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AN EFFICIENT TOKEN BUCKET ALGORITHM INCREASING WIRELESS SENSOR NETWORK LIFETIME

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ABSTRACT- Due to their rapid and promising development, Wireless Sensor Networks (WSNs) have been predicted to invade all domains in our daily life in the near future. However in order to reach their maturity, researchers must find solution to some difficulties which are slowing down the wide spread use of these networks. Wireless sensor network comprise resource sensor nodes that are used to sense the environment, transmit the data to base station for further processing. Only cluster head is used for gathering data from each cluster and transmit that data to base station. Due to unbalancing in clustering process result, thereby causing packet loss, network lifetime, degradation of quality of services metrics. In this study we propose a token bucket algorithm technique that is used to increase the mobility and heterogeneity of the nodes to detect the congestion in network. The experimental result demonstrate that TBACCC achieved better performance in term of data transmission to base station, network lifetime and other quality of services metrics compared with priority based application specific congestion control clustering.

KEYWORD- TBACCC, WSN, DARPA, DSN, PASCCC, CH, BS

1. INTRODUCTION

Wireless Sensor network [3] Composed of many small distributed sensor nodes that provide the reliable monitoring in various environments such as military and civil applications. In WSN every sensor node contains specific hardware receiving hardware, memory, processing unit, which are required. With the help of networking tiny sensor nodes, it becomes easy to acquire the data about physical phenomena which was quite difficult with conventional methods. These node process data and send it to base station called as sink. For communication of data between nodes and sink many routing technologies are used initially, such as direct communication and multi hop data transmission.[6] But due to limited battery life of nodes these techniques were not so effective because of early death of some nodes in both techniques were fail to achieve the network suitability periods. In a clustered sensor network, a cluster member in a cluster is used to transmit its data to its cluster head over a short distance. The cluster head collects data from its cluster members and perform data aggregation on the data before it transmits the aggregated data to the sink by directly or along a multi-hop path.

