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ASAR: An ant-based service-aware routing algorithm for multimedia sensor networks

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Abstract Aimed at three basic services (event-driven, data query and stream query), the paper presents a QoS routing model for multimedia sensor networks. Moreover, based on the traditional ant-based algorithm, we propose an ant-based service-aware routing (ASAR) algorithm. The ASAR chooses suitable paths to meet diverse QoS requirements from different kinds of services, thus maximizing network utilization and improving network performance. Finally, extensive simulation is conducted to verify the effectiveness of our solution and we give a detailed discussion on the effects of different system parameters. Compared to the typical routing algorithm in sensor networks and the traditional ant-based algorithm, our ASAR algorithm has better convergence and significantly provides better QoS for multiple types of services in the multimedia sensor networks.

Keywords QoS routing, service-aware, ant-based algorithm, multimedia sensor networks

1 Introduction

Recent advances in micro-electro-mechanical systems (MEMS) technology, wireless communication, and digital electronics have made possible the development of low-cost, low-power, multifunctional sensor nodes. Wireless sensor networks, which can provide information regarding the physical phenomena of interest and enable us to construct more accurate models of the physical world, have attracted tremendous attention. Potential applications of wireless sensor networks span a wide spectrum from military to industrial, and from commercial to environmental monitoring [1,2].

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At present, lots of pioneering work have mainly focused on some important aspects of wireless sensor networks, such as architecture, protocol design, energy conservation, data management and location. However, supporting QoS in wireless sensor networks is left unaddressed, especially in the QoS-sensitive multimedia sensor networks [3]. In particular, for the multimedia applications, QoS differs in different applications. Therefore, providing QoS services while maximizing network utilization emerges as a hot issue.

In general, there exist two kinds of basic service modes: event-driven mode and query-driven mode.

1) Event-driven service mode: It contains only one type of service, event-driven service (R service). Most event-driven applications in multimedia sensor networks are delay intolerant and error intolerant applications. For an application, monitoring results obtained from nodes are critical. In this service mode, multimedia sensor nodes pre-process (e.g. compression, identification and match) the raw environmental data, filter out and transmit valuable semantic data to sink node. Take the surveillance system for the elder or patients as an example, when audio nodes detect a groan or video nodes detect an act of tumbling, nodes will send an alarm message of tiny data amounts to arouse the surveillant's attention [4]. Thus, it can be seen that event-driven service should meet the requirements of strong real time and high reliability.

2) Query-driven service mode: It contains two types of services: data query service and stream query service.

Data query service (D service): Most D service aims at the error intolerant but query-specific delay tolerant applications. For example, when users query the parking information in a garage, video nodes need to transmit semantic result data instead of a video stream. Compared with event-driven service, D service still needs to receive desired data as reliable as possible. However, D service tolerates query-specific delay.

Stream query service (S service): Most S services aim at the delay intolerant but query-specific error tolerant applications. For instance, when users query real-time audio/video data within a time period, real-time audio/video data are

delay-constrained with a certain bandwidth requirement. Packet losses can be tolerated to a certain extent.

Considering that multimedia sensor networks are data-centric and application-related, one of the highlighted issues in multimedia sensor networks is how to react to service changes rapidly, satisfy different requirements of multimedia applications efficiently, and provide corresponding quality of service. Aimed at the three types of services, we research the routing selection for different types of data packets with the four QoS parameters such as latency, packet loss, energy consumption and bandwidth. A path with little traffic and high signal-to-noise ratios is attractive for R service. A path with significant congestion and a high signal-to-noise ratio on each link may be used for D service. Naturally, a path with less traffic and lower signal-to-noise ratio may be better for S service.

Considering the characteristics of the three types of services provided by the multimedia sensor networks and the effect from different types of QoS-constrained data, we first introduce the ant-based algorithm [5] into multimedia sensor networks in search of the service-aware optimal path, and to propose a novel ant-based service-aware routing algorithm (ASAR). Each cluster head generates the ants for each type of service (R/D/S service) respectively. Also, we design the corresponding objective function for each type of service. In this way, we can find out different paths from each cluster head to sink to meet the QoS requirements of the three types of services. Moreover, we quantify the pheromone value on the sink to decrease the sending frequency of reverse ants, thus quickening the convergence of the algorithm. Finally, extensive simulation is conducted to verify the effectiveness of our solution and detailed discussion on the effects of different system parameters is given.

