

# Towards an Efficient Content-Based Dissemination Protocol and Notification Techniques for Disconnected MANETs

Hassana Maigary Georges and Wang Dong

**Abstract**—Opportunistic Networking is a kind of communication in which hosts that compose the network must store, carry and forward a message and must keep as much messages as possible to increase the chance of sharing them to other hosts. In this kind of network, nodes update continuously their cache according to their mobility and interest. Thus deleting a message in a cache when its deadline is reached reduces the possibility of carrying and sending it to other hosts. According to some realistic scenarios, a host may be interested in content that has just been discarded from a cache. Moreover, cache management in the same area of communication is important for it increases the delivery rate of a message or document. The actual paper presents a protocol that supports communication in sparse and disconnected Network and addresses the problems mentioned above by designing a content notification scheme and a forwarding decision algorithm based on the expiring time of message in disconnected Mobile ad hoc network scenario. Experiments and simulations show that these two approaches of data dissemination we propose improve the content delivery rate and enable fast dissemination of messages

**Index Terms**—Cache management, documents dissemination expiring time, notification service.

## I. INTRODUCTION

Nowadays, the popularity of mobile computing and communication devices such as cell phones, laptops and digital devices such as personal digital assistants (PDA) is increasingly growing. Wireless Technologies through which those devices are connected allow them to form networks or group based on some specific interest or characteristics and this connection is made thanks to a communication mode called ad hoc. The mobile ad hoc networks have thus been much researched over the last decade. Most of the researches aimed to overcome eventual problems related to lack of connectivity between mobile communications devices. These works that aimed to solve the problem of intermittent connectivity have led to the concepts of Delay-tolerant networking and opportunistic networking. Currently, most of the connections among wireless devices are achieved through fixed infrastructure service providers or private networks. Recently most of application services don't need to connect to a fixed service provider to communicate but directly to a mobile device which is by the neighborhood consequently the network topology might change anytime since they are moving every time. The principle of opportunistic

networking, disruption and delay-tolerant have been developed to solve the problem of communication between devices that belong to a sparse topology. Content-based Communication is a new kind of communication that feats also the principles of delay-tolerant and opportunistic networking to allow devices to communicate without a fixed infrastructure. Content-based Communication as a particular application of these principles was the subject of several researches with the aim to create communication support in a disconnected and sparse network.

In this paper, we examine the problem of fast dissemination of documents in content-based communication in disconnected Mobile Ad hoc Network (MANET) emphasizing on the Opportunistic aspect; to achieve our goals which are to build a strong and reliable function for fast document dissemination, we designed a new forwarding decision system based on content cache notification service and integrated it in the second layer of the middleware DoDWAN (Document Dissemination in Wireless Ad hoc Network) [1] and we designed also a new cache management system in order to enable fast documents dissemination within the network. We also plan to give some solutions to the problems encountered while providing enlightenment on the nodes traffic issues.

## II. RELATED WORKS

Content-based communication has become one of the most attractive researches in wireless communication area. It has been combined recently with opportunistic networking and delay tolerant networking to overcome the problem of communication discovered in sparsely and intermittently connected network [1]. Thus, a protocol for content-based communication has been designed in order to support communication between devices in disconnected MANETs. This protocol leverages the dissemination approach of Multipoint Relay developed according to OLSR protocol. The protocol helps to choose the best device that relays the message to a node or another part of the network. It feats the concepts of opportunistic networking and delay-tolerant networking to solve the problem of the absence of end-to-end connectivity in disconnected MANETs. The protocol has been embedded within the middleware DoDWAN. Providing services oriented applications is still a challenge in delay tolerant and opportunistic networking, in [1], a solution is provided by implementing on the top of the protocol described in [2] a service discovery and invocation to allows communication between nodes in the network. The problem of fast dissemination still remains in content-based communication. In [3] a selective protocol has been designed

Manuscript received August 15, 2012; revised October 12, 2012.

