

IoT-Enabled Smart Environments: A Daoist-Inspired Approach to Adaptive Sensor Networks.

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Abstract: Smart environments are composed of sensors and actuators as well as of communication networks and of intelligent control systems. They monitor a physical as well as a human environment in detail and, on this basis, they react in a flexible manner. The use of smart environments is already becoming a matter of course in smart homes, in the monitoring of patients, in industrial automation as well as in environmental sensors and in smart cities and communities. However, in most cases, the design of sensor networks still remains static. In this context, the classical challenges of energy efficiency, scalability, self-organization, as well as adaptability are not yet fully satisfied. Typically, sensor networks have a fixed observation structure and a centralized decision-making process. They often generate a high amount of data that is transmitted in an uncontrollable manner. Furthermore, the sensor networks are often not sufficiently sensitive to the context. This paper proposes a novel approach to designing adaptive sensor networks for IoT-enabled smart environments by applying key Daoist principles, namely wu wei, yin-yang, harmony with nature, simplicity and natural flow to design sensor networks in a novel and creative way. Instead of using traditional sensor networks that are dependent on rigid control structures to achieve their goals, the proposed approach adopts a fully decentralized approach whereby, using the principles of balance and natural flow, nodes operate in a manner that results in minimal intervention and, using fully distributed balancing of resources, sensor nodes operate in a fully adaptive manner to alter their modes of operation in order to respond to changes in the environment, to reduce activity when the environment is not changing, to ensure that all nodes in.

the environment are operating in a manner that results in a balance of load and, where appropriate, to cooperate with other nodes in order to achieve an overall sense of efficient operation of sensors and other components in the smart environment.

Keywords: IoT-enabled smart environments, adaptive sensor networks, Daoist philosophy, wu wei, energy efficiency, self-organization, decentralized sensing, yin-yang balance, harmony with nature

Introduction

The Internet of Things (IoT) is progressing at a tremendous pace and is now influencing how we monitor, manage and interact with our environment on an on a permanent basis. Smart Environments, combining sensors and actors, communication systems and decision support systems, are currently being implemented in residential, industrial, health and urban environments. These environments enable continuous and permanent data collection, the environment is always up to date and enables intelligent automation. As environments with numerous sensors and actors are becoming more and more common and are required to be highly interconnected, to be able to function perfectly, managing large sensor networks is becoming more and more complex. Most sensor networks today are designed as static systems and are controlled by a central instance. Furthermore, the sensing process itself is designed to be static, i.e. it is constantly running at fixed time intervals. However, these fixed designs lead to a number of inefficiencies, i.e. excessive energy consumption for transmitting data, for redundant data and for delayed reactions. In addition, sensor networks are sensitive and fail quickly if individual sensors or parts of the network fail. Thus, today's sensor networks are not yet designed to deal with dynamic environments in an efficient manner and require a large amount of manual interaction. Thus, in addition to energy efficiency, the main challenge currently facing IoT-environments is their scalability and failure robustness.

An attempt is also made to apply some philosophical concepts to address the identified challenges in designing sensor networks for IoT environments. Applying Daosim principles such as maintaining balance and ensuring smooth flow and harmony with the environment; simplifying actions and processes and minimizing human intervention; following principle of wu wei or effort less action by enabling system to change and adapt naturally to its environment; maintaining yin-yang balance between the competing forces such as between energy efficiency and data fidelity and between activity in network and stability of network are fundamental for design of adaptive self-organizing and intelligent network of sensors. The Daoist-inspired approaches for design of sensor networks for IoT-enabled smart environment would support development of intelligent sensor network which would automatically self-organize, change its sensing and communication parameters, and redistribute its resources to effectively respond to environmental changes around it. A conceptual model is designed for decentralized decision-making support, for context-aware-sensing, and for supporting flow-oriented-management of IoT sensor network. The study aims to enable the development of network of intelligent sensors that would support its optimal functioning, enable its efficient and effective use, increased energy efficiency and reduced data redundancy, improved robustness and higher human-centricity.

The paper describes an approach that draws on Daoist-inspired design principles to enable the development of adaptive sensor networks within IoT-based smart environments. A primary goal of the approach is to enable individual sensor nodes to function as part of a self-organizing network that is able to adjust the manner in which it senses and communicates on an on-going basis. It also enables the nodes to redistribute resources within the network in real time in order to ensure that the overall performance of the network is maintained in the event of environmental change. A number of key design strategies are described including a conceptual model that supports the deployment of the sensor network. The model, which supports a number of key design strategies, supports a range of decentralized decision-making strategies that are able to take into account a range of environmental context. A range of strategies are also described that support the sense to send function of individual nodes within the network including those that are able to support a number of different sensing modalities. The flow-oriented nature of the sensing and communication system described in the paper enables a number of key design characteristics to be supported including those associated with the

