Supporting QoS Aware Data Delivery in Information Centric Networks

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Introduction

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- Number of studies on an optimal and efficient routing of Interest requests have been published
- So far, QoS related discussions in ICN is mainly centered around forwarding of Interest request
  - A very little discussion is provided on how to implement and enforced the QoS on the Data packet path
- It is imperative for the service providers (Cisco VNI 2016-2021) to meet the quality of service (QoS) demands to provide a better quality of experience to their users
  - QoS handling in ICN is still an open research topic and we are proposing an approach to achieve it
- We provide a rational for QoS in ICN, propose an approach and changes in ICN protocol to support DiffServ based QoS mechanism

Draft Outline

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Table of Contents

Prior Work on QoS in ICN

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- M.F. Al-Naday et.al. attribute the scalability limitation of IP based QoS model to its lack of information awareness, which can be resolved in an ICN like network
  - Propose using the QoS aware name prefixes; however, it puts a limitations on third parties in defining an alternative QoS enforcement mechanisms
- Weibo Chu et.al. present a QoS model based on the popularity ranking of the content and its placement/location in the network
  - Classify content into three categories - locally cached, remotely cached, and un-cached contents
  - Network delay is modeled as a function of the distance of the content from the requester
- Xingwei Wang et.al. present a QoS mechanism applicable to the routing of Interest requests
  - Decide the suitability of the forwarding link to make the process more energy efficient
- Christos et.al. argue about need for a differentiated routing and forwarding mechanisms
  - Use the name of the content as well as specify the nature of the traffic
  - Traffic differentiation is better handled at the network level

QoS related discussions are mainly focused on the forwarding of the Interest requests

QoS – An Opportunity in ICN

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- ICN provides flexibility in forwarding the Interest traffic on to multiple next hops; however, Data packets are always forwarded on the Interface recorded in the PIT
  - A contention for transferring Data packets serving multiple content on the same interface
  - Forwarding of Data packet traffic also becomes the problem of scheduling of traffic
  - Also, very nature of type of traffic requires a differentiated traffic handling to ensure QoS
- Newer ICN deployment scenarios provide further opportunity and requirements for extending ICN specific QoS (*all three are current/active Internet-Drafts*)
  - Native deployment of ICN in 4G/LTE networks
  - ICN based extensions to 5G control and user plane
  - Hybrid ICN (hICN) and its use in management of mobility in 5G networks
- Variety of QoS classes for different networks
  - IP based differentiated services code points (DSCP)
  - QoS Class Identifiers (QCI) used in 4G mobile networks
  - Flows based QoS Identifiers (QoS Flow Identifier – QFI) used in 5G mobile networks

Supporting QoS in ICN

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- The per-hop behavior (PHB) design of DiffServ QoS model makes it a natural choice for implementation of QoS in hop-by-hop based CCN/NDN network
- QoS DSCP codes required to be encoded in Data messages to achieve differentiated packet processing required for Data traffic handling
- DSCP codes are encoded in to Interest packet at the consumer end
  - CCN/NDN router (or origin server/producer) locating the content copies DSCP code into Data message
- Each router on the Data packet path use DSCP codes to enforce the PHB QoS behavior

