Master's Thesis Proposal: Analyzing the Quality of Service for Stream Processing Applications

Fredrik Heintz, AIICS and Unmesh Bordoloi, ESLAB, June 21, 2011

We seek two highly motivated, capable and proactive students for a Master's thesis which combines formal analysis of real-time systems with artificial intelligence applications on unmanned aerial vehicles.

The high-level goal of the Master's thesis is to provide a framework to analyze the quality of service (QoS) in stream processing applications on-board unmanned aerial vehicles (UAVs). An example application could be processing video streams to detect traffic violations for a UAV monitoring an urban area. Since the computational resources on a UAV are limited, there is a need to analyze how to best use these resources in order to guarantee the QoS of the given application. The framework should support both the analysis of the QoS of a particular stream processing application and design space exploration for classes of stream processing applications.

The theoretical basis for the framework is the Real Time Calculus (RTC), a formal framework for reasoning about real-time systems and in particular streaming applications. RTC has its mathematical roots in the Network Calculus. It supports timing analysis, estimating loads and predicting memory requirements.

Stream processing applications are modeled and implemented using the DyKnow stream-based knowledge processing middleware. DyKnow models a streaming application as a set of computational units connected by streams. A computational unit represents a computation which takes one or more streams as input and produces one more streams as output. Each stream is associated with a policy which is a declarative representation of its desired properties. DyKnow has successfully been used in a number of UAV applications such as traffic monitoring and search and rescue which require high-level reasoning based on low-level sensor processing.

The concrete goals of the project are:

1. Evaluate the applicability of RTC performance models by making a concrete case-study using a real streaming application and the actual UAV hardware.

2. Develop a methodology for deriving an RTC performance model given a particular Dyknow stream application and a specific system specification. The system specification includes the available CPUs and communication channels as well as the scheduling policies used by them.

3. Study how RTC performance models can be used for design space exploration of stream processing applications modeled using DyKnow.

4. Study how dynamic aspects of stream processing applications, such as a varying number of streams and computational units, can be modeled using RTC.

Potential students are expected to have a computer science or computer engineering background with good knowledge of real time systems and programming. Knowledge of embedded systems, computer networks, computer architectures and artificial intelligence are beneficial. The programming will mainly be done in C++ and Matlab but also Java programming might be required. Very good verbal and written communication skills are essential for this thesis.