



Delay / Disruption Tolerant Networking Enhancements for Streaming Data

Tom Rich / Pete Gonzalez May 8, 2017

NASA JSC CD231 – Mission Systems Strategic Projects





- Delay / Disruption Tolerant Networking (DTN)
- Opportunities for DTN Enhancement
- DTN BSS Payload Conditioning
- bss_player Stream Control Application
- Demo Setup, Re-use Elements
- JSC / JPL DTN / DSN Overview
- DTN BSS Telemetry Demo
- BSS Player Video Architecture
- DTN BSS Video Demo
- Summary

DTN Operational Enhancements for Streaming Data 2 May 8, 2017 Approved for Public Release via the NASA Science and Technical Information Process DAA 39211

Delay / Disruption Tolerant Networking (DTN)



- DTN provides store-and-forward data transmission.
 - Missing data is automatically detected and re-transmitted.
 - Data is held at the origination node until receipt confirmation is received from the destination node.
- DTN is delay tolerant.
 - DTN is designed for transmission delays at interplanetary distances
 - Up to 20 minutes transmission delay for a Mars mission
- NASA's Spacecraft Communications and Navigation (SCaN) Program Office has directed that DTN be incorporated into the Deep Space Network.
- Therefore, the MCC will need to account for the effects of DTN on data received from the DSN.
- This work addresses operational enhancements to the Interplanetary Overlay Network (ION).





- Situation: An unconditioned DTN data stream produces out-of-order data, as missing data frames are re-transmitted and mixed in with the real-time data stream.
 - Out-of-order data would look like a transient glitch on a flight controller display.
 - A data gap would be preferable to out-of-order data.
 - This problem *is* addressed by the Bundle Streaming Service (BSS) bundled with ION.
 - However, the data samples are delivered in bursts due to DTN (LTP) aggregation.
 - This presents a problem for applications that rely on a steady stream of samples, such as voice and video.
 - A way to meter the data is needed.
- Situation: The user needs to know when 100% of the data has been received. Delay Tolerant Payload Conditioning (DTPC) does do this. This work uses a different approach.
- Situation: For timing sensitive applications, such as H.264 compressed video, the 100% complete received data stream timing should match the original timing, even though the original data samples may have been aggregated into larger blocks for space-to-ground transmission.
- All three of these streams are required simultaneously over the Licklider Transmission Protocol (LTP), which is DTN's long haul space-to-ground (aggregating) protocol.
- All of these situations are addressed by DTN BSS Payload Conditioning.





- DTN BSS Payload Conditioning provides:
 - A metered real-time data stream
 - Monotonically increasing time tags and sequence numbers, no out-of-order packets, may have gaps
 - Metering; timing of the output data stream matches the original, even though aggregation may have occured during space-to-ground transmission.
 - Real-time metering will be important for transmission of voice over DTN.
 - A fully conditioned data stream
 - 100% confirmed reception; real-time data advancement when 100% is reached
 - A metered, fully conditioned data stream
 - Suitable for H.264 compressed video; lags behind real-time
- These capabilities require:
 - (Minimal) modification to the DTN bpsend() function to add a unique sequence number and a microsecond time tag to the DTN ECOS extension block
 - Modification to the ION DTN Bundle Streaming Service (BSS) library to add these two new parameters to the BSS database
 - The bss_player data stream control application
 - All three types of streams are available simultaneously
 - bss_player can distribute each stream independently over BP, UDP, or multicast

