CCN/NDN Protocol Wire Format and Functionality Considerations

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Agenda

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- Wire Packet Considerations
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  - Elastic TLVs
  - Forwarding Target
  - Non-Shareable Content
  - Context Handling
  - Interest Notification
- Header Compression
- Selectors Usage
- Caching as a service
- Packet Formats
- Summary

Motivation

- TLV discussions are primarily considering performance requirements.
- Future Internet Architecture has to accommodate other requirements too.
  - Flexibility
  - Scalability
  - Expressiveness

  which needs support at the wire format level
- Following are some of these requirements for future considerations.

Flexible TLV Schema(s)

- "One TLV to rule them all" is bad. Need support for a multiplicity of TLV schemas:
  - one (or few) TLV format for the fixed header
  - potentially many TLV flavors in the option fields and payload
    (policies might restrict what a net accepts, but the functionality is very useful)
- Examples:
  - To support Backward Compatibility and Service Expressiveness
  - forward a CCNx2.0 payload through a CCNx1.0 net
  - forward a NFN thunk [1] representation through CCNx1.0
  - Service composition [2]
- Relies on a generalized "name-to-forward-on" schema,
  see the "forwarding target ptr" slide later on
- **Requires sufficient Type space in Interest/Data Global Header.**
- In ccn-lite v0.2.0 and its multiprotocol support, a "switch code sequence":
  [0x80, NDNENC(schemaID)] (bytes according to schemaID….)

[1]Minolakis Sifalakis, Basil Kohler et al, "An Information Centric Network for Computing the Distribution of Computations", ICN, Siggcomm, 2014.
[2] Peyman Talebifard, Ravi Ravindran et al "Towards a Context Adaptive ICN based Service Centric Framework", Qshine, Q-ICN, 2014.

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Elastic TLV for CCN

Variable “Length” definition to accommodate heterogeneous application/device/interface-capability contexts e.g. Optical, IoT

- One possibility to support large Content Payloads

T= 2B	Flag Bits (K=2b)	L= 14 bits

(00) B/Unit-Size
(01) KB/Unit-Size
(10) MB/Unit-Size
(11) GB/Unit-Size

- The proposal keeps it simple, in terms of limiting over head to 2/2 Type and Length, while using two bits to determine granularity of the payload.

- The selection of the *per-unit* resolution can be chosen by the application, based on the feedback from ICN forwarding layer, based on strategic path level feedback.

Identifying the Length Format to Support Elastic Payload

- Typical format of “k+L”:
  - 2^k represents the number of size-level’s,
  - 2^k represents the matching size
- “2+14” enables 4 size-levels with 2^14 of each component size
- How do we assign the size-level’s?
  - Overlapping, as in, B, KB, MB, GB, or
  - Non-overlapping, as in, B, *x*KB, *y*MB, *z*GB (e.g., *x*=16, *y*=256, *z*=4096)

Forwarding Target (a.k.a Locator)

- Allow **Interest forwarding** to operate on something **other** than the Interest name proper (which nevertheless stays in the packet)
- Alternate targes can be an ICN Name, or Flat Label, or …
  – /huawei/g.q/phone → /att/sc/ap-x [1]
  – alternate name or flat label for mobility mechanisms like Kite [2]
- Supports mobility, late-binding, or other application-centric requirements.
- **Proposal: store target bits as Optional TLVs ("forwarding labels"), add a pointer ("forwarding target"). FL-flag indicates their presence**
- **The pointer field in the hop-by-hop hdr selects which label is the target**
  `T={Forwarding-Target} L=sizeof(offset) V=offset-of-"FT-Bytes"`
- The Header-Len field is still used to access the Name-TLV (if FL-flag clear). Packet layout:

Header [FL-Flag]	Header-len	Forwarding-Target-Bytes (Optional TLV)	Forwarding Label (Optional TLV)	Interest/Data Message TLV	Interest Payload