Apart from that, the rest of this paper is organized as follows. In Sect. 2, we introduce relative works. Section 3 describes the QoS routing model for the multimedia sensor networks. Following that, in Sect. 4 we improve the traditional ant-based algorithm and propose a novel ant-based service-aware routing algorithm (ASAR). Furthermore, extensive simulations are conducted in Sect.5. Finally, Sect. 6 concludes the paper.

2 Related works

2.1 QoS routing in wireless sensor networks

SAR [6] is the first active QoS protocol proposed in wireless sensor networks (WSNs). This protocol can efficiently provide QoS. However, it has two significant disadvantages: redundant routing information on each node consumes limited storage resource and the cost of information updating is high. The authors of Ref. [7] presented an energy-aware QoS routing protocol for

multimedia sensor networks. The author introduced the concept of differentiated service into WSNs and adopted different scheduling algorithms for two types of streams according to respective QoS requirements. While for simplicity, the delay intolerant and error intolerant traffic were not taken into account in this paper. The authors of Ref. [8] proposed a new QoS routing protocol (QSR). Inspired by the work of Ref. [8], this protocol employed an ant colony algorithm to search for the optimal paths. Aimed at three types of services provided by multimedia sensor networks, we propose a novel service-aware, multi-path routing selection scheme.

2.2 Ant-based routing algorithm

The ant-based algorithm is a new optimization method proposed by M. Dorigo in 1992 [9], of which the basic idea comes from the social search behavior of biological ant colonies. In nature, ants move around in a rather random way, but they have a certain tendency to follow the walk of other ants. They can recognize these walks because, while moving, each ant leaves a chemical substance called pheromone on the path. Sensing pheromone on a path increases the probability of an ant to follow it, which further reinforces the pheromone on this path. In this sense, short paths between a starting point and a goal point are favored in this mechanism, leading to a kind of heuristic optimization behavior. This algorithm is independent of the detail of issue, and has a strong ability of global optimization. Meanwhile, compared with the early evolutionary algorithms such as genetic algorithm [10] and simulated annealing algorithm [11], the ant-based algorithm possesses more reliability and faster convergence. The authors of Ref. [12] presented an ant-based distributed route algorithm for Ad-hoc networks (ADRA). ADRA can provide more redundant loop-free routes, reduce the overhead and delay of route reselection, and decrease the control overhead of forward ants by discarding them at the congested nodes. Authors of Ref. [13] presented a protocol for WSNs routing operations, which, based on ant-based optimal routing algorithm, provided an effective multi-path data transmission to obtain reliable communication in the case of node faults. In this paper, we mainly address routing selection for three typical services in multimedia sensor networks. To our best knowledge, this is the first time that a routing selection scheme aimed at three typical services has been adopted in multimedia sensor networks.

3 QoS routing model for multimedia sensor networks

In view of its simplicity, flexibility and robustness, cluster-based network architectures have been widely

used in WSNs, particularly for data-centric and location-centric paradigm. Therefore, multimedia sensor networks hereinafter are designed based on the cluster-based architecture. The basic node in the cluster is responsible for collecting and simple-processing multimedia data. The cluster head fuses these multimedia data, then transfers the data result upstream. The sink node manages the status of cluster heads and broadcasts signals in multimedia sensor networks. The cluster head connects the sink node via multi-hop wireless links. Therefore, in the paper, we mainly address the routing scheme between the cluster head and sink node.

A multimedia sensor network can be presented as a undirected weighted graph $G, G = (V, E)$, where $V = \{v_1, v_2, \dots, v_n\}$ is a finite set of nodes (including cluster heads and sink node) in the network and $E = \{e_1, e_2, \dots, e_k\}$ is the set of link. For a pair of nodes $v_i, v_j \in V (i \neq j)$, the link $e = (v_i, v_j)$ and $e \in E$, then v_i, v_j is a pair of adjacent nodes. Considering the case of node faults, the node set V and the link set E should be dynamic. If $v_s \in V$ and v_s is sink node, then $v_o \in V - \{v_s\}$ may be the corresponding source nodes. Each node $e_{ij} \in E$ includes four metric elements $\{b_i, d_i, p_i, c_i\}$, where b_i denotes available bandwidth, d_i is queuing delay, p_i is packet loss rate and c_i denotes the energy consumption when v_i sends data to v_j .