DTN Operational Enhancements for Streaming Data 5 May 8, 2017 Approved for Public Release via the NASA Science and Technical Information Process DAA 39211

bss_player Stream Control Application



BSS Player (on dtn7-vm) × File Edit View Help Source Entity ID (e.g. ipn:5.3): ipn:3.72 Database: /home/pgonzalez/tmp/bssDB-ipn:3.72 Realtime/Playback Streams 5 г onditioned Stream Delay: 10 Realtime layback Stream Delay: 11 Conditioned Playback 0 *5*400 5450 5500 5550 5600 5650 Sequence Number ÷ Max Playback Delay 10 Playback Catchup Rate (%) 25 ÷ Realtime Conditioned Playback 5681 2017/03/24-15:18:43: 22571 bytes 5674 2017/03/24-15:18:39: 13331 bytes 5674 2017/03/24-15:18:39: 13331 bytes 5683 2017/03/24-15:18:45: 30491 bytes 5675 2017/03/24-15:18:39: 30491 bytes 5675 2017/03/24-15:18:39: 30491 bytes 5684 2017/03/24-15:18:46: 19931 bytes 5676 2017/03/24-15:18:39: 30491 bytes 5676 2017/03/24-15:18:39: 30491 bytes 5688 2017/03/24-15:18:49: 29171 bytes 5677 2017/03/24-15:18:40: 30491 bytes 5677 2017/03/24-15:18:40: 30491 bytes 5689 2017/03/24-15:18:50: 30491 bytes 5678 2017/03/24-15:18:40: 30491 bytes 5678 2017/03/24-15:18:40: 30491 bytes 5690 2017/03/24-15:18:51: 23891 bytes 5679 2017/03/24-15:18:41: 30491 bytes 5679 2017/03/24-15:18:41: 30491 bytes 5692 2017/03/24-15:18:53: 30491 bytes 5680 2017/03/24-15:18:42: 30491 bytes 5680 2017/03/24-15:18:42: 30491 bytes 5693 2017/03/24-15:18:54: 6731 bytes 5681 2017/03/24-15:18:43: 22571 bytes 5681 2017/03/24-15:18:43: 22571 bytes 5694 2017/03/24-15:18:55: 25211 bytes 5682 2017/03/24-15:18:44: 30491 bytes 5682 2017/03/24-15:18:44: 30491 bytes 5695 2017/03/24-15:18:55: 30491 bytes 5683 2017/03/24-15:18:45: 30491 bytes 5683 2017/03/24-15:18:45: 30491 bytes 5696 2017/03/24-15:18:56: 30491 bytes 5684 2017/03/24-15:18:46: 19931 bytes 5684 2017/03/24-15:18:46: 19931 bytes **Publish Realtime** Publish Conditioned Publish Playback O None O BP Output O None O BP Output O None O BP Output Conditioned Start Time Conditioned Stop Time Playback Start Time Playback Stop Time 016/01/01-00:00:00 020/01/01-00:00:00 020/01/01-00:00:00 016/01/01-00:00:00 Realtime Address Realtime Port Conditioned Address Conditioned Port Playback Address Playback Port 139.169.8.182 6001 139.169.8.182 \checkmark 139.169.8.182 6003 Start Recording Stop Recording Start Conditioned Stop Conditioned Start Playback Stop Playback Exit

DTN Operational Enhancements for Streaming Data

May 8, 2017

6





- A DTN node in the iPAS lab, JSC Bldg. 29 simulates the vehicle transmission point.
- The simulated Deep Space Operations Center (DSOC) at JPL anchors the DTN LTP space-to-ground link.
- JPL models the space link with a 2 sec. one-way-light-time (OWLT) delay, and a 2% frame drop rate on the downlink.
- JPL provides the multi-center DTN distribution node.
- The OTF in JSC Bldg. 30 provides five independent DTN data reception nodes.
 - Their sole connectivity is through JPL
 - This configuration simulates geographically dispersed control centers



JSC / JPL DTN / DSN Overview





Initial Cislunar Habitat Software Defined Radio iPAS Lab, JSC Bldg. 29

DTN / LTP Telemetry, Voice, Video Downlink DTN / LTP Command, Voice Uplink



Protocol Test Lab@JPL DSN Operations Center Sim Space-to-Ground Comm Link Sim 2 sec. one way light time delay 2% frame drop rate on the downlink 0.1% frame drop rate on the uplink Available 24 / 7 / 365 UDP, STCP, DGR DTN Convergence Layers