[1] Aytac Azgin, Ravi Ravindran, G.Q.Wang, "Scalable Mobility-Centric Architecture for Named data Networking", IEEE, CCNC (SCENE Workshop), 2014
[2] Yu Zhang, Hongli Zhang, Lixia Zhang , "Kite: A Mobility Scheme for NDN", ICN Siggcomm, 2014

Shareable versus Non-Shareable

- Non-Shareable content (e.g. conversational, transactional) can be on fast path without PIT/CS processing.
  - As communication is bi-directional
  - Include both Source/Destination Names
- **As a new type of Interest/Data PDU**

Global Header (New Interest Type)	Interest/Data Message	<Source-Name>	<Destination-Name>

Ravi Ravindran, Asit Chakraborti, Xinwen Zhang, G.Q.Wang, “Supporting Dual Mode Forwarding in Content Centric Networking” IEEE, ANTS, 2011

Context Handling

- Provision to include context metadata that can be processed in the Network Layer.
  - Contexts includes Identity/Location/Device etc.
  - Attachment to a Service Instance
  - Discovering Content/Services
  - Policy based Routing/Forwarding
  - **Optional Interest TLVs**

Global Header	Interest/Data Message TLV	Interest Name	<Optional Context Metadata>

Interest Notification/Action

- Enable to Notify/Actions using Interest payload, e.g. IoT applications
- Distinguished by a new Interest Type.
- Bypass the PIT Processing, potentially new strategy forwarding rules (Notification Multicast)
- Name components can be **label**=*value* type.
- Could be handled in a special way by the network
  - E.g. also piggyback, a cacheable object with the Interest Notification.
- **New type of Interest Packet**

Fixed Header Type = Int. Not.	**Type= Int. Not.**	Interest Name	<Cacheable Object>

Sugang Li, Yanyong Zhang, Deepankar Raychaudhuri, Ravi Ravindran, "**An Evaluation on ICN based IoT Architectures**" , ICN-QSHINE, 2014

Using Selectors

- Should be a Protocol Feature that can be optionally enabled
  - Implication on the PIT design
- Selectors can be avoided in the network infrastructure with authoritative sources exist.
- Selectors are useful where authoritative source doesn’t exist, and learning from cache or source is the only option.
  - Discovery Services, Inventory in Home, Campus etc.
  - Ad hoc V2V, IoT scenarios, Pub/Sub case

Header Compression

- Hooks for header compression, especially for names. But *encoding context switching* could also be used for type dictionaries as in ccnb.
- Examples:
  - Ask downstream node to accept “name abbreviations”. The name mappings would be stored in a “context”, hence the need for a “contextID” field in the fixed header.
  - IoT setting: use a 1+1 TLV schema internally, the gateway will expand it to 2+2 for the rest of the world.
- Remember MNP5 from modem times[1], TCP header compression, UDP ROHC [2], and 6LoWPAN.

[1] http://en.wikipedia.org/wiki/Microcom_Networking_Protocol
[2] RFC 1144, RFC 2058, RFC 4019 (Robust Header Compression)

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Caching as a Service

- CCN/NDN domains may not have any caching at all.
- Or domains could enable caching/storage only at the edges.
- PARC document [1] on distributing PIT/CS/FIB functionality.
- Flexibility of handling different type of Interest/Data PDU – Sufficient global header Type space.

[1]http://www.ccnx.org/pubs/hhg/5.1%20CCNx%201.0%20Implications%20for%20Router%20Design.pdf

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Proposed Packet Format

Interest/Data Type Space

- Motivated by different type of forwarding processing.

Interest

- Interest
- Interest-Notification
- Interest-Conversational

Data

- Data
- Data-Conversational

- CCNx1.0 Interest/Data PDU is used as a reference for the proposal.
- Definition of Payload-Len/Header Len follows CCNx1.0.