pursuit of energy efficient, reduced data redundancy, and increased network resilience. The approach is designed to support a number of key human-centric design objectives associated with the deployment of smart sensor networks, including the reduction of complexity for individual users, the support of a number of different behaviors and uses by individual nodes and the facilitation of a number of different functions and uses by the network as a whole. The study reported in this paper also describes an evaluation framework that may be used to support the evaluation of a range of other engineering design approaches that are inspired by philosophical concepts. In summary, the study described in this paper provides a number of novel insights into the design of sensor networks for a number of applications within smart environments, and highlights a number of key design strategies that may be used in order to support the creation of intelligent, adaptable, and sustainable systems that are able to be used within a number of different environments in a number of different ways.

Literature Review

IoT-Enabled Smart Environments

Smart environments enabled by IoT comprise a diverse number of inter-connected products including sensors, devices and actuator or effectors as well as interconnected communication and data processing systems. It encompasses smart homes and health monitoring systems, intelligent cities and smart-industry applications. The fundamental function of a smart home is to improve efficiency of the home environment in terms of sustainability of energy to power products and devices as well as real time monitoring and control of security functions including automated lighting and heating for greater comfort and automating a wide array of domestic functions. Monitoring and management of patients in order to observe and detect any vital parameter change, as well as treatment of patients in distant locations by means of ambulatory monitoring of health using wearables and monitoring of environment in order to provide patients with safe and efficient healthcare are all applications of health functions in smart environments. Cities leverage traffic management, environmental and public safety functions to become smart and in doing so improve the overall urban living environment by creating greater efficiencies and helping to deliver environmentally sustainable outcomes in all that they do. To address the varying functions delivered by diverse devices in smart environments a variety of layers have been developed to form overall architecture in the form of perception or sense layer, network or middleware layer and application layer where inter-operations among various types of devices and information are managed and an abundance of technologies including wireless sensor network, RFID function, Bluetooth Low Energy (BLE) and other varieties of wireless communication including Zigbee, and the low power wide area network functions of LoRaWAN, as well as 5G have been designed and developed and in addition to these core technologies in IoT environment, they are supported by numerous systems associated with computing functions including cloud computing and edge computing. Information that is collected by the percept layer is then processed in real time in order to generate the various added value functions in smart environments. As a result, IoT-enabled smart environments deliver enhanced comfort, improved healthcare services, and increased efficiency in everyday life.

Adaptive Sensor Networks

In order to overcome problems like energy consumption, network congestion and environmental influences traditional WSNs are expanded to adaptive sensor networks. Here, networks with dynamic topologies, context-sensitive measurement and self-healing abilities are developed. Adaptation of the topology allows for the optimal routing and for a load-balanced distribution of messages within the network. This allows for an efficient operation of a sensor network, even in cases where single sensors fail. The context-sensitive measurement enables a priority-based measurement, in order to prevent unnecessary measurements and to increase the energy efficiency of a sensor network. Self-healing allows for a fault-tolerant operation of a sensor network. Here, redundant paths for routing and for the recovery from single failures are implemented in the network. In recent years, adaptive sensor networks are more and more combined with artificial intelligence and machine learning in order to optimize the behavior of single sensors, to predict failures and to support the decision-making process. For this purpose, the data is processed in edge computing in real time and locally. In Distributed System

the data of IoT-sensors is collected and processed in a decentralized network without a central server. This allows for an adaptive, flexible and scalable sensor network, which is able to handle complex problems in different environments.

Philosophical and Inspirational Frameworks in Engineering

Design principles for bio-inspired by Bio- and Nature- and even philosophical- have been thoroughly studied for engineering of adaptive, robust, efficient systems. Such systems are often implemented with the aid of so called swarm intelligence for distributed control, Evolutionary Algorithms for optimization, and even models of neural networks. It is clear that in order to gain from study of Nature (Bio- and Nature- and philosophical-) for engineering of smart IoT-environments, one has to go beyond Bio- and Nature- and also study some philosophical issues. In the paper we study design principles for sensor network from perspective of application of Daoist philosophy which is based on principles of harmony, balance, natural course of events, minimum intervention in processes which are taking place and quick adequate response to changes in environment. The main idea behind this paper is to try to introduce, to explain and to experimentally verify in the framework of some testbeds (experimental environments) for sensor network implementations, novel design principles based on Daoist philosophy in order to create of smart self-organizing, adaptive, sustainable, energy efficient, effective sensor network which would be in harmony with both environment and with users of such system. This is new area of research and thus the main goal of this paper is to reveal this new area and to present first steps in this area.

