International Workshop on Wireless Traffic Measurements and Modeling (WitMeMo '05)

Seattle, WA
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KEYNOTE ADDRESS

Summarized by Minkyong Kim

- ***Dynamic Adaptation and Mobile Wireless Systems: Experiences and Challenges***

Margaret Martonosi, Princeton University

Mobile computing systems present several challenges. First, mobile computing happens on devices with constrained optimization and highly varying applications. Applications constantly change, and new applications present new constraints. Second, hardware also changes quickly. Instead of abstracting hardware, people tend to make software to fit their needs. Without hardware abstraction, the first challenge becomes more severe. Third, there are always new metrics for success. David Kotz (Dartmouth College) commented that the reason people do not do abstraction is that they want more control.

ZebraNet, a project consisting of a network of mobile sensors designed for animal tracking, started three years ago in response to biologists' desire to track animals over an extended period and long distances. Biologists will use the resulting information to suggest ways to manage land to preserve wildlife.

ZebraNet uses a store-and-forward network to collect sensor data. Each sensor has a radio with a one-kilometer range, though the effective range was only 100–800 meters due to a ground loop caused by the stitching in the collar. Sensor collars put on the necks of seven zebras exchange data every two hours with others within range (i.e., 2 km). The collar, designed from scratch, trades processor cycles to optimize radio transmissions, because computation requires less energy than radio transmissions.

Beyond ZebraNet, there are three challenges: a lack of stable application drivers on which to experiment, a lack of good experimental infrastructure, and a lack of data sharing among researchers. The first two challenges are difficult to change, but the last should be easier. Currently, data sharing takes place more or less exclusively at conferences or workshops. This community needs broader-scale sharing. Martonosi also advocated creating test-beds and simulation environments.

Martonosi concluded her talk with the following research questions: What can we do to tolerate sparse and high-disruption wireless networks? What do we do if a source-to-destination route never exists or exists only rarely? How can we reduce the packet delivery latency for disseminating data? How do we better support infrastructure for real-system wireless measurements?

Maria Papadopouli (University of North Carolina) commented on the difficulty of correlating data from different sensors and also the problem of measurement errors. David Kotz (Dartmouth) asked whether there have been similar problems in space research. The speaker said that it is similar but the distinction is that the events in space operations are relatively well scheduled, whereas zebras are random. She mentioned that the range of control is also different.

http://www.princeton.edu/~mrm/zebranet.html

MORNING PRESENTATIONS

Summarized by Irfan Sheriff

- ***Analysis of a WiFi Hotspot Network***

David P. Blinn, Tristan Henderson, and David Kotz, Dartmouth College

David Blinn began by talking about some large-scale WiFi studies that have been conducted. This study is smaller than many of those and is based on the analysis of data from 312 access points installed at Verizon phone booths in New York. However, this is the first work based on the traces collected from a production 802.11 network. The access points are connected through an ADSL backbone.

The study involved looking at the number of active users and pending users, and the movement of users among access points. It was conducted for five weeks in November–December 2004. Most results were not surprising—diurnal usage, weekly usage patterns, 5% of cards generating about 85% of traffic, and the like. The paper concluded that users were not very mobile and usually stuck to one access point.

Maria Papadopouli suggested that users who were always on the network might be working from home. People were interested in the data and there was discussion of attempts to make the data public.

- ***MobiNet: A Scalable Emulation Infrastructure for Ad Hoc and Wireless Networks***

Priya Mahadevan and Amin Vahdat, University of California, San Diego; Adolfo Rodriguez, IBM and Duke University; David Becker, Duke University

Priya Mahadevan presented an emulation environment for ad hoc wireless networks called the MobiNet. The advantage of this work is that real applications can be simulated on a large scale in the emulator. The drawbacks of the simulator, such as simplified physical layer models and simplified mobility models, remain. This work tries to combine the good features of the simulators (repeatability, efficiency) with that of live deployment (real application usage).

Mahadevan presented the general architecture and evaluation results, which showed that the model is accurate, scalable, and can support applications unmodified. MobiNet performed as well as NS-2, at the same time supporting NS-2.

