

# The Benefits of Packet Service in Evolving Space Communications Provider Networks

Jay Gao<sup>1</sup>, Loren Clare<sup>1</sup>, and David Israel<sup>2</sup>

<sup>1</sup>Jet Propulsion Laboratory, California Institute of Technology

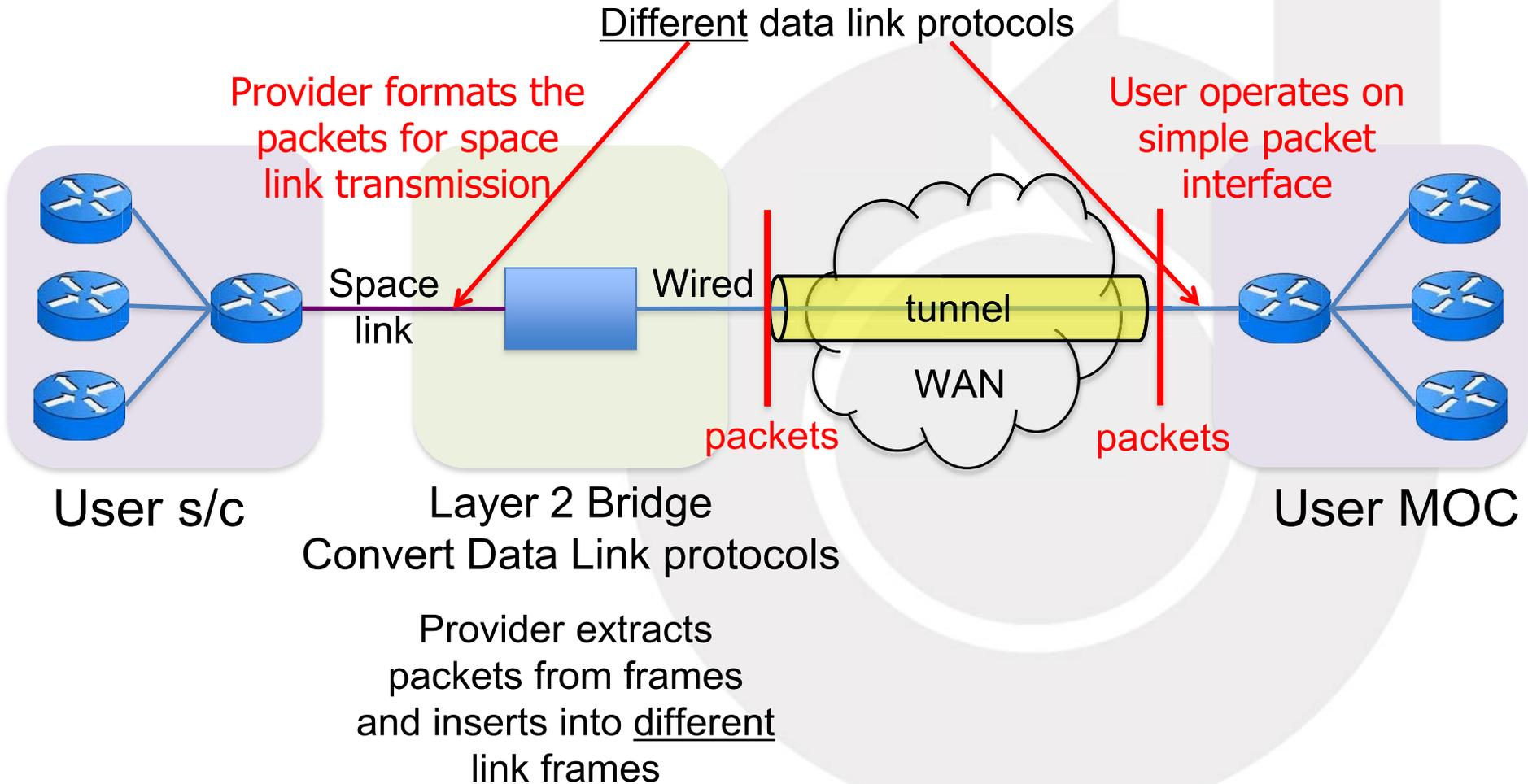
<sup>2</sup>NASA/Goddard Space Flight Center