Due to different features of three types of services (event-driven service, data query service and stream query service) and their unexpected properties, for each link $e \in E$, the parameters b, d, p and c may be variable. Assume that 1) each node can find its neighboring nodes; 2) the node can know the current status of its neighboring links. For a unicast path $l = (e_1, e_2, \dots, e_m)$ from some cluster head to sink node, its QoS parameters $d(l)$ and $c(l)$ are additive parameters, $b(l)$ is a maximal and minimal parameter, $p(l)$ is a multiplicative parameter. All these parameters are computable.

$$d(l) = \sum_{i=1}^m d(e_i), p(l) = 1 - \prod_{i=1}^m (1 - p(e_i)),$$

$$b(l) = \min_{i=1}^m b(e_i), c(l) = \sum_{i=1}^m c(e_i).$$

In multimedia sensor networks, the cluster head may transfer three kinds of data, that is, abnormal result data (R_Data), query-based data (D_Data) and query-based audio/video stream (S_Data). The issue of routing selection from cluster head to sink involves finding out three service-aware accessible paths to meet different QoS requirements, thus minimizing the interference among the three types of services, balancing the traffic distribution and improving network performance.

Let v_o denote the cluster head and v_s denote the sink node. The issue of routing selection from v_o to v_s is finding out three different accessible paths l_h , where $h \in \{R, D, S\}$, to express the above three types of data. The

objective function of path l_h can be expressed as follows:

$$f(l_h) = \gamma_h^b(b(l_h)) + \gamma_h^d(d_{\max} - d(l_h)) + \gamma_h^p(1 - p(l_h)) + \gamma_h^c(c_{\max} - c(l_h)), \quad (1)$$

where variable d, p, b and c respectively denote delay, packet loss rate, bandwidth and energy consumption required by the corresponding type of traffic. d_{\max}, c_{\max} are the maximal tolerable delay and the maximal tolerable energy consumption. $\gamma_h^d, \gamma_h^p, \gamma_h^b, \gamma_h^c$, are the weight factors of delay, packet loss rate, bandwidth and energy consumption for global QoS parameters respectively. The values of γ_r^b and γ_d^b can be set small, because R-Data and D-Data are insensitive to bandwidth resource.

4 Service-aware routing algorithm based on ant-colony

4.1 ASAR algorithm description

Many algorithms inspired by the foraging behavior of ant colonies have been applied to the solution of difficult discrete optimization problems. A generic routing problem in communication networks is one of them. In the ant-based approach, each ant randomly chooses a successor node of the node currently located. The probabilities for the successor nodes are computed from ‘‘pheromone values’’ assigned to the path. The ‘‘promising’’ paths are then reinforced by pheromone increments. The probabilistic rule $(P_{ij}^h(t))_k$ determines the probability of moving from v_i to v_j for the service h at time t , as expressed in Eq. (2).

$$(P_{ij}^h(t))_k = \begin{cases} \frac{(\tau_{ij}^h(t))^\alpha (\eta_{ij}^h(t))^\beta}{\sum_{v_s \notin V_{\text{pass}}} (\tau_{is}^h(t))^\alpha (\eta_{is}^h(t))^\beta}, & v_j \notin V_{\text{pass}} \\ 0, & v_j \in V_{\text{pass}} \end{cases}, \quad (2)$$

where V_{pass} is a set of nodes that ant k has passed. $\tau_{ij}^h(t)$ is the value of pheromone from v_i to v_j for the service h at the time t , $\eta_{ij}^h(t)$ is called visibility value that is used for heuristic evaluation for the service h . α, β are parameters that control the relative weight of the pheromone trail and heuristic value.

The ant k moves from source cluster head to sink node during the period Δt , the path that the ant k passed is denoted as l . We adopt ant-cycle based on global status information to update the pheromone value. In multimedia sensor networks, a great amount of nodes and complex network topology cause us to hardly obtain global status information at any moment. Therefore, we need to build heuristic value based on local status

information. In this way, the probability function reflects both global and local status information of the network, and we can optimize global and local information by adjusting parameter α , β . Once the sink node cannot obtain global information immediately due to some unexpected reasons, we can increase the heuristic value and select routing according to more local information. The pheromone value updating rule on the path l is

$$\tau_{ij}^h(t + \Delta t) = \rho \tau_{ij}^h(t) + \Delta \tau_{ij}^h(t, t + \Delta t), \quad (3)$$

$$\begin{cases} \Delta \tau_{ij}^h(t, t + \Delta t) = \sum_{k \in A} \Delta(\tau_{ij}^h)_k(t, t + \Delta t) \\ 0, & k \text{ has not passed this path} \end{cases} \quad (4)$$

