HIGH-RESILIENCE LOW-LATENCY INDUSTRIAL EXPERIENCES
DTN WG - IETF116 (Tokyo, 28.03.2023)

1. Introduction: Use-cases why we ended up in DTN (5min)
2. Findings: Measurement results and DTN cooperation (10min)
3. Future: Challenges and opportunities for DTN (5min)

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The document provides information about Delta Cygni Labs - Finland. It includes details about the core team, locations, experience, products, customers, users, and industries.

**Core Team**
- **BORIS KRASSI, CEO**
- **SAULI KIVIRANTA, CTO**
- **MARKO KUULA, KEY ACCOUNTS**
- **IGOR LEVOCHKIN, FRONT-END LEAD**
- **MARCO CARANDENTE, BACK-END LEAD**

**Locations**
- Finland; Germany; USA; Brazil

**Experience**
- 10+ years industrial distributed systems

**Products**
- **XRTC®**
- **POINTR®**

**Customers**
- 45 Corporates

**Users**
- 50,000+ in 125 countries

**Industries**
- Automotive, Energy, Marine, Machinery, Medical
Business as usual!
Let’s do it!
Let’s open some ports, shall we?
Open ports between multiple military contractors not going to happen

Some times you know the right answer but you still have to go the other way...
Interactive Latency

Fig. 3. Goodput performance of DTN protocols in transmission of a 5 MB data file over a simulated cellphone channel with constant BER = 10^(-4) and varying link delays.

**NOT SURE IF THIS IS A GOOD IDEA**

**LET DO IT ANYWAY!!**

**Question about real time streaming with UDP**

I'm a networking student and have learned the basics of TCP and something in a wireshark capture and had a question.

Generally, 'real time' connections (e.g., VoIP, online gaming, video streaming) use TCP, because it has less overhead.

What confuses me is I just did a wireshark capture of a live twitch.tv stream, and noticed it uses RTMP - which is carried by TCP.

The 'live' stream isn't live. It's delayed by several seconds. I've never used twitch.tv, but I've done some 15-45 seconds behind the live take. If you can afford that much latency (and streaming video applications usually can) then TCP is fine.

It's important to use UDP when there will be 2-way communication like in VoIP/video conference.

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**It's Time to Replace TCP**

John Omero
Stanford U.
January

This position paper has been updated since its original publication. Updates are in italics; none of the original text for chapters to comments on the paper, see the Home Wiki/AOM overhaul tcp lapse?TCP.

That's where UDP can be incredibly useful when you require fast streaming and accuracy is less important. UDP is considered a connectionless protocol because it doesn't require a virtual circuit for data transfer. UDP simply sends packets with a much lower bandwidth overhead and latency. Though some packets might be lost or received out of order, UDP is useful for live streaming and other real-time applications.

**UDP**

<table>
<thead>
<tr>
<th>When Speed Matters</th>
<th>TCP: What Accuracy Matters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Connectionless protocol</td>
<td>Connection based protocol that includes a handshake and authentication.</td>
</tr>
<tr>
<td>One to one, one to all to many (multicast, unicast, broadcast).</td>
<td>One to one (unicast).</td>
</tr>
<tr>
<td>Packets are sent as if individual packets.</td>
<td>The sequence is not maintained in order.</td>
</tr>
<tr>
<td>No reordering or packet retransmission.</td>
<td>No reordering or packet retransmission.</td>
</tr>
</tbody>
</table>

The primary reason why the UDP data, TCP delivers a reliable stream. TCP buffers all the packets in a stream in order to the application devices.

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**High Performance Networking**

What Every Web Developer Should Know About Networking and Browser Performance

O'REILLY

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SUCCESS!

With comments…

… see you later?

Feedback resulted in POINTR
Security is matter of life and death...
Multiple enterprise boundaries...
Baseline is variable connectivity... Legacy systems will be involved...
Disruptions, disturbances and delays nominal...
Offline steps in day-to-day process...
Objectives of the service

Finnish high tech company Delta Cygni Labs is transforming industrial services with the new remote collaboration solution POINTR. Powered by augmented reality, POINTR is secure, reliable, scalable, easy-to-use solution for industry.

