Museum Environmental Monitoring System: A Demonstration of PAQ

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Introduction

The research in the Networking lab this summer focused on building and analyzing PAQ, (Persistent Adaptive Queries) which is a middleware that allows programmers to easily develop applications which utilize persistent queries in wireless ad hoc networks. Our project aimed to implement the abstractions of PAQ and demonstrate its usefulness through the rapid development of a wireless museum environmental monitoring system. My individual contributions consisted of completing the implementation of PAQ, designing new abstractions for our specific application, designing a graphical user interface for our application, and dealing with communication between the application and the wireless sensors.

Background

In recent times we have seen growing use and demand for wireless ad hoc networks. One issue that arises is finding an efficient an accurate method of retrieving data from these networks. Traditional methods would use persistent queries to monitor the network and provide application users with an updated view of the network. However, these persistent queries become far too expensive in ad hoc networks as each node now has a high degree of mobility. PAQ offers an affordable solution by approximating a persistent query as a series of one time queries.

PAQ Overview

• PAQ approximates a persistent query with a series of one time queries and is defined by the four major components in the flow chart below.

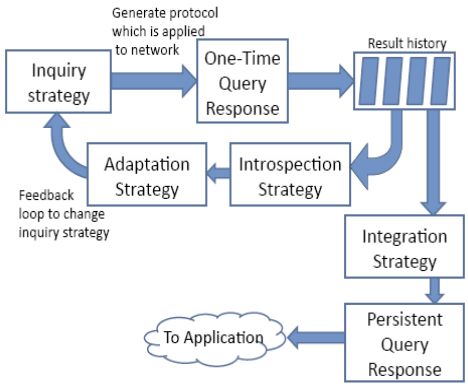

Figure 1: PAQ flow - chart

Inquiry Strategy:

- Defined by an inquiry mode and a frequency of issue
- The inquiry mode defines which nodes to probe for data (e.g., location, random, flooding)

Introspection Strategy:

- Gives a metric that determines the quality of the results that are returned

Integration Strategy:

- Gives a method of how to aggregate the series of one time query results into a single result
- This accumulation of results is what the application sees as the persistent query

Adaptation Strategy:

- Gives the application the ability to adapt the inquiry strategy when the introspection result is not ideal
- This gives the ability to acquire higher quality and lower cost results

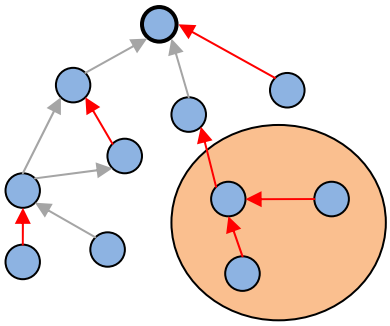

Figure 2: Location and Random Sampling Inquiry Mode

Museum Monitoring System

Goal: Develop an application that demonstrates the benefits of PAQ

Completing PAQ

The first step in building our monitoring system was completing the implementation of PAQ. This involved completing the current version, making corrections and adding new ideas.

Defining Strategies

With this new specific application, we had a need to define new PAQ strategies that would best fit our application. One example is shown above in figure 2. In this inquiry mode we want to retrieve the information from a defined location, and randomly probe the network everywhere else. The red arrows represent messages that are returned, so as we see all messages inside the location are returned, and the others are sent at random.

Developing Interface

Our final step was the development and testing of our environmental monitoring application. This involved designing a GUI that would interact with both PAQ and the wireless sensors. The basic flow of our prototype application would allow users to define certain thresholds where the application would then attempt to keep light and temperature, which negatively impact the lifetime of artwork, inside those thresholds. We would send probes to the sensors based on our inquiry strategy and the sensors would return their data appropriately. This data was visualized in real time as seen in the screen shot on figure 3.

Figure 3: Screen Shot of Monitoring System

Impact

- **Our system is a fully functional prototype and has the potential to be deployed and tested in a real museum environment**
- **The new PAQ strategies developed could be used by future applications**
- **The benefits of PAQ were well showcased from the development of our system**

Conclusions

While no quantitative testing was done, we did qualitatively demonstrate the usefulness of PAQ, and also develop a base for which quantitative testing can be performed against. There were also several personal skills gained during this summer REU some of which are listed below.

- Gained experience with many different networking concepts
- Learned several new technologies such as java SunSpots, and other sensors
- Learned the difficulties and values of working on a team project

Future Work

There are many directions we would like to take this project in the future.

- Testing in a real world situation
- Creation of new PAQ strategies
- Research into better visualization methods of real time data
- Research into other applications that would benefit from the use of PAQ