

# A Review on Fuzzy Logic Based Smart Routing Algorithm for WSN

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**Abstract:** For a WSN systems moving packets is just a medium to access an end but not the actual purpose. Rather Wireless Sensor Networks is useful if they provide meaningful information and actions for fulfilling a given task. This work focus on utilizing node characteristics with fuzzy logic based intelligent decision mechanism for mitigate the major challenges of the nodes selection for establishing the multi hop routing of the wireless sensor networks. The node characteristics are considered in terms of nodes data forwarding success rate probability evaluation by simple and flexible fuzzy rules.

**Keywords:** Fuzzy Logic, WSN, Routing Protocol, Sensor Nodes

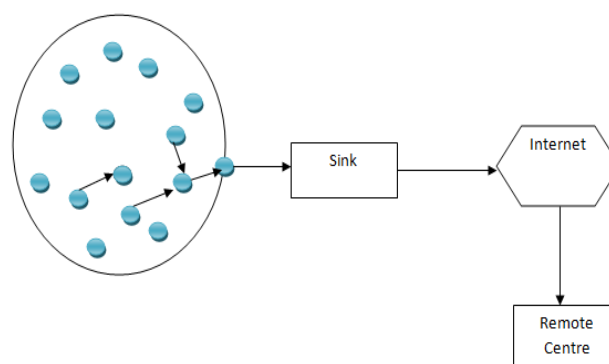
## 1. Introduction:

Wireless Sensor Networks possess a large number of sensor nodes with limited resources in terms of energy, computation and memory. They are operated by a small battery attached to it. This battery possess some initial energy, and in every communication it dissipates a fraction of the energy. Many such communications take place during the network lifetime, and every time sensor node consumes some energy which makes battery exhaust eventually. When nodes are deployed in harsh environment, where it is hard to reach, in most of the cases there is no way to recharge these batteries [1].

Sensors are considered as significant components of electronic devices. Important and critical information must be delivered to the sink in a multi-hop and energy-efficient manner in most applications of wireless sensor networks (WSNs). In as much as the energy of sensor nodes is limited, prolonging network lifetime in WSNs is considered to be a vital issue. Therefore, researchers should consider energy consumption in routing protocols of WSNs in order to extend the network lifetime

Recent advances in micro-electro-mechanical systems (MEMS) and wireless communications have highlighted the importance of WSNs as significant reporting devices. Indeed, sensor nodes in WSNs are deemed to be resource constrained in terms of energy, communication range, processing capability and memory capacity. WSNs are used

in applications such as target tracking, environmental monitoring and battlefield applications. The main purpose of WSNs is to disseminate the information from the source to the sink in multi-hop scheme [6]. Figure 1 shows a typical WSN.



**Fig. 1. Architecture of WSN**

A sensor node typically consists of five main components:

One or more sensors gather data from the environment. The central unit which is in the form of a microprocessor manages the tasks. A transceiver communicates with the environment and a memory is used to store data generated during processing or temporary data. The battery provides energy to all parts. Energy efficiency in all parts of the network is crucial in order to assure a sufficiently long network lifetime. To fulfil this need, data processing tasks are often spread over the network, i.e. nodes co-operate in transmitting data to the sinks. In spite of the fact that most sensors have a traditional battery there is some early stage research on the production of sensors without batteries, using similar technologies to passive RFID chips without batteries.

## 2. Related Work:

The potential for collaborative, robust networks of micro sensors has attracted a great deal of research attention. For the most part, this is due to the compelling applications that will be enabled once wireless micro sensor networks are in place; location-sensing, environmental sensing, medical monitoring and similar applications are all gaining interest.

However, wireless micro sensor networks pose numerous design challenges. For applications requiring long term, robust sensing, such as military reconnaissance, one important challenge is to design sensor networks that have long system lifetimes. This challenge is especially difficult due to the energy constrained nature of the devices. In order to design networks that have extremely long lifetimes, we propose a physical layer driven approach to designing protocols and algorithms. **Eugene Shih, et. al. (2001)**, [1] first presented a hardware model for our wireless sensor node and then introduce the design of physical layer aware protocols, algorithms, and applications that minimize energy consumption of the system. Our approach prescribes methods that can be used at all levels of the hierarchy to take advantage of the underlying hardware. **Eugene Shih, et. al. (2001)**, [1] also show how to reduce energy consumption of non-ideal hardware through physical layer aware algorithms and protocols.