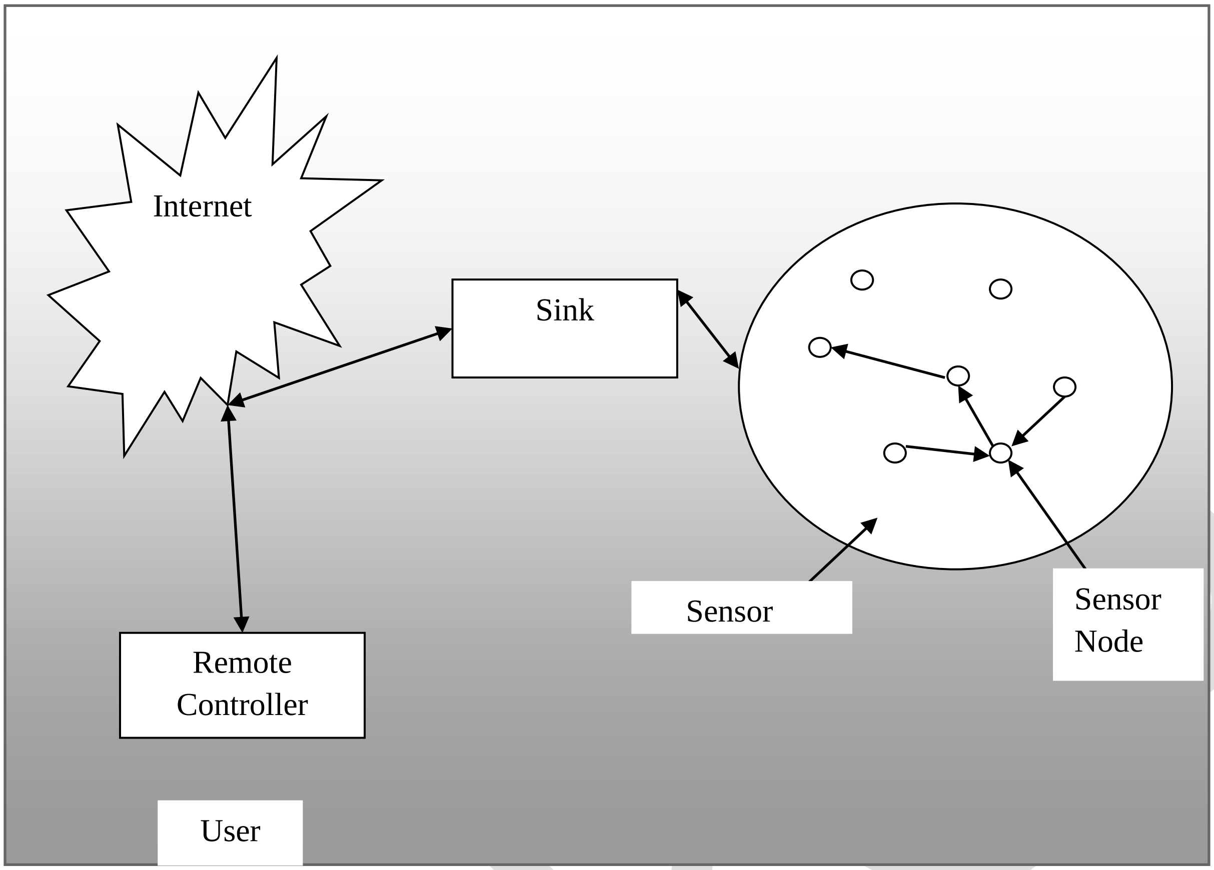

FIGURE 1.1 ARCHITECTURE OF WIRELESS SENSOR NETWORK

1.1 ORIGIN OF WIRELESS SENSOR NETWORKS (WSN$_s$)

The origin of wireless sensor networks traces back to the cold war era where a system of acoustic sensors on the ocean bottom was placed by USA military in 1950 for the sound surveillance to detect and track Soviet submarines.[4] At the same time, US developed the method of air defence radars to defend its territory. Echoing the investments created in Nineteen Sixties and Seventies to develop the hardware for today's net , the U.S Defence advanced analysis comes agency (DARPA) started Distributed sensing element Network (DSN) program in 1978 to formally explore the challenges in implementing distributed/wireless sensing element networks.. The early military, science/technology were all based on heavy, expensive sensors and possessory networking protocols. These WSNs increased the functionality but other factors such as hardware cost, deployment cost, power consumption, scalability and networking standards were not considered.[8] Reducing WSN deployment costs while increasing functionality involves major advances in sensors, CMOS based semi-conductor devices, networking protocols and energy storage or generation technology. The advancement in semi-conductor, networking and material science technologies are driving the deployment of large-scale WSNs. Together, these technologies have made up to create a new generation of WSNs that are different from the WSNs developed and deployed 5 to 10 years ago.[9] Today's WSNs have low deployment and maintenance costs, last longer and are more rigorous.

1.2 DATA AGGREGATION IN WIRELESS SENSOR NETWORK

Modern progresses in digital electronics [2], micro-electro-mechanical system, and wireless communications have empowered the growth of small-sized sensor nodes, which have low-power, low-cost and are multifunctional. These sensor nodes have capability to sense and communicate. Wireless sensor networks [1] are made up of a large number of sensor nodes, densely deployed either inside the region or very near to it in WSN, sensor nodes sense data and transmit it to the base station. Since data from neighbouring sensor nodes [3] may be redundant, it becomes complex for base station to process large amount of data. Moreover, sensor nodes have their own energy. Due to redundant transmissions and loss of energy, lifetime of sensor nodes can decrease. To increase lifetime, data aggregation [3, 4] is performed. Data aggregation means to collect and aggregate data [3, 5] from multiple sensors to eliminate redundancy and conserve energy.