Supporting QoS CCNx Message

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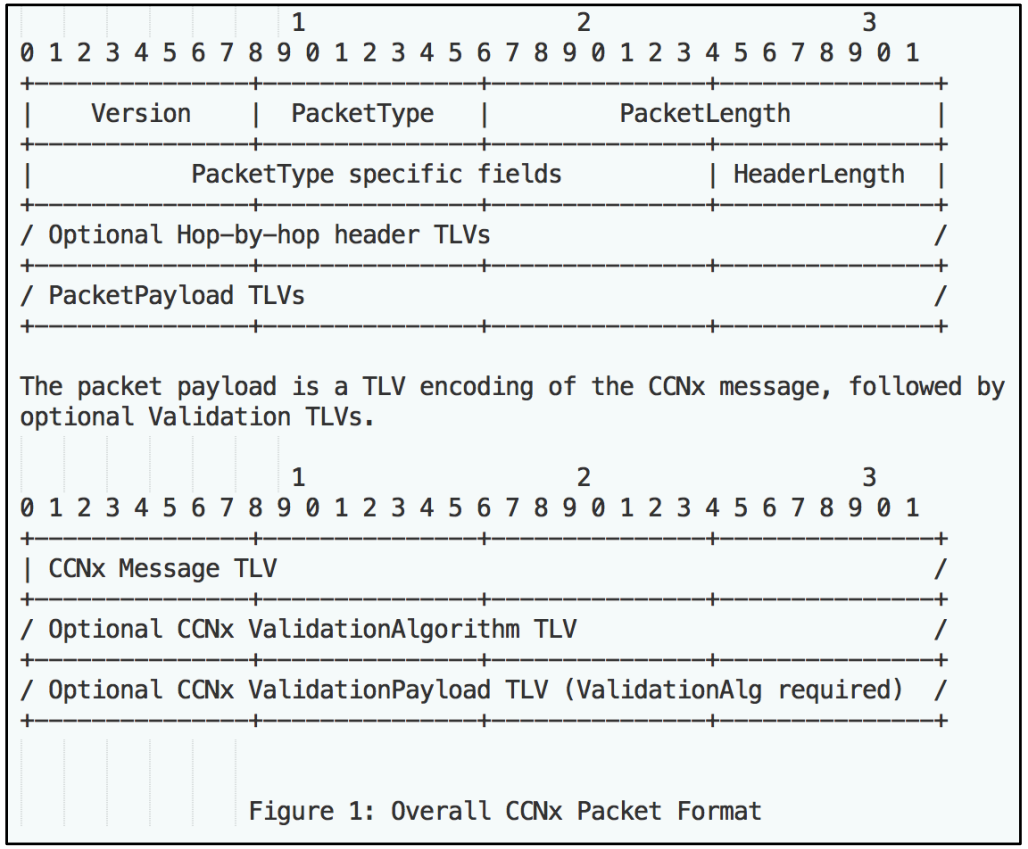