Throughout this work, they have shown techniques at various levels of the system hierarchy that take advantage of underlying hardware to produce more energy efficient solutions. In some instances, we have shown how to take advantage of hooks and knobs in the physical layer to build more energy-efficient protocols and algorithms. In other instances, we demonstrated how non-idealities of the hardware can be mitigated by making careful, yet simple protocol design choices. As a whole, we advocate a physical layer driven approach to protocol and algorithm design for wireless sensor networks. In order to meet the system lifetime goals of wireless sensor applications, considering the parameters of the underlying hardware are critical. If protocol designers treat the physical layer as a black box, system designers may design protocols that are detrimental to energy consumption.

In a Wireless Sensor Network, sensor nodes may fail for several reasons and the network may split into two or more disconnected partitions. This may deteriorate or even nullify the usefulness and effectiveness of the network. Therefore, repairing partitions is a priority. In this work **Gianluca Dini, Marco Pelagatti, and Ida Maria Savino (2008)**, [2], presented a method to repair network partitions by using mobile nodes. By reasoning upon the degree of connectivity with neighbours, a mobile node finds the proper position where to stop in order to re-establish connectivity. Factors influencing the method performance are singled out and criteria for their selection are discussed. Simulations show that the proposed method is effective and efficient notwithstanding packet loss.

With reference to a WSN, **Gianluca Dini, Marco Pelagatti, and Ida Maria Savino (2008)**, [2], have presented a method for repairing network partitions based on mobile nodes. The work has the following merits. First of all, it treats an important problem that, so far, has received limited attention. Furthermore, the work suggests a method that is

based on a few mobile nodes that move through the network reducing the communication overhead. The work presents the main factors influencing the algorithm behaviour and performance and discusses their selection criteria. By simulation, the work shows that the proposed method is effective in terms of disconnection probability and efficient in terms of communication overhead. Future steps consist in deploying an early prototype on the multi-agent platform we have been developing.

Radio transmission and reception consumes a lot of energy in a wireless sensor network (WSN), which are made of low-cost, low-power, small in size, and multifunctional sensor nodes. Thus, one of the important issues in wireless sensor network is the inherent limited battery power within the sensor nodes. Therefore, battery power is crucial parameter in the algorithm design in maximizing the lifespan of sensor nodes. It is also preferable to distribute the energy dissipated throughout the wireless sensor network in order to maximize overall network performance. Much research has been done in recent years in the area of low power routing protocol, but, there are still many design options open for improvement, and for further research targeted to the specific applications, need to be done. In this work, **Shio Kumar Singh, M P Singh, and D K Singh (2010)** [3], proposed a new approach of an energy-efficient homogeneous clustering algorithm for wireless sensor networks in which the lifespan of the network is increased by ensuring a homogeneous distribution of nodes in the clusters. In this clustering algorithm, energy efficiency is distributed and network performance is improved by selecting cluster heads on the basis of (i) the residual energy of existing cluster heads, (ii) holdback value, and (iii) nearest hop distance of the node. In the proposed clustering algorithm, the cluster members are uniformly distributed and the life of the network is further extended.

In this work they have illustrated a homogeneous clustering algorithm for wireless sensor network that saves power and prolongs network life. The life span of the network is increased by ensuring a homogeneous distribution of nodes in the clusters. A new cluster head is selected on the basis of the residual energy of existing cluster heads, holdback value, and nearest hop distance of the node. The homogeneous algorithm makes sure that every node is either a cluster head or a member of one of the clusters in the wireless sensor network. In the proposed clustering algorithm the cluster members are uniformly distributed, and thus, the life of the network is more extended. Further, in the proposed protocol, only cluster heads broadcast cluster formation message and not the every node. Hence, it prolongs the life of the sensor networks. Battery power being scarce resources of sensors, energy efficiency is one of the main challenges in the design of protocols for WSNs. The ultimate objective behind the protocol design is to keep the sensors operating for as long as possible, thus extending

the network lifetime. The factors affecting cluster formation and CH communication are open issues for future research. This investigation will be highly useful for energy efficient wireless sensor network.