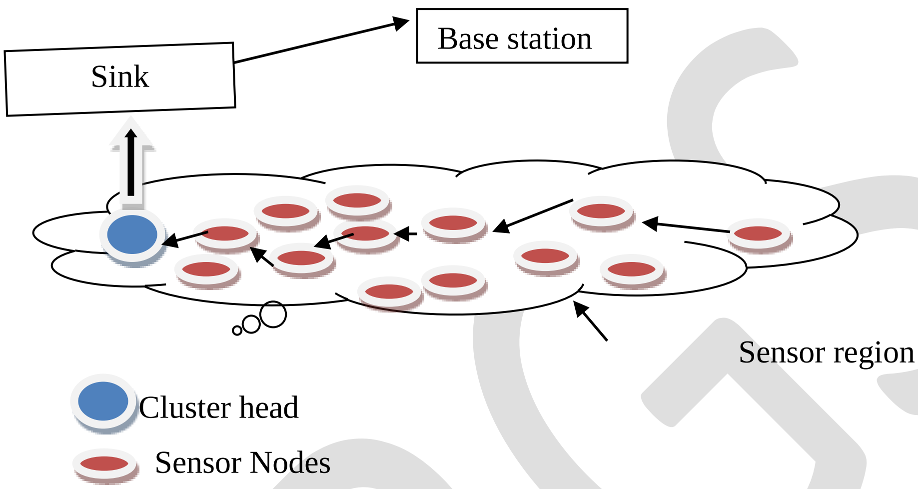

FIGURE 1.2 WORKING OF WIRELESS SENSOR NETWORK

Wireless sensor networks have a wide range of applications in areas [2] such as security, military and health. For instance, a doctor can monitor the physiological data about a patient remotely. The current health condition of the patient is better understood by the doctor. Foreign chemical agents can be detected in the air and water with the help of sensor network. Pollutant's type, amount and location can be identified.

1.3 CLUSTERING

Clustering in wireless sensor networks aims to gather the data among sets of nodes, which choose leaders among themselves. The first cluster-heads has got the role of aggregating the data and reporting the same to the base station [6]. The advantages obtained are in terms of reduction in energy usage of each node and communication cost of network. The clustering algorithms which can be developed are based on homogeneity and heterogeneity of nodes.

1.3.1 CLUSTERING OBJECTIVES

Various objectives have been pursued by different literatures in designing clustering architecture for WSN. Most objectives are set to meet the application constraints. The main objective of clustering is given below:

1) MAXIMIZING NETWORK LIFE-TIME

Unlike in cellular networks, where mobile gadgets (e.g. phones) can easily be recharged constantly after battery drainage, thus power management in these networks remains a secondary issue. However, WSN is heavily constrained in this regard, apart from being infrastructure-less system their battery power is very limited. Most of the sensor nodes are equipped with minimal power source. [7] Thus, power efficiency will continue to be of growing concern and will remain one of the main design objectives of

WSN. In order to cope with energy management in WSN, clustering scheme has been pursued, to extend network life-time and help ease the burden of each node transmitting directly to BS as in conventional protocols like Direct Transmission. When some nodes which are having less energy in the WSN then aim is to provide the energy to those nodes before they declared to be fully dead nodes.

2) FAULT-TOLERANCE

The failure of a sensor node should have a minimal elect on the overall network system. The fact that sensor nodes will be deployed in harsh environmental conditions, there is tendency that some nodes may fail or be physically damaged. Some clustering techniques have been proposed to address the problem of node failure by using proxy cluster-heads, in the event of failure of the original elected cluster-head or have minimal power for transmission. Some other literatures have employed adaptive clustering scheme, to deal with node failures such as rotating the cluster-head. Tolerating node failure is one of the other design goals of clustering protocols.

3) LOAD BALANCING

Load balancing technique could be another design goal of clustering schemes. It is always necessary not to over burden the cluster-heads as this may deplete their energies faster. So, it is important to have even distribution of nodes in each cluster. [10] Especially in cases where cluster-heads are performing data aggregation or other signal processing task, an uneven characterization can extend the latency or communication delay to the base station.

1.4 CLUSTER HEAD SELECTION CRITERIA

1) **Initial Energy:** To select the initial energy cluster head is an important parameter. When any algorithm starts it usually considers the initial energy.
2) **Residual Energy:** Once some of the rounds are completed, the cluster head selection should be based on the energy left behind in the sensors.
3) **Average Energy of the Network:** This energy is used as the reference energy for each node. It is the ideal energy that each node should own in current round to keep the network alive.

1.5 TOKEN BUCKET

The token bucket is an algorithm used in packet switched computer networks and telecommunications networks. It can be used to check that data transmissions, in the form of packets, conform to defined limits on bandwidth and burstiness (a measure of the unevenness or variations in the traffic flow) [6]. It can also be used as a scheduling algorithm to determine the timing of transmissions that will comply with the limits set for the bandwidth and burstiness: see network scheduler.

