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Evaluating the Energy Consumption of Web Services Protocols in Ad Hoc Networks

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Abstract

Due to the continuous change in the topology of ad hoc networks and the lack of a central directory for publishing web services, makes the process of finding web services a very difficult challenge, several approaches have been proposed, all these solutions are based on either a keyword or ID representing the service to be searched, or using a specific scenario of discovery, all this with trying to respect the constraints of ad-hoc networks such as energy, bandwidth ... etc. In this work we proposed a model for measuring the cost of the overall energy consumption in ad hoc networks depending on the mechanisms proposed by the approaches and protocols for discovering web services.

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1. Introduction

Like any innovation, the emergence of services has resulted in a set of opportunities and new applications. Today, Web services are everywhere in numbers. Whether services online reservations or management of bank accounts and even business applications, all these services share in common the fact of being accessible

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as Web services. Web services speaks XML, they are described in a WSDL (Web Services Description Language) [1] format specifying the methods that can be invoked, their signature and service's access points (URL, Port, Etc.). These methods are accessible via SOAP (Simple Object Access Protocol) [2]. Web services are centralized (their publications) in a common repository UDDI (Universal Description Discovery and Integration) [3] in order to facilitate their research.

Because of frequent changes in network topology in an ad hoc mobile environment, the absence of a fixed centralized directory, the limits of wireless connection and energy constraints of mobile devices makes the achievement of discovery protocols web services designed for ad hoc networks a very sought challenge, several approaches and protocols have been developed in that regard, in this article we present our model to calculate, verify and validate protocols of web services discovery in mobile ad hoc networks depending on energy cost to respect in these types of networks.

2. Web service discovery protocols in ad hoc networks

The key elements in web service discovery protocols are: service description, search mechanisms and the type of network. The discovery of services in ad hoc network is an important problem, in the works that exist; each one is based on the above elements.

In KONARK [4], which is a protocol for discovering web services for ad hoc networks, which aims mobile e-commerce applications, each node in the network acts as a directory of services available in the network, the authors use a tree in each node to classify the available services in the network, the classification is generic in top-level (root) and becomes increasingly accurate down the tree. The authors proposed a mechanism for web services discovery and publication. In publication, each provider broadcasts its new services in the network, so that each node incorporates this service in its tree (Replication of information about services available in the network). In Discovery Phase, if a client looks for a service, he broadcasts a request based on a Name or Type of service, the relevant servers returns responses containing the desired services and the URL of their WSDL descriptions, the client records this information in his local tree of services. The major disadvantage of KONARK protocol is the significant waste of resources due to the recording of the same information in each node of the network, even if the information will not be used by the node.

In the approach proposed by [5], the authors have segmented the network to reduce traffic areas because it is not obvious that each node acts as a registry to record all the services, even less a replication of the same information in all nodes of the network, So they assume that in each area there are a Master-Host who acts as a UDDI registry, it can also recognize all the nodes that connects in this area, They also proposed a mechanism for replication and synchronization of UDDI registries information to ensure the reliability and consistency of the information available in the network (bandwidth consumption). The major inconvenient in [5] is the use of the principle of Master-Host as access point! It means they assume it is fixed so it returns to a network with infrastructure, otherwise it begs the next question, what happens when the Master host is disconnected from the area?

In [6] the authors proposed a web services discovery and publication protocol that interacts with routing protocols to optimize the services research, they assumed two types of services (ordinary and special) each provider broadcast advertisements of special services it offers, and if a client wants to find an ordinary service it sends a request based on the distance (HOP) and the type of service looked for, this mechanism requires the client interaction for the selection of desired services and will be repeated with increasing HOP until the client satisfaction, the intermediate nodes uses a cache to store the common services found. The disadvantage in this approach is the replication of information about special services in all nodes of the network and a high consumption of bandwidth by the messages of the research and the additional use of storage resources for intermediate storage of the services found even if they will not be used.

3. Evaluation of the energy cost

We noticed that each of the approaches discussed violated one or more constraints posed in ad hoc networks such as bandwidth and storage resources ... etc. This will result in a significant consumption of energy. We also noted that the proposed discovery approaches are based on the IDs of the services, their names and types with a client intervention for the selection of service that satisfied their needs.

The following table shows a comparison between the approaches studied, depending on a set of elements which influence in direct or indirect manner on the energy consumed in the ad hoc networks.

Table 1. Comparison between existing approaches

	Bandwidth				Resources			Discovery Mechanism		Energy
	Adver-tisement Packets	Synchro-nization Packets	Disco-very Packets	Resp-onse Packets	Replica-tion of Infor-mation	Routing Table	Services Storage	Discovery Elements	Search and Selec-tion	Energy Con-sumed
KONARK	Broadcast	No	Unicast	Unicast	All services between all nodes	Routes to all network providers	Database "tree" of all existing services	Name or Service Type "Uncertain Discovery"	Client inter-vention	Impor-tant
SEDIRAN	Broadcast	No	Broadcast	Unicast	Only the special services between all nodes	Routes to all providers of special services + Routes to the ordinary services desired	Database of all special services + Cache of ordinary services	Services Identifiers "Uncertain Discovery"	Client inter-vention	Impor-tant
WSDRS	Broadcast between areas	Between UDDIs	Unicast	Unicast	All services between UDDIs	Routes to UDDIs	UDDI Database in every area	Services Identifiers or Service Name "Uncertain Discovery"	Client inter-vention	Impor-tant

In Table 1, we collected several constraints C_i that influence in a direct or indirect manner on the main constraints to be respected in the ad hoc networks, where C_i = {*Bandwidth, Resources, discovery mechanism, Energy*}, we used all this specific constraints to web services discovery approches in ad hoc networks as well as the results of works in [7] and [8], to propose a formula for measuring the energy cost which allow us to evaluate the relationship between ad hoc the energy constraint and web services discovery protocol.

