Experimenting with Real-life Opportunistic Communications using Windows Mobile Devices

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ABSTRACT

Pocket Switched Networks (PSN) is a novel communication paradigm which aims to exploit the opportunistic contacts between mobile devices to exchange data over multiple hops. A key characteristic and enabler of PSN is the human mobility, and consequently the detection of the arising contact opportunities. In this paper we present a prototype implementation of a software to detect contact opportunities and the initial experimental observations.

1. INTRODUCTION

In Pocket Switched Networks (PSN) personal mobile devices such as Smartphones or PDAs take an advantage of the local contact opportunities in addition to user mobility and infrastructure access to exchange data between devices. PSN falls under the more general concept of Delay Tolerant Networking (DTN)[1].

Human mobility is a key characteristic of PSN. In order to design, test and analyse efficient forwarding algorithms, and system architectures in general, for PSN, we need detailed understanding of how contact opportunities arise among users of personal devices. In the Haggle project[2], human mobility has been previously studied using Intel Motes (iMotes) in university and conference environments [1, 2]. The iMote experiments were an important first step towards understanding the feasibility of PSN. However, due to the limitations of the iMote platform [3], the natural next step is to extend these experiments on a real mobile programming platform and devices. Mobile devices enable contacts tracing using multiple networking interfaces and the deployment of real applications.

For practical reasons we have chosen to work with Windows Mobile platform. Windows Mobile is a compact operating system targeted to resource constrained handheld devices such as PDAs and Smartphones. The native Windows Mobile APIs provide all the required functionality to implement contacts detection and opportunistic connections and data transmissions between devices.

We implement a simple networking library for Windows Mobile to support Bluetooth and Wifi device power management, configuration, device and service discovery and data transmissions. For cellular radio we experiment with the discovery functionality i.e. listing of available network operators and the current cell id. Using the library we build a testbed that extends the previous iMote experiments by logging not only Bluetooth contacts, but also the available Wifi networks and the cellular radio environment.

In the remaining sections we present shortly some initial results obtained with our testbed from controlled experiments (Section 2) and from a real-life human mobility measurement experiment (Section 3). Finally, we conclude the paper with future work directions in Section 4.

[1]http://www.dtnrg.org
[2]http://www.haggleproject.org

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2. CONTROLLED EXPERIMENTS

We perform controlled experiments to evaluate the battery life, the neighborhood detection performance and the data transmission rates and delays over various radio interfaces. Table 1 shows the connection setup delay which is the minimum required contact duration in order to begin transmit user data between devices. The discovery time for Bluetooth consists of the device inquiry (set to 10.24s as recommended by the Bluetooth standard). Wifi discovery consists of listing the available networks (a hard-coded 5s timeout), the BSS association, the interface configuration and a simple UDP-based handshake to discover the IP address of the neighbor. The association and the interface configuration take together around 4s in both ad hoc and infrastructure mode regardless of how the IP address is

	Discovery	Service	Connection
Bluetooth	10.67s	1.08s	0.19s
Wifi	11.30s		0.09s

Table 1: Bluetooth and Wifi connection setup

assigned (DHCP or static). The UDP handshake overhead is thus around 2-3 seconds. The service overhead for Bluetooth comes from the service discovery on a selected device. Finally, the connection time is the time to setup the actual socket connection.

We also measure the delays and troughputs when sending variable amount of data between devices using RFCOMM over Bluetooth and TCP over Wifi links. The delay variation (as seen by the receiver) is depicted in Figure 1. We can see that Bluetooth performs well compared to Wifi when sending small files, while Wifi outperforms, as expected, when sending more data. The drawback of Wifi is that it consumes more energy. Having the Wifi interface on all the time is not currently feasible while Bluetooth is already by design aimed for power constrained environments.

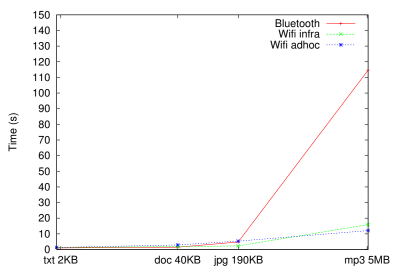

Figure 1: Data transmission times

3. REAL-LIFE CONTACTS

We perform a first larger-scale human mobility measurement with the testbed at our research lab in Paris using fifteen HTC s620 Smartphones. The devices are distributed to the lab staff and they use it as their normal mobile phone during a 6-week period. We collect almost 600 days of traces including discovered Bluetooth devices, Wifi networks and available operators and the current cell id recorded every 2 minutes. Some of the devices and traces suffer still from occasional testbed application crashes, limited battery life (the up-time is around 8h in normal use) or user "interference". Figure 2 shows the contact time distribution and Figure 3 the inter-contact time distribution over various interfaces.

4. CONCLUSION

This paper presents our experiments with real-life opportunistic communications using Windows Mobile devices.

In the future we plan to continue the development of our testbed towards an opportunistic communications architecture offering a standard API for application developers to build new and innovative PSN applications.

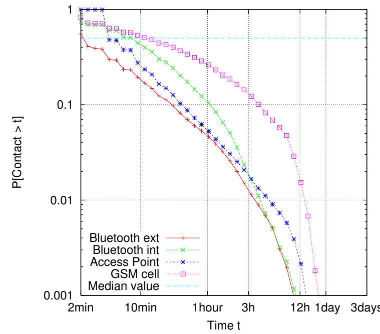

Figure 2: Contact times

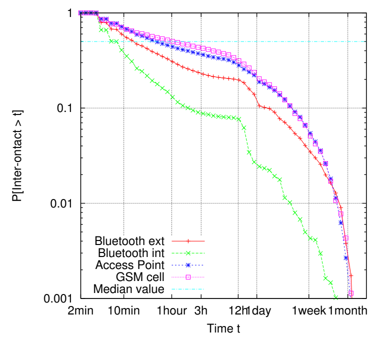

Figure 3: Inter-contact times

5. REFERENCES

[1] A. Chaintreau, P. Hui, J. Crowcroft, C. Diot, R. Gass, and J. Scott. Pocket switched networks: Real-world mobility and its consequences for opportunistic forwarding. Technical report, University of Cambridge, Computer Laboratory, 2005.

[2] P. Hui, A. Chaintreau, J. Scott, R. Gass, J. Crowcroft, and C. Diot. Pocket switched networks and the consequences of human mobility in conference environments. In *Proceedings of ACM SIGCOMM first workshop on delay tolerant networking and related topics*, 2005.

[3] E. Nordström, C. Diot, R. Grass, and P. Gunningberg. Experiences from measuring human mobility using bluetooth inquiring devices. In *MobiEval '07: System Evaluation for Mobile Platforms*, 2007.