Figure 1: Overall CCNx Packet Format

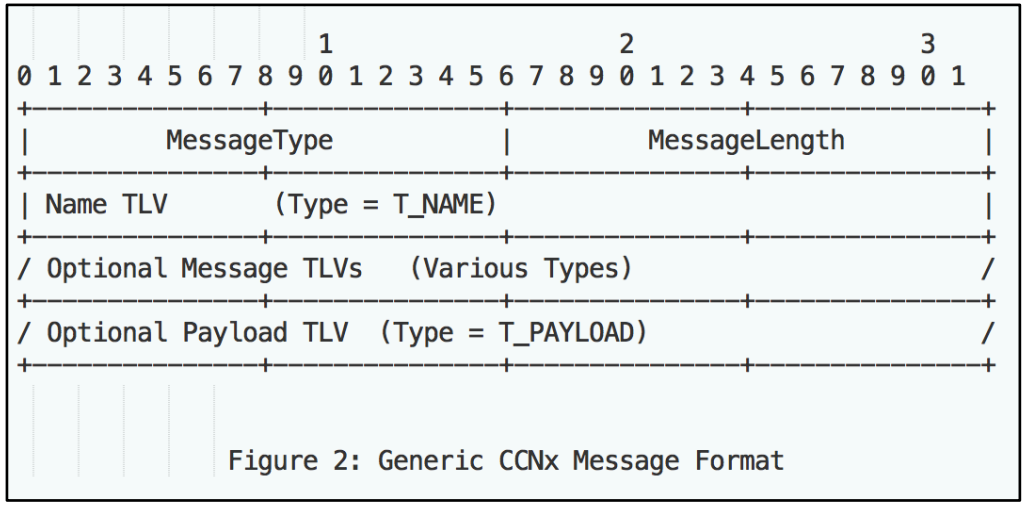

Figure 2: Generic CCNx Message Format

DiffServ Fields Message TLV

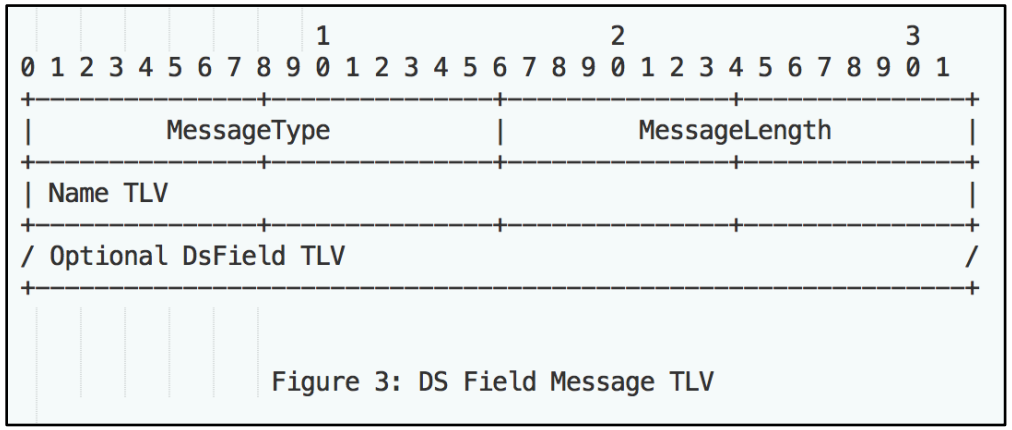

Figure 3: DS Field Message TLV

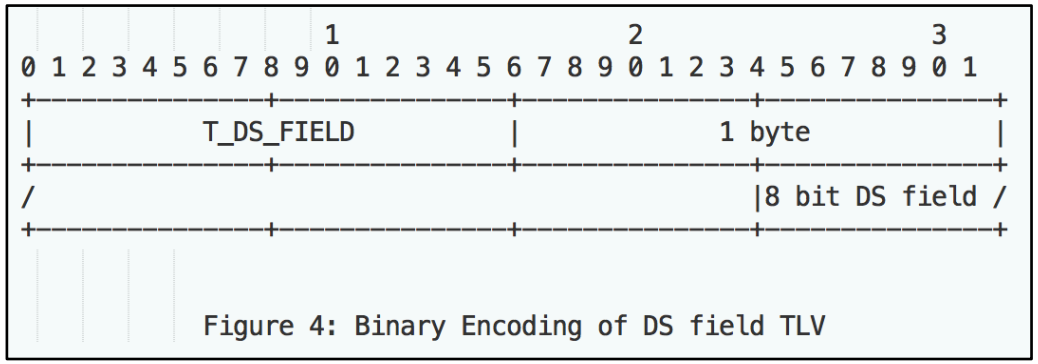

Figure 4: Binary Encoding of DS field TLV

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Modified Interest & Content TLV

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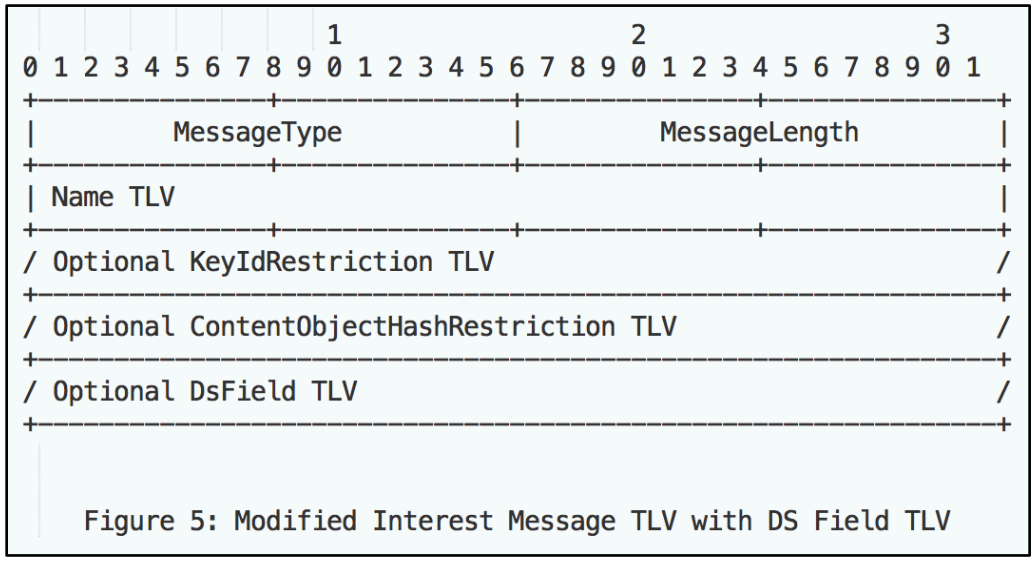