In Eqs. (3) and (4), set A denotes ants that have been sent, $\Delta \tau_{ij}^h(t, t + \Delta t)$ denotes the pheromone h increments on the link (v_i, v_j) during the searching cycle launched at discrete time t . The pheromone values for three kinds of services on each link of each path should be updated, in order to direct the cluster head to set up the corresponding routing tables for three kinds of services. When a cluster head transmits some type of data, it will choose a QoS path that is suitable for this traffic. $\rho \in (0, 1)$ is ‘‘evaporation factor’’ which controls the degree of emphasis on the given pheromone information. $\Delta(\tau_{ij}^h)_k(t, t + \Delta t)$ depicts the total quantity of the pheromone h released on the link (v_i, v_j) by the ant k during the time period $(t, t + \Delta t)$, as expressed in Eq. (5):

$$\begin{aligned} \Delta(\tau_{ij}^h)_k(t, t + \Delta t) = & \gamma_h^b(b(l_h)) + \gamma_h^p(1 - p(l_h))^{\frac{1}{|l_h|}} \\ & + \frac{\gamma_h^d(d_{\max} - d(l_h)) + \gamma_h^c(c_{\max} - c(l_h))}{|l_h|}. \end{aligned} \quad (5)$$

We construct the heuristic value $\eta_{ij}^h(t)$ to reflect local information as

$$\begin{aligned} \eta_{ij}^h(t) = & \gamma_h^b(b_{ij}^h) + \gamma_h^p(1 - p_{ij}^h) \\ & + \gamma_h^d(d_{\max} - d_{ij}^h) + \gamma_h^c(c_{\max} - c_{ij}^h). \end{aligned} \quad (6)$$

In the multimedia sensor networks, the amount of multimedia data upstream is vast and the QoS requirement is urgent. So, we should limit the transmission for control messages downstream in network. Meanwhile, we should accelerate the convergence of the ant-based algorithm and reduce the computation complexity. Based on the above consideration, we adopt the method of pheromone quantization. The maximal pheromone τ_{\max}^h for each type of traffic is a key parameter to affect our algorithm performance. First, we quantify $[0, \tau_{\max}^h]$ into M_h quantization levels, depicted as $[\tau_1^h, \tau_2^h, \dots, \tau_{M_h-1}^h,$

$\tau_{\max}^h]$. If the pheromone values belong to some interval $[\tau_q^h, \tau_{q+1}^h]$ ($q = 1, 2, \dots, M_h - 1$) according to Eq. (7):

$$\tau_{ij}^h(t + \Delta t) = \frac{\tau_q^h + \tau_{q+1}^h}{2}, \quad (7)$$

then we quantify the pheromone value with a finite quantization level by uniform quantization method. In this way, we can not only quicken the convergence of the algorithm, but also optimize network resource. This is because, once two different pheromone values belong to the same quantization interval, their quantified pheromone values become the same. Therefore, we need not send reverse ants to update the pheromone value and the transition probability on the path, which consequently decreases the amount of control messages downstream.

4.2 ASAR algorithm process

The ant-based algorithm is often used for optimization for routing and load-balancing in telecommunications and networking. Considering the three types of services in multimedia sensor networks and their diverse QoS requirements, we propose a novel ant-based service-aware routing algorithm. The ASAR algorithm periodically selects three paths for three types of services. Event-driven service is delay intolerant and error intolerant. However, this service requires less bandwidth, so a route with little traffic and a high signal-to-noise ratio is attractive for R service. For data query service, it is error intolerant but query-specific delay tolerant, so a path that has significant congestion and a high signal-to-noise ratio on each link may be used for D service. For stream query service, it is delay intolerant but query-specific error tolerant, so a path with less traffic and lower signal-to-noise ratio may be better for S service. All these three services focus on the energy consumption parameter, and maximize the use of network resource by decreasing the probability that a few nodes work for a long time. Furthermore, three paths can effectively avoid link congestion when multiple kinds of service data reach a node at the same time, thus improving network service quality.

The ASAR algorithm is run on all the cluster heads in multimedia sensor networks. It searches for three available QoS paths for different services by the positive feedback mechanism used in ant-based algorithms. The current optimal solutions for three different QoS paths are stored on cluster heads respectively.

Definition 1 Optimal path table (OPTable) $_h$, each cluster head maintains three optimal path tables for the three kinds of services, and update them till the convergence of each iteration.

Definition 2 Pheromone routing table (PRtable) $_h$, each cluster head maintains three pheromone tables for

the three kinds of services, and also maintains the real-time pheromone value and transition probability for its next hop.

The ASAR algorithm is described as follows:

Step 1 Initialization: $\tau_{ij}^h = \tau_1^h$, $\Delta\tau_{ij}^h = \tau_1^h$, PRtable = NULL, OTable = NULL; sink node quantifies $[0, \tau_{\max}^h]$ into M_h quantization levels. We averagely position $3m$ ants onto m cluster heads, that is, there are 3 ants on each cluster head, and the three ants are used to search for the best paths for three kinds of services.