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in order to limit the saturation of each host's cache and to limit the copy of message in the network. Thus, the scope is to build an efficient message dissemination system based on a selection of document that stipulates each host should request and receive from the neighborhood only document that it is interest in. But the cache management policy is ignored here because the authors supposed that each host should fix itself a cache policy. Another approach to improve fast dissemination has been described in [4]. It shows how content classification can affect the delivery rate. A new data dissemination method, which classifies the forwarding messages by their content, every node only requests the message that it is interested in and the message/document that is requested the least is simply deleted from the cache. This approach is much more interesting but it focuses only in delay tolerant principle not in opportunistic networking. Since the communication is interest-oriented, we think that the message reinjection policy based on document expiring time could appear as an appropriate solution in order to determine whether there exist documents that are going to be deleted and some of them could interest new comers (hosts) within the network. In [5] an approach based on time awareness has been developed in order to facilitate content dissemination. A concept of temporal utility has been introduced for intelligent buffer management and for content routing. Temporal profiles are associated to each subscription and allow the construction of temporal profiles of infostations. This approach is similar with one of our idea which is to set a decision function based on expiring time awareness of each message contained within a local cache in order to avoid a copy of the same message/document that has been deleted recently, for the main purpose in opportunistic networking and content based communication is to have as many carriers as possible within the network. [6], [7]. In the following lines, we describe properly the platform of our work which use the concept of content based communication in disconnected MANETs and opportunistic networking, delay tolerant networking and we explain our new ideas to solve the problem of data dissemination.

### III. SYSTEM MODEL

#### A. Periodical Announce of Catalog

In disconnected network, more precisely opportunistic network, every node sends periodically the announcement of its catalog to inform the neighborhood about the document contained in its cache. Each catalog is composed of descriptors of document. Whenever hosts within an island of the disconnected part needs a document it will send a request to get the document that is missed in its cache. The communication is thus based on interest profile.

#### B. Expiring Time, Documents Deletion and Cache Management

Every document has a certain deadline/expiring time in a host's cache; the system is thus configured such that if a document has reached its deadline, it is simply discarded from the cache. This approach seems to be a disadvantage in

opportunistic networking since each host should or must keep in its cache as many documents as possible in order to satisfy an eventual new host(s) that joins the network [7], [8]. This problem led us to the design of an approach where hosts give notifications about the content that they are going to discard in order to meet a request coming from new nodes. We will then present in the following lines our new scheme of notifying the nodes about the cache updating.

#### C. Forwarding Decision

In opportunistic and delay tolerant networking, keeping a document or message for a long time does not allow a fast dissemination, for example if a node receives all the documents it has requested after a long period of waiting, that means either the document is lost or the time of forwarding it nodes by nodes is too long. We design in this paper a forwarding scheme based on periodical announces that improves the delivery rate of documents.

### IV. NOTIFICATION SERVICE AND FORWARDING DECISION SCHEME

#### A. Notification Service

As mentioned above, if a document has reached its deadline, the nodes in the neighborhood will inform the neighbors according to the condition predefined in section in order to know their interest. To achieve this, we plan to implement a service notification that allows nodes to broadcast the descriptors of the concerned documents with a low expiring time. If there is no request related to the notification (interest profile that matches the Document listed), every group of interest will simply apply the cache management which consist of pushing on the top of the stack the documents that are going to be discarded. For this, we apply the LIFO method that fits the previous scenario.

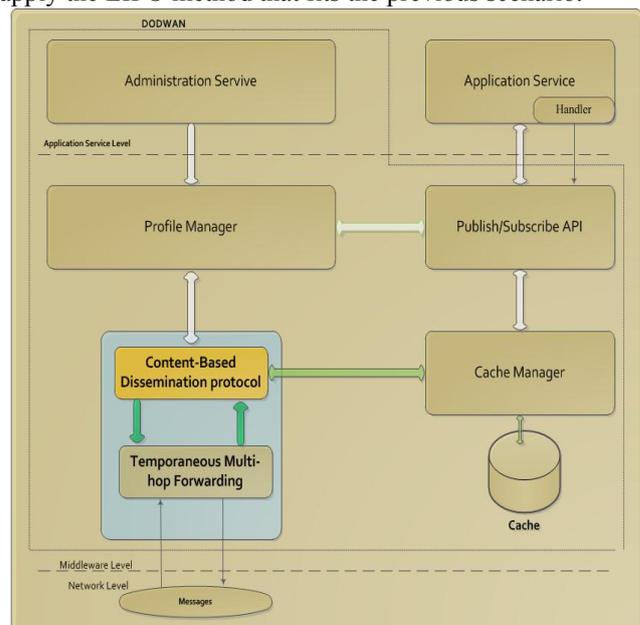


Fig. 1. Architecture of the communication platform

#### B. Forwarding Decision Scheme

In this part, we describe deeply the forwarding decision scheme that aims to speed up and enhance the performance of document Dissemination, we modify and update the