Basic TLV Design

Elastic TLV for Content Payload

T= 2B	Flag Bits (2b)	L* = 14 bits

(00) B/Unit-Size
(01) KB/Unit-Size
(10) MB/Unit-Size
(11) GB/Unit-Size

For all other TLV Except Content Object TLV

T= 2B	L = 2B

- We use the Elastic TLV structure in our proposal for the Content Payload.
- For the rest we use the 2/2 based TLV format.

Interest PDU

<table>
<tr><td>Version (1B)</td><td>Packet Type = Interest (1B)</td><td>Pay Load* Length (2B)</td><td>Reserved (2B)</td><td>Header Length (2B)</td><td>Fixed Header (8B)</td></tr>
<tr><td colspan="5"><Optional Forwarding Target Pointer TLV ></td><td rowspan="3">Optional Headers</td></tr>
<tr><td colspan="5">< Optional Forwarding Label ></td></tr>
<tr><td colspan="5">< Optional headers></td></tr>
<tr><td colspan="2">Message Type = Interest</td><td colspan="3">Message Length* (2B)</td><td rowspan="2">Interest Message</td></tr>
<tr><td colspan="5">Name TLV</td></tr>
<tr><td colspan="5">< Metadata TLV > (Selectors/Context TLV)</td><td>MetaData Payload</td></tr>
<tr><td colspan="5">Security TLV</td><td>Security Payload</td></tr>
</table>

- 1B Type should be sufficient to different forms of Interest Payloads.
- 2B of Payload length should be enough to accommodate all the metadata fields related to Forwarding Target TLV, Context TLV etc.

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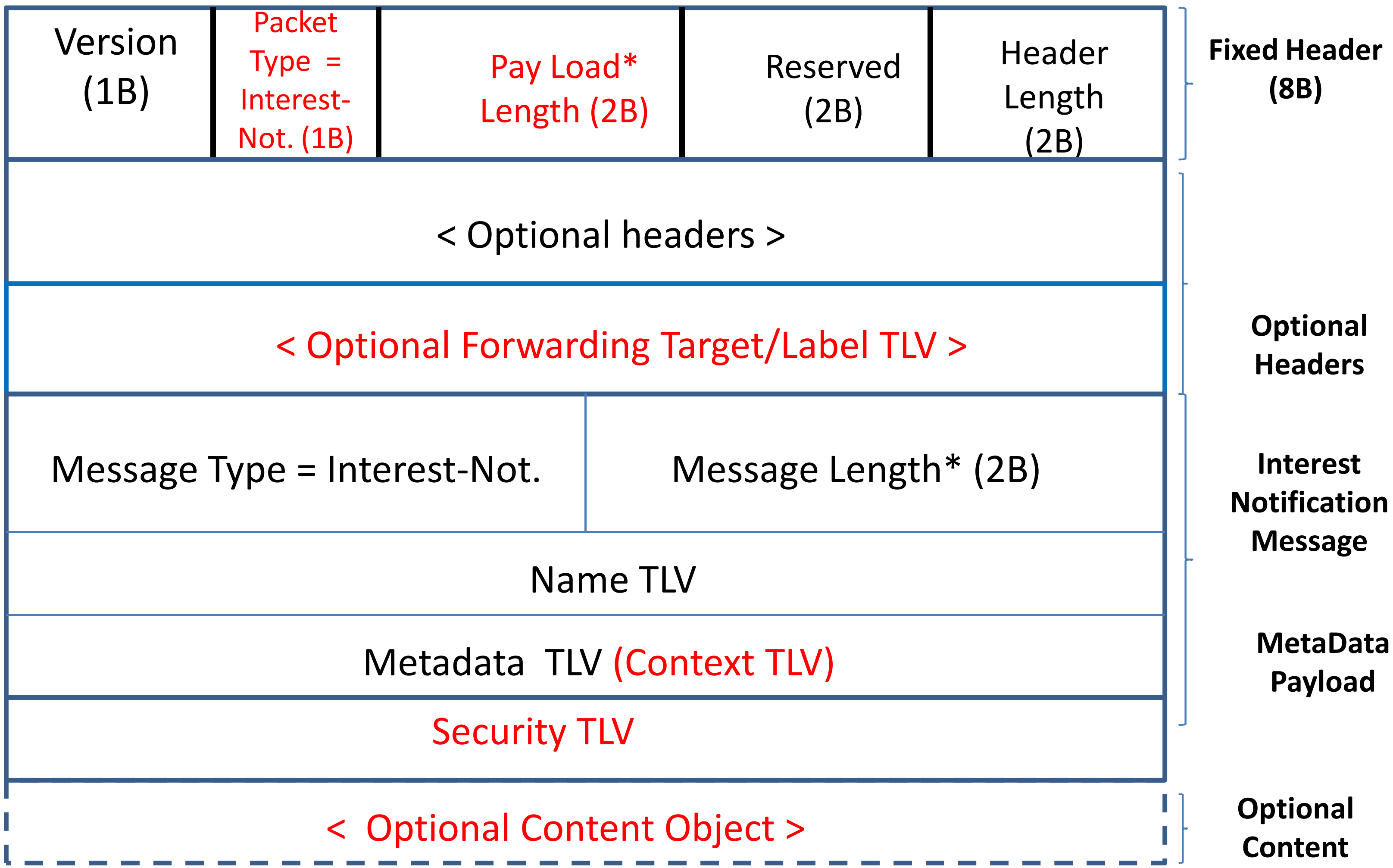
Interest-Notification