The token bucket algorithm is based on an analogy of a fixed capacity bucket into which tokens, normally representing a unit of bytes or a single packet of predetermined size, are added at a fixed rate. When a packet is to be checked for conformance to the defined limits, the bucket is inspected to see if it contains sufficient tokens at that time. The packet does not conform if there are insufficient tokens in the bucket, and the contents of the bucket are not changed. Non-conformant packets can be treated in various ways:

- They may be dropped.
- They may be enqueued for subsequent transmission when sufficient tokens have accumulated in the bucket.

- They may be transmitted, but marked as being non-conformant, possibly to be dropped subsequently if the network is overloaded.

1.6 EXPERIMENTAL SETUP

In order to implement the proposed algorithm, design and implementation has been done in MATLAB. Table 1.1 shows the parameters used in the implementation along with their values.

TABLE 1.1 WSNS CHARACTERISTICS

PARAMETER	VALUE
AREA(X,Y)	100,100
BASE STATION(X,Y)	150,150
NODES(N)	300
PROBABILITY(P)	0.1,
INITIAL ENERGY	0.1J
TRANSMITER_ENERGY	$50 * 10^{-9}$J/BIT
RECEIVER_ENERGY	$50 * 10^{-9}$J/BIT
FREE SPACE(AMPLIFIER)	$10 * 10^{-13}$J/BIT/m^2
MULTIPATH(AMPLIFIER)	$0.0013 * 10^{-13}$ J/BIT/m^2
EFFECTIVE DATA AGGREGATION	$5 * 10^{-9}$J/BIT/SIGNAL
MAXIMUM LIFETIME	400
DATA PACKET SIZE	4000 KB

1.7 RESULT

In this section, we present comparisons between TBACCC and PASCCC routing protocols. We conducted our experiments using E_{elec} = 50 nj/bit, N=300, E_{fs} = 10 pj/bit/m^2, $E_{multipath}$ = 0.0013 pj/bit/m^4, d_0= 87, p= 0.1, E_0= 0.01,max time=400 sec, Queue length=7,k= 4000 bytes , E_{DA}= 5nj/bit/message. Thus comparisons were made between TBACCC and PASCCC hierarchical routing protocols in terms of data transmission (packets send to CH and Base station) and energy consumption. In addition a probabilistic approach was used to prevent congestion, which was then validated based on the Matlab coding results.

TABLE 1.2 LISTS OF SYMBOLS

PARAMETER	MEANING OF PARAMETER
N	No. of nodes

E_{elec}	Energy consumed by electronic component of nodes when processing the sensed packet
E_{fs}	Energy consumption during transmission
$E_{multipath}$	Energy consumption during the two way ground propagation
d_0	Cross over distance
k	Size of packet in bits
E_{DA}	Energy consumed during data aggregation and fusion
E_0	Initial energy
p	Probability

1.7.1 PACKET TRANSMITTED TO BASE STATION

On the behalf of packets delivered during the same round of time under privilege techniques like TBACCC and PASCCC protocols. It is observed that TBACCC have very low duty cycle and amount of data delivered to the base station in abundance as shown in Table (1.2), TBACCC is decrease the obstacles and increase the strength of the network and increase the tendency to prevent the congestion. In token bucket algorithm the packet dropped round time is up to appreciable level and packet loss rate is fewer as compare to the previous queue models. In TBASSCC and PASCCC after the completion of 100 round both techniques transmit the same number of packet to the base station. But after the 200 round the PASCCC technique transmit the less amount of packet to the base station as compare to TBACCC. In this token bucket algorithm the redundancy eliminates and rate of transfer data is increased due to fulfil condition of front end requirements due to specific transmission of packets the life time of sensors is enhanced. In TBACCC after the completion of 300 round of time this technique transmit the 8000 packet to base station up to 400 rounds, but PASCCC transmit only the 4600 packet up to 400 round, so TBACCC is more efficient and reliable in case of data transmitted to the base station than the PASCCC technique.