The proposed formula (1) for measuring the cost of influence on the energy consumed in each node depending on constraints C_i is given as follows

$$Cost_{enr} = Cost_{ack} + \prod_{i=1}^{3} Cost_{C_i} \quad (1)$$

Nomenclature	
$Cost_{enr}$	cost of energy consumed in each node
$Cost_{ack}$	cost of energy consumed by the transmission of recognition packets in the network
$Cost_{Ci}$	cost of influence on energy relative to each constraint C_i in each node

To calculate $Cost_{C1}$ that represents the cost of influence on the electrical energy consumed in each node depending on the number, size and type of packets circulating in the network. We are oriented to the work proposed in [7] who presented several results measuring energy consumption, they identified four states of energy consumption:

- Transmission: The transmission of packets.
- Reception: The reception of packets.
- Waiting: Waiting for a packet transfer.
- Sleeping: The state of lowest energy consumption when the node cannot receive or transmit.

The energy cost associated with each packet to each node is represented by the total incremental cost m proportional of the packet size, and a fixed cost b associated with acquisition channel. The formula (2) below is used to calculate the energy cost for each packet in each node of the network.

$$Cost = m \times size + b \quad (2)$$

This formula indicates the direct relationship between the size, number of packets and bandwidth at each node, the formula (3) is the formula that we have proposed to calculate $Cost_{C1}$

$$Cost_{C1} = Cost_{E_{adv}} + Cost_{E_{disc}} + Cost_{E_{sync}} + Cost_{E_{resp}} \quad (3)$$

Nomenclature	
$Cost_{Eadv}$	cost of energy consumed by the transmitting and receiving services advertisements packets
$Cost_{Edisc}$	cost of energy consumed by the transmitting and receiving services discovery packets
$Cost_{Esync}$	cost of energy consumed by the transmitting and receiving nodes synchronization packets
$Cost_{Eresp}$	cost of energy consumed by sending response packets by the provider

The Formula (4) below, is the proposed formula to calculates $Cost_{C2}$ which represents the cost of influence of used resources depending on energy consumed in the processing of stored information.

$$Cost_{C2} = Cost_{R_{repl}} + Cost_{R_{rout}} + Cost_{R_{stor}} \quad (4)$$

Nomenclature	
$Cost_{Rrepl}$	cost of replication of the same information between nodes
$Cost_{Rrout}$	cost relative to routes stored in the network nodes

$Cost_{Rstor}$	cost relative to the structure of the directory of services

The formula (5) represents the proposed formula for calculating $Cost_{C3}$ which represents the cost of influence on the energy consumed in the node relative to the proposed discovery mechanism.

$$Cost_{C3} = Cost_{M_{resr}} + Cost_{M_{client}} \tag{5}$$

Nomenclature

$Cost_{Mresr}$	cost relative to the discovery elements proposed
$Cost_{Mclient}$	cost relative to the involvement of the client in the discovery process

The proposed formula to calculates the cost of influence on the overall energy consumed in all the network depending on the discovery approach is represented as follows,

$$Cost = \sum_{j=1}^{nb\_nodes} (Cost_{ack_j} + \prod_{i=1}^{3} Cost_{Ci_j}) \tag{6}$$

The following Fig 1 represents the graph of comparison between the different discovery approaches studied depending on the cost of energy calculated from the proposed formula, where the Node axis represents the number of nodes in the network and the Energy-Cost axis represents the cost of energy calculated from the proposed formula.

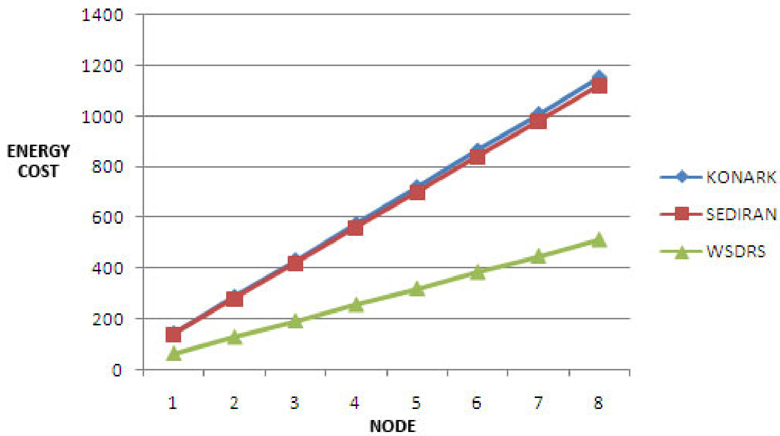

Fig. 1. Comparison between discovery approaches depending on the energy cost

As shown in Fig 1 after evaluation of studied approaches by the formula proposed, the approach proposed in [5] is less greedy in terms of the overall energy consumption compared to SEDIRAN [6] and KONARK [4] protocols.

4. Conclusion

In this paper we have presented our proposed formula to calculate the cost of the energy consumed in an ad hoc environment depending on the approaches or protocols of Web services discovery. This formula is based on *Ci* parameters that we have taken in our comparative studies between different existing discovery approaches. This formula will allow us to evaluate any web services discovery protocol depending on the total of energy consumed.

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