End-to-End Transport Layer Services in the MobilityFirst Network

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Transport Services From TCP/IP to ICN

- Classical IP based End-to-End transport protocols focus in point to point communications.
- UDP: basic message base multiplexing.
- TCP: multiplexing, full reliability, ordered delivery of stream of bytes.
- RTP: focus on media streams.
- What about Information Centric Networks?
Information Centric Network Concepts

- Information Centric Networks architectures move the focus to end-to-end communications to named data retrieval.
- General characteristics: name-based, content-centric, instead of host-centric
  - Each content is uniquely named
  - Client requests content by its name, without caring about the location of the content
  - Anycast & multicast are common transfer patterns
MobilityFirst: Service Abstractions

• Service Abstractions
  • Named Base Services.

• Direct Addressability for All Network Principals.

• Multi-Point Addressability.

send(A, data) → Network Object A

send(Group1, data) → Host 1, Host 2
MobilityFirst: Introduction and Motivations

Historic shift from PC’s to mobile computing and embedded devices...

- ~4 B cell phones vs. ~1B PC’s in 2010
- Mobile data growing exponentially – Cisco white paper predicts 3.6 Exabytes by 2014, significantly exceeding wired Internet traffic
- Sensor/IoT/V2V just starting, ~5-10B units by 2020
MobilityFirst: Main Features

- Separation of names (ID) from network addresses (NA)
- Globally unique name (GUID) for network attached objects
  - User name, device ID, content, context, AS name, and so on
  - Multiple domain-specific naming services
- Global Name Resolution Service for GUID <-> NA mapping
- Hybrid GUID/NA approach
  - Both name/address headers in PDU
  - “Fast path” when NA is available
  - GUID resolution, late binding option
MobilityFirst: Routing (GSTAR)

- Storage aware (CNF, generalized DTN) routing exploits in-network storage to deal with varying link quality and disconnection.
- Routing algorithm adapts seamlessly from switching (good path) to store-and-forward (poor link BW/short disconnection) to DTN (longer disconnections).
- Storage can have benefits for wired networks as well.
MobilityFirst: Transition to a Name Based API

- Name based communications based and end point access to name resolution service provides direct addressability of different internet objects (i.e. devices, contents, services, contexts, etc.)

- Name based communications provide the abstraction for message based communications and content/service specific operations.

- Support for application specific requirements, e.g. multi-access connectivity support.

- Natively support multipoint addressability
Summary: Transport Protocol Requirements for MobilityFirst

- Support network heterogeneity, disconnection/mobility and failure recovery in coordination with the network provided functionality.

- Name based abstractions introduce requirements to support content/service centric operations and multipoint addressability (e.g. multicast, anycast).

- Exploit name based communications to support multihomed devices and services through multipath delivery.

- Support for reliable aggregation of multisource information (e.g. sensor information)

- Congestion control mechanisms in the context of a hop-by-hop reliable transport.
Transport Protocol: Core Design Elements

Proxy transport stores data for temporary disconnections. Sender is notified of store event. GNRS query reveals newfound reachability.

Send(guid, data)

Storing event signaled to original sender

GNRS

Stored chunk

Sporadic failures of network components are handled through end-to-end feedback

Hybrid unicast-multicast approach used for requesting retransmission of specific portions of the transmitted data

Efficient Content-based transfer: maintain sequencing and ordering at content level (not across contents): avoid head of line blocking

Periodic acknowledgements for large transfers. Efficiency for small files/contents

Reliable multicast support transparently provided to the application

Mobile client changing location updates GNRS entry

Sequencing, aggregation of chunks across different local interfaces

Congestion control distributed along the path through backpressure and end-to-end feedback

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Design: Lightweight Reliable Transfer

- Three-way handshake to establish conn.
- Congestion recovery and error recovery both done on end-to-end basis.
  - Sender being stateful, i.e. rely on receiver’s ack, to detect loss, failure, and congestion
Design: Lightweight Reliable Transfer

- Hop-by-hop error/congestion recovery at packet level
- Occasional failure recovery not resolvable through hop-by-hop retransmission is handled end-to-end.
- Only specific portions of data (chunks) are requested for retransmission through a NACK-based mechanism.
- Congestion control mechanisms scale back performance when congestion is detected along the communication path
Design: Lightweight Reliable Transfer

- Interaction with transport proxies to store and retransmit because of mobility and disconnections.
- Retransmissions because of loss are handled locally.
- Connectionless protocol allows for small start-up and recovery times.

- Experimental scenario: webpage requests to a webserver. 1% loss probability on WiFi link. Comparison between TCP/IP and Mobilityfirst.
Design: Support for Multicast/Anycast

- Small scale multicast: reliability provided end to end transparently to the application through a mix of multicast and unicast messages.
- Lost data will be retransmitted via unicast unless loss affected a number of users above an appropriate threshold.
- Large scale: use of network infrastructure for aggregation and retransmission

![Diagram of multicast and unicast messages]

**GNRS**

<table>
<thead>
<tr>
<th>GUID</th>
<th>MGUID / NA</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>U1, U2, U3</td>
</tr>
<tr>
<td>U1</td>
<td>NA1</td>
</tr>
<tr>
<td>U2</td>
<td>NA2</td>
</tr>
<tr>
<td>U3</td>
<td>NA3</td>
</tr>
</tbody>
</table>
Design: Support for Real-Time Services

Network layer Service ID (SID) marks chunk as real-time. Hop by hop reliability is not employed for marked chunks. Moreover, advanced delivery service.

Transport provides sequencing, aggregation across multiple paths reaching different local interfaces.
Conclusions

• We defined a set of requirements needed by and end-to-end transport service in an Information Centric Network.

• We designed a collection of techniques that are meant to meet the defined requirements.

• We applied these design choices to the MobilityFirst architecture and developed a working prototype.

• Future work:
  • Complete the development and verification of our prototype
  • Provide a comprehensive use case based evaluation of our design.