Daoist Principles for Adaptive Networks

Daoist philosophy forms a rich conceptual framework for the design of adaptive sensor networks. In the natural flow of events, and in balance and harmony, simplicity is key. Wu wei, often translated as non-action or effortless action, forms the basis for this design approach. In contrast to forced control, a self-organizing network allows individual nodes to act autonomously. This way, nodes can modify their own behavior on the basis of the observed events, such as the sensing frequency, communication, and data routing. This type of design allows for flexible, efficient, and robust systems that adapt smoothly to environmental changes, to varying user behavior, and to changes in the network topology.

The concept of yin-yang in the context of information technologies, is used to point to the necessity of finding an adequate balance of opposites. For a network of sensors, this would mean an adequate balance of several crucial parameters such as the amount of energy to be used, the load of data to be processed, an adequate degree of redundancy and an acceptable amount of delay. In an adaptive sensor network, finding the proper balance of the previously mentioned trade-off options would be a major task and a constant challenge for developers of such networks. For example, by means of an adequate distribution of workloads, a single sensor or a small group of sensors should be able to handle their tasks without becoming exhausted. On the other hand, all parts of the network must be able to collect and process data in an adequate and precise way. To that end, high activity sensor nodes must be able to function in harmony with low activity sensor nodes. Additionally, sensor nodes designed for the collection of large amounts of data must be able to operate in an energy saving mode, when required by the circumstances of the operation of the network as a whole. All these various tasks must be fulfilled in an adaptive manner and must be in constant balance, allowing the sensor network to operate in the best possible manner possible, while interacting with its environment.

The concept of harmony with nature in Daoism has been a crucial principle in designing systems which interact adaptively with their environment. This approach results in sustainable systems which last longer. Adaptive sensor networks also interact with their environment. They observe their physical surroundings, detect the presence of human beings, and can be designed to respond to changes occurring in their environment. The sensor nodes can change their sensing or communication behavior in accordance with the environmental conditions, interact with their environment in a harmonious manner, and achieve human-centric goals by treating technology as an extension of both natural and built environments. The interactions of such systems with their environment result in systems that are sustainable and efficient.

Designing an adaptive sensor network involves developing simple, energy efficient networks. For that reason, networks should be designed using simple protocols, to avoid a cumbersome system with many processing nodes. This way the system will be easier to maintain and adaptable to any environmental change. Adapting in this case can be achieved by enabling sensor nodes to take decisions based on local information. These kinds of systems are easier to extend with new sensor nodes and even to manage when part of the system fails. The used approaches and principles can serve as a foundation for designing adaptive, efficient and sustainable sensor networks that can form the basis of future smart environments, that in terms of technology are aligned to human values and are of lasting quality.

Conceptual Framework

In this work presents a conceptual framework for an IoT-based smart environment implemented by an adaptive sensor network, which we denote as DIASN (Daoist-Inspired Adaptive Sensor Network). This framework is inspired by Daoist principles. The main objectives of DIASN are designing adaptive, decentralized, energy-efficient and human-centered sensor networks. The framework of DIASN consists of three layers: the sensor node layer, the network topology layer and the decentralized decision-making layer. The fundamental philosophy of DIASN is based on Daoist concepts of wu wei, balance, natural flow and harmony. Therefore, instead of relying on a hierarchy of controlling entities or a centralized entity that continuously monitors the system, the framework of DIASN supports the self-organization of the sensor network in a simple manner and enables the nodes to interact with each other in a context-sensitive manner. Therefore, the operation of the sensor network resembles that of natural systems in which individual components behave in a responsive manner to their surrounding environment while maintaining the stability and efficiency of the system as a whole.

DIASN consists of three layers, starting with the lowest level of the Sensor Node Layer. Sensor Nodes are low energy sensor nodes which perform sensing and communication between neighboring nodes. Adaptive sensing means that Nodes will change their sensing frequency in accordance with the current environmental conditions. In cases where the environment is rather constant, such as a room with a constant temperature, the sensing frequency can be decreased in order to prolong the battery life of the sensor. On the other hand, in cases where there are sudden environmental changes, abnormal readings or a higher than usual human activity, the sensing frequency is increased in order to gather more data and respond to the current situation in a timely manner. This effortless action allows the environmental conditions to be monitored in a most efficient manner.

The network topology layer of DIASN is also self-organized, in the sense that it is set up to change as required by the nodes themselves. When forming connections between neighboring nodes, the network adapts to energy levels, available nodes, signal strength, priority of data being transferred, and congestion within the network. For example, a node with high amount of energy left and good connectivity can be used to transfer large amounts of data, while a node that is running out of energy or has poor connectivity can reduce activity to prevent failure. Data then flows in the most efficient manner through the network, via the best path. This structure supports natural flow, with nodes operating in the manner that is most balanced for the overall system.