Step 2 Each ant k ($k=0, 1, \dots, 3m$) chooses a successor node of the node where it is currently located according to the probability $(p_{ij}^h(t))_k$, which can be computed by Eq. (2).

Step 3 When all the ants arrive at the sink node, the sink node will calculate the average pheromone increments $\Delta\tau_{ij}$ for each link on the $3m$ paths according to Eqs. (4) and (5) and the current pheromone value τ_{ij} for each link on the $3m$ paths according to Eq. (3).

Step 4 Compare and judge which quantization interval each pheromone value should belong to, and quantify the current pheromone value by Eq. (7).

Step 5 Find the number of paths (on which the current pheromone value is changed) n ($n \leq 3m$). Send n reverse ants to the corresponding cluster head, modify the pheromone value on each link (i, j) and the intensity of the pheromone trail according to the paths which each ant passed through, thus to update the corresponding OTable and PRtable for each kind of service on the cluster head.

Step 6 For each link (i, j) , set $\Delta\tau_{ij}^h = 0$ and $N_c = N_c + 1$.

Step 7 If N_c is less than the iteration number pre-set and this cycle iteration is not convergent, then go to Step 2; else go to Step 8.

Step 8 Update the corresponding OTable for each kind of service on the cluster head, the process of path searching is over. When next loop begins, go to Step 1.

5 Experimental results and performance analysis

We evaluate our algorithm in a number of simulation tests. In detail, we compare its performance with traditional ant-based algorithm and a classic directional diffusion routing algorithm (DD) in WSNs. In Sect. 5.1, we describe the simulation environment and the test scenarios. In Sect. 5.2, we show the efficiency and the effectiveness of ASAR for supporting differentiated service in multimedia sensor networks via simulation studies compared with DD algorithm. Also, simulation results in Sect. 5.3 show that the ASAR algorithm has an advantage over the traditional ant-based one, as far as the convergence speed is concerned.

5.1 Simulation environment

The simulation software we used is NS2. All our simulation scenarios are derived from a base scenario. In this base scenario, 20 nodes are randomly placed in an area of 500×500 m². Figure 1 illustrates the network topology and Table 1 summarizes the parameters.

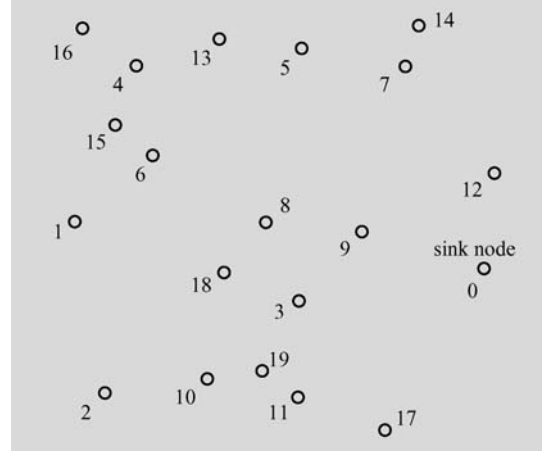


Fig. 1 Screenshot of network topology generated by NS2

Table 1 Main configuration parameters of node

name of parameters	value of parameters
link layer	LI
MAC layer	IEEE 802.11
radio propagation	two ray ground
interface queue	PriQueue
transmission range	200 m
antenna	omni-antenna

Based on this topology, we generate 20 constant bit rate (CBR) sources via sending one 512-byte packet per second. Each source starts sending at a random time between 0 and 150 seconds after the start of the simulation, and keeps sending till the end. The queuing delay, received packets rate and dropped packets rate of each packet are respectively shown in Figs. 2 (a)–(b).

We adopt the Free-Space model as the communication model of each node, so the transmitting energy consumption of the node is proportional to the square of the communicating distance. Here, we denote the transmitting energy consumption between two nodes with the square of the communicating distance.

5.2 Comparison with Dijkstra & DD

For three types of services, we compare ASAR with Dijkstra and DD through a set of simulation tests, and discuss how these algorithms affect QoS.