algorithm described in the Appendix by using the following scheme: Let  $E_t$  the expiring time of a document in a cache and  $A_t$  the arrival time of a node within one island of nodes,  $P_a$  Period of announce,  $t_{i-1} < t_i < t_{i+1}$ ; if  $t_i - t_{i-1} \leq E_t$  (time of two consecutive periodical announces of a catalog) and the Expiring time  $E_t \approx P_a$  then Broadcast the document to the fresh nodes arrived within the network using a short announce or simply forward the document to the neighborhood. We suppose that the arrival time is fixed at a certain threshold depending on the mobility defined. This approach allows a document to stay continuously in the network hence fulfilling the goal of increasing carriers in opportunistic networking. Our forwarding of a document is thus based on the above scheme. A node decides to forward a document if its expiring time is lower than a certain value, allowing to others nodes to carry it until a new node makes a request about it.

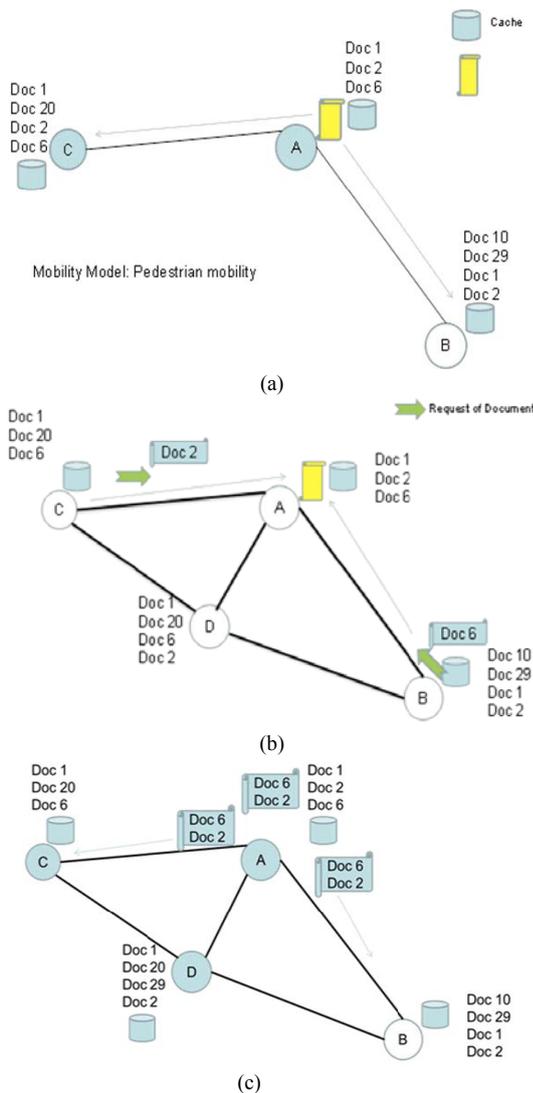


Fig. 2. (a) Periodical Broadcasts and announce of catalog and interest profile; (b) B and C request for documents which miss in their respective cache; B, C and even the new node receive the Documents requested by B and C

## V. SIMULATION AND RESULTS

### A. Motivating Scenario

To provide solution to the problems listed above, we

consider a scenario where nodes are grouped by two categories of interests. A node can move to another part of the disconnected network according to its interest. We suppose that there are always at least two new nodes joining each island of the network since the communication is interest-based. Nodes exchange documents based on their interest profile. We set the LIFO (Last In First Out) cache policy to each kind of group-based interest in order to evaluate the influence of cache management. Every node can request a certain number of documents to its neighbors. We suppose that each document has an expiring time (Deadline) and we set the arrival of a node within the network according to some specific mobility models listed in the next section. We use three different mobility models in order to evaluate the performance of the forwarding scheme and compared it to our own scheme. New documents are introduced in the network at an average rate of one document. Each document has a 20 minutes lifetime, and it pertains to a specific topic. We chose 20 different topics, each group is characterized by two categories of interests and each host is interested in only one of these topics in each category of interest. Each host broadcasts one announce containing its own profile and its catalog) every 10 seconds.