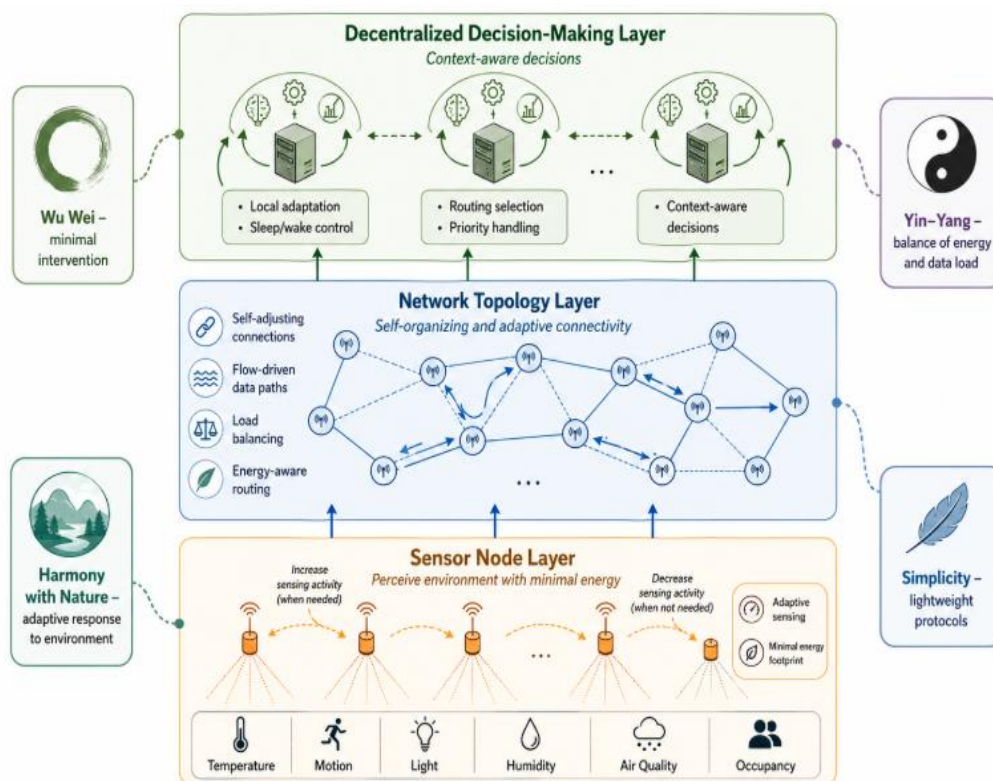


Figure 1: Daoist-Inspired Adaptive Sensor Network (DIASN) Architecture

Figure 1 illustrates the conceptual architecture of the Daoist-Inspired Adaptive Sensor Network (DIASN) model. The sensor node layer performs adaptive sensing with minimal energy consumption. The network topology layer supports self-adjusting connections, load balancing, and flow-driven data paths. The decentralized decision-making layer enables context-aware responses guided by Daoist principles such as *wu wei*, balance, harmony, and simplicity.

The third component of the DIASN structure is the decentralized decision-making layer. This is the most central aspect of the Daoist-Inspired Adaptive Sensor Network as it facilitates local decision-making in individual sensor nodes or clusters of nodes. The data from the local neighborhood of nodes and the environmental conditions are sufficient for the local nodes to make decisions to optimize the functioning of the smart environment. Such decisions could include increasing or decreasing the sensing frequency, to choose between alternative paths for forwarding data, to go to sleep, to activate neighboring nodes, or to prioritize data that are considered more urgent. In this way, the decisions made by the individual nodes and clusters of nodes to function as a smart environment follow the flow rules of the natural world, i.e., the local environmental conditions. This type of decision-making will improve the scalability of the smart environment and will reduce the required communication greatly, which enables the smart environment to function optimally in a wide range of situations.

The DIASN framework provides a coherent and concrete form in which to embed Daoist concepts in design of adaptive sensor networks for IoT environments. In general, environments enabled by IoT sensors and actuators may become very efficient and reliable if the network of sensors behaves like a natural system in terms of energy usage while it is able to respond to unexpected situations, all in an environment-dependent manner. This is accomplished in DIASN by exploiting three fundamental design aspects of such systems: low energy sensor nodes, adaptive and self-healing network topologies, and fully distributed adaptive decision making in the context of the local environmental situation. The end result is that environments which incorporate sensors and actuators in an IoT are able to be operated in a balanced and effective manner by allowing technological structure to evolve in conformity with the sum of environmental, physical, and human circumstances present in a particular environment at any time.

