Simple and Scalable Handoff Prioritization in Wireless Mobile Networks

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Outline

- Motivation: Quality of Service in wireless mobile networks
- Basics on handoff prioritization
- Requirements: Scalability, easy administration,...
- SiS-HoP: Simple and scalable handoff prioritization
- Simulation results
Quality of Service in IP-based Mobile Networks

- Advantages of IP-based wireless mobile networks:
  - Support for applications with variable bit rates
    - e.g., WWW browsing, video streaming
  - Higher resource utilization

- Problem: Quality of Service (QoS) support necessary
  - Mobile telephony, streaming, games,...

Mobile-specific problem: Handoff drop
Well-known Approach: Handoff Prioritization

- **Resource reservation for handoff resource requests**
  - Based on mobility prediction

- **Early blocking of new session request**
  - Admission control

**Compromise:**

*Less handoff drops vs. high resource utilization*

- Handoff resource reservation
- Modified admission control
Requirements on Handoff Prioritization

- **Robustness**: The IP paradigm
  - Error tolerance in case of failure of a single system
  - Decentralized approach on each base station

- **Easy administration**:
  - Network configuration already highly complex for provider

- **Adaptivity**:
  - High performance for different mobility patterns:
    - High / low mobility
    - High / low speed
    - Directional / random mobility

- **Scalability**: The Differentiated Services paradigm
  - No per-flow state information/signaling in the network
Available Approaches for Handoff Prioritization

- Analysis of > 30 existing approaches

- Problems:
  - Limited to few mobility scenarios (low mobility, large cells)
  - Low scalability because of per-flow state keeping
  - Complex configuration
  - Errors in evaluating the approaches

- No approach fulfills requirements sufficiently
SiS-HoP: Simple and Scalable Handoff Prioritization

- Focus on the most probable bottleneck links

Scope of SiS-HoP:
- Internet
- Gateway
- Backbone
- Base station
- Last wired mile
- Cell
- Mobile terminal
SiS-HoP: Mobility Prediction

- Aggregated prediction per cell
  - Variant 1: Based on destination cell
  - Variant 2: Normalized version of variant 1

- History cache with limited size
  - On each base station

- Example for cell A, variant 1:
  - 5 handoff to B, 3 to C, 1 to D, 3 to E, 0 to F, 5 to G, 3 session terminations:
    - Sum: 20 entries in history cache
  - Handoff probabilities:
    - 25%→B, 15%→C, 5%→D, 15%→E, 0%→F, 25%→G
    - Sum: < 100% because of session terminations
Aggregated resource reservation in neighboring cells

- Considering the handoff probabilities
- Considering the current resource utilization

Signaling between neighboring cells

- Periodical

Example (cont.):

- Handoff probability A→B: 25%
- Cell A reserves 25% of currently utilized resources in cell B
SiS-HoP: Admission Control

Resource request from new session admitted only:
- If resource available in local cell
- If weighted amount of resources available in neighboring cell
- Weights: handoff probabilities

Periodical signaling: Resource utilization

Example (cont.):
- Admitting new session request only:
  - if requested resources available in cell A
  - if 25% of resource request available in cell B
SiS-HoP: Design Parameter CUR

- SiS-HoP: Conservative Approach
  - Low handoff drop probability
  - Low resource utilization because of high handoff reservation

- Improvement: Controlled Under-Reservation (CUR)
  - Reduction of reservation to $<\text{CUR}>\%$
  - Similar to reservations in airline reservation systems
  - Assumption: handoff reservation not completed used

- Enhancing resource utilization

- but: Handoff drop probability may increase!
Simulation SiS-HoP: Scenarios

Random mobility

Directional mobility

- 80-95%
- 5%
- 33%-50%
- 1%
<table>
<thead>
<tr>
<th>Approach</th>
<th>Handoff resource reservation</th>
<th>Admission control</th>
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<tbody>
<tr>
<td>NOPRIO</td>
<td>none</td>
<td>local</td>
</tr>
<tr>
<td>STATLAC</td>
<td>static</td>
<td>local</td>
</tr>
<tr>
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<td>static</td>
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<tr>
<td>LEPDAC</td>
<td>load-dependent</td>
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<tr>
<td>OPT</td>
<td>optimal</td>
<td>distributed (all cells)</td>
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</table>
Example 1: Scenario with highly directional mobility

Result: No handoff drops in SiS-HoP
Results SiS-HoP: Directional Mobility II

- Drawback: Higher number of new session requests blocked
Results: Random + Low Mobility

- LEP-DAC + SiS-HoP: No handoff drops
- SiS-HoP: less new session blocks

Graph showing blocking rate vs. offered load for different prioritization schemes.
Results: Easy Administration

- Performance improvement:
  - Less amount of new session blocking
Drawback: Handoff drop at high loads

Robustness: Smooth change of the handoff drop rate
SiS-HoP: Conclusions

- All three components
  - robust (no additional per-flow state information)
  - adaptive to different mobility patterns
  - scalable (no additional per-flow state information)
  - simple to configure (cache size, signaling period, CUR)
  - incrementally deployable (bottleneck link)
SiS-HoP: Conclusions (cont.)

- Compared to less complex approaches:
  - Less handoff drops or
  - More new session requests admitted

- But: Resource utilization can be improved
  - Further component of my Ph.D. thesis: MoDiQ service model
Thank you for your attention!

Questions?