### B. Experimental Setup

We conducted our simulation in two steps: firstly, we used The ONE (Opportunistic Network Environment) simulator to test our scheme of forwarding document/message in opportunistic network [9] and to study the nodes movement using different movement models such as Pedestrian mobility model and Random waypoint model. This simulator allowed us to visualize both mobility and message passing in real time to make sure that our scheme works properly before embedding it within the Middleware DoDWAN.

Secondly, we tested the service notification by using DoDWAN in which we have implemented both the forwarding scheme and the Content Notification Service to evaluate our forwarding scheme for content dissemination; we consider some specific metrics according to the expected results. We then finally compared the delivery rate using the Dissemination with content Notification and the delivery rate without the Content Notification.

### C. Results and Analysis

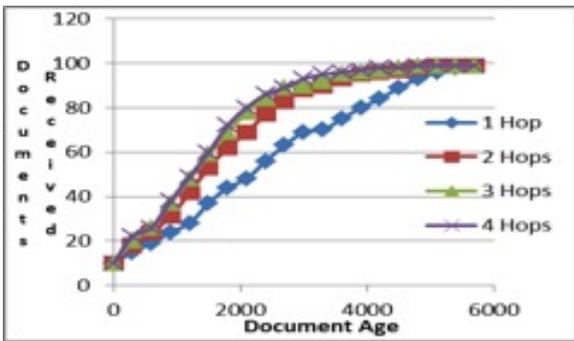
We have considered at first a scenario where documents can propagate eternally in the network. We assumed that the hosts cache capacity could be extended and has no limit, and that no document is given a set lifetime by its publisher. Moreover we assumed, the hosts don't behave altruistically, so that each of them is only willing to collect, carry, and forward documents that match its own interest profile. We observed how long it takes for documents to reach interested hosts, This results which are represented in Fig. 3(a) and 3(b) show the normalized distribution of the age of these documents at delivery time.

We have also considered a scenario where the hosts can only use 1-hop transmission. In this kind of case, we obtained the following result: about 40 % of the documents are delivered in less than 30 minutes. After an hour, about 75% of the documents have reached their receivers, and after two

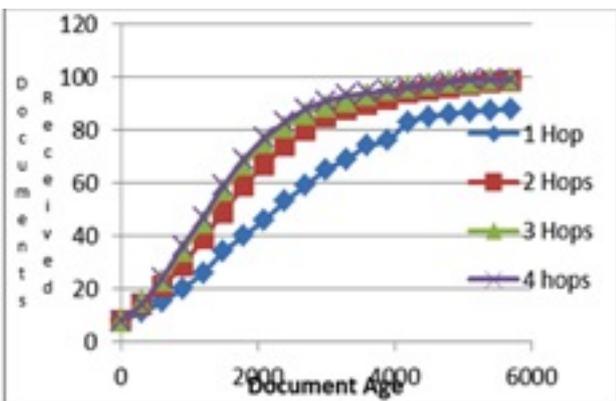
hours about 95 % have been delivered because the notification service allowed some document to be forwarded when their expiring time is reached. We have finally observed how multi-hop forwarding has an important impact on the performance of document dissemination. Fig 3(a) shows that, when temporaneous 2-hop forwarding is used, meanwhile when each host is allowed to have a direct contact with its 1-hop and 2-hop neighbors, most documents are received after about 20 minutes (against 30 minutes when only 1-hop forwarding is used). In such conditions about 99 % of the documents are actually received in less than two hours, about 95 % in less than an hour, and about 70 % in less than 25 minutes.

TABLE I: DOCUMENT DELIVERY RATE

	Time (hours)	1 hop transmission (%)	Multi-hop transmission (%)
	1/2	40	99
Delivery Rate	1	75	95
	2	95	70



(a)

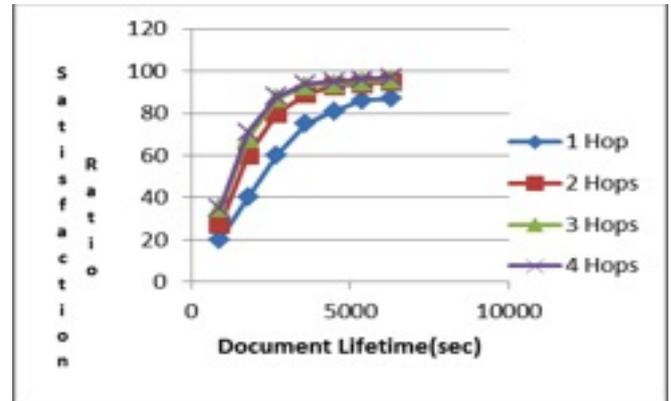


(b)

