Mobility and the Networking Stack

Azarias Reda Brian Noble
University of Michigan
{azarias, bnoble}@umich.edu

1. POSTER OVERVIEW

Even as wireless technologies are enabling anytime, anywhere internet connectivity, developing countries still face significant challenges in network access—bandwidth is low, latency is high and packets get dropped all the time [5]. Wireless devices bring new promises to these areas, and in fact, most of the world's population will probably experience the internet for the first time on cellular telephones. More than a quarter of the world's 4.2 billion cell phone subscribers live in developing countries, and the African continent has the fastest growing market. Nonetheless, severe infrastructure challenges limit the extent to which the traditional networking stack can help in these areas. We propose to augment the existing network infrastructure with calculated uses of individual mobility, coupled with widely available communication tools and excess storage in devices, to support bulk data transfer in challenged network environments. This is particularly essential as more personal data is stored on the cloud.

Our project explores several techniques to better use challenged networks. These techniques build up on prior works in file systems, ad-hoc and delay-tolerant networks, extending them in several directions. One such approach is a hybrid overlay network for efficient transfer of bulk data in these environments. In designing the system, we make a few observations. First, people tend to move with patterns that can be probabilistically learned. With the availability of cheap storage devices, as well as gadgets with storage capacity, individuals can also carry sizable amounts of data with them as they move. Second, not all points in the system are poorly connected, and local connectivity, such as in-range radio, often far exceeds remote connectivity. Whenever good connectivity is available, it can be used for route shortcuts among peers as well as last-mile delivery to destination nodes. Third, nodes often have at least some (poor) connectivity that can be used for opportunistically transferring control plane messages. While such connectivity should not be required for correctness, it can aid in improving performance and delivery. Fourth, any system that is expected to operate in these environments should not require changes to the networking stack, and should be easily deployable as an additional service on the existing network infrastructure.

The distinguishing characteristic of our system is its hybrid nature, enabling it to use a combination of *natural mobility* and *existing network connectivity* for delivering bulk data. This differentiates our system from research efforts most directly related to our work—ad-hoc and delay tolerant networks. While ad-hoc networks are generally good at utilizing mobility in a system to deliver messages [1, 4], they do not take advantage of other available connectivity. On the other hand, delay tolerant networks consider the diversity of links in the system [2, 3], but make a number of assumptions about these links such as bidirectionality and stability. As a result, they often ignore or underutilize natural mobility and opportunistic data transfers. Different *purposes* for different kinds of links are not considered either. Furthermore, DTNs have not been simplified enough to be integrated with the existing network framework in developing countries yet.

Our system provides a simple interface to its best effort, hybrid overlay network among peers within challenged or well connected environments. It is easy to deploy and runs entirely on an unmodified network stack. This overlay network is best suited for bulk data that allows for some delay. If it was run in a completely well connected system, it will reduce to a bulk data transfer network built upon TCP. On the other hand, if it was run in a collection of isolated nodes, it will reduce to using only mobility for data delivery. Most systems we consider lie somewhere in between, and our system should operate over them as a hybrid overlay network.

Complementary to this hybrid network, another approach is an infrastructure for distributing private data in challenged environments—effectively, user-directed specific prefetching. Traditional caching and prefetching techniques leverage redundancy in data requests to avoid fetching a piece of data several times, and deliver it from a local cache upon request. However, these solutions cannot help with personal and private data that is requested by a single user. We propose a solution to this problem by extending the idea of individualized content distribution networks that take personal usage patterns into account. Our system addresses this problem by leveraging the near-ubiquity of cellular phones able to send and receive simple SMS messages. Rather than visit a kiosk and fetch data on demand—a tiresome process at best—users request a future visit. If capacity exists, the kiosk can schedule secure retrieval of that user's data, saving time and more efficiently utilizing the kiosk's limited connectivity. When the user arrives at a provisioned kiosk, she need only obtain the session key on-demand, and thereafter has instant access. This approach can be combined with individual mobility information to facilitate a tolerable access to cloud data, better leveraging large-scale cloud infrastructure offerings.

2. REFERENCES

[1] X. Chen and A. Murphy. Enabling disconnected transitive communication in mobile ad hoc networks. In *Proceedings of the Workshop on Principles of Mobile Computing*, 2001.

[2] S. Jain, K. Fall, and R. Patra. Routing in a delay tolerant network. In *SIGCOMM '04*. ACM, 2004.

[3] E. P. C. Jones, L. Li, and J. K. Schmidtke. Practical routing in delay-tolerant networks. *IEEE Transactions on Mobile Computing*, 6(8):943–959, 2007.

[4] A. Lindgren, A. Doria, and O. Schelén. Probabilistic routing in intermittently connected networks. *Lecture Notes in Computer Science*, 3126:239–254, January 2004.

[5] B. Petrazzini and M. Kibati. The Internet in developing countries. *Commun. ACM*, 42(6):31–36, 1999.