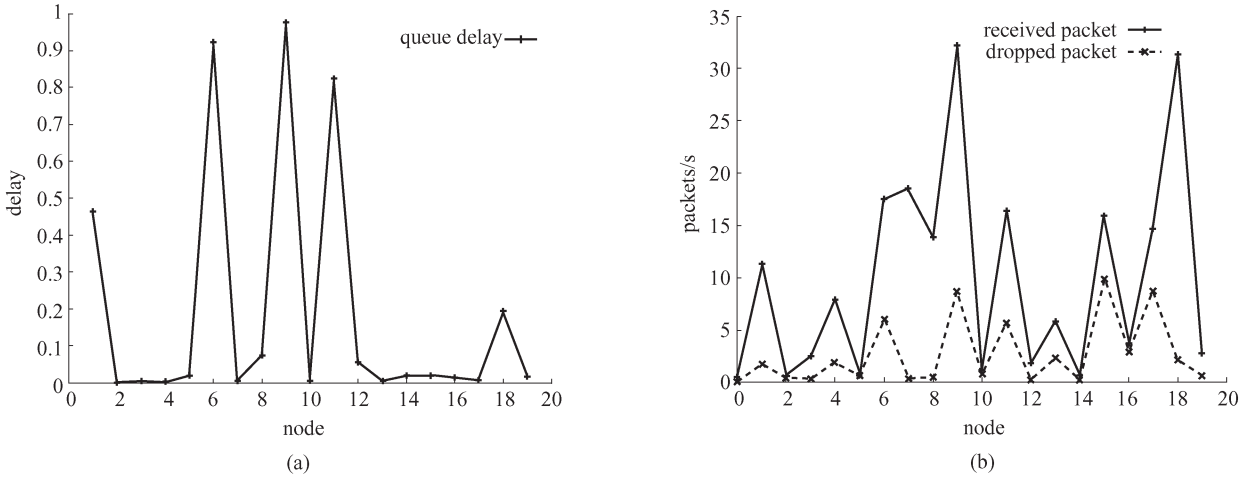


Fig. 2 (a) Queuing delay in every node; (b) received packet rate & dropped packet rate in every node

In the simulation, we assume that the sink node is the No. 0 node, and the source node is the No. 1 node. When we evaluate the path from the No. 1 node to the No. 0 node using Dijkstra algorithm, the weighted value for the path can be decided by the distance between two nodes. For DD algorithm, we reinforce the path according to four parameters (e.g., delay, packet loss rate, occupied bandwidth, and energy consumption). For the ASAR algorithm, we set the weighted values as listed in Table 2. After running, each algorithm finds a corresponding path, as shown in Table 3.

Table 2 Weight setting

	α	β	r^b	r^d	r^p	r^E
S	1	1.5	5	2	1	2
R			1	4	4	1
D			1	1	7	1

Table 3 Path information

routing algorithm	route from node 1 to node 0	
Dijkstra	1-18-9-0	
DD	1-4-13-5-7-12-0	
ASAR	S	1-15-13-5-14-12-0
	R	1-4-5-14-7-12-0
	D	1-4-5-7-12-0

We obtain some important QoS parameters (delay, energy consumption, packet loss rate and bandwidth) on the path for three algorithms, as described in Figs. 3(a)–(d). The corresponding values of QoS can be obtained by replacing the corresponding variables in objective function with the four QoS parameters. From Fig. 3(a), we find that event-driven service is concerned with delay, and delay for event-driven service reaches its minimum for ASAR. Compared with the other two kinds of services, delay is significantly lower for ASAR than for

Dijkstra while a bit higher than for DD. In Fig. 3(b), energy consumption is far less for Dijkstra than for others due to our assumption that energy consumption is proportional to the distance between nodes. Figure 3(c) shows that packet loss rate for stream query service is higher for ASAR than for others. Moreover, packet loss rate for data query service and event-driven service maintains the lowest for ASAR among the three algorithms. This is because the stream query service is error tolerant while it is the opposite for other services. From Fig. 3(d), we can see that the bandwidth for stream query service is the highest. It is obvious that this type of service demands vast bandwidth resources.

From Fig. 3(e), we conclude that for stream query service, ASAR has a significant advantage over the others. As for event-driven service, ASAR is superior to Dijkstra but is inferior to DD; while for data query service, no distinction is made among these three algorithms.

5.3 Comparison with the traditional ant-based algorithm

Taking the stream query service as an example, we discuss how pheromone quantization accelerates the convergence of the algorithm. We carry out two groups of experiments on calculating the values of the objective function for the path ants found in each iteration. The result after 150 iterations is illustrated in Fig. 4. Figure 4 (a) shows the case of no quantization, while Fig. 4 (b) shows the reversed case ($\tau_{\max}^h = 800$, quantization level = 200). We can easily see that our algorithm with quantization is significantly superior to the one without quantization, and it quickly converges to the value of the objective function.

