-L.: Ubiquitous Computing: Design, Implementation and Usability: Design, Implementation and Usability. IGI Global, Hershey (2008)
7. Saha, D., Mukherjee, A.: Pervasive computing: a paradigm for the 21st century. Comput. (Long. Beach. Calif.) **36**, 25–31 (2003)
8. Wing, J.M.: Computational thinking and thinking about computing. Philos. Trans. R. Soc. Lond. A Math. Phys. Eng. Sci. **366**, 3717–3725 (2008)
9. Chung, W.Y., Oh, S.J.: Remote monitoring system with wireless sensors module for room environment. Sens. Actuators B Chem. **113**, 64–70 (2006). https://doi.org/10.1016/j.snb.2005.02.023
10. Sevusu, P.: Real-time air quality measurements using mobile platforms (2015)
11. Al Nuaimi, E., Al Neyadi, H., Mohamed, N., Al-Jaroodi, J.: Applications of big data to smart cities. J. Internet Serv. Appl. **6**, 25 (2015)
12. Solanas, A., et al.: Smart health: a context-aware health paradigm within smart cities. IEEE Commun. Mag. **52**, 74–81 (2014)
13. Bibri, S.E., Krogstie, J.: Big data and context–aware computing applications for smart sustainable cities of the future. Presented at the 2017 (2017)
14. Bhattacharya, S., Sridevi, S., Pitchiah, R.: Indoor air quality monitoring using wireless sensor network. In: 2012 Sixth International Conference on Sensing Technology (ICST), pp. 422–427. IEEE (2012)
15. Jang, W.-S., Healy, W.M., Skibniewski, M.J.: Wireless sensor networks as part of a web-based building environmental monitoring system. Autom. Constr. **17**, 729–736 (2008)
16. Gao, R., Zhou, H., Su, G.: A wireless sensor network environment monitoring system based on TinyOS. In: 2011 International Conference on Electronics and Optoelectronics (ICEOE), pp. V1–497. IEEE (2011)

17. Li, L., Yang, S., Wang, L., Gao, X.-M.: The greenhouse environment monitoring system based on wireless sensor network technology. In: 2011 IEEE International Conference on Cyber Technology in Automation, Control, and Intelligent Systems (CYBER), pp. 265–268. IEEE (2011)
18. Lee, Y.K., Jung, Y.J., Ryu, K.H.: Design and implementation of a system for environmental monitoring sensor network. In: Chang, K.C.-C., et al. (eds.) APWeb/WAIM 2007. LNCS, vol. 4537, pp. 223–228. Springer, Heidelberg (2007). https://doi.org/10.1007/978-3-540-72909-9_24
19. Satyanarayanan, M.: Pervasive computing: vision and challenges. IEEE Pers. Commun. **8**, 10–17 (2001)
20. Nichols, J., Myers, B.A., Litwack, K.: Improving automatic interface generation with smart templates. In: Proceedings of the 9th International Conference on Intelligent User Interfaces, pp. 286–288. ACM (2004)
21. Denning, P.J., Metcalfe, R.M.: Beyond Calculation: The Next Fifty Years of Computing. Springer, New York (1998). https://doi.org/10.1007/978-1-4612-0685-9
22. Alansari, Z., Soomro, S., Belgaum, M.R., Shamshirband, S.: The rise of Internet of Things (IoT) in big healthcare data: review and open research issues. In: Saeed, K., Chaki, N., Pati, B., Bakshi, S., Mohapatra, D.P. (eds.) Progress in Advanced Computing and Intelligent Engineering. AISC, vol. 564, pp. 675–685. Springer, Singapore (2018). https://doi.org/10.1007/978-981-10-6875-1_66
23. Meruje, M., Samaila, M.G., Franqueira, V.N.L., Freire, M.M., Inácio, P.R.M.: A tutorial introduction to IoT design and prototyping with examples. In: Hassan, Q. (ed.) Internet of Things A to Z: Technologies and Applications, pp. 153–190. Wiley, Amsterdam (2018)
24. Cook, D., Das, S.K.: Smart Environments: Technology. Protocols and Applications. Wiley, Hoboken (2004)
25. EPA: VOC Exposures Indoor. https://www.epa.gov/indoor-air-quality-iaq/volatile-organic-compounds-impact-indoor-air-quality
26. Sensortec, B.: Environment Sensor BME680. https://www.bosch-sensortec.com/bst/products/all_products/bme680
27. Pung, H.K., et al.: Context-aware middleware for pervasive elderly homecare. IEEE J. Sel. Areas Commun. **27**, 510–524 (2009)
28. Jena, A.: JENA Rule-based Reasoning. https://jena.apache.org/index.html