National Aeronautics and Space Administration

EDOS Initiatives to Decrease Latency of NRT Data for LANCE

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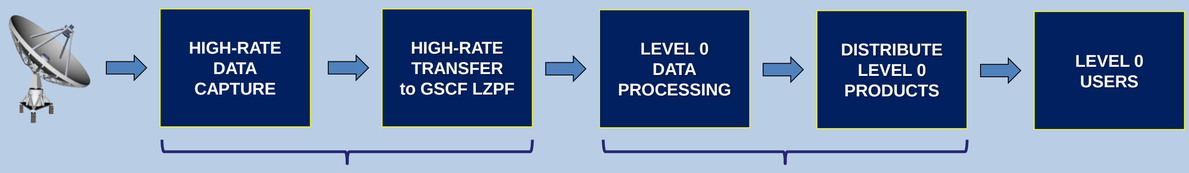
Abstract

NASA's EOS Data and Operations System (EDOS) is the primary supplier of NRT (near real-time) data to the NASA NRT user community known as the Land, Atmosphere NRT Capability for EOS (LANCE). EDOS provides NRT data for various instruments on the EOS missions Terra, Aqua, Aura, as well as for the NOAA missions Suomi NPP and NOAA-20. This poster describes an overview of the EDOS multi-mission system with emphasis on the NRT products distributed for LANCE elements: AIRS, MISR, MLS, MODIS, MOPITT, OMPS, OMI and VIIRS . Remote EDOS high-rate data capture systems are deployed at NASA ground stations which provide data-driven capture of high-rate science for EOS missions. The remote EDOS components transfer the science data via high-rate WANs to the centralized EDOS Level-zero processing systems located at Goddard Space Flight Center. EDOS produces session-based data sets especially for LANCE NRT use from a single ground station contact; this data is sent to dual LANCE destinations as part of the standard redundancy requirement for LANCE elements. EDOS has implemented various latency improvements with the ultimate goal to have EDOS processing of NRT data keep up with the spacecraft data downlink. EDOS enhancements have included implementation of priority-based QoS, expanded network architecture to include open networks, and use of a delay-tolerant protocol. EDOS has streamlined its systems and infrastructure to minimize latency for NRT data delivery for LANCE. EDOS begins to transfer the NRT data to the LANCE elements within minutes of the end of the contact session with an average packet latency from instrument observation to Level 0 product delivery to each LANCE element of just over one hour.

EDOS is NASA's high-rate, multi-mission Level 0 science data system for EOS



- Currently supports Level 0 science operations for 8 missions in a *data-driven* mode
- Autonomously captures science data at remote ground stations (NASA and commercial stations) located at 7 sites
- Performs front-end processing including demodulation, de-randomization, frame synchronization, and decoding
- Automatically initiates transfer of science data to GSFC over NASA's high-rate closed or open networks
- Performs level zero science data processing at centralized L0 processing facility
- Delivers roughly 1 Terabyte of level zero products daily worldwide in a variety of formats and protocols

NASA's Land Atmosphere Near real-time Capability for EOS (Earth Observing System) (LANCE) provides global data and imagery from selected EOS satellites in less than 3 hours from satellite observation to meet the needs of the near real-time (NRT) users, such firefighters and first responders. LANCE defines latency as the time from satellite observation to product delivery. EDOS produces session-based data sets especially for LANCE NRT use and delivers the Level 0 products in an expedited manner to designated LANCE elements.

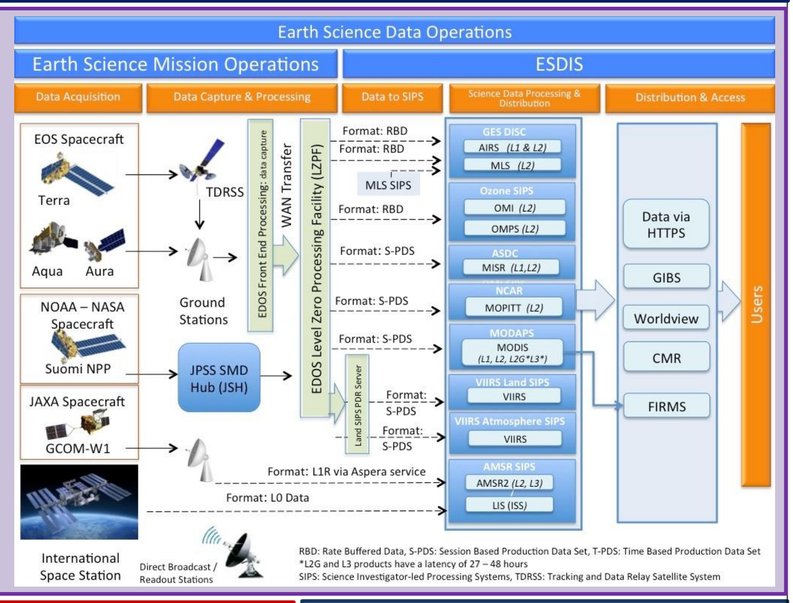
EDOS performs the Level 0 processing for all of the LANCE NRT data except for GCOM-W1 (AMSR-2) and ISS (LIS).