In the initial process of iteration, the difference among the “promising” path selected by multiple ants is great, this will cause the pheromone increments on some paths

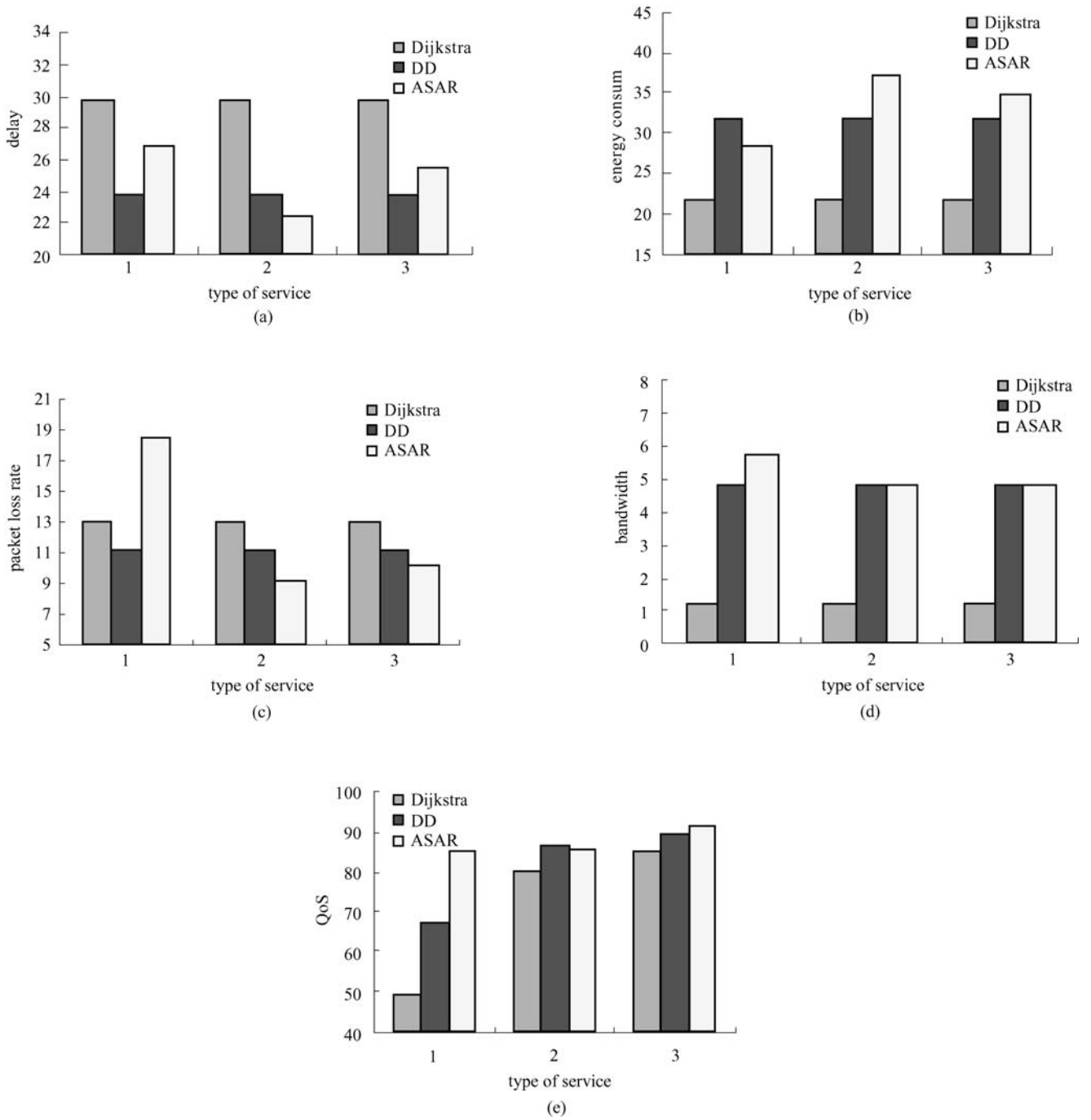


Fig. 3 Performance comparison. (a) Delay; (b) energy consumption; (c) packet loss rate; (d) bandwidth; (e) QoS
 Note: The X-axis denotes three types of services (1: stream query service; 2: event-driven service; 3: data query service), and the Y-axis denotes the normalized value of QoS parameter

to be very small. Even though these pheromone values are quantified, their corresponding quantization levels need not to be modified at all. In this case, we will not send reverse ants to modify the pheromone values on these paths. Therefore, pheromone quantization not only helps improve the convergence of the algorithm, but also reduces network traffic in the process of iteration.

