The Role of Auto-ID Technologies in Mobile E-commerce Databases (Vision Paper)

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I. Mobile E-commerce Database

Consider smart phones and PDA's equipped with RFID or barcode readers, and users that scan and store product information and electronic coupons in their mobile devices. Users may scan products and coupons when considering (and possibly postponing) the purchase of the product. Since nowadays mobile devices may have Gigabytes of storage, a reasonably large database of product and coupon information may be created on each device. Furthermore, mobile devices may be interconnected via short range wireless protocols, such as IEEE 802.11, Bluetooth, Zigbee, or Ultra Wide Band (UWB). These protocols provide broadband (typically tens of Mbps) but short-range (typically 10-100 meters) wireless communication. These technologies can also be used to transmit the coupon or product information directly to the mobile device.

In this environment each mobile peer has a local database that stores and manages a collection of reports (where each report is a product record, or a coupon), and all the local databases maintained by the mobile peers form a ***mobile E-commerce*** (or, more generally, a ***mobile P2P***) ***database*** (see [1] and [2]). Fig. 1 below illustrates the definition. Queries on this database are posed by potential customers, and they search for coupons and products pertaining to a limited geographic environment. For example, a customer may search for a store that sells a ThinkPad 61 power cord in a mall or an airport, or for a coupon on an Adidas tennis racquet that is accepted by the SportsMart store in the mall.

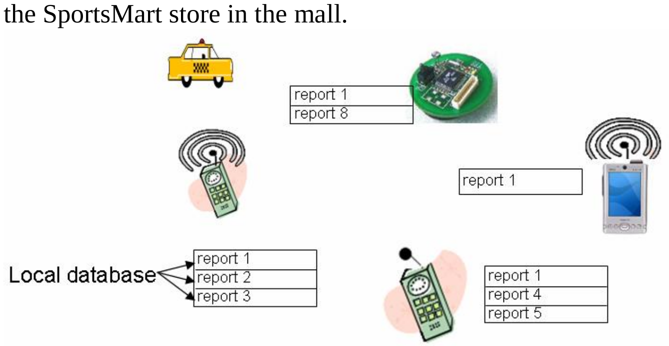

Fig. 1 A mobile database for E-commerce

The peers communicate reports and queries to neighbors directly. However, observe that the wireless technologies have a short range compared to the search area (e.g. a mall). Thus, reports and queries need to propagate by transitive multi-hop transmissions. If a query locates the answer product-information in a remote device, the information may be propagated to the query originator in a P2P fashion, or via the internet. Observe that the query cannot be sent directly via the internet since the id of the device storing the answer is not known; thus, local dissemination is ensured by multi-hop short-range wireless communication. However, if the id of the query originator is appended to the query, then it is possible to propagate the answer back to the originator via the infrastructure.

A mobile E-commerce database may arise in a vehicular environment as well, in which products and coupons pertain to travel, e.g. gas. A query may be asking for the cheapest gas station on the highway within 30 miles of the current location, or for a coupon at the closest Burger King in the direction of travel. The vehicles read reports using auto-ID technologies, and they communicate with each other using inter-vehicle communication technologies such as DSRC (see http://www.its.dot.gov/vii/).

Local search, also called *geographic web search*, services a user looking for a resource (e.g. a gas station or an Italian restaurant) in a limited geographic area. Google is an example of a provider of such services; local.com is another. This type of local search is provided by a centralized architecture, and it enables the discovery of static local resources, but not dynamic ones such as a coupon that expires in 30 minutes (such a coupon may be issued electronically by a merchant experiencing a slow afternoon, and is directed towards a customer in the vicinity). Such a temporary coupon requires timely, real-time update rates; and so do frequent inventory changes. Such rates are unlikely to be provided for the country or the world by a centralized server or server farm, as provided by Google. Thus temporary coupons and frequent inventory changes require many local servers, each dedicated to a limited geographic area, and the necessity for many such servers is avoided by a mobile E-commerce approach. In this approach each local mobile device is a mini-server and a part of a distributed local database, obviating or augmenting information provided by dedicated local servers. Further, the cost of messaging the queries and responses would be expensive for the user, and likely limited in bandwidth, such as a 130 character text message. Short range wireless bandwidth is unlicensed (thus free), and has higher bandwidth thus can provide media rich information, such as maps, menus, and even video. Thus, mobile E-commerce databases have the following advantages over centralized ones:

1. Due to the fact that short-range wireless networks utilize the unlicensed spectrum, communication to the mobile P2P database is free. It also has a higher bandwidth. Furthermore, there is also no cost involved in setting up and maintaining the fixed infrastructure database.
2. Mobile e-commerce databases are more conducive to privacy preservation due to distribution of information.
3. Mobile E-commerce databases are more reliable in the sense that failure of the central site will not render the system unavailable.
4. Mobile E-commerce databases can withstand high the update rates that will be generated when representing temporary coupons.

