Context Delivery in Ad Hoc Networks using Enhanced Gossiping Algorithms *

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Abstract. The dissemination of context data across a pervasive environment has proven to be a difficult problem. Techniques using gossiping algorithms offer simplicity and flexibility but often result in poor performance with respect to timeliness of delivery and communication cost. In this ongoing-work, we present enhanced gossiping algorithms that aim to improve the efficiency of context data delivery in a decentralised manner using network and data-driven approaches.

1 Introduction

Context delivery is important to facilitate context-based interaction in pervasive computing environments. The dissemination of context information around *ad hoc* networks is particularly challenging due to scalability issues and to the dynamic characteristics of the networks. Different devices will likely have differing context information requirements to make appropriate adaptation to their behaviour. By distributed data throughout a network, each device has only a partial store of the global knowledge. Also, out-of-context information is often delivered to devices due to vague information requirement and representation. Improvements to existing distribution algorithms should attempt to minimise these problems.

Gossiping communication algorithms [1] can provide a robust and scalable solution to the problem of distributing context throughout an *ad hoc* network. Nodes (representing devices) maintain a table of other nodes known to them (their neighbours), and periodically select a node with which to exchange or gossip context data. Gossiping algorithms include a degree of unpredictability, but require far less in the way of guarantees about network structure, communications loss, and latency than other communications techniques. The high robustness offered by gossiping has utility for dealing with *ad hoc* arrangements of devices to be found in pervasive context-aware computing environments. However, heterogeneous node properties such as power, memory and connectivity make it unwise to blindly deliver massive volume of context data throughout

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a network of devices. The continuous range of probability and unpredictability, raises the need for more optimisation of each node's network utilisation and more subtle interpretation for context data. Therefore, it is important to locate interesting and meaningful relations of devices in order to increase efficiency of context data delivery using our improved gossiping implementation.

2 Improved Gossiping Techniques

The distinction between our approach and those described by Voulgaris et al [1] is the use of selective information dissemination and discovery techniques for determining the most relevant context data to gossip, and most relevant nodes to gossip to, in a purely decentralised manner. We propose algorithms that analyse characteristics of the network and build multiple logical networks (overlays) connecting nodes independently of the underlying physical network. The overlays construction are built using a combination of three approaches:

Network-Centric Minimising the volume of superfluous context data that propagates across physical network boundaries by organising nodes into clusters.

Data-Centric Semantically defining the context of interest for a node and transferring context data to those neighbouring nodes with mutual interest.

Query-Centric Routing a node's request for a specific pieces of data to the most relevant neighbours.

The *network-centric* approach uses an analysis of the role of network structure and behaviour in controlling the amount of context information delivered across a wide area network. Since network structure directly affects gossiping statistical properties (i.e. number of propagated messages, number of hops), finding the best way to characterise and customise network topology is fundamental. To achieve this, we propose to integrate information about the physical organisation of nodes to create logical views of the network. This can be done by examining the network topology about a node to estimate the relative importance of its neighbouring nodes in communicating with the wider network. Nodes are organised into clusters so that they will communicate mainly with each other. These clusters can be interconnected in such a way that there is a reduced probability of sending context information across physical network boundaries, and minimising overall network communication overhead.

The *data-centric* approach takes into consideration each node's context data consumption requirements during gossiping. To determine a node's requirement, we propose to describe context data semantically [2]; providing context specification and precisely defining topics of interest for each node. By examining the topic *utility* (the frequency of topic occurrence) at its disposal, it is possible for a node to compile a list of topics that it is interested in based on degree of importance for a particular context. For example, considering a node that runs location-tracking systems, semantic representation involving *weather* context may be regarded as having low utility. Using the data-centric approach, nodes prefer to gossip with neighbouring nodes that have mutual interests.

The data-centric approach may have some disadvantages. The technique requires content examination to resolve the differences between two nodes and may have large traffic overhead. To overcome this, if a node only requires a single piece of data, the *query-centric* approach to gossiping makes it possible for a node to issue a query to be sent to a set of neighbouring nodes. The basic principle is that queries are forwarded to the neighbouring nodes with a high likelihood of returning an answer. To achieve the objective, neighbours will be prioritised based on degree of similarity between a source node and its neighbour by analysing the semantic relationship between nodes. Semantic link is computed based on meta-data that each return messages were tagged with using following metrics:

Knowledge value Relationship between nodes may be one of the these types; full or partial relationship, super-type or sub-type relationship, or semantically unrelated. Each type will denotes a knowledge value indicating node's knowledge on specific topic.

Confidence value Confidence value will denote node's satisfaction competency (i.e. number of returned answer, accuracy of returned answer) with respect to a local query history.

This meta-information is computed to determine the degree of similarity between nodes on a scale from 0 to 1. Nodes will be ranked based on this scale and in future gossiping interactions, queries will be only forwarded to top ranked node in the neighbour table. If a new prospective neighbour is found to have a higher rank than the least similar node among the existing neighbours, the neighbour table will be dynamically updated. If a piece of data is requested frequently , it will be favoured and the node will continuously update its content to ensure the freshness of the context data. This is an important feature of this approach in improving the timeliness of delivery of sought-after data.

The data-centric and query-centric approach may be broadened by gossiping queries for topics of interest to neighbouring nodes that have no interest in those topics themselves. As these queries find nodes that can satisfy them, paths through the network will emerge in a stigmergic manner [3]. The nodes connected by query paths will form semantic community that links nodes sharing similar interest. Moreover, these paths would be dynamic, fault-tolerant and de-centralised.

3 Conclusion

Gossiping provides a simple means of communicating context data across unstructured ad hoc networks. The need for smarter gossiping algorithms to overcome the limitations of current approaches is the key motivation of this work.

This paper presents some novel enhancements to the existing gossiping algorithms that consider local network awareness about a node, and the individual data requirements of nodes. Our next step is to perform evaluations of our proposed algorithms using a dedicated gossiping evaluation framework.

References

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