The objective of the POINTSAT project was to strengthen the POINTR offering for maritime, offshore, mining and energy sectors by integrating satellite communication capability and advanced interaction for harsh environments.

The particular focus of the project is on the maritime applications. POINTSAT involved two industrial collaboration partners: Valmet (marine solutions and automation) and KONE Marine (vertical transportation in maritime sector).
Delay Tolerance
Disruption Tolerance
Store and Forward
Design from Extremes

Continous Measurement
Temporal and Spatial bitrate adaptation
Communicate Quality to Users
DISRUPTION RESILIENCE TEST - DTN

5G at 0.25%, 4G at 0.5%, Base Station Congestion 0.75%, Satellite 1%, Storm Satellite 10%

<table>
<thead>
<tr>
<th>RTT:</th>
<th>Packet Loss:</th>
<th>Average Delay:</th>
<th>99th Percentile:</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 ms</td>
<td>0.00%</td>
<td>119.59 ms</td>
<td>204.78 ms</td>
</tr>
<tr>
<td>100 ms</td>
<td>1.00%</td>
<td>127.38 ms</td>
<td>493.17 ms</td>
</tr>
<tr>
<td>100 ms</td>
<td>2.00%</td>
<td>135.94 ms</td>
<td>660.97 ms</td>
</tr>
<tr>
<td>100 ms</td>
<td>4.00%</td>
<td>144.54 ms</td>
<td>740.32 ms</td>
</tr>
<tr>
<td>100 ms</td>
<td>6.00%</td>
<td>165.45 ms</td>
<td>1124.59 ms</td>
</tr>
<tr>
<td>100 ms</td>
<td>8.00%</td>
<td>186.95 ms</td>
<td>1380.04 ms</td>
</tr>
<tr>
<td>100 ms</td>
<td>10.00%</td>
<td>208.08 ms</td>
<td>1543.32 ms</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Goodput:</th>
<th>Retransmissions:</th>
<th>Overhead:</th>
<th>Samples:</th>
<th>Sample Size:</th>
</tr>
</thead>
<tbody>
<tr>
<td>96.98%</td>
<td>0.01%</td>
<td>3.01%</td>
<td>150</td>
<td>0.5 Mb</td>
</tr>
<tr>
<td>95.89%</td>
<td>1.11%</td>
<td>3.00%</td>
<td>150</td>
<td>0.5 Mb</td>
</tr>
<tr>
<td>94.63%</td>
<td>1.87%</td>
<td>3.50%</td>
<td>150</td>
<td>0.5 Mb</td>
</tr>
<tr>
<td>91.99%</td>
<td>4.12%</td>
<td>3.89%</td>
<td>150</td>
<td>0.5 Mb</td>
</tr>
<tr>
<td>89.45%</td>
<td>6.39%</td>
<td>4.16%</td>
<td>150</td>
<td>0.5 Mb</td>
</tr>
<tr>
<td>87.58%</td>
<td>8.05%</td>
<td>4.37%</td>
<td>150</td>
<td>0.5 Mb</td>
</tr>
<tr>
<td>85.20%</td>
<td>9.97%</td>
<td>4.82%</td>
<td>150</td>
<td>0.5 Mb</td>
</tr>
</tbody>
</table>

10% packet loss condition is Starlink during storm

Reference from Auckland NZ Cyclone Gabrielle (Ulrich Speidel)

Inspiration:
1. Licklider Transmission Protocol (LTP)-Based DTN for Long-Delay Cislunar Communications (Link)
2. Use of a Hybrid of DTN Convergence Layer Adapters (CLAs) in Interplanetary Internet (Link)
**DELAY RESILIENCE TEST - DTN**

Earth **200ms**, ISS **500ms**, Moon **1200ms** (Extreme **5000ms**)