Wireless sensor networks (WSNs) are mostly deployed in a remote working environment, since sensor nodes are small in size, cost-efficient, low-power devices, and have limited battery power supply. Because of limited power source, energy consumption has been considered as the most critical factor when designing sensor network protocols. The network lifetime mainly depends on the battery lifetime of the node. The main concern is to increase the lifetime with respect to energy constraints. One way of doing this is by turning off redundant nodes to sleep mode to conserve energy while active nodes can provide essential  $k$ -coverage, which improves fault-tolerance. Hence, **T. V. Padmavathy, and M. Chitra (2010)** [4], used scheduling algorithms that turn off redundant nodes after providing the required coverage level  $k$ . The scheduling algorithms can be implemented in centralized or localized schemes, which have their own advantages and disadvantages. To exploit the advantages of both schemes, we employ both schemes on the network according to a threshold value. This threshold value is estimated on the performance of WSN based on network lifetime comparison using centralized and localized algorithms. To extend the network lifetime and to extract the useful energy from the network further, we go for compromise in the area covered by nodes.

In this work, they used coverage-preserving centralized node-scheduling scheme to reduce energy consumption and therefore increase system lifetime, by turning off some redundant nodes. Further, to increase the network lifetime and to extract the residual energy from the remaining nodes, we change the monitoring area levels. The improvements obtained from the proposed scheme are an increase in the network lifetime by 30000–50000 rounds and a reduction in energy consumption by 41.2% to 58.09%, when compared to that without the scheduling scheme. However, it also infers that only about 30% of the deployed sensors are utilized in subset formation and the remaining nodes are not used. Hence, to utilize those nodes, here it is opted to go for the compromise in area. Thus, from the results, it is concluded that by com-promising in area, more number of nodes are utilized, residual energy is reduced, and network lifetime is improved. From the results, we conclude that the localized algorithm provides better performance than the centralized one when the network size is smaller. That is when the network has 25 nodes, it provides 21,000 rounds greater life. But when the network size increases, the exchange of hello packets consumes a considerable amount of energy in LSKA. Hence, CSKA provides better results for larger networks. When the results of CSKA and LSKA are plotted in the same graph, a crossing point is found. This is the threshold to switch from LSKA to CSKA. This

threshold to switch from one algorithm to another depends on the required coverage level  $k$ , the buffers required for nodes to store adjacent nodes information for localized algorithm, the sensing range, etc. The future vision is to use the algorithm for the sensors with adjustable sensing range and to consider the buffer variation in network area to find the threshold expression.

Wireless sensor networks (WSN) technologies are widely used in today's world for monitoring purposes. In most applications, the sensors are not plugged in. Instead, they get power from the batteries they carry. To keep the network alive for a long time with such limited power, it is very important to conserve energy while the network is functioning. In this work, **Yuping Dong et. al. (2011)** [5], presented an energy efficient routing algorithm for WSN. In this algorithm, we divide the sensor nodes into several scheduling sets and let them work alternatively. In this way, the sensors do not have to be active all the time which saves a lot of energy. When choosing the next sensor to forward the information to, we consider both the distance from the base station to the sensor and its current energy level. So the network power consumption will be distributed among the sensors. When the network does not have enough sensors that have sufficient energy to run, it generates new scheduling sets automatically. Simulations and comparisons demonstrate that our algorithm outperforms the previous work on energy efficient routing algorithms.

In large scale wireless sensor networks, the small sensors are randomly distributed in great volume which makes battery recharging or replacement impossible. Energy conservation becomes the only solution to prolonging network lifetime. The EECCR algorithm in [5] divides the whole network to  $s$  scheduling sets and lets different sets work alternatively to distribute power consumption among nodes. However, when setting up the scheduling sets, the EECCR algorithm did not take into account nodes' energy level which may cause some nodes deplete very soon. In this work, they proposed an improved energy aware routing algorithm to distribute data traffic among sensor nodes. When setting up the scheduling sets, we consider both the hop count and the energy level of nodes. Simulation results verified that our algorithm prolongs network lifetime much more than the EECCR algorithm while maintaining better network coverage and  $n$ -connectivity ratios. With multiple sink nodes, the network power consumption was further improved. The transmission latency is also shortened because of the smaller distance between each sensor node and the sink node. However, the nodes that are closer to the sink nodes still carry most data traffic. These nodes will be the first nodes that deplete their energy. In order to further distribute power consumption, we could use moving sink nodes to improve energy efficiency.

