Effect of Multiple Simultaneous HSDPA Users on HSDPA End-User Performance for Non-Real Time Services in One Cell System

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Contents

Introduction

- Mobile networks evolution:
  - 1G→2G→2.5G→3G→3.5G→*3.99G→4G*
- HSDPA belongs to 3.5G
  - Specified in 3GPP Release 5
- But, why more features like HSDPA?
  - Higher bit rates But why high bit rates?
    - Internet and its services may be one reason
  - Access any time anywhere

Motivation

- HSDPA is a young technology
- Most operators are including HSDPA in their portfolio
- HSDPA is being deployed
- High expectations

Research Problem

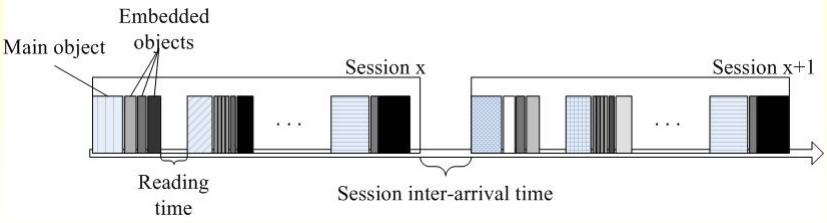
- Few commercial deployed HSDPA networks; thus,
  - How HSDPA technology really behaves?
  - How HSDPA performs?
- No simple tools for HSDPA network planning and dimensioning
- HSDPA algorithms are vendor specific

Solution Method

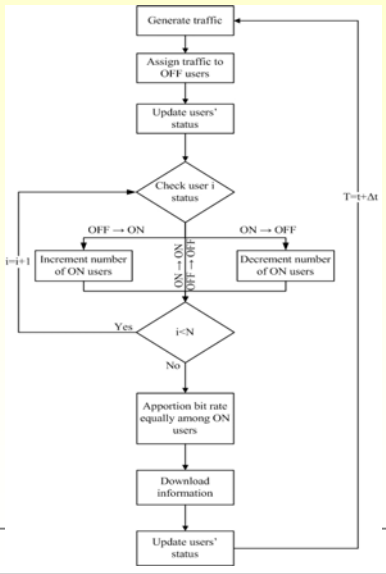
- Build a 'simple' HSDPA simulator
  - Assumptions
    - UEs have same radio conditions in average
    - No software or hardware limitations
      - Unlimited buffers and buffer sizes, unlimited HSDPA power, unlimited number of codes
    - Mean cell throughput indicator of the radio conditions.
    - Web-browsing traffic created according to 3GPP TR 25.892

Solution Method

- Web-browsing traffic



Solution Method: Simulator



Results: Outputs

$$\text{user's session throughput}_{j,k} = \frac{\sum_{i=1}^{n} page\_throughput_{i,j,k}}{n}$$

Mean of all page throughputs within session *j* of UE *k*

$$\text{user's session download time}_{j,k} = \frac{\sum_{i=1}^{n} page\_download\_time_{i,j,k}}{n}$$

Mean of all page download times within session *j* of UE *k*

$$\text{user's mean session throughput}_{k} = \frac{\sum_{j=1}^{m_k} \frac{\sum_{i=1}^{n} page\_throughput_{i,j,k}}{n}}{m_k}$$

Mean of all user's session throughputs for UE *k*

$$\text{user's mean session download time}_{k} = \frac{\sum_{j=1}^{m_k} \frac{\sum_{i=1}^{n} page\_download\_time_{i,j,k}}{n}}{m_k}$$

Mean of all user's session download times for UE *k*

Results: Outputs

$$\text{total mean session throughput} = \frac{\sum_{k=1}^{p} \frac{\sum_{j=1}^{m_k} \frac{\sum_{i=1}^{n} page\_throughput_{i,j,k}}{n}}{m_k}}{p}$$

Mean of all user's mean session throughputs for all UEs

$$\text{total mean session download time} = \frac{\sum_{k=1}^{p} \frac{\sum_{j=1}^{m_k} \frac{\sum_{i=1}^{n} page\_download\_time_{i,j,k}}{n}}{m_k}}{p}$$

Mean of all user's mean session download times for all UE

$p \equiv$ maximum number of UEs

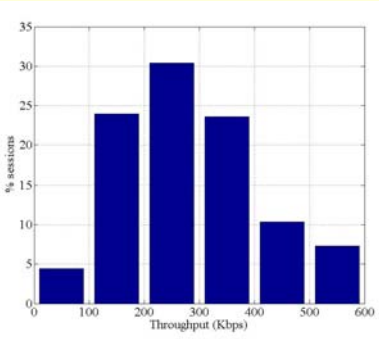
$m_k \equiv$ number of sessions of UE_k

$n \equiv$ number of pages in the session m_j of the UE_k

$page\_download\_time_{i,j,k} \equiv$ download time of page i of session m_j of UE_k