Table 1.3 PACKETS TRANSMITED TO BASE STATION

ROUNDS	PASCCC	TBACCC
50	1200	1200
100	2800	2800
150	4100	4600
200	4500	5800
250	4550	7100
300	4600	8000
350	4600	8000
400	4600	8000

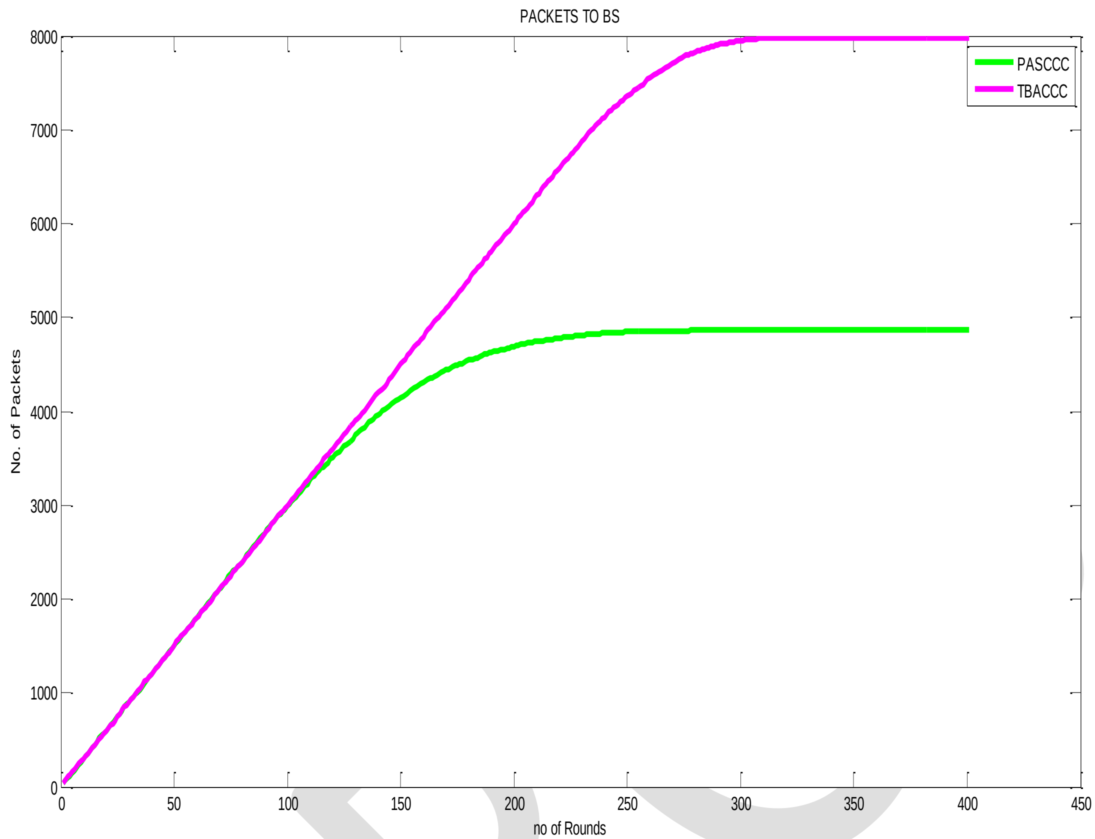

FIGURE 1.3 PACKETS TRANSMITED TO BASE STATION

1.7.2 NUMBER OF DEAD NODES

We have different scenarios to examine the nodes dead in the both existing techniques. To compare the energy efficiency of PASCCC and TBASCC, on the basis of number of packets delivered in the number of rounds. We can observe from the figure that dead nodes in both techniques have variant characteristics and observe that PASCCC'S more erergy consumable than TBASSC'S techniques. Up to some extent both techniques exhibit similar behaviour but after increasing the number of rounds the dead nodes of latest technique is much appreciable because at the 100 rounds the PASCCC techniques have 25 nodes dead while the latest technique TBASSC have 0 nodes dead. So TBASSC is more efficient and reliable than PASCCC technology. As well as the number of rounds are increases, existing technique PASCCC then the number of dead nodes are increases up to 250 rounds above that the latest technique its optimum level vanish the 260 dead nodes as compare to 300 dead nodes in the PASCCC technique.