Figure 5: Modified Interest Message TLV with DS Field TLV

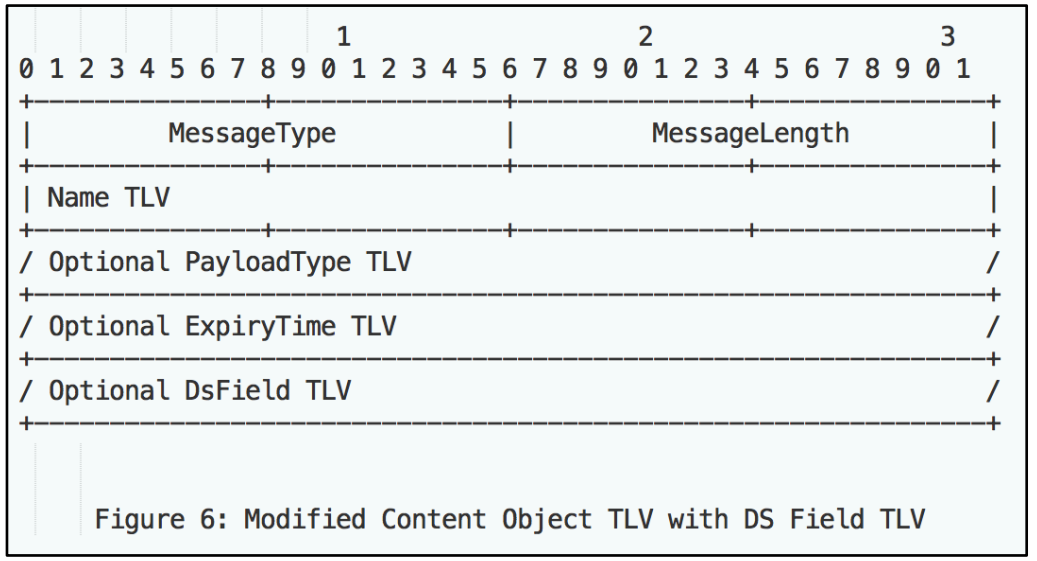

Figure 6: Modified Content Object TLV with DS Field TLV

- As Interest packet travel multiple hops until the requested content it found, we propose to add a new optional DsField TLV in the CCNx Interest message.
- The DsField TLV shall be copied over from the Interest message into the Content Object TLV

Evaluation Approach

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- A tentative progression of the verification step is given below
  - Implement and test the protocol changes through simulation using ndnSIM NDN simulator
  - Based on the learning and insight from the simulation study, we plan to implement a real application setup using [VICN] platform

Summary

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- A prior art study provides a scope for implementing QoS in ICN network
- We presented how DiffServ based QoS mechanism can be used in ICN (CCN/NDN) network
  - Presented changes in CCNx protocol to support differentiated services code point (DSCP)
- Compatibility between the two architectures stem from the fact that both these architectures work on hop-by-hop basis
- More study and investigation required to understand applicability in other ICN based network adoptions, such as 4G, 5G mobile networks and hICN based networks
- Security related aspects need further elaboration not only in the context of DifffServ framework, but also from the perspective of 4G and 5G mobile networks

Thank you!

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- We look forward to further comments and suggestions for improvements
- Thank you for your continued support and valuable feedback