EDOS Support for LANCE

The primary contributor to latency of Level 0 data is the transfer of the data across the high-rate WAN.
EDOS has implemented numerous latency enhancements to decrease WAN transfer time:

- Removal of Reed-Solomon decoding bits from the transfer frame (128 bytes/frame)
- Implementation of lossless compression
- Expansion of network bandwidth
- Use of open network architecture at all ground stations
- Implementation of priority-based QoS
- Use of delay-tolerant protocol UDT

EDOS continues to reduce latency with the goal of transferring the data from the ground station to LZPF in near real-time.



Open Networks

EDOS began an initiative in 2013 to add additional "open" (public) network connections to existing "closed" (private) network connections at ground stations, where a high-rate open connection was available:

- Alaska Satellite Facility (Internet2)
- White Sands (NASA Corporate Network)
- Wallops (NASA Corporate Network)
- TrollSat (KSAT satellite to Internet link)
- Svalbard (Internet2)

The open networks provid increased bandwidth with lower latency at minimal increased cost.

IPSec Tunnel

To protect the high-rate data over the open network links, an IPSec tunnel is used to encrypt the data over the public portion of the transfer, similar to a VPN connection. IPSec wraps the original IP packet at the ground station, encrypts it, adds a new public IP header and sends it to the other side of the tunnel to the IPSec peer at Goddard Space Flight Center. IPSec uses two security mechanisms (authentication header and encapsulating security payload) which provide the necessary authentication and integrity checking.

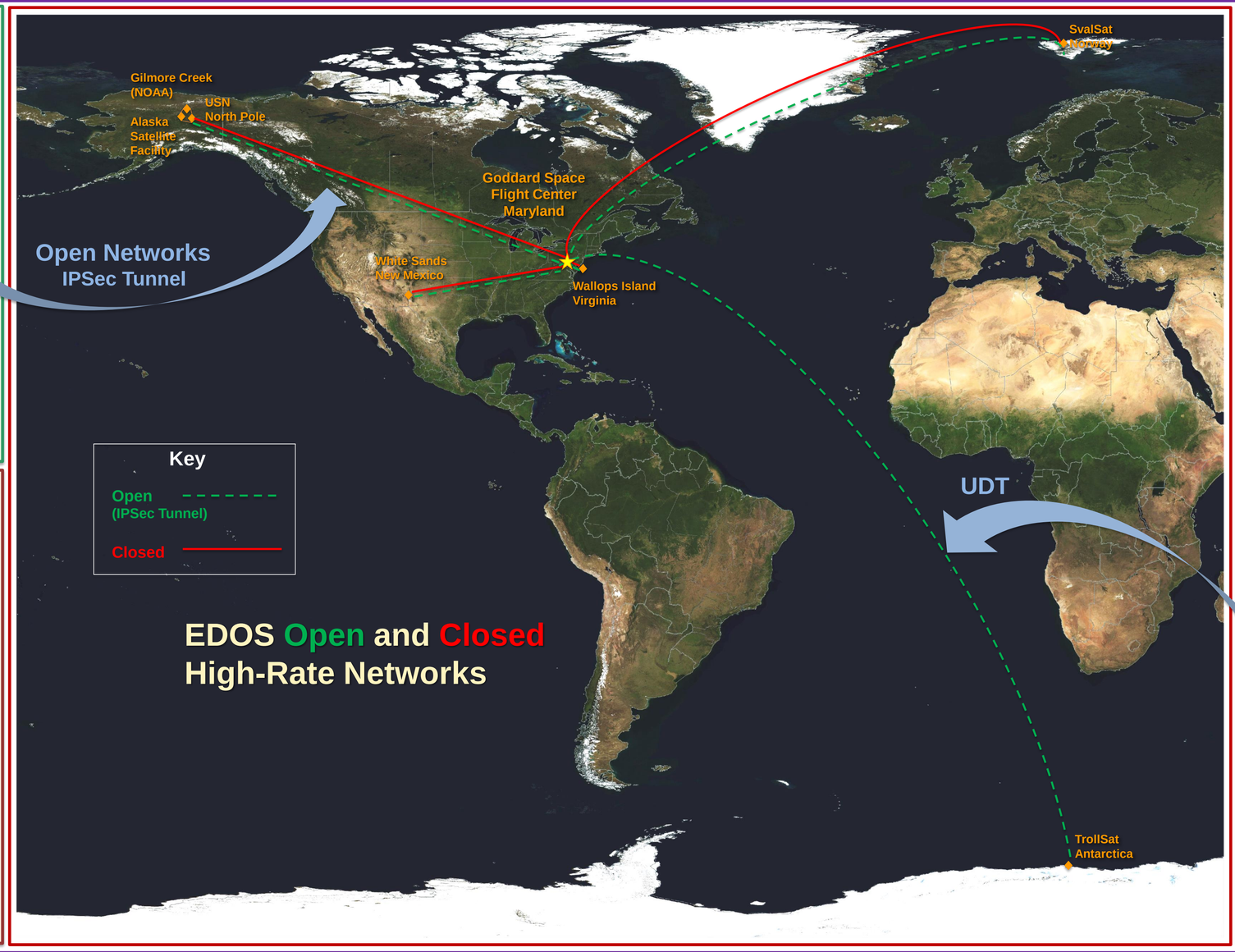
Hybrid Architecture

Architectural changes were needed for EDOS to make use of the available open networks in addition to the existing closed network connections. Ground station resources were uniquely allocated between open and closed networks since physical separation between open and closed networks is required for security. This new EDOS architecture is called the "hybrid" architecture.

