QOS Management for camera networks

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Introduction

Introduction to FTT-SE

The Current Setup

QoS Approach

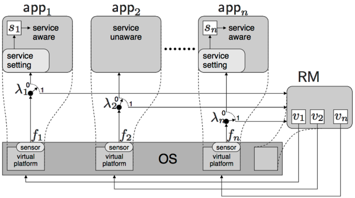
Preliminary Results

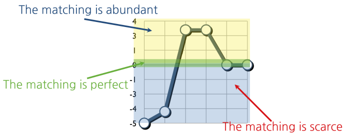
Introduction

- Adaptive resource management for camera networks
- Connected at a local level through Ethernet connection
- Contracts define the resolution and frame rates of the cameras
- Based on previous work by Martina on multicore systems

Resource Manager for Multicore Systems

- Dynamically allocates resources and applications choose their service levels
  - λ_i = 0 means that application adjusts
  - λ_i = 1 means that the manager adjusts
- Decides on the allocated amount depending upon the matching function
  - $f_i < 0$ means matching is scarce
  - $f_i > 0$ means matching is abundant
  - $f_i = 0$ means matching is perfect





The matching is abundant

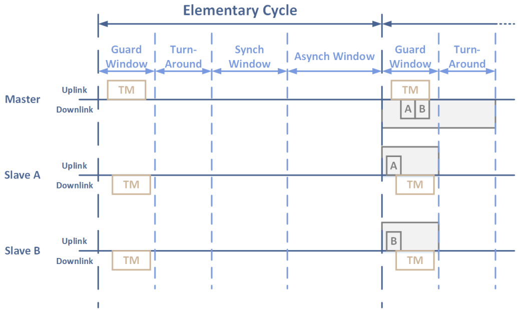
The matching is perfect

The matching is scarce

FTT-SE

- Flexible Time Triggered paradigm triggered by a master
- Dynamic reconfiguration of slaves
- Admission control
- Traffic controlled by a master on network
- Switched ethernet, FTT-SE is implemented on COTS switch

Elementary Cycle



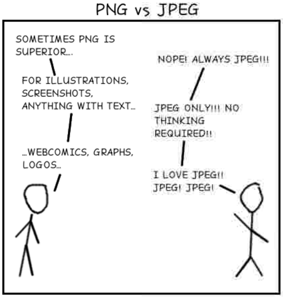
- EC is the traffic schedule in FTT-SE
- The elementary cycle consists of [TM], Async and Sync windows
- Synchronous messages are scheduled by the master.
- Asynchronous messages are sent by the slaves

The Camera Setup

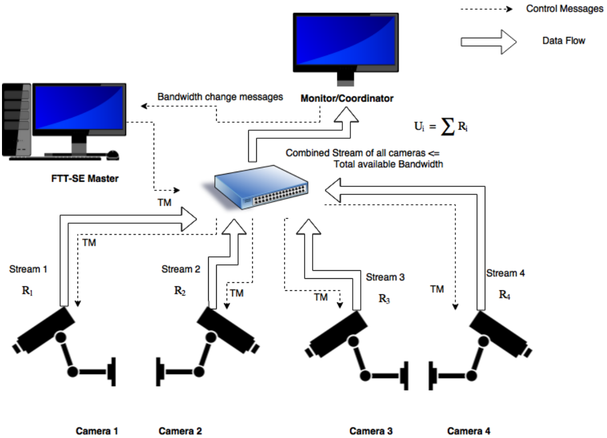
- 4 nodes connected to a switch.
  - One master node, one monitor, and two cameras.
- Master
  - Allocates bandwidths for slaves connected.
  - Notifies BW changes
- Monitor
  - Receives the data/image
  - Monitors BW usage
  - Notifies master for BW changes
- Currently only uses Async messages

A look at the cameras

- Cameras
  - Off the shelf Logitech cameras
  - Captures, encodes and sends the data/image to monitor
  - JPEG compression using OpenCV
  - JPEG is suitable to process and store images
  - Buffer size is varied to fit image


PNG vs JPEG
SOMETIMES PNG IS SUPERIOR...
NOPE! ALWAYS JPEG!!!
FOR ILLUSTRATIONS, SCREENSHOTS, ANYTHING WITH TEXT...
JPEG ONLY!!! NO THINKING REQUIRED!!
...WEBCOMICS, GRAPHS, LOGOS...
I LOVE JPEG!! JPEG! JPEG!

Overview


Control Messages
Data Flow
Monitor/Coordinator
Bandwidth change messages
FTT-SE Master
$U_i = \sum R_i$
Combined Stream of all cameras <=
Total available Bandwidth
TM
TM
Stream 1
R_1
Stream 2
R_2
TM
TM
Stream 3
R_3
TM
Stream 4
R_4
Camera 1
Camera 2
Camera 3
Camera 4

What do they know

- Master
  - Slave channels, Global settings
- Monitor
  - Global settings, Camera contract, Camera state
- Cameras
  - Camera Contract, Camera State
- This allows two control loops. Global QoS and camera
  - Global QoS approach - Game theoretic resource manager
  - On the cameras - PI controller

QoS Approach

- Steady state calculation

$$\begin{aligned} B_i^{ss} &= b_i^{ss} B_c \\ b_i^{ss} &= w^p \frac{\rho_i}{\sum_{j=1}^{n} \rho_j} + w^q \frac{q_i}{\sum_{j=1}^{n} q_j^a} \end{aligned}$$

- Error function

$$f_i = \alpha \left(\frac{B_i^{ss} - B_i}{B_i^{ss}} \right)_{[-1\;1]} + (1-\alpha) \left(\frac{R_i^{ss} - R_i}{B_i^{ss}} \right)_{[-1\;1]}$$

- if f_i is less than 0, matching is scarce
- if f_i is greater than 0, matching is abundant
- if f_i is equal to 0, matching is perfect

Game Theoretic Manager

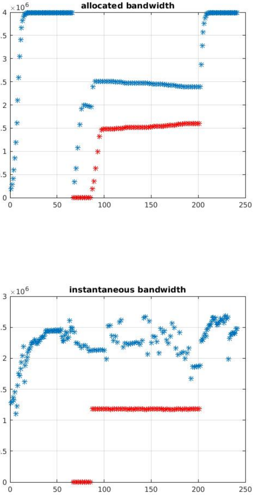
- Present in the Monitor
- Does the following
  1. Measure the current performance $f_i(t)$
  2. Updates the channel as

$$bw_i(t+1) = bw_i(t) + \epsilon(-\lambda_i f_i(t) + \sum_{j=1}^{n} \lambda_j f_j(t)\, bw_i(t))$$

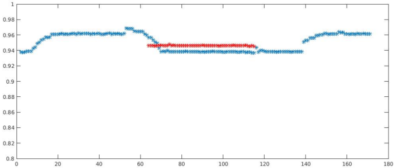
  3. Computes value of bandwidth to allocate

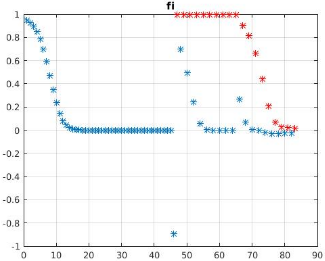
$$B_i(t) = n * bw_i(t+1)$$

Preliminary Results



SSIM and f_i


1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0.8
0
20
40
60
80
100
120
140
160
180


fi
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
10
20
30
40
50
60
70
80
90

Thank you