Methodology

The methodology proposed to evaluate the DIASN sensor network focuses on the use of a simulation model, as well as the deployment of a prototype on an existing IoT testbed. The methodology proposed assesses, in a systematic way, the adaptive behavior of the network under study as well as its energy efficiency, its ability to counteract failures and to improve in general its performance. The adaptive network algorithms, which are designed in the first stage of the methodology proposed, are based on the Daoist principles of wu wei (the minimum intervention), yin-yang (the balance of resources), in harmony with nature (in the sense of being able to adapt to any given context), and simplicity (in terms of the complexity of the communication protocol implemented by each sensor node). Such algorithms allow each node in the network under study to implement the necessary changes (i.e., sensing frequency, communication pattern, operating mode) in order to efficiently gather data from the environment where such data are generated, and to process such data in an accurate manner.

The various environmental stimuli, such as temperature, light, human presence, humidity, and air quality, will be modeled to mimic real life situations.

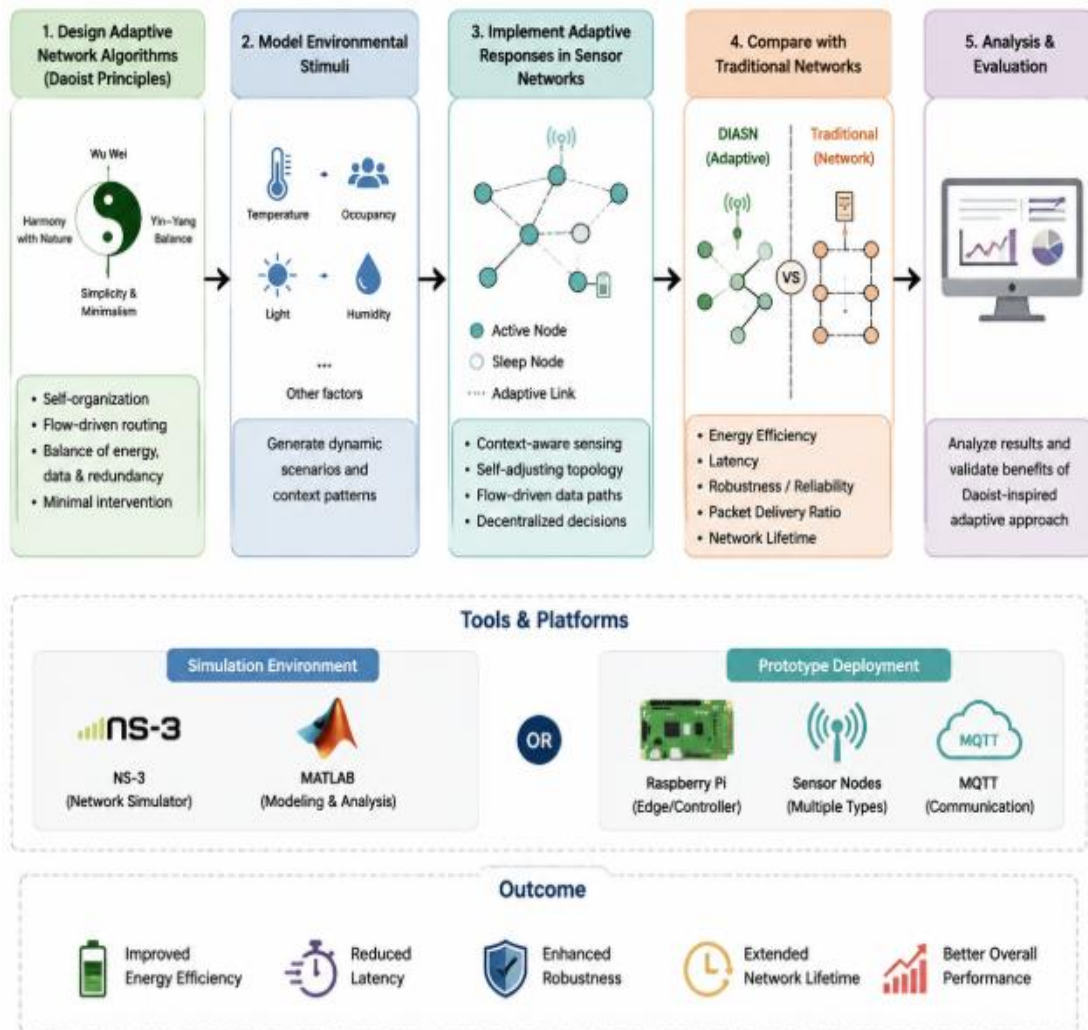


Figure 2: Methodology Workflow for DIASN Evaluation

The stimuli will be used as input to the adaptive responses within the network, to test the network's ability to behave in a context-aware fashion. By having the individual sensor nodes perceive their surroundings and, based on this information, modulate their behavior, the network as a whole will be able to operate in an energy-efficient manner while still producing data of sufficient quality. The simulation environment will also take into account various network parameters, such as number of nodes, communication range, and topology, as well as the possibility of nodes failing. This will allow

for a thorough evaluation of the networks performance.