The disadvantages of Mobile E-commerce search compared to a centralized one are: 1) Due to mobility and dynamic topology, a response to a query is not guaranteed even if the information exists in the database; and 2) a minimum density of mobile peers is necessary to find product information or coupons.

From the historical point of view, the currently prevalent centralized architecture was designed at a time when the mobile devices did not possess the capability to make them intelligent. And therefore, in such an architecture, the intelligence of mobile communication lies in the fixed network infrastructure, and not in the devices. However, nowadays, mobile devices have hundreds-of-MHz processors, and hundreds of megabytes of random access memory. So another way of looking at this proposal is as a shift of paradigm towards mobile E-commerce by intelligent devices.

II. Existing Related Experimental Projects

Currently, there are quite a few experimental projects in mobile P2P databases. Their results can be used for implementing mobile E-commerce databases. These projects can be roughly classified into pedestrians and vehicular projects. Vehicular projects deal with high mobility and high communication topology change-rates, whereas pedestrians projects have a strong concern with power issues. The following are several active experimental mobile P2P database projects for pedestrians and vehicles:

A. Pedestrians Projects

1) iClouds - Darmstadt University

http://iclouds.tk.informatik.tu-darmstadt.de/
Focuses on the provision of incentives to brokers (intermediaries) to participate in the mobile P2P database.

2) MoGATU - University of Maryland

http://mogatu.umbc.edu/
Focuses on the processing of complex data management operations, such as joins, in a collaborative fashion.

3) PeopleNet - National University of Singapore

http://www.ece.nus.edu.sg/research/projects/abstract.asp?Prj=101
Proposes the concept of information Bazaars, each of which specializes in a particular type of information; reports and queries are propagated to the appropriate bazaar by the fixed infrastructure.

4) MoB - University of Wisconsin

http://www.cs.wisc.edu/~suman/projects/agora/
Focuses on incentives and the sharing among peers of virtual information resources such as bandwidth.

5) Mobi-Dik - University of Illinois at Chicago

http://www.cs.uic.edu/~wolfson/html/p2p.html
Focuses on information representing physical resources, and proposes stateless algorithms for query processing, with particular concerns for power, bandwidth, and memory constraints.

B. Vehicular Projects

1) CarTALK 2000 - A European project

http://www.cartalk2000.net/
Develops a co-operative driver assistance system based upon inter-vehicle communication and mobile P2P databases via self-organizing vehicular ad-hoc networks.

2) FleetNet - Internet on the Road Project

http://www.ccrle.nec.de/Projects/fleetnet.htm
Develops a wireless multi-hop ad hoc network for inter-vehicle communication to improve riders' safety and mobility. A data dissemination method called "contention-based forwarding" (CBF) is proposed in which the next hop in the forwarding process is selected through a distributed contention mechanism based on the current positions of neighbors.

3) VII - Vehicle Infrastructure Integration, a US DOT project

http://www.its.dot.gov/vii/
The objective of the project is to deploy advanced vehicle-to-vehicle (using the mobile P2P paradigm) and vehicle-to-infrastructure communications that enhances safety.

4) Grassroots, Trafficview - Rutgers University;

TrafficInfo – University of Illinois at Chicago

http://paul.rutgers.edu/~gsamir/dataspace/grassroots.html
http://discolab.rutgers.edu/traffic/veh_apps.htm
http://cts.cs.uic.edu/
Develops an environment in which each vehicle contributes a small piece of traffic information (its current speed and location) to the network, using the P2P paradigm, and each vehicle aggregates the pieces into a useful picture of the local traffic.

References

[1] B. Xu and O. Wolfson, "Data Management in Mobile P2P Networks", *Springer Verlag Lecture Notes in Computer Science, Proc. of the 2nd International Workshop on Databases, Information Systems, and P2P Computing (DBISP2P'04)*, Toronto, Canada, Aug 2004.

[2] O. Wolfson, B. Xu, H.B. Yin, and H. Cao, "Search-and-Discover in Mobile P2P Network Databases", in *Proc. of the 26th IEEE International Conference on Distributed Computing Systems (ICDCS'06)*, Lisbon, Portugal, 2006