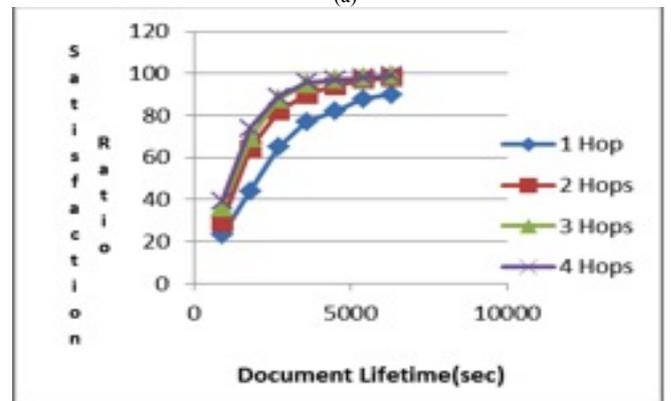
Fig. 3. (a) Distribution and cumulative distribution of the age of documents at delivery time without Service Notification; (b) with Service Notification.

The Fig 4(a) and 4(b) represent the satisfaction ratio which is percentage of documents that are delivered to interested receivers) versus the lifetime of documents and we noticed that the satisfaction ratio is rising when we give a long lifetime to the documents. In Fig 4(a) the satisfaction ratio shows a percentage of 85% when using 1 hop transmission without the notification service meanwhile the satisfaction ratio using notification service reaches up to 93% for the same transmission. Also when we use multi hop transmission without our scheme the Satisfaction ratio resolves around

96% whereas it reaches 100% when the using our fast dissemination scheme. The improvement is due to fact that each host will always inform its neighbors about its cache update and then totally deliver the documents that were requested.



(a)



(b)

Fig. 4. (a) Satisfaction ratio (of document delivery) vs. document lifetime without Service Notification; (b) Satisfaction ratio (of document delivery) vs. document lifetime with Service Notification.

## VI. CONCLUSION

In this article, we have presented one of the crucial problems of fast dissemination in Opportunistic network and delay tolerant network. This paper allowed us to understand deeply the communication and message traffic in disconnected mobile ad hoc Networks. The scheme we have designed enhances the performance of the middleware DoDWAN and was successfully tested by some real computer. The simulation results we have obtained by testing the middleware platform on a mobile ad hoc network device show that it offers a more efficient system model (protocol) than the formal one for our scheme of forwarding and content notification service enhance the communication. We plan in the future to study the different mobility models used in opportunistic networking and we will design if possible a mobility model that fit the performance requirements in realistic scenarios (e.g. [10], [11]). We would like also to have a particular look at the link prediction concept and see the impact of these mobility models in routing protocols in order to design a strong communication platform (e.g. [12]).

## APPENDIX

Algorithm for Periodical announce and Service

Notification

T: Time of periodical announce, Et expiring time, Cat catalog, C cache,

```

send(ANNOUNCE)
1 if conditionsHaveChanged () then
// Prepare a comprehensive announce and store a copy in
cache
2 C = C - {announce};
3 cat = createCatalog (neigh, C);
4 key = hashKey (cat, profile);
5 announce =ANNOUNCE<self, key,profile,cat>
6 C = C U {announce};
7 msg = announce
8 neigh = 0;
9 else
// Prepare a short announce
10 if Et< Σ (T1-T2)(consecutive period of two announces)
then
11 Send_notification (Cati);//only Documents with low
expiring time *
12 forward(Doci,n_hop); //automatically forward the
documents up to n_hop neighbors*
11msg = ANNOUNCE<self, key>
12 S = broadcast (msg)
* our proposed functions and methods
    
```

ACKNOWLEDGMENT

This work was partly supported by National Natural Science Foundation of China (No. 61003305), the fundamental research funds for the central universities of china (No.531107040263) and Hunan Natural Science Foundation of China (No. 10JJ5069).

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