Ashu Sabharwal said he did not see a big difference between MobiNet and distributed NS-2, because real application traces can also be fed into NS-2. He also noted that with large-scale deployment, the jitter encountered on the Ethernet line between the core and edge nodes could affect the results. Mahadevan countered by saying that this could be solved by limiting the number of applications per edge node and having separate Ethernet lines.

Additional information is available at http://ramp.ucsd.edu/~pmahadevan/publications/Mobinet_techrep.pdf.

- ***An Accurate Technique for Measuring the Wireless Side of Wireless Networks***

Jihwang Yeo, Moustafa Youssef, and Ashok K. Agrawala, University of Maryland; Tristan Henderson, Dartmouth College

Tristan Henderson presented a measurement architecture for 802.11 networks on the wireless side of the network using a set of sniffers. Most earlier measurement work has been on the wired side of the 802.11 network, which cannot capture the full details of the packets, because the access point strips some of the headers before handing over the packets. This work looks at countering the deficiencies of the earlier work.

The setup consisted of three sniffer PCs equipped with prism2 802.11 cards. The tools used included libpcap-based ethereal to capture data. The metric of importance was completeness of data, and three sniffers were found to be sufficient for one access point. There was a discussion of the effect of different drivers on the packet data collected. Maria Papadopouli thought it should not have an effect. However, people agreed that current device drivers handle packets differently and that such handling should be standardized. SNMP seems to be buggy too, as they found a weird packet result count with SNMP.

Ashu Sabharwal asked how intrusions and MAC layer misconfigurations can be detected? Papadopouli pointed out that *some* cases of misconfigured clients and APs can be detected by analyzing SNMP data.

- ***Modeling Users' Mobility Among WiFi Access Points***

Minkyong Kim and David Kotz, Dartmouth College

Minkyong Kim presented a paper on modeling user mobility based on traces collected at Dartmouth College. The tests were conducted from April to May 2003. The Flux model, as it is called, clusters the set of access points that have the common behavior of user distribution during different periods of time.

The model constructs five clusters with a set of access points that have similar peak behavior. Alex wondered why there were just five clusters. Kim responded that the number should probably depend on the environment and the behavior of the users. Ashu Sabharwal asked if there were any surprises in the peak behavior. Kim felt there were no significant surprises. There was a discussion about the need for better models that closely simulate realistic user behavior.

AFTERNOON PRESENTATIONS

Summarized by David Blinn

- ***An Experimental Study of Multimedia Traffic Performance in Mesh Networks***

Yuan Sun, Irfan Sheriff, Elizabeth M. Belding-Royer, and Kevin C. Almeroth, University of California, Santa Barbara

Irfan Sheriff presented experimental results of streaming video and voice traffic testing on a 25-node 802.11b mesh network test-bed (http://moment.cs.ucsb.edu/meshnet/). The network topology consisted of static routes between a sequence of nodes in a four-hop path.

The experimenters observed that fewer simultaneous voice flows could be well supported than video flows and determined that the number of packets per second sent by an application had a greater impact on quality than the size of the packets. Increasing the number of multimedia flows beyond a saturation point caused dramatic jumps in both latency and loss, and increasing the number of hops decreased the saturation point. A greater number of flows also resulted in an increase in latency variation, or jitter.

With multiple video flows, unfairness became an issue, with some flows consuming great amounts of bandwidth leaving little for the other flows. Unfairness was an even bigger problem in voice flows. At the conclusion of the presentation, some members of the audience expressed concern that some of the measured results, such as the effects of RTS/CTS, might be specific to the testing topology and would fail to generalize to other networks.

- ***The Perils of Simplified Simulation Models for Indoor MANET Evaluation***

Eyal de Lara, University of Toronto

Eyal de Lara opened his invited talk by questioning the value of Mobile Ad Hoc Network (MANET) simulations when the simulations use extremely simplified space and mobility models. MANET simulations frequently assume that the networks are deployed in free space, with no impediments to radio communication, and that users move between random waypoints. These models are inadequate and not robust.

He introduced a detailed model, called attenuation factor (AF), of space and user mobility with an AutoCAD map of a building and waypoints between sensible points in building rooms. In evaluating two routing protocols, DSDV and DSR, using these models, the detailed model predicted similar results to the simplified models for DSDV, but dramatically different results for DSR. He identified that this difference was caused by the effect of frequent link breakages. The AF model observed these breakages, which greatly affected the results.