One of the important issues in wireless sensor networks is the inherent limited battery power of the network sensor nodes. The battery power in the sensor nodes plays an important role in increasing the lifespan of the nodes. Hierarchical routing protocols are the best known protocols to minimize the energy consumption. Leach is one of the fundamental protocols in the clustering technique hierarchical routing protocols that can be used for minimizing the energy consumed in collecting and disseminating. **J. Gnanambigai, Dr. N. Rengarajan, and K. Anbukkarasi, (2012)** [6], have surveyed the state-of art of different hierarchical routing protocols that have been developed from the LEACH. This work highlights some of the drawbacks and issues in LEACH and discuss how these issues are overcome by the descendants of LEACH. This work also compare the features and performance issues of all hierarchical routing protocols.

In this survey, the drawbacks and issues addressed by the LEACH protocol and how these issues are overcome by the descendants of LEACH are discussed. Each of the routing protocol has its own advantages compared to the fundamental leach routing protocol. This work also compares the features and performance of each hierarchical clustering routing protocol. Finally, it can be concluded from the given survey that for an energy efficient and prolonged wireless sensor networks, still it is needed to find more efficient, scalable and robust clustering scheme.

The wide utilization of Wireless Sensor Networks (WSNs) is obstructed by the severely limited energy constraints of the individual sensor nodes. This is the reason why a large part of the research in WSNs focuses on the development of energy efficient routing protocols. **Stefanos A. Nikolidakis, Dionisis Kandris, Dimitrios D. Vergados and Christos Douligeris, (2013)**, [7] worked on a new protocol called Equalized Cluster Head Election Routing Protocol (ECHERP), which pursues energy conservation through balanced clustering, is proposed. ECHERP models the network as a linear system and, using the Gaussian elimination algorithm, calculates the combinations of nodes that can be chosen as cluster heads in order to extend the network lifetime. The performance evaluation of ECHERP is carried out through simulation tests, which evince the effectiveness of this protocol in terms of network energy efficiency when compared against other well-known protocols.

In this work, ECHERP, an energy efficient protocol for WSNs, was presented. ECHERP considers the current and the estimated future residual energy of the nodes, along with the number of rounds, that can be cluster heads in order to maximize the network lifetime. The protocol computes the energy consumed using the Gaussian elimination algorithm in order to minimize the overall network energy consumption at every single round. Therefore, it elects as a cluster head the node that minimizes the total energy

consumption in the cluster and not the node with the higher energy left, as in many other protocols. ECHERP also adopts a multi-hop routing scheme to transfer fused data to the base station. Therefore, ECHERP achieves substantial energy efficiency, as shown through simulation tests, which indicates that ECHERP outperforms several previously proposed protocols, namely LEACH, PEGASIS and BCDCP. In future work, ECHERP can be further enhanced by taking into consideration metrics related to QoS and time constraints.

The advancement in last decade in electronics & communication, computer science and information technology domain has resulted in the new computing and communication era, known as Wireless Sensor Networks. The routing protocols differ on the basis of application and network architecture. With awareness is a compulsory design criterion, many new protocols have been specifically designed for routing, power management and data dissemination. Efficient routing in a sensor network requires that routing protocol must minimize network energy dissipation and maximize network lifetime. **Md. Zair Hussain, M. P. Singh and R. K. Singh, (2013)** [8], analysed the lifetime of different routing protocols for wireless sensor networks.

The work analyzed seven different existing routing protocols namely, mLeach, pathdcs, BVR, ABVCap, PSVC, VCP and greedyHVP in WSNs on the basis of the lifetime of sensor networks. The performance of these protocols over lifetime metrics such as network lifetime, energy consumption of a node, and average hop distance is simulated on OMNet++ and the result analyzed. The analysis of simulation result for the seven existing protocols in WSNs shows that the solution based on virtual coordinate assignment consumes less energy resulting in increase in lifetime of WSNs. However, routing protocols based on virtual coordinate normally proceeds by choosing some reference nodes known as anchors. These anchors are extensively used for initialization of virtual coordinates of all the other nodes and for routing between these coordinates. As a result, these anchors are prone to more loss of energy and thus shorter lifetime. When the total energy of the anchor (or of any other node) is used up, it creates a hole or dead end in the network which may lead to either failure of network functions or break the network.

