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Homework #2.A
Hours worked on: 2.5hrs

Response To:
Philo Juang, Hidekazu Oki, Yong Wang, Margaret Martonosi, Li Shiuan Peh, and Daniel Rubenstein. "Energy Efficient Computing for Wildlife Tracking: Design Tradeoffs and Early Experiences with ZebraNet." Tenth International Conference on Architectural Suppor
t for Programming Languages and Operating Systems (ASPLOS-X), October 2002.
http://www.princeton.edu/~dir/pdf_dir/2002_Juang_asplos_zebranet.pdf

Summary

ZebraNet is an animal-tracking sensor network that was designed to work with a moving basestation. The data gathered is purley GPS data showing the position and facing angle of a zebra. The aggregation of this will be used to create a mobility model for zebras, to help understand their interactions with eachother. Since the herd will presumably be moving, an immobile basestation is not possible. Instead, the basestation must follow the herd, collecting data about once a week.

Goal

The goal of ZebraNet was to allow better collection of herded animals. Some targetted problems included dealing with a mobile herd, and isolated motes that only occasionally came near the herd.

Do

Collars were designed to hold the required sensor equipment. One collar would be placed on a few zebras in the herd, which would represent the collective herd. Each collar must be able to collect GPS data, communicate with the other collars, and if it's nearby the basestation, then communicate with the basestation, and also use solar power to keep a charge. GPS collection happens every 3 minutes, and detailed activity logs are taken for 3 minutes once per hour. Data transfer was accomplished using two radios: a Linx SC-PA radio for short-range, and a Tekk KS-960 for 8-km range to the mobile basestation. Using GPS-time for synchronization, time-division multiplexing was used to prevent collisions when searching for peers and transmitting data. A custom routing protocol was developed to transition data towards the most-likely place for data to be sent to the basestation. Eventual data propogation was desired here: it didn't matter when data made it to the basestation, as long as it did. To assist with this, a delete-list datastructure was used to help decrease the loss of data, and keep newer data around as long as possible, before marking it as acceptable to delete (high probability of being successfully sent to the basestation). A simulator for this network was also developed: ZNetSim. It simulated zebra movement (validated against biologist collected data), battery drain, queue statuses and data propogation in a 20km by 20km map. The simulator was used to test the efficiency and viability of the protocols.

Findings

Low-speed zebras would need a radio range of nearly the entire map in order for single-hop network communication to occur 100% successfully. This set a precedence that multi-hop communication is necessary for 100% data propogation to occur. When using multi-hop routing, a radio range of 4000m was sufficient for herds to eventually propogate data 100% to the basestation. When looking at protocol implementations and infinite storage, the flood algorithm for data propogation consistently out-performed the historical and direct communication protocols in terms of percentage of data that reaches the basestation. With limited storage and infinite bandwidth, however, the historical protocol reaches 100% data propogation at a lower radio range than flood and direct protocols: 9km range vs 11km range. Based on the results gathered from simulations, the verdict is that unless huge radios are used, data will never be propogated, or will be lost entirely. Also, all results were only seen from the simulator: it does not seem like a collar network was ever deployed.

Extend/Summarize Field

ZebraNet seems to ignore some of the problems that most sensor networks face: Huge radios, huge batteries, and consistent data-collection was used. Most sensor networks attempt to use smaller batteries, as limited data-collection as possible, and try to limit radio size and power consumption. Based on the battery drain seen by the long-range radio, it seems like using a satellite modem in more periodic usage would have led to less power usage. The simulated results are also not encouraging: they basically state that their network is not capable of gathering data. Given that this paper is 12 years old now, I think the topic could be revisted, and a more successful network could be made that would use less power, more efficient radios with longer range, and be able to 100% propogate data. The results reached, however, show the actual peer-to-peer ranges that are needed for data to be propogated across the herds. This is a property that is stalemate within the zebra population: this cannot be helped, only avoided. At the time, this was likely an extension of the snesor network field: as the authors mentioned, never before had someone tried to have a network with a mobile basestation, nor was it likely that someone had attempted such a sparse, long-distance ad-hoc network.

Discussion

One important, depressing question that I've begun strongly considering is: what's the point in a disertation if it doesn't do anything? This paper is an excellent example of a huge project that resulted in almost nothing. This includes the failure to meet the goal of the project: accurately measure the mobility of zebras. A simulation was made that was validated with previous data. Once this happens, is there still a reason to use collars to collect data from zebras? The premise of the paper seems to fall apart. From a technical standpoint, the challenges faced by the project are great, but the results are not great. If the project were repeated, I would expect a different approach, and success. For example, using cellular-level radios with mobile modems could be used, or satellite radios, or even high-powered radios, which should hopefully be more efficient now.