Overlay Routing Problem Statement

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Internet is Entering a New Era, Requiring Significantly Higher Communication Quality

- A new era of Internet: more interactive, immersive and real-time
  - RTC: 2,900% growth since COVID-19 pandemic
  - VR: 48.7% annual growth rate over 2021-2026
- Much higher, more strict and deterministic quality requirement
  - E.g., low latency, high throughput

<table>
<thead>
<tr>
<th>Application</th>
<th>Delay req</th>
<th>Bandwidth req</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voice call</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>DL &amp; UL 0.6~3Mbps</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Online gaming</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>100ms</td>
<td>DL 50Mbps, UL 1Mbps</td>
<td></td>
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<tr>
<td>Video conference</td>
<td>Medium</td>
<td>Medium</td>
</tr>
<tr>
<td>200ms</td>
<td>DL &amp; UL 50Mbps</td>
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<tr>
<td>Self-driving</td>
<td>Low</td>
<td>Low</td>
</tr>
<tr>
<td>5~20ms</td>
<td>DL &amp; UL 50Mbps</td>
<td></td>
</tr>
<tr>
<td>Intelligent manufacturing</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>1~10ms</td>
<td>DL 1Mbps, UL 10~50Mbps</td>
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</tr>
<tr>
<td>Media on demand</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>400ms</td>
<td>DL 100Mbps, UL 0.2Mbps</td>
<td></td>
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<tr>
<td>Telemecine</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>1~10ms</td>
<td>DL &amp; UL 1~100Mbps</td>
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<tr>
<td>Metaverse</td>
<td>Medium</td>
<td>Medium</td>
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<tr>
<td>1~10ms</td>
<td>DL &amp; UL 300-500 Mbps</td>
<td></td>
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<tr>
<td>XR (VR, AR)</td>
<td>High</td>
<td>High</td>
</tr>
<tr>
<td>50ms</td>
<td>DL &amp; UL &gt; 100Mbps</td>
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<tr>
<td>Immersive Internet</td>
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</tbody>
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Technique gap in wide-area and public (cross-domain) networks

- Traditional Internet: best-effort delivery, BGP, no performance guarantee
- Recent advance (e.g., 5G, SD-WAN): single domain, not end-to-end solution
Overlay Networking: Provide Better Path Selection in Internet

- OTT (over-the-top) service providers use private infrastructure to provide better network performance
  - Multiple PoPs (Point of Presence) are deployed worldwide to relay traffic
  - Overlaying private circuits and the public Internet
  - Endpoints use overlay forwarding paths instead of default direct paths (e.g., for shorter distances or bypassing congestion points)
Overlay Routing Problems

End-to-end routing is divided into two segments:

- **Access segment: nearby access**
  - Obtain access controller address by DNS
  - Assign access points (ingress and egress) based on geographic location or latency

- **Backbone segment: backbone optimal path**
  - Configures the optimal path in the backbone

Problem 1: Local optimal is not global optimal

\[ \text{Opt}_{E2E} \neq \text{Opt}_{access} + \text{Opt}_{backbone} \]

Problem 2: Complex signaling

- DNS request for des address
- DNS request for access controller
- Access point request
- ...

Problem 3: Path unawareness at endpoints

- Zero information about the path or path properties (e.g., latency, jitter, bandwidth...)

Potential Extensions

Extension 2: Configure endpoint path via DNS
- Controller as a root DNS server
- Return both destination address and candidate path set with path properties
- Extension Mechanisms for DNS (EDNS) [RFC2671]
- New OPTION-CODE pseudo Resource Record (OPT RR)

Extension 3: Endpoint determine the final path
- Select path from DNS response
- Source routing starting at endpoint

Extension 1: End-to-end joint path computation
- Compute entire overlay paths, include both access and backbone segments

New standard

Extension Mechanisms for DNS (EDNS) [RFC2671]
Relation to PANRG, and moving forward

• In the charter: “...aims to support research in *bringing path awareness to transport and application layer protocols*, and to bring research in this space to the attention of the Internet engineering and protocol design community”

• Moving forward:
  • Any interest in documenting the PS first of all?
Q & A

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