With the recent technological advances in wireless communications, integrated digital circuits, and micro electro mechanical systems (MEMS); development of wireless sensor networks has been enabled and become dramatically feasible. Wireless sensor networks (WSNs) are large networks made of a numerous number of sensor nodes with sensing, computation, and wireless communications capabilities. Many various routing, power management, and data dissemination protocols have been designed for

wireless sensor networks (WSNs) dependent on both the network architecture and the applications that it is designed for. In this work, **Samira Kalantary, and Sara Taghipour, (2014)**, [9], presented the state of the art of wireless sensor networks' architecture and design features. Also, in this work, we introduce recent work on routing protocols for WSNs and their design goals and challenges. Also, an overview of the application that WSNs assist in is presented. Finally, several open research questions of wireless sensor networks management and issues are suggested and put forward.

In this work, they presented the state of the art of wireless sensor networks; their architecture, routing protocols for WSNs, their applications. Also, in this work, we introduced some recommendation and directions as guidelines and hints that would assist and give enhancements to the future design of protocols and algorithms for wireless sensor networks. Also, in this work, a brief review of the application based on wireless sensor networks is given. Finally, our directions and recommendations for wireless sensor network management are suggested and put forward.

A sensor is a device for detecting and signalling a changing condition. The "changing condition" is simply the presence or absence of an object or material (discrete sensing). It can also be a measurable quantity like a change in distance, size or colour (analog sensing). This information, or the sensor's output, is the basis for the monitoring and control of a manufacturing process. In a wireless sensor network (WSN), event detection and tracking are significant for several applications. Wireless sensor networks (WSNs) have gained worldwide attention in recent years, particularly with the proliferation in Micro-Electro-Mechanical Systems (MEMS) technology which has facilitated the development of smart sensors. These sensors are small, with limited processing and computing resources, and they are inexpensive compared to traditional sensors. WSNs have great potential for many applications in scenarios such as military target tracking and surveillance, natural disaster relief, biomedical health monitoring and hazardous environment exploration and seismic sensing. These sensor nodes can sense, measure, and gather information from the environment and, based on some local decision process, they can transmit the sensed data to the user. The goal of **G. Sasikumar, H. Vignesh Ramamoorthy, and S. Natheem Mohamed, (2014)**, [10] survey was to present a comprehensive review of the recent literature on sensor networks especially in Animal Tracking.

Unlike other networks, WSNs are designed for specific applications. Applications include, but are not limited to, environmental monitoring, industrial machine monitoring, surveillance systems, and military target tracking. Each application differs in features and requirements. To support this diversity of applications, the development of new communication protocols, algorithms, designs, and services

are needed. In a wireless sensor network (WSN), animal detection and tracking are significant for several applications. Typically, a sensor needs to continuously sense the attribute of the event of interest. An attribute is regarded as a user specified predicate on sensor data, which satisfies some properties (e.g., temperature greater than fifty). The majority of existing works primarily utilize sensors, equipped with the same sensing units to track the single event formed by only one attribute. However, animal detection and tracking are unlikely to be achieved if the event is formed by multiple attributes, any one of which is unable to be detected by the same kind of sensors (i.e., sensors with the same sensing units). Thus, sensors with various kinds of sensing units are necessary for such application. In this work we have presented some of the specific applications of sensors and also with an overview of sensors in animal tracking given by many authors. Sensors have wide range of applications. Animal tracking is one of the major one. Several techniques proposed by various authors can be incorporated to develop an efficient animal tracking system.

A wireless sensor network (WSN) is a network consisting of wireless computing devices called sensors that sense environmental conditions like motion, sound, etc in an area. These networks collect the information from the environment and send it to the sink node. The main constraint in these networks is the energy of the nodes. As these sensors have limited battery life, routing protocol should be designed appropriately so that minimal energy is used. Long communication distances between the sensors and the sink in the WSN drain the energy of the sensors and reduce the lifetime of the network. Clustering reduces energy consumption. By clustering a sensor network they can help minimize the total communication distance, thus increasing the network lifetime. In this work, **Tripti Sharma, G. S Tomar, Radhika Gandhi, Srishti Taneja and Kiran Agrawal, (2015)**, [11], an algorithm based on LEACH (Low Energy Adaptive Clustering Hierarchy protocol) using genetic algorithm has been proposed in order to achieve increased lifetime of the network and energy efficiency in WSN. The genetic algorithm is used to select the cluster heads for the WSN and hence create the energy efficient clusters for transmission of data in the wireless sensor network. The fitness function proposed in this algorithm considers both the distance of the nodes from the sink and their energies. The simulation results show that the proposed protocol results in prolonged network lifetime and optimal energy consumption of the wireless sensor network.

