Simulation-based Optimization of Signaling Procedures in IP Multimedia Subsystem

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Introduction
Introduction

- **IP Multimedia Subsystem (IMS)**
  - Logical architecture for a Next Generation Network (NGN) control plane
  - Supports a development of next generation services
  - Faces a challenge of rapidly increasing amount of signaling

- **Call Session Control Function (CSCF)**
  - Manages much of the signaling that occurs in the IMS
  - Configured to process SIP messages using a FIFO scheduling

- **First In First Out (FIFO)**
  - Does not enable
    - SIP messages that increase the efficiency of IMS to be processed earlier
    - Service differentiation because all SIP messages are treated equally
    - Prevention of SIP messages to loopback through one or more CSCFs
Research Motive

● Motive
  ● Need for a differentiated handling of SIP messages in order to optimize SIP signaling procedures

● Previous work
  ● Proposal of SIP message classification and prioritization algorithm
    ● Class 1: SIP messages that terminate the communication session, such as BYE, CANCEL
    ● Class 2: Light weight SIP messages such as REGISTER, MESSAGE, PUBLISH, NOTIFY and SUBSCRIBE
    ● Class 3: SIP messages that establish the communication session, such as INVITE, and provisional responses, such as 1xx status codes
Research Aim

- **Aim**
  - Implement SIP message classification and prioritization algorithm in Network Simulator version 2 (ns-2)
  - Analyze an impact of proposed algorithm on SIP performance metrics
    - Registration Request Delay, Session Request Delay, Session Disconnect Delay
  - Perform the simulation-based optimization of SIP signaling procedures
    - Under high-load or overload conditions

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Related Work

1. Introduction
2. Related Work
3. Algorithm for SIP Message Classification and Prioritization
4. Simulation-based Optimization of Signaling Procedures
5. Results and Discussion
6. Conclusion and Future Work
Related Work

- SIP server overload control
  - Load balancing approach
    - Tries to avoid the overload by distributing the traffic load equally among the local SIP servers
  - Load reducing approach
    - Tries to prevent the overload collapse by reducing the traffic load in the whole SIP network
      - Priority-based
      - Push-back
      - Retransmission-based

- Focus is based on priority-based overload control
  - Mitigate overload by rejecting the SIP messages with low priority
  - Prioritization is performed by using different SIP message header fields
Algorithm Description

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Informal Algorithm Description

- SIP message classification and prioritization algorithm
  - Two modes of operation:
    - Normal mode, wherein the SIP messages are processed using FIFO scheduling
    - Priority mode, wherein the SIP messages are processed by our three-priority level classification scheme
  - Normal mode of operation is switched to the priority mode when congestion is detected
    - Congestion is determined by exceeding the predefined queue length
  - Priority mode of operation implies the packet’s content check and classification according to SIP message type
Formal Algorithm Description

Pseudocode 1 SIP message classification and prioritization

Algorithm SIPMsgClassPrio
receive packet
IF congestion status is true THEN
CASE msgType inside packet OF
CASE reqMethod OF
SM_BYE : set high priority
SM_ACK : set medium priority
SM_CANCEL : set low priority
SM_INVITE : set high priority
OTHERS : set medium priority
ENDCASE
CASE rspCode OF
IF rspCode >= 100 AND rspCode < 200 THEN set low priority
ELSE IF rspCode >= 200 AND rspCode < 300 THEN set high priority
ELSE IF rspCode >= 300 AND rspCode < 700 THEN set medium priority
ELSE set low priority
ENDIF
ENDCASE
ENDCASE
ELSE enqueue packet
ENDIF
send packet to node
END SIPMsgClassPrio
Simulation Environment

- Simulation environment for SIP message classification and prioritization algorithm
  - Different simulators are compared
    - ns-2, ns-3, OPNET, OMNET++, QualNet
  - Comparison in terms of
    - Modelling capabilities
    - Credibility of simulation models and results
    - Extendibility
    - Usability
    - Cost of licenses
  - Simulator ns-2 is chosen (version 2.27)
    - Free and open-source simulator
    - Provides IMS functionality by adding an independently developed SIP module
      - SIP proxy server incorporate the functionality of CSCF
Simulation Setup

- Different number of SIP messages exchanged during SIP signaling procedures
  - Three types of SIP signaling procedures considered: registration, establishment and termination of session
- Simultaneous SIP signaling procedures are used to generate background traffic
  - Number of simultaneous SIP signaling procedures is in the range from 0 to 900
- Simulations are run for 500 simulations seconds
Results and Discussion

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Simulation results

- SIP performance metrics
  - Registration Request Delay
  - Session Request Delay
  - Session Disconnect Delay

- Defined in RFC 6076
Discussion

● Priority mode of operation
  ● High priority value
    ● SIP messages to terminate the session
      ● Improve QoS, e.g., reduce duration of session termination procedure
      ● Improve QoE, e.g., improve billing user experience
  ● Low priority value
    ● SIP messages to establish the session
      ● Improve QoS, e.g., block a new communication sessions
      ● Improve QoE, e.g., users do not accept service degradation or interruption
Conclusion and Future Work

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Conclusion

- SIP message classification and prioritization scheme is implemented in ns-2
- Simulation-based optimization of SIP signaling procedures is performed
  - Simulation results are analyzed in terms of RRD, SRD, SDD
  - Assigning high priority value to SIP messages that terminate existing sessions may reduce network congestion and improve QoS
  - Assigning low priority value to SIP messages that establish a new session may improve QoE
Future Work

- Development and deployment of algorithm for SIP message classification and prioritization in **experimental environment**
- Three-priority level classification of SIP messages
  - Enables the prioritization of different types of services
    - Useful in emergency situations
      - All SIP messages of one type of service (e.g., instant messaging) may be prioritized over all SIP messages of another type of service (i.e., voice calls)
  - This could not be simulated due to the limitations of used SIP module
  - This will be tested in experimental environment in future research activities
Thank you for attention.

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