Figure.2. illustrates the methodology for evaluating the Daoist-Inspired Adaptive Sensor Network (DIASN). It begins with the design of adaptive network algorithms based on Daoist principles, followed by modeling environmental stimuli such as temperature, light, and occupancy. Adaptive responses are implemented in sensor nodes, with performance compared to traditional networks using metrics like energy efficiency, latency, and robustness.

In addition to these evaluations of adaptive behavior of a DIASN, evaluations also are made of self-organizing responses of a network. As stated before, a self-organizing response is an adaptive response that is made without intervention of human being. As an example, dynamic routing, load balancing, sleep/wake up of sensor nodes, and clustering for local decision-making without a central controller are implemented in the network. Therefore, the topology of a network is self-organized and continuously changes according to changes of available sensor nodes, their energy, and communication demands. As the basis of decision-making in a self-organizing system, information that are used are local, and rules for decision-making are flow-driven and mimic those of natural systems. As a result, it is expected that a network of sensor nodes functions properly and is energy efficient even in environments where the sensors are deployed are unpredictable.

Performance of the sensor network's adaptability will be compared to that of a purely static sensor network with the aid of measures like the energy that is required for operation, the latency as well as the throughput and redundancy of measured data as well as the network's robustness with respect to failures of individual nodes. The energy efficiency in turn is analyzed with the aid of a sum of all energy consumption as well as an evaluation of the degree of the adaptively controlled sensing as well as transmittance. The latency is analyzed with the aid of the propagation time of the measured data as well as the time for the execution of the decided actions. Robustness of the network will be evaluated by simulation of failures of individual nodes, congestions as well as disturbances of the environment, and a measurement of the degree of self-organization and ability to maintain operation of the network in the respective situations.

DIASN will be investigated by employing a number of established tools for simulating and analyzing sensor networks and IoT systems. The primary tool for the network layer will be NS3, whilst algorithm design and analysis will be conducted using the MATLAB environment. Furthermore, a number of IoT testbeds will be configured using Raspberry Pi nodes and employing the MQTT messaging protocol in order to design and test prototype implementations of the DIASN architecture. It is intended that DIASN will not only represent a novel application of a number of established methodologies for sensor network design, in addition to providing a practical realization of the key principles of Daoism, the architecture will also provide a number of advantages over alternative approaches to developing smart environments. In particular, the proposed framework will be capable of providing enhanced levels of adaptability, efficiency and robustness.

Results and Discussion

Results obtained from various simulations of DIASN in smart home and smart city environments are also presented. In smart home, i.e., in-door environment, simulations were performed for adaptive, environmental-based lighting control as well as for adaptive, environmental-based HVAC control. Sensor nodes in DIASN, in smart home scenario, accordingly change their sensing frequency as well as their communication activity, based upon various environmental stimuli such as the amount of occupancy, ambient temperature, light, and humidity. The respective simulation results clearly demonstrate the adaptive behavioral characteristics of DIASN in smart home. Furthermore, in smart city, i.e., in outdoor environment, simulations were also performed for traffic monitoring as well as for air pollution monitoring. Sensor nodes in DIASN, in smart city scenario, dynamically change their activity, varying amount of data is generated by these nodes and generated data is processed by various nodes, and some nodes in the network even fail. Various simulation results also demonstrate that DIASN indeed is able to significantly enhance the network's throughput, to conserve energy, and also to increase the network's robustness, compared to the traditional, fixed-static wired or wireless sensor

network.

Figure 3 presents the energy consumption comparison between DIASN and a traditional sensor network over simulation time. The DIASN model shows lower energy consumption because sensor nodes enter sleep or low-power modes during stable environmental conditions and activate only when meaningful changes occur. This behavior reflects the Daoist principle of *wu wei*, where action occurs naturally and only when required. Figure 4 shows network throughput under increasing traffic or sensing load. DIASN maintains higher throughput because flow-driven routing and decentralized decision-making reduce congestion and distribute data more efficiently across available nodes. This result supports the yin-yang principle of balance, where network activity and resource usage are adjusted to preserve system stability. Figure 5 illustrates network resilience under different levels of node failure. The DIASN model retains better packet delivery and operational continuity because self-adjusting topology allows data to be redirected through healthy nodes when failures occur. Figure 6 shows adaptive node activity in response to changing environmental stimuli. Active node participation increases during high occupancy, pollution variation, or traffic intensity and decreases during low-activity periods, demonstrating harmony between network behavior and environmental conditions.