<table>
<thead>
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<th>RTT</th>
<th>Packet Loss</th>
<th>Average Delay</th>
<th>99th Percentile</th>
</tr>
</thead>
<tbody>
<tr>
<td>100 ms</td>
<td>1.00%</td>
<td>126.35 ms</td>
<td>523.76 ms</td>
</tr>
<tr>
<td>200 ms</td>
<td>1.00%</td>
<td>223.84 ms</td>
<td>772.32 ms</td>
</tr>
<tr>
<td>400 ms</td>
<td>1.00%</td>
<td>430.86 ms</td>
<td>1240.97 ms</td>
</tr>
<tr>
<td>600 ms</td>
<td>1.00%</td>
<td>640.87 ms</td>
<td>1781.66 ms</td>
</tr>
<tr>
<td>800 ms</td>
<td>1.00%</td>
<td>849.21 ms</td>
<td>2655.72 ms</td>
</tr>
<tr>
<td>1000 ms</td>
<td>1.00%</td>
<td>1044.19 ms</td>
<td>2534.43 ms</td>
</tr>
<tr>
<td>1200 ms</td>
<td>1.00%</td>
<td>1247.39 ms</td>
<td>2910.18 ms</td>
</tr>
<tr>
<td>1500 ms</td>
<td>1.00%</td>
<td>1567.88 ms</td>
<td>4057.77 ms</td>
</tr>
<tr>
<td>2000 ms</td>
<td>1.00%</td>
<td>2070.03 ms</td>
<td>4310.00 ms</td>
</tr>
<tr>
<td>2500 ms</td>
<td>1.00%</td>
<td>2611.44 ms</td>
<td>5771.04 ms</td>
</tr>
<tr>
<td>3000 ms</td>
<td>1.00%</td>
<td>3083.55 ms</td>
<td>6405.83 ms</td>
</tr>
<tr>
<td>3500 ms</td>
<td>1.00%</td>
<td>3595.17 ms</td>
<td>6826.15 ms</td>
</tr>
<tr>
<td>4000 ms</td>
<td>1.00%</td>
<td>4150.57 ms</td>
<td>8637.32 ms</td>
</tr>
<tr>
<td>4500 ms</td>
<td>1.00%</td>
<td>4691.15 ms</td>
<td>10872.70 ms</td>
</tr>
<tr>
<td>5000 ms</td>
<td>1.00%</td>
<td>5359.38 ms</td>
<td>12801.08 ms</td>
</tr>
</tbody>
</table>

**Inspiration:**

1. Licklider Transmission Protocol (LTP)-Based DTN for Long-Delay Cislunar Communications ([Link](#))
2. Use of a Hybrid of DTN Convergence Layer Adapters (CLAs) in Interplanetary Internet ([Link](#))
Only 14% of companies can utilize sub second latency
While 57% of companies wants / needs sub second latency
Example 1: Process monitoring and control

100 000 sensors, 2 updates / sec
Up to 1 Gbps up, 700ms on AWS

Resilience and latency constrained
Example 2: Machine assisted fleet control

Cargo handling, logistics and transportation
Local as only big harbors have enough volume

Resilience and latency constrained
HIGH-RESILIENCE LOW-LATENCY STREAMING

$1.5 TRILLION MARKET (... AND MORE IN THE MAKING BY DTN WG!)

DTN WG IS AT THE CORE OF ENABLING THIS MARKET
DTN WG
Delay / Disruption Tolerant Networking
IETF116 (Tokyo, 28.03.2023)

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BIG O NOTATION AND COMPLEXITY

Resources required to get an desired output from a specific input conditions.

**Space complexity**, the amount of space needed for desired output $O(m)$, the space complexity with a given input $m$.

**Time complexity**, the amount of time needed for desired output $O(n)$, the time complexity with a given input $n$.

What are our options with packet loss?

- Loss of a packet is space complexity issue
- Increase of delay is time complexity issue