Integrative Systems Engineering

Simulation Examples

Prof. Michael Zink
Overview

- Self-created: VoD System
- Trace-based: YouTube work
- MatLab: Radar placement
- ANSOFT: Phased-array antenna simulation
Self-created Simulation: VoD System

- Motivation
- Scalable adaptive streaming
- Retransmission scheduling
- Heuristics
- Simulation
Motivation

- Situation in today’s Internet
  - No guaranteed services (e.g. bandwidth) available
  - Streaming must be performed adaptive

- Scalability
  - Large amount of users
  - (Geographically distributed)
  - Heterogeneous client (high-end PC to mobile phone)
Scalable Adaptive Streaming = 
System Scalability + Content Scalability

Original 4 layer video

Internet

Subnet A

Proxy Cache

Quality on cache

Quality on clients

Subnet B

Proxy Cache

Quality on cache

Quality on client

Origin Server

Quality on client
Reduce layer variations in the video delivered to the client

Retransmission Scheduling

- Server
- Proxy Cache
- Client

retransmitted segments

video streamed to client

initially cached video
Example

Segments requested for retransmission $s(v_i) = 12.55$

<table>
<thead>
<tr>
<th>Segments (retransmitted)</th>
<th>Complete search (seconds)</th>
<th>Spectrum</th>
<th>Heuristici (seconds)</th>
<th>Spectrum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>Complete search (seconds)</td>
<td>0.0003</td>
<td>0.0054</td>
<td>0.1222</td>
<td>2.8206</td>
</tr>
<tr>
<td>Heuristic (seconds)</td>
<td>$5.3\times 10^{-5}$</td>
<td>$5.3\times 10^{-5}$</td>
<td>$5.3\times 10^{-5}$</td>
<td>$5.3\times 10^{-5}$</td>
</tr>
<tr>
<td>Spectrum</td>
<td>20.73</td>
<td>22.67</td>
<td>16.73</td>
<td>18.92</td>
</tr>
</tbody>
</table>
Heuristics for Retransmission Scheduling

Lowest Layer First (U-LLF)

Shortest Gap Lowest Layer First (U-SG-LLF)

Lowest Layer Shortest Gap First (U-LL-SGF)
Simulation for Retransmission Scheduling

- Own C++-based simulation Environment
- Instance of layered video on the cache is randomly created
- Average of 1000 simulations
Trace-based Simulation: YouTube Study

- Motivation
- Measurement study
- YouTube traffic traces
- Synthetic traces
- Simulations:
  - P2P caching
  - Proxy caching
Motivation

- YouTube is different from traditional VoD
- Access to YouTube from a campus network
- Influence on content distribution paradigms?
- Correlation between global and local popularity?
- 1 billion views per day (WSJ, July 9th 2008)

Methodology:
- Monitor YouTube traffic at campus gateway
- Obtain global popularity
- Video Clip traffic analysis
- Traffic generation
- Trace-driven simulation for various content distribution approaches
How YouTube Works!

[Diagram of YouTube's infrastructure]

- **YouTube Web server**
- **Monitor box**
- **CDN server** located in YouTube or Limelight network

(1) HTTP Get MSG
(2) HTTP Redirect MSG
(3) HTTP Get MSG
(4) Flash video stream

[Example of (1)]
Get /get_video?video_id=G_Y3y8escmA
HTTP/1.1

[Example of (2)]
HTTP/1.1 303 See other
Location: http://sjc-v110.sjc.youtube.com
/get_video?video_id=G_Y3y8escmA
### YouTube Traffic Traces

<table>
<thead>
<tr>
<th>Trace</th>
<th>Date</th>
<th>Length (Hours)</th>
<th># of Unique Clients</th>
<th>Per Video Stats</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Total</td>
</tr>
<tr>
<td>T1</td>
<td>05/08-05/09</td>
<td>12</td>
<td>2127</td>
<td>12955</td>
</tr>
<tr>
<td>T2</td>
<td>05/22-05/25</td>
<td>72</td>
<td>2480</td>
<td>23515</td>
</tr>
<tr>
<td>T3</td>
<td>06/03-06/07</td>
<td>108</td>
<td>1547</td>
<td>17183</td>
</tr>
<tr>
<td>T4</td>
<td>09/04-09/11</td>
<td>162</td>
<td>7538</td>
<td>82132</td>
</tr>
<tr>
<td>T5</td>
<td>01/29-02/12</td>
<td>336</td>
<td>16336</td>
<td>303331</td>
</tr>
<tr>
<td>T6</td>
<td>03/11-03/18</td>
<td>168</td>
<td>8879</td>
<td>131450</td>
</tr>
</tbody>
</table>
Measurement Results: Hourly Request Rate
Synthetic YouTube Traces

- Overcome limitations of trace-driven simulations
- Investigate scalability of distribution system
- Traces generated based on statistical information

<table>
<thead>
<tr>
<th>Trace</th>
<th>S1</th>
<th>S2</th>
<th>S3</th>
<th>S4</th>
<th>S5</th>
<th>S6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length(hours)</td>
<td>12</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
<td>24</td>
</tr>
<tr>
<td># of unique clients</td>
<td>1553</td>
<td>2520</td>
<td>2734</td>
<td>7051</td>
<td>16184</td>
<td>19776</td>
</tr>
<tr>
<td>Per video stats</td>
<td>Total</td>
<td>25976</td>
<td>20244</td>
<td>8954</td>
<td>27045</td>
<td>57102</td>
</tr>
<tr>
<td>Single</td>
<td>78.1%</td>
<td>79.6%</td>
<td>81.1%</td>
<td>79.0%</td>
<td>71.8%</td>
<td>71.6%</td>
</tr>
<tr>
<td>Multi</td>
<td>21.9%</td>
<td>20.4%</td>
<td>18.9%</td>
<td>21.0%</td>
<td>28.2%</td>
<td>28.4%</td>
</tr>
</tbody>
</table>
Simulation: P2P Caching