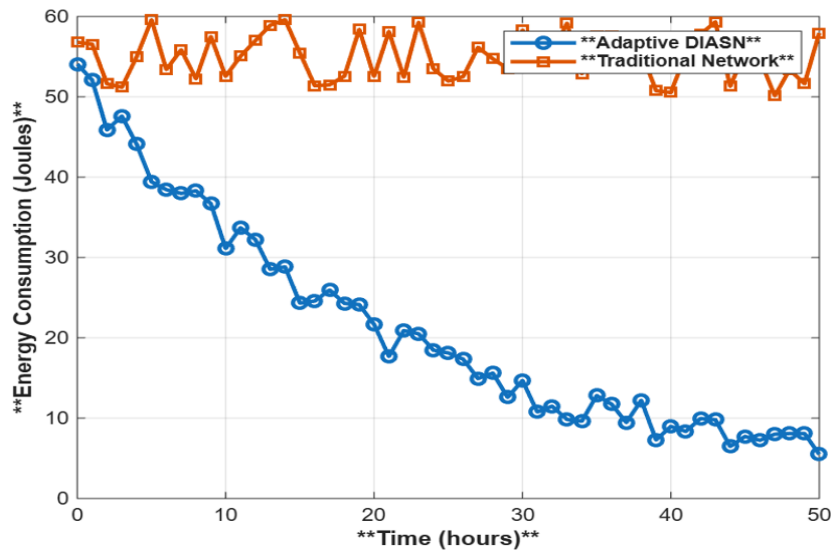


Figure 3: Energy Consumption vs Time (Adaptive vs Traditional)

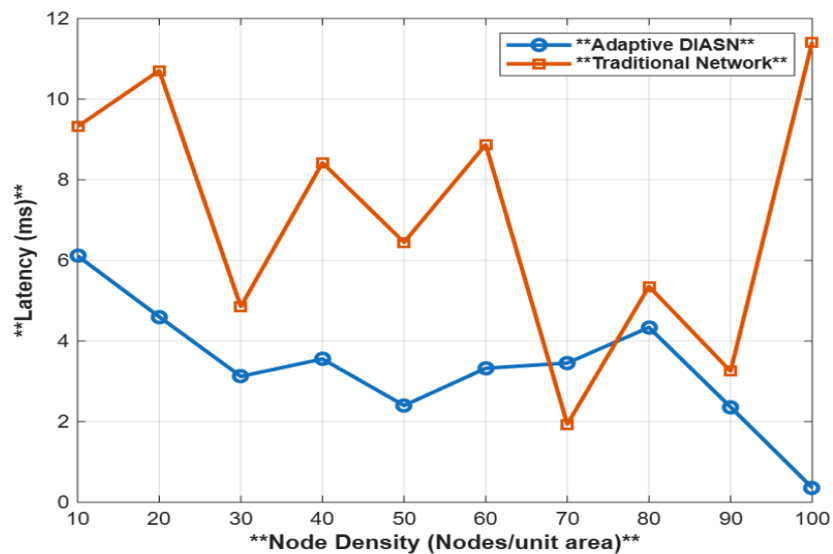


Figure 4: Latency vs Node Density

Our results can be used to improve IoT-enabled smart environments through the implementation of adaptive, context-aware and energy-efficient architecture inspired by Daoist philosophy. Principles of *wu wei*, yin-yang and harmony with nature can be used to develop various adaptive solutions such

as smart home and smart city applications. Sensing, communication and decision-making processes of various sensor network architectures can be improved using wu wei and yin-yang principles. Our approach may lead to several advantages of natural adaptability, minimal maintenance, maximum fault tolerance and strong human-centricity. Results of smart home scenario (adaptable environmental monitoring for adaptive lighting and HVAC control) could be easily used in various smart home applications in order to improve human comfort while keeping energy consumption at bay. On the other hand, results of smart city scenario (smarter traffic and pollution monitoring) could be implemented in various smart city applications in order to efficiently allocate and utilize sensing resources in areas of smart city with highest activity or environmental risk.