- This would be a different Interest Type.
- Optional Forwarding Target is still applicable
- Following the Interest Not. message could be a cacheable content object.

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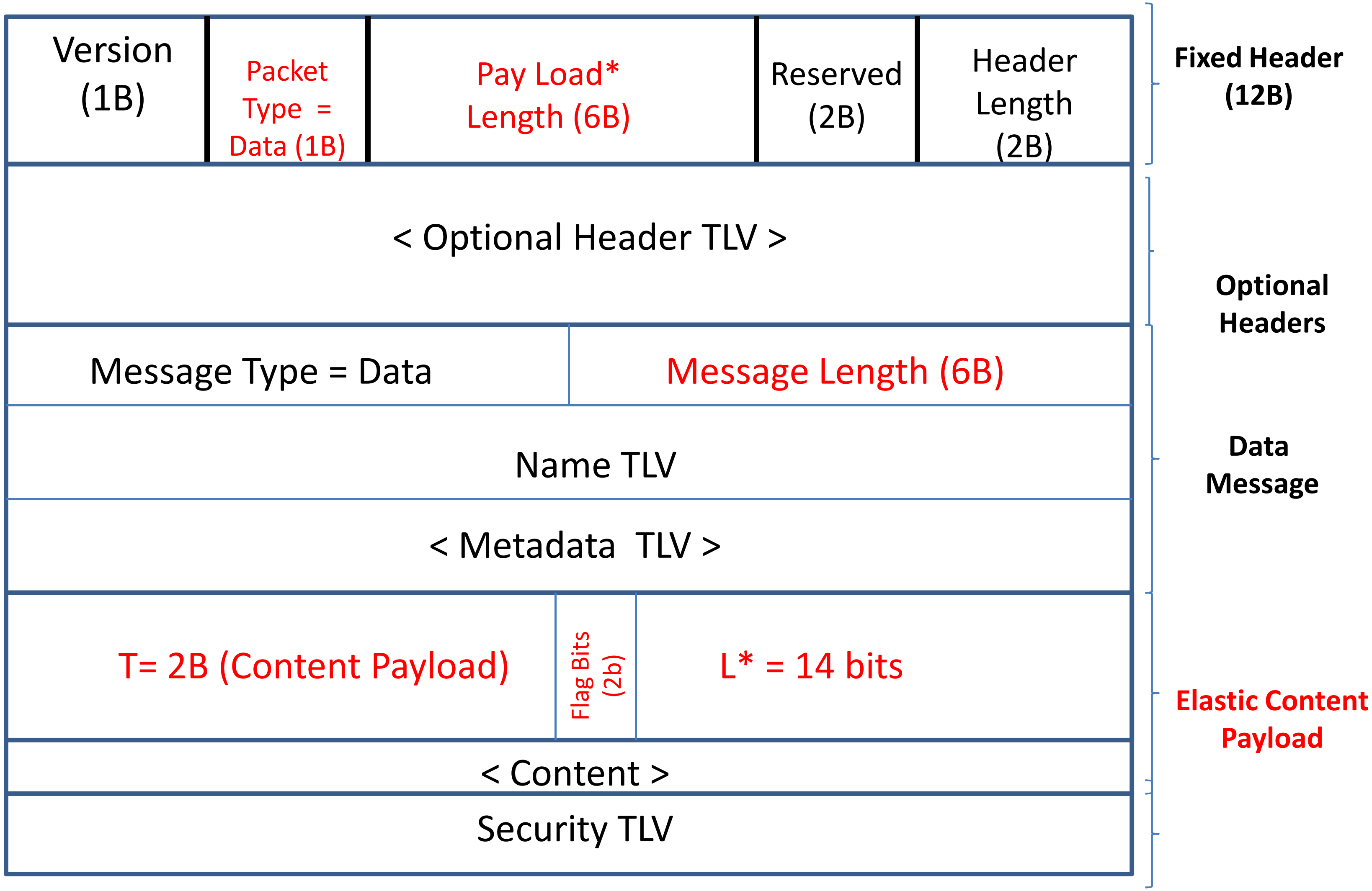
Interest-Conversational