De Lara stressed that he was not claiming his AF model was perfect, but rather that he wished to show that simplifications in models could produce nonuniform variations, and that it is nontrivial to determine which simplifications are important and which are not.

A paper describing the work is available at http://www.cs.toronto.edu/~delara/papers/secon2004/.

- ***Measurement Study of Path Capacity in 802.11b-Based Wireless Networks***

Tony Sun, Guang Yang, Ling-Jyh Chen, M.Y. Sanadidi, and Mario Gerla, University of California, Los Angeles

Tony Sun began by remarking that studying wireless path capacity is complicated by the dynamic conditions affecting the links, and presented a scheme to better estimate the maximum achievable data rate in a multi-hop wireless path.

The new scheme, AdHoc Probe, builds upon the previous CapProbe (http://nrl.cs.ucla.edu/CapProbe/) scheme, which uses a packet pair to estimate the capacity of a link. Measuring path capacity in a wireless ad hoc network is more difficult than in a wired network, due to the effects of bottleneck capacity, network topology, interference, the use of 802.11 auto-rate, and RTS/CTS. AdHoc Probe is superior to CapProbe because it uses faster, less interference-prone one-way transmission instead of CapProbe's two-way transmission. Tristan Henderson (Dartmouth) questioned the absence of SIFS/DIFS delays in the researchers' calculations. Sun responded that the aim of the research was only a rough estimation of theoretical link capacity.

Implementation issues in the new scheme include system time synchronization between the links, which can be negated by summing over minimum recorded times, and clock skew caused by clock racing, which can be accounted for by examining trends in clock timing. In an experimental setup of 802.11 access points, experimental results verified the scheme's prediction of C/3 for a three-hop network and C/4 for a network with four hops or more, with C being the single-hop capacity of the links. The presentation concluded with a debate over the precise meaning and usefulness of the notion of wireless path capacity.

PANEL SESSION

Summarized by David Blinn

- ***Who's Afraid of Wireless Measurements Studies?***

Panelists: Christophe Diot, Intel Research Cambridge; David Kotz, Dartmouth College; Maria Papadopouli, University of North Carolina; Ashu Sabharwal, Rice University

The panelists took turns expressing their hopes and fears for the future of the field of wireless measurement studies. Maria Papadopouli emphasized the need to integrate two directions: measurement and modeling. Benchmarks and metrics should be defined to identify access patterns. David Kotz stressed the need to build a strong measurement community, noting the inconsistencies in definitions and tools. He introduced a new endeavor, CRAWDAD: A Community Resource for Archiving Wireless Data at Dartmouth (http://crawdad.cs.dartmouth.edu), which will include an archive of wireless data sets and a set of tools and will run measurement workshops. Ashu Sabharwal worried that the community might be reinventing the wheel by focusing too much effort on systems that are essentially irrelevant. He introduced the CMC Open Wireless Platform, an upgradable and expandable wireless testbed for testing in all layers of the network stack. Christophe Diot pointed out the need for a strong community and uniform testing equipment along with a common standard to calibrate test-beds. After these introductions, the panel took questions and a spirited discussion followed.

Papadopouli and Sabharwal argued for the need to raise standards within the community, which might require more visible workshops and conferences and a willingness to reject papers that make no attempt to justify their underlying assumptions. The panelists also emphasized the need for multi-disciplinary and interdisciplinary research to support different layers of the systems (from the physical layer all the way through the application), as well as the need for strong ties with statisticians.

James Scott (Intel Cambridge) asked if trace-based experiments could be made as simple as running a simulator. The panel answered that it might be possible to take a measurement and replay it, but someone has to set up actual equipment and find the traces in order to make it easy. People will want scalability in such a setup and will want to be able to tweak parameters of the trace.

Scott also asked how we might judge the success of a simulation or trace when we have to sacrifice realism for reproducibility. David answered that this problem is one encountered in the natural sciences because, like a wireless network, not all elements of nature can be controlled. Following the example of these sciences, the solution is to perform many studies and use statistics to overcome the problem of the huge number of parameters in experiments, for instance in a multi-factor experiment. Simulation can then be used to drive experimentation.