PTL@JPL

OTF@JSC Bldg. 30

DTN Operational Enhancements for Streaming Data

8

May 8, 2017

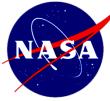


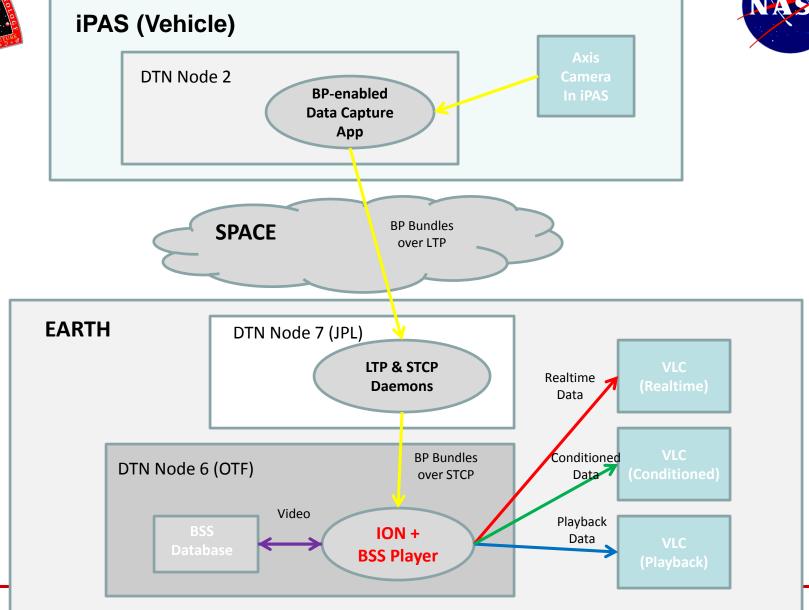


- bss_player, showing metered realtime, 100% conditioned, and metered replay data streams
- Sample telemetry display of metered realtime stream (red)
 - Skipped sequence numbers are evident, indicating missing data.
 - Sequence numbers monotonically increase



BSS Player Video Architecture









- bss_player, showing metered realtime, 100% conditioned, and replay data streams
- Video display of original low-def 4 fps Motion JPEG video signal, provided by an Axis 214 PTZ camera in the iPAS Pathfinder lab in Bldg. 29
- Video display of metered BSS realtime signal (red), propagated through the JSC / JPL DTN / DSN simulated space-to-ground and ground-to-ground network
 - Video glitches correspond to dropped MJPG frames.
 - Real-time received video lags the original by ~2 sec., the modeled OWLT
- Video display of real-time 100% conditioned DTN video signal (green)
 - Video freezes while bss_player waits for retransmission of missing data.
 - When all missing data are restored, the video jumps to the most current frame.
 - Intervening video is skipped; events will be missed.
- Video display of metered replay 100% conditioned DTN video signal (blue)
 - Smoothly displays the complete video signal
 - Lags behind real-time



Summary



- DTN Bundle Streaming Service (BSS) addresses the problem of out-of-order data in real-time displays.
 - DTN BSS Payload Conditioning includes this capability.
 Plus, it adds metering capability to the real-time stream, so that the output timing matches the input timing.
- DTN BSS Payload Conditioning addresses the need to confirm reception of 100% of the data transmitted over DTN, and to know real-time when 100% reception has occurred.
- DTN BSS Payload Conditioning addresses the need to match the output data timing to the input timing for the fully conditioned data stream.
 - Important for timing sensitive data streams such as H.264 compressed video

DTN Operational Enhancements for Streaming Data 12 May 8, 2017 Approved for Public Release via the NASA Science and Technical Information Process DAA 39211







DTN Operational Enhancements for Streaming Data 13 May 8, 2017 Approved for Public Release via the NASA Science and Technical Information Process DAA 39211







DTN Operational Enhancements for Streaming Data 14 May 8, 2017 Approved for Public Release via the NASA Science and Technical Information Process DAA 39211



DTN Voice Communication Architecture