<table>
<tr><td>Version (1B)</td><td>Packet Type = Interest-Con. (1B)</td><td>Pay Load* Length (2B)</td><td>Reserved (2B)</td><td>Header Length (2B)</td><td>Fixed Header (8B)</td></tr>
<tr><td colspan="5">< Optional headers ></td><td rowspan="2">Optional Headers</td></tr>
<tr><td colspan="5">< Optional Forwarding Target/Label TLV ></td></tr>
<tr><td colspan="3">Message Type = Interest-Con.</td><td colspan="2">Message Length* (2B)</td><td rowspan="2">Interest Notification Message</td></tr>
<tr><td colspan="5">Source Name TLV</td></tr>
<tr><td colspan="5">Destination Name TLV</td><td rowspan="2">MetaData Payload</td></tr>
<tr><td colspan="5"><Metadata TLV> (Context TLV)</td></tr>
<tr><td colspan="5">Security TLV</td><td></td></tr>
</table>

- New Interest Type with Source and Destination Name TLV.

DATA PDU



- Fixed Size payload length to accommodate Elastic Content Payload
  - e.g. for GB should 6B : $2^{48} > 2^{44}$
- The Elastic PDU allows to attach payload of varying sizes with minimum overhead.

Data-Conversational PDU

Version (1B)	Packet Type = Data.Con (1B)	Pay Load* Length (6B)	Reserved (2B)	Header Length (2B)

Fixed Header (12B)

//Optional Data headers

Optional Headers

Message Type = Data-Con.	Message Length (6B)
Source Name TLV	
Destination Name TLV	
Metadata TLV	

Data Message

T= 2B (Content Payload)	Flag Bits (2b)	L* = 14 bits
//Content		
Security TLV		

Elastic Content Payload

- New type of Data to handle conversational traffic

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Summary

- CCN/NDN Protocol design not just on performance, but also on flexibility, scalability, and expressiveness.
- Several considerations laid out to be accounted for current design and future enhancements.
- Eventual consensus between CCN and NDN, do not desire two versions of the same protocol.
- Interest/Data Packet formats proposed for consideration.

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