- Trace-based simulations
- Simple: only one copy
- Improved: multiple copies
- Availability of clients from traces
- Windows-based availability approach
Simulation: Proxy Caching

- FIFO cache replacement
- Effective low cost solution since storage in the order of 100 GB is required
- Hit rates quite similar for all three traces compared to P2P results
Simulation Results

![Graphs showing hit rate versus cache size for different traces.](image-url)
Lessons Learned

- High-level abstraction sufficient in this case
- Difficult to prevent bugs
- Simulations can be used to “look into the future” based on existing data
MatLab-based Simulation: Radar Placement

- Motivation
- Existing test bed
- Alternatives
Motivation

- Plan to extend existing 4-node test bed
- Multiple options to add 2 more radars in test bed
- Which one is the best solution?
- Looking for a relatively simple way to answer this question

- Note: Answers are only as good as the specified requirements!!
Existing Test Bed
Build Out: Alternative 1

BBH and DEM (m)

8-Radar IP1 Network Beam Height Histogram:
KRSP Elev: 1 degs, Height: 29.9136 ft
KCYR Elev: 1 degs, Height: 54.776 ft
KSAO Elev: 1 degs, Height: 99.9068 ft
KLWE Elev: 1 degs, Height: 40.1144 ft
KNEW Elev: 1 degs, Height: 37.72 ft
KBRN Elev: 1 degs, Height: 37.72 ft
Build Out: Alternative 2

BBH and DEM (m)

6-Radar LP1 Network Beam Height Histogram:
- KRSP Elev: 1 degs, Height: 29.9136 ft
- KCYR Elev: 1 degs, Height: 54.776 ft
- KSAO Elev: 1 degs, Height: 69.8668 ft
- KLWE Elev: 1 degs, Height: 40.1144 ft
- KELR Elev: 1 degs, Height: 37.72 ft
- KBRI Elev: 1 degs, Height: 37.72 ft

Number of Occurrences

Height of Beam (m)
Build Out: Alternative 3

BBH and DEM (m)

- Radar IP1 Network Beam Height Histogram:
  - KRSP Elev: 1 degs, Height: 29,9136 ft
  - KCYR Elev: 1 degs, Height: 54,778 ft
  - KSAO Elev: 1 degs, Height: 59,8468 ft
  - KLIJE Elev: 1 degs, Height: 40,1144 ft
  - KKEB Elev: 1 degs, Height: 37,72 ft
  - KNEW Elev: 1 degs, Height: 37,72 ft

ECE Department
Build Out: Alternative 3

- 44.6% Dual-Doppler Coverage Area (9175 km²)
- 55.4% No Dual-Doppler Coverage Area (11418 km²)
Lessons Learned

- Verify simulation based on information available for existing test bed
- MatLab comes with a large set of additional tools
- Solution that is applicable wherever map information is available
- Easy to extend
- Easy way to determine a series of parameters
ANSOFT-based Simulation: Radar Placement

- Motivation
- Microstrip patch antenna
- Phase-tilt antenna
Advantages:
- E-scan in Azimuth and M-Scan in elevation.
- Dual polarized with good cross-polarization

Limitations:
- Elevation beam width: 3.5 °
- Maximum peak TX power: ~ 60 Watts
Antenna Simulation

A small frequency-scan array antenna composed of 16 microstrip patch antenna elements was designed at 9.6 GHz, using Ansoft Designer, and then tested in a far-field compact range of the antennas laboratory at UMASS.

The elements of the linear array are interconnected by a series feed (microstrip transmission lines) and the width of each patch is defined using a synthesis approach in order to achieve -20dB sidelobe level. The antenna performs an electronic scan of 15 degrees using a range frequency from 9.3-9.9 GHz.

Measured results in the plots shows a good agreements with simulated results using ANSOFT. The mismatch of measured and simulated sidelobes is because of the fact that in the antenna measurement there was no contemplated the a large ground plane.
The phase-tilt antenna is made up of an active linear array and a mechanical actuator; both allow the antenna to perform electronic scanning in azimuth and mechanical scanning in elevation. The linear array is a planar structure of 64x32 elements arranged in 64 columns; each column is made up of 32 dual-polarized microstrip elements interconnected by series-fed networks in each polarization. The column is fed by dedicated T/R modules where phase and amplitude control provides beam steering, azimuth aperture power distribution and desired polarization in the azimuth plane.

Measured results of one column linear array (32 elements) embedded in a planar array (32x18) was performed in a FF compact range. The plots to the right shows a very good agreement of the antenna patterns for H and V with simulated results using ANSOFT.

C-RAM FF-2 is a thin, ferrite filled, silicone rubber sheet stock which has high magnetic loss at UHF and microwave frequencies up to X-band. It is applied to metal surfaces to attenuate RF surface currents. It can be used to modify antenna patterns, lower the Q of a cavity, act as a transmission line attenuator, and modify the radar cross section of targets.

Simulation of this magnetic material can be performed using the Ansoft and HFSS using the Frequency Selective Surface method and a unit cell that represents a specific area of the material. The right plot shows a good agreement between measured results (provided by the Cuming Microwave Corporation) and the simulated results using Ansoft Designer.
Lessons Learned

- Simulations come close to reality
- Still a difference between both
- Some details only revealed through measurements
- Example how simulation can aid the design process
Summary

- Examples of simulations
- From system to component based simulation
- Self-created and tool-based simulations