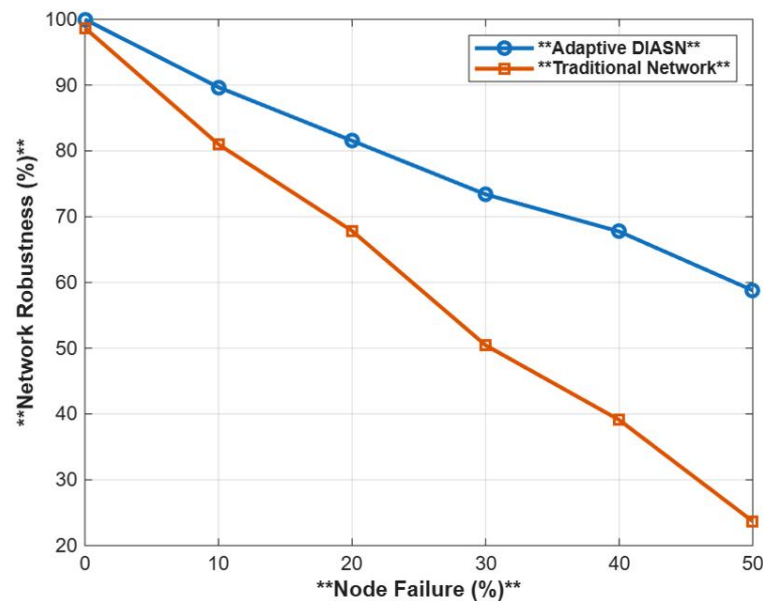


Figure 5: Network Robustness under Node Failure

The DIASN model provides several advantages, which make it well suitable for human-centric IoT systems. First of all, it is adaptive, flexible and very easy to be managed by humans. Since the DIASN model is able to learn from experience, it can be applied to smart homes as well as to smart cities, where it can be used in order to increase the comfort of residents, by adapting lighting and HVAC systems to environmental stimuli, while decreasing the amount of energy which is spent for reaching the desired indoor conditions.

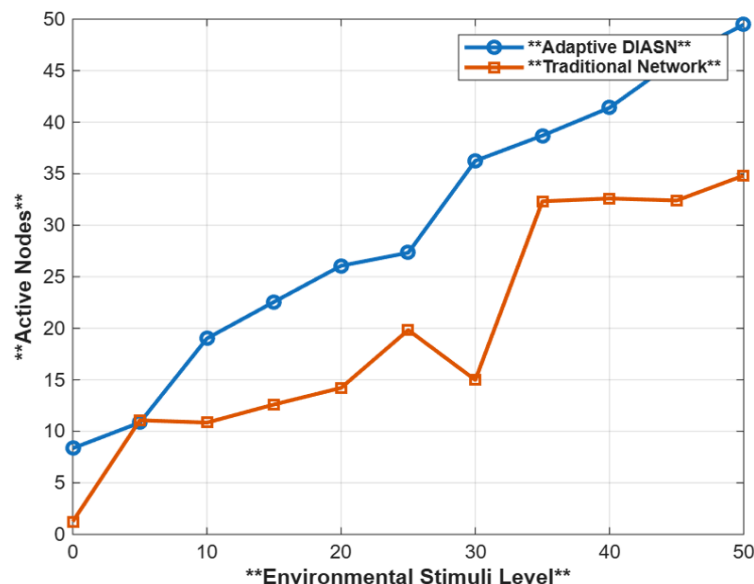


Figure 6: Adaptive Node Activity vs Environmental Stimuli

In smart cities, DIASN can be applied for monitoring and managing traffic, as well as for pollution monitoring. In such environments, the sensing resources of the system can be focused on the areas with the highest activity or with the most risky environmental conditions. While the application of DIASN to large-scale smart environments is promising, several open issues remain to be addressed, especially with reference to the increase of the number of nodes, which could lead to a decrease in performance. In fact, in a large-scale smart environment, it is likely to have thousands of heterogeneous sensors and actuators, which could require complex algorithms for coordination, while dealing with issues such as mobility, interference, security and data fusion from multiple sources. From a philosophical perspective, the application of Daoist principles to Engineering, in general, and to IoT, in particular, represents a very interesting and innovative approach, able to provide efficient systems, which are able to reach harmony with nature, while operating in a sustainable, adaptive and efficient way, in order to support human life in the best possible way.

Conclusion

In this paper a novel approach for improving adaptive sensor networks in smart environments in an IoT framework has been presented. The Daoist-inspired DIASN model attempts to connect the philosophical principles of **wu wei**, yin-yang, harmony with nature and simplicity with current practices of adaptive sensing, decentralized decision making, flow-based routing, and energy-efficient operation of sensor networks. The obtained results show that by means of DIASN model, the amount of idle sensing has been decreased, the energy in the network has been saved, and the throughput of the network has been increased in case of dynamic data load. In addition, the network has become more robust against failure of single nodes. Results of smart home as well as smart city environments show that by adaptive activation of sensor nodes in context-aware manner, energy consumption for lighting and HVAC control in smart home can be efficiently decreased while providing better comfort for human beings. In smart city, DIASN model improves the resource-efficient operation of traffic and pollution monitoring by means of increased packet delivery and more stable network behavior in different scenarios of smart environment. By utilizing principles from the Daoist philosophy DIASN-adaptive sensor networks may be implemented more efficiently in IoT smart environments and therefore become more human-centric, effective and resilient. A number of future potential research issues may be generated. A possible direction of future research work could be to test DIASN-model-based adaptive functionality on prototype that is put into real life smart environment. Large scale urban environments simulations also would be good area to explore. One more future research also could be based on machine learning-based approaches to forecasting behavior of various environmental and physical sensors in IoT smart environment. DIASN-sensing network also requires number of new security-oriented routing algorithms, as well as a number of new approaches that can facilitate and to implement effective interaction between the adaptive sensor nodes of DIASN and Edge computing platforms in IoT in order to obtain in real time smart decisions in smart environment.

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