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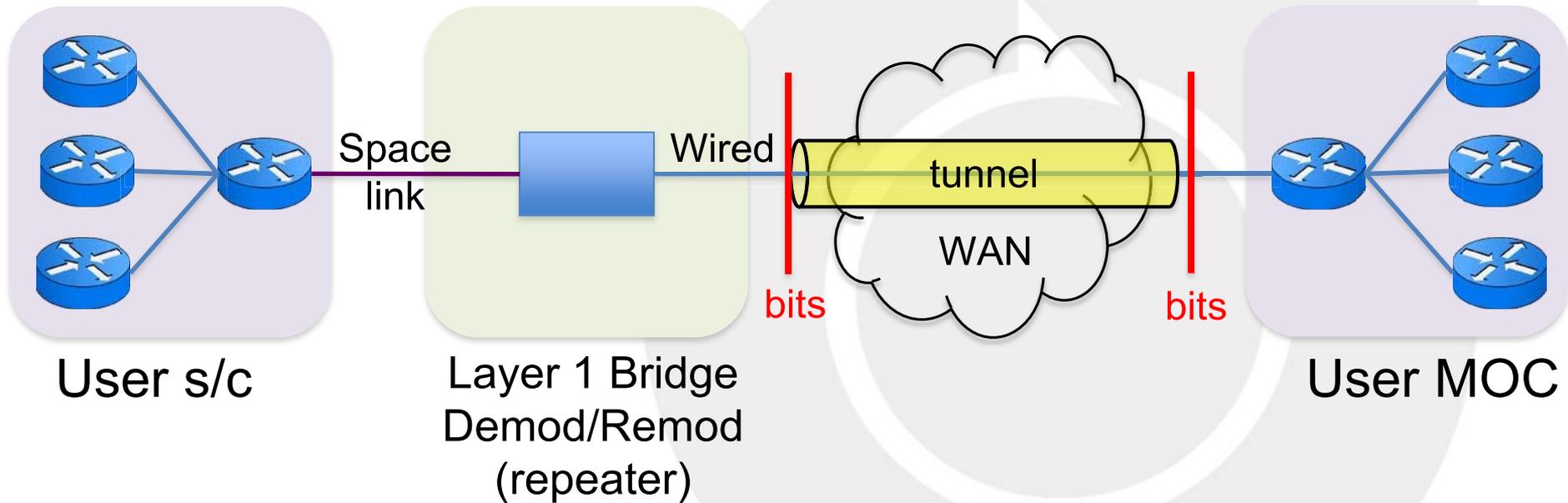
## Outline

- Packet Service definition
  - Contrast with other service types
- Benefits of Packet Service
  - Decouples the space link: Adaptive Link Control
  - Evolutionary path to Space Internetworking (SI)
- Packet Service Implementation
- Packet Service Augmentations
- Summary