A WSN consists of a number of small sensor nodes used to entirely cover an environment; hence, the sensor nodes should be low cost, low power and have limited energy use. These nodes can communicate to each other across a short distance. WSNs may be deployed either randomly or

deterministically, depending upon the application. Cluster based approaches are appropriate for monitoring applications that require a continuous stream of sensor data; thus, routing protocols are applied to lower the cost of delivering a data packet on time. In this work, a clustering algorithm has been proposed for routing wireless sensor networks based on genetic algorithm. The proposed algorithm begins by randomly selecting nodes in a network to be cluster-heads. By adjusting cluster-heads based on fitness function, the proposed algorithm is able to find an appropriate number of cluster-heads and their locations. The proposed algorithm takes different parameters into consideration to increase the network lifetime. The main parameters considered for evaluating fitness function for selecting next population are – energy of candidate cluster head nodes and the distance of candidate cluster head nodes to base station. The results of the simulations show the effectiveness of the proposed mechanism. As proved by simulation results, the proposed algorithm has prolonged network lifetime by increasing the number of rounds at which half the number of nodes die and the number of round at which last node dies inside the network. This algorithm is also increasing the number of packets transmitted as compared to that in LEACH by a factor of 10. The future work will be to maximize network stability for heterogeneous networks. Due to the drawbacks of LEACH, many protocols have been emerged to solve these problems. However, various surveys have displayed that more work is still needed to find more efficient, scalable and robust clustering scheme to enhance energy consumption and prolonging networks lifetime in small and large WSNs.

Sensors are regarded as significant components of electronic devices. In most applications of wireless sensor networks (WSNs), important and critical information must be delivered to the sink in a multi-hop and energy-efficient manner. Inasmuch as the energy of sensor nodes is limited, prolonging network lifetime in WSNs is considered to be a critical issue. In order to extend the network lifetime, researchers should consider energy consumption in routing protocols of WSNs. In this work, a new energy-efficient routing protocol (EERP) has been proposed for WSNs using A-star algorithm by **Ali Ghaffari, (2015)**, [12]. The proposed routing scheme improves the network lifetime by forwarding data packets via the optimal shortest path. The optimal path can be discovered with regard to the maximum residual energy of the next hop sensor node, high link quality, buffer occupancy and minimum hop counts. Simulation results indicate that the proposed scheme improves network lifetime in comparison with A-star and fuzzy logic(A&F) protocol.

Since battery-powered sensor nodes have limited energy, enhancing the lifetime of the WSNs is considered to be an important issue. This work used A\* algorithm and proposed a new scheme to improve the lifetime of WSNs. The EERP

scheme accommodated a node's residual energy, packet reception rate and free buffer in order to find the optimal path with minimum hop count. The outstanding characteristic of the proposed scheme was that it allocated the task of data dissemination to the sensor node with higher residual energy in order to prevent packet dropping as a result of energy termination. Simulation results showed that our proposed was capable of increasing the network lifetime when compared with A&F scheme.

### 3. Conclusion:

In this work sensor network on large-scale transmission networks is implemented. The nodes are initially powered by limited energy. An algorithm for sensor node is shown the architecture of a WSN. Each node decisions as per the information it currently has, knowledge of its computing, communication, and energy resources. The node have capability to collect and forward propagate data by systematic routing approach to other neighboring nodes and consequently to base station. The algorithm decides the best neighbour on the basis of surrounding nodes parameters by simple fuzzy rules. The performance of algorithm are validated in terms of nodes residual energy and it has been observed that the fuzzy based nodes status evaluation and propagation to most suitable node is work better. In future more input parameters can be considered which can help in energy consumption better managed to maximize the network lifetime.

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