From Fig. 5 we find that in the first 40 iterations, the situation where quantization level need not be modified occurs 9 times. Compared to the scheme without quantization, the one with quantization obviously saves energy by canceling the spread of some reverse ants. Here we roughly measure energy conservation with the hop number of reverse ants.

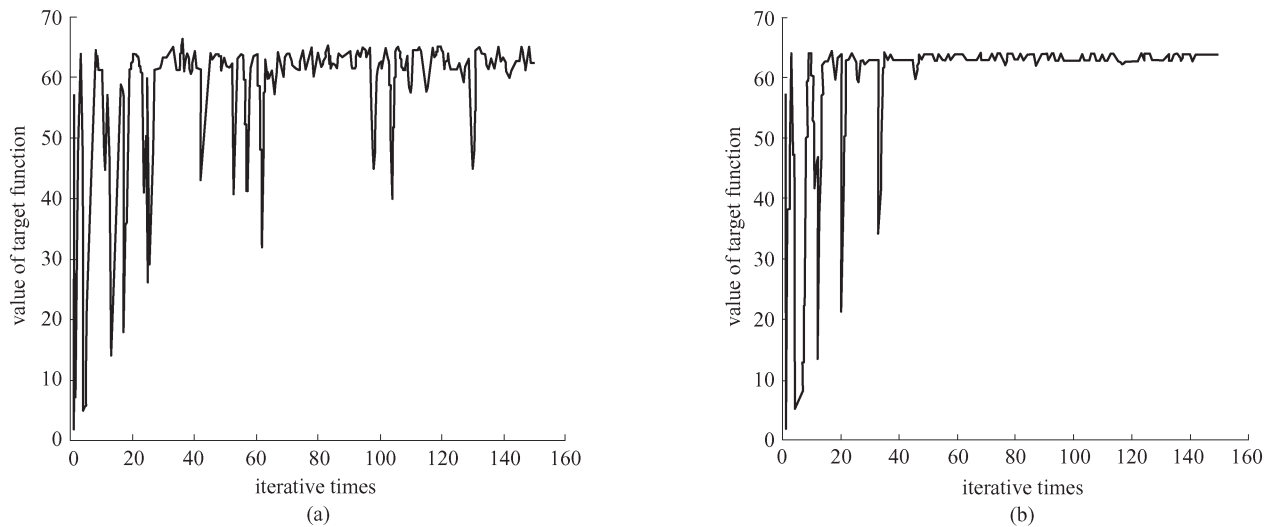


Fig. 4 Iteration process. (a) Traditional ant-based algorithm; (b) ASAR algorithm

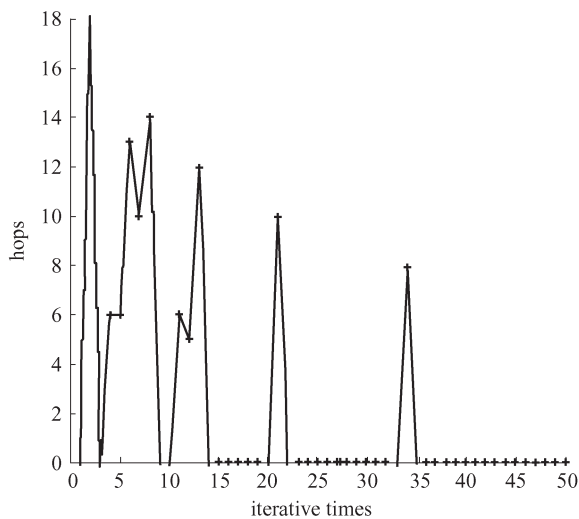


Fig. 5 Hops number of reverse ants for ASAR algorithm

6 Conclusions

As an advanced form of sensor network, multimedia sensor networks have been widely applied in many fields. Different characteristics of multimedia sensor networks demand efficient methods of providing flexible QoS requirements. Motivated by this, the paper proposes a QoS routing model for multimedia sensor networks. By differentiating three types of typical services (e.g., event-driven service, data query service, stream query service), we satisfy diverse QoS requirements of all these services. Moreover, we improve the traditional ant-based algorithm to quicken the convergence of our algorithm. In particular, we propose a novel ant-based service-aware routing algorithm (ASAR). Aimed at three kinds of typical services in the multimedia sensor networks, the

ASAR algorithm can select the optimal paths to meet their individual QoS requirements, thus improving network performance. Finally, the ASAR algorithm is proved to be effective through our experimental results.

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