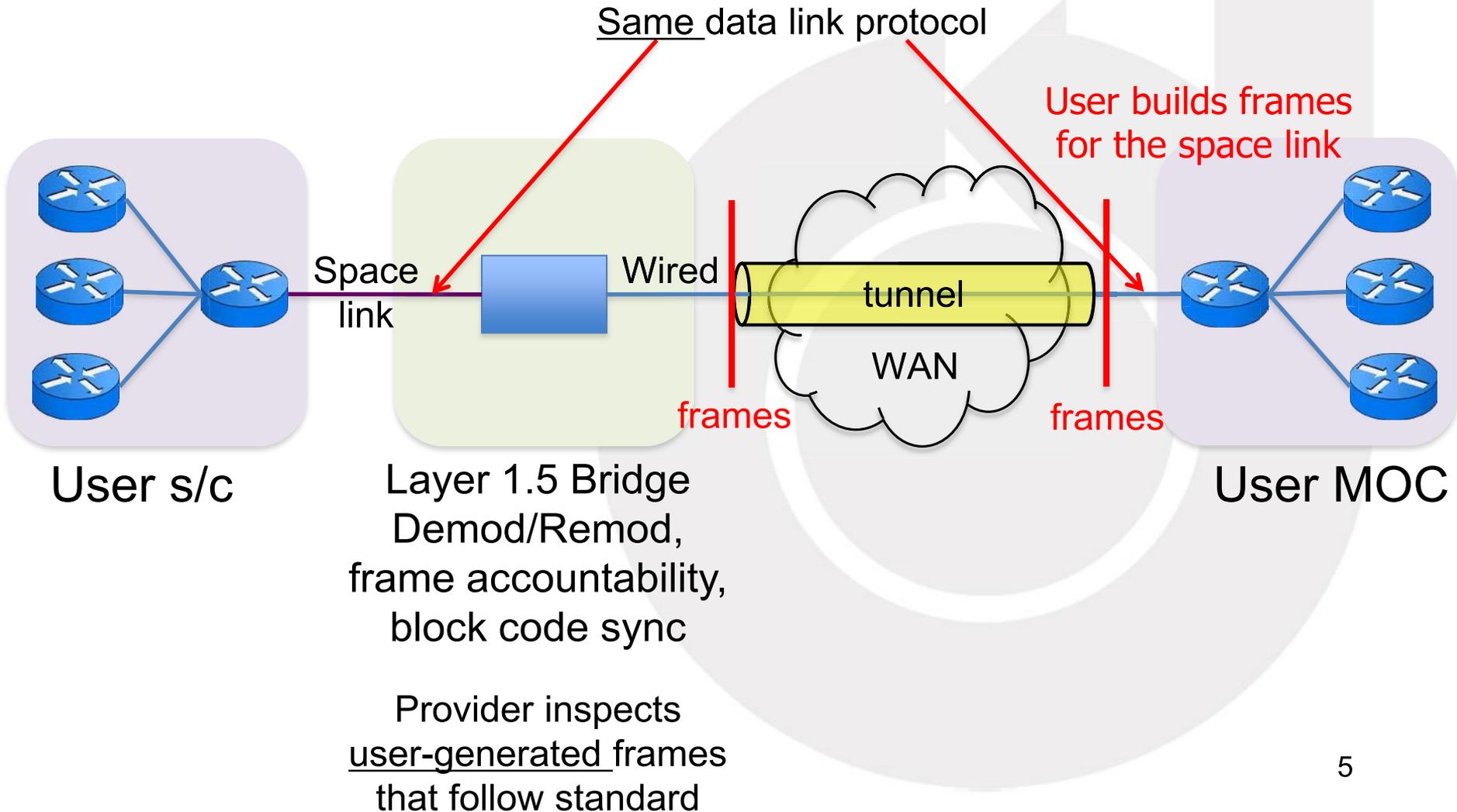
# Packet Service Definition



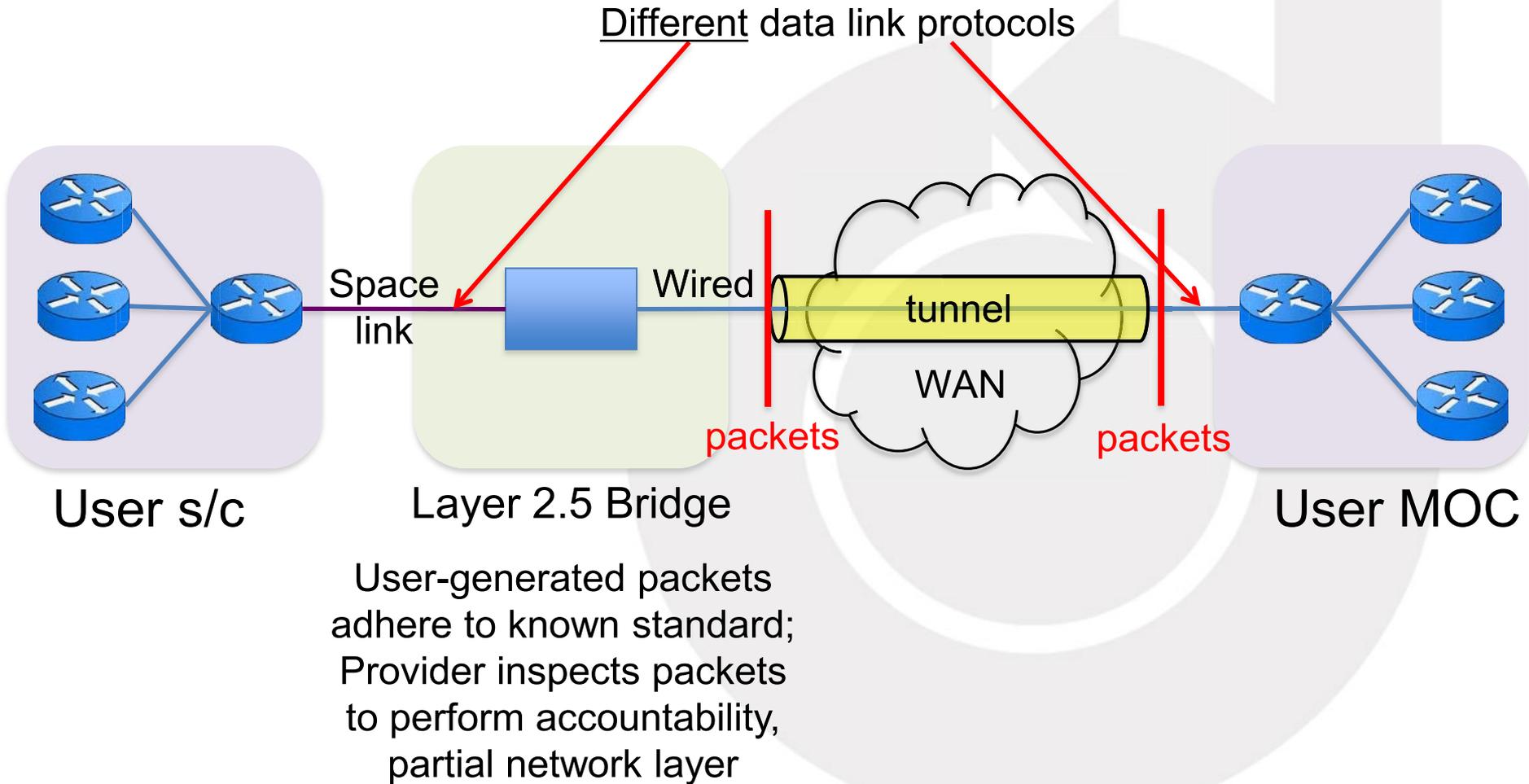
## Contrast: Bitstream Service