Results: Maximum number of UEs

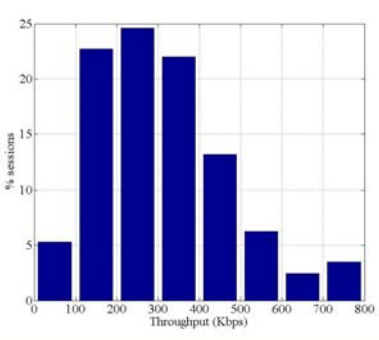
- Mean cell throughput
  - 600 Kbps
- Max UEs
  - 42
- User's mean session throughput
  - 200 – 300 Kbps
- Total mean session throughput
  - 286 Kbps
- Total mean session download time
  - 1.70 seconds



User's session throughput distribution

Results: Maximum number of UEs

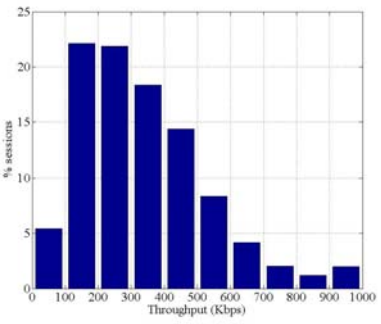
- Mean cell throughput
  - 800 Kbps
- Max UEs
  - 62
- User's mean session throughput
  - 300 – 400 Kbps
- Total mean session throughput
  - 312 Kbps
- Total mean session download time
  - 1.71 seconds



User's session throughput distribution

Results: Maximum number of UEs

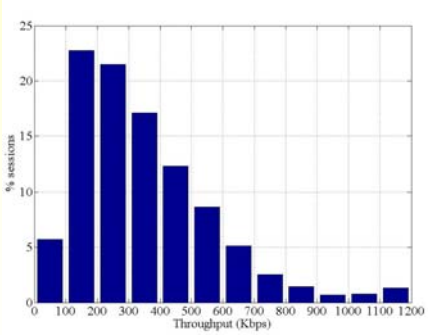
- Mean cell throughput
  - 1 Mbps
- Max UEs
  - 81
- User's mean session throughput
  - 300 – 400 Kbps
- Total mean session throughput
  - 338 Kbps
- Total mean session download time
  - 1.68 seconds



User's session throughput distribution

Results: Maximum number of UEs

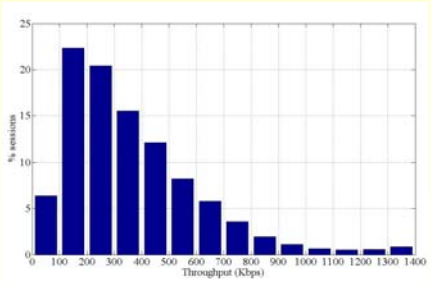
- Mean cell throughput
  - 1.2 Mbps
- Max UEs
  - 101
- User's mean session throughput
  - 300 – 400 Kbps
- Total mean session throughput
  - 349 Kbps
- Total mean session download time
  - 1.70 seconds



User's session throughput distribution

Results: Maximum number of UEs

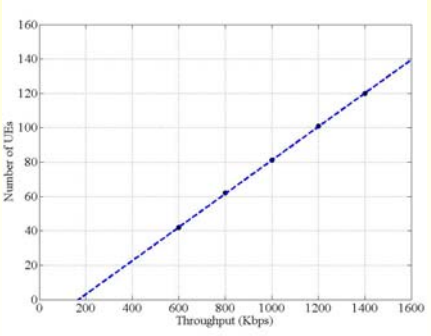
- Mean cell throughput
  - 1.4 Mbps
- Max UEs
  - 120
- User's mean session throughput
  - 300 – 400 Kbps
- Total mean session throughput
  - 365 Kbps
- Total mean session download time
  - 1.70 seconds



User's session throughput distribution

Results: Maximum number of UEs

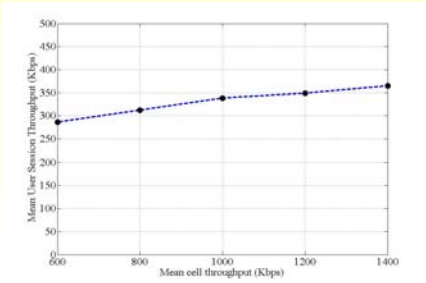
- Iteration Threshold:
  - 90 % of sessions of 90 % of the users have to have a user's session download time below 4 seconds
- Linear shape



Mean cell throughput vs. number of UEs

Results: Maximum number of UEs

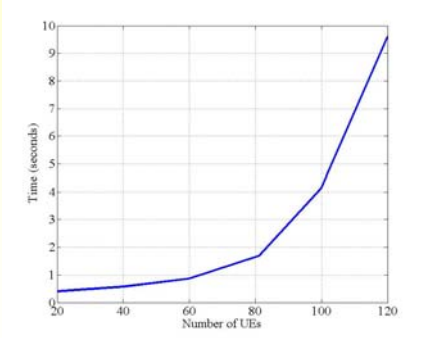
- QoE slightly improves whether mean cell throughput increases
- Needs to be checked in real networks