Table 1.4 DEAD NODES

Rounds	PASCCC	TBACCC
50	0	0
70	0	0
100	25	0
150	127	0

200	245	2
250	280	80
300	300	260

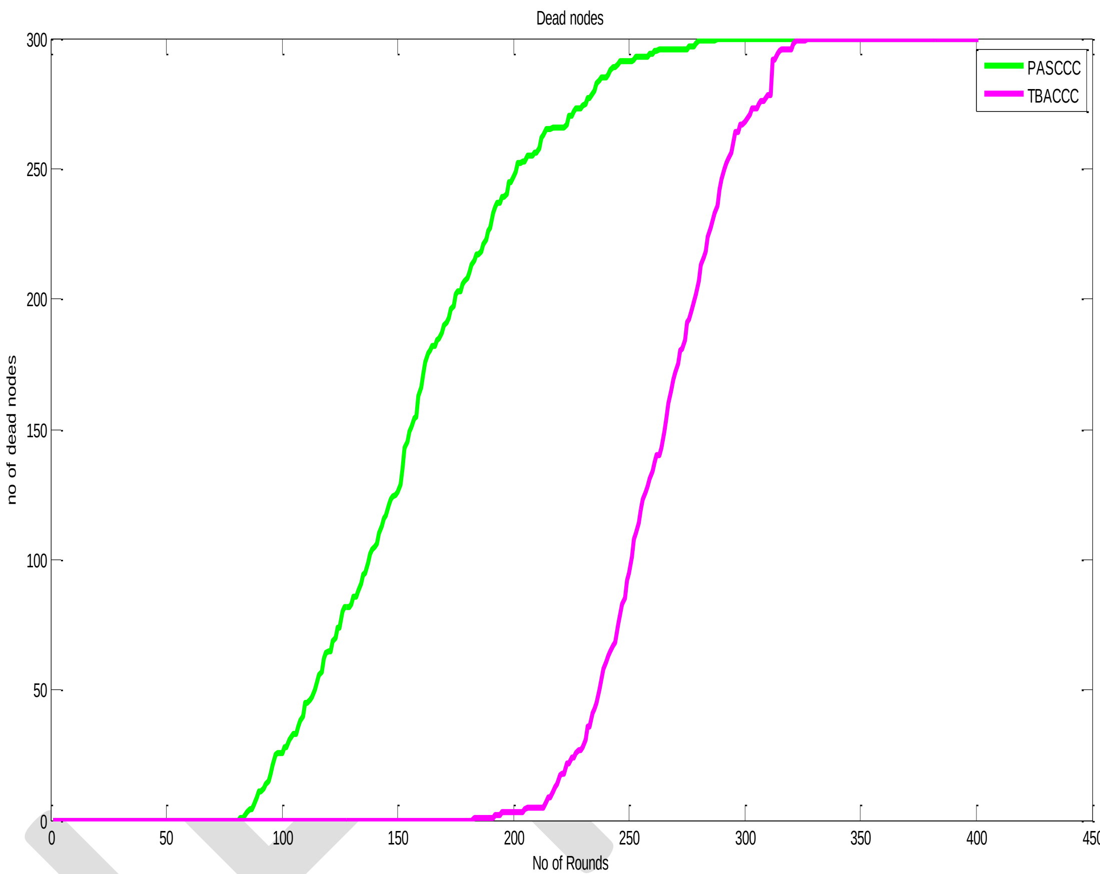

FIGURE 1.4 DEAD ZONES OF NODES

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1.8 CONCLUSION

In the application based WSNs situation, energy and bandwidth of the sensors are valued resources and essential to consume proficiently. Data aggregation at the base station by individual nodes causes flooding of the data which consequences in maximum energy consumption. To diminish this problem a new data aggregation technique has been proposed which uses inter-cluster data aggregation and token bucket based compression. It has improved the performance of packet sent to base station and nodes dead of the homogeneous and heterogeneous WSNs. The experimental results indicate that proposed approach TBASCCC significantly improves the lifetime, energy consumption and data delivery to the base station and less number of nodes dead after a few rounds. The token bucket algorithm has reduced the energy consumption problem and also aggregates and transmits the packet to the base station in efficient manner. In addition, the TBASCC technique has used the additive and divisible data aggregation function at cluster head (CH) as in-network processing to reduce nodes dead after a short round of period. The proposed algorithm has been designed and simulated in the MATLAB tool. Hence TBASSC is more efficient and reliable than PASCCC technology in terms of span of dead nodes and packet delivered to base station in specific rounds.

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