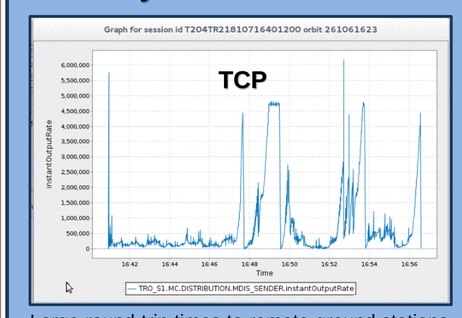
All antennas at the ground station can be switched to EDOS front-end systems on either the open or closed network. The Hybrid Architecture provides the following benefits:

- The 2 networks serve as backup for each other
- The 2 networks can be used in parallel to increase total WAN bandwidth for concurrent mission downlinks.
- By using the high-rate matrix switch the same data can be routed to both closed and open front-end systems and routed in parallel to both the operational and backup LZPF systems for testing and transitions.

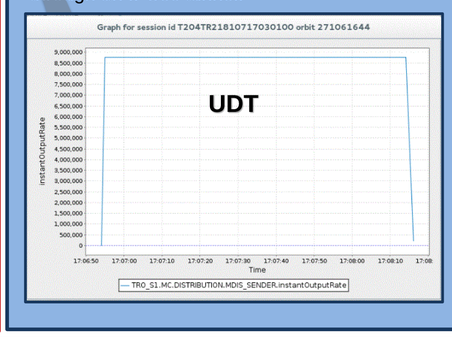
An important additional benefit of the hybrid architecture development is the realization that EDOS can be deployed at new ground stations worldwide where high-rate open connections are available.



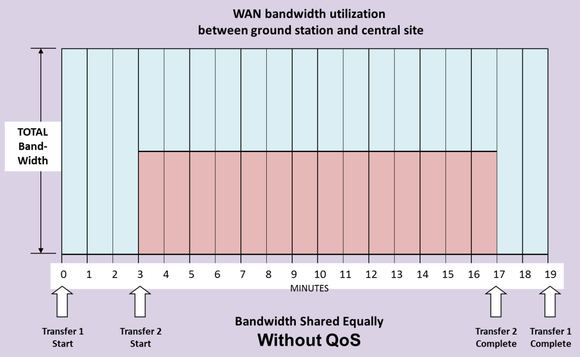
Delay-Tolerant Protocol



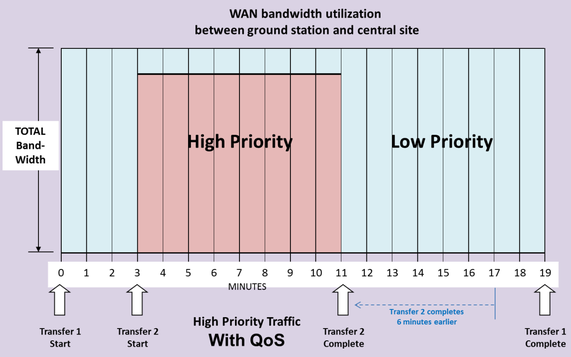
Large round-trip times to remote ground stations via satellite hops limit the efficiency of normal TCP data transfers. EDOS researched available simple delay-tolerant protocols that overcame the delays inherent in TCP acknowledgements and chose UDT (UDP-based Data Transfer Protocol) as a delay-tolerant replacement for TCP. UDT is a stable, open source protocol that uses UDP for data transport. UDT functions similarly to TCP by being a connection-oriented, reliable, duplex, unicast data streaming protocol with congestion control. Reliability is provided by sequencing and acknowledgment between the sender and receiver. Any EDOS front-end processor can be configured to use TCP/IP or UDT whether it is on the open or closed network. EDOS has been able to achieve throughput above 95% of the available bandwidth on the open networks with UDT through an IPSec tunnel.



Quality of Service (QoS)



- QoS is a set of rules to control bandwidth utilization on a network based on assigned priority
- EDOS uses QoS to prioritize multi-mission high-rate WAN transfers to give missions with NRT data higher priority
- EDOS QoS configurations are extremely flexible providing an arbitrary number of priority levels
- EDOS QoS appliances use only the SUSE Linux operating system kernel with no additional software required
- EDOS QoS device performs traffic shaping on the data egress interface based on mission's priority
- EDOS QoS permits rate limiting, sharing of bandwidth, and prioritization of packet flow



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