Mean cell throughput vs. total mean session throughput

Results: Effect of number of UEs

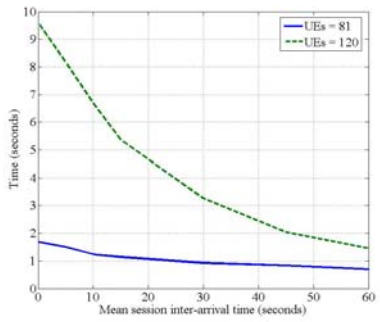
- Mean cell throughput constant to 1 Mbps
- Max. number of UEs was 81
- Exponential shape



Total mean session download time vs. number of UEs

Results: Effect of session inter-arrival time

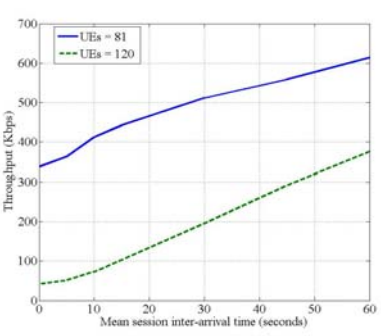
- Mean cell throughput constant to 1 Mbps
- When arrival time=0 & UE=81, 81 % of sessions had a user's session download time < 4 seconds
- When λ=1/60 & UE=81, 99 % of sessions had a user's session download time < 4 seconds
- When arrival time=0 & UE=120, ~52 % of sessions had a user's session download time < 4 seconds
- When λ=1/60 & UE=120, 92 % of sessions had a user's session download time < 4 seconds



Total mean session download time for different mean session inter-arrival times

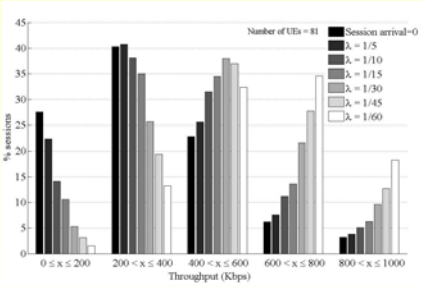
Results: Effect of session inter-arrival time

- When arrival time=0 & UE=81, 90 % of sessions had a user's session throughput below 600 Kbps
- When λ=1/60 & UE=81, ~50 % of sessions had a user's session throughput below 600 Kbps
- When arrival time=0 & UE=120, 99 % of sessions had a user's session throughput below 200 Kbps
- When λ=1/60 & UE=120, 20 % of sessions had a user's session throughput below 200 Kbps

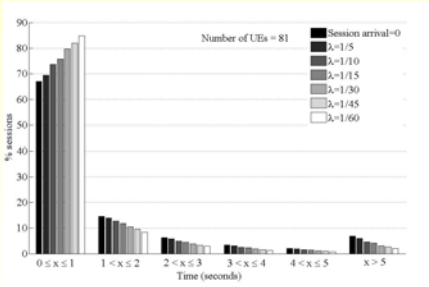


Total mean session throughput for different mean session inter-arrival times

Results: Effect of session inter-arrival time

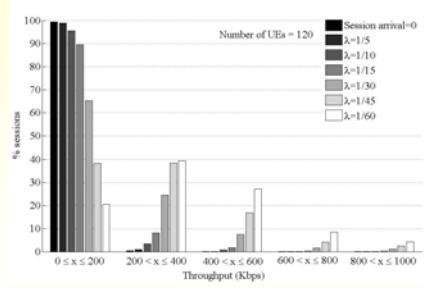


User's session throughput histograms for different λ

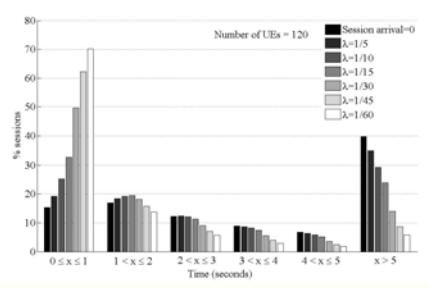


User's session download time histograms for different λ

Results: Effect of session inter-arrival time



User's session throughput histograms for different λ



User's session download time histograms for different λ

Conclusions

- HSDPA seems to perform very well for web browsing traffic
- Hardware and software seems to be a bigger constraint
  - Power limitations, admission limitations, timers, counters, etc.
- Need to keep UEs below the maximum level; otherwise, QoS/QoE is not controllable
- Admission control algorithms will play an important role.
- Mean session inter-arrival time is a rather critical parameter which need to be fine-tuned by operators in order to optimize their networks

Summary

- HSDPA origins
- HSDPA motivation
- What was the problem?
- How we solved it?
- Which were the results?
  - Max. number of simultaneous HSDPA users
  - Effect of the number of HSDPA users
  - Effect of the mean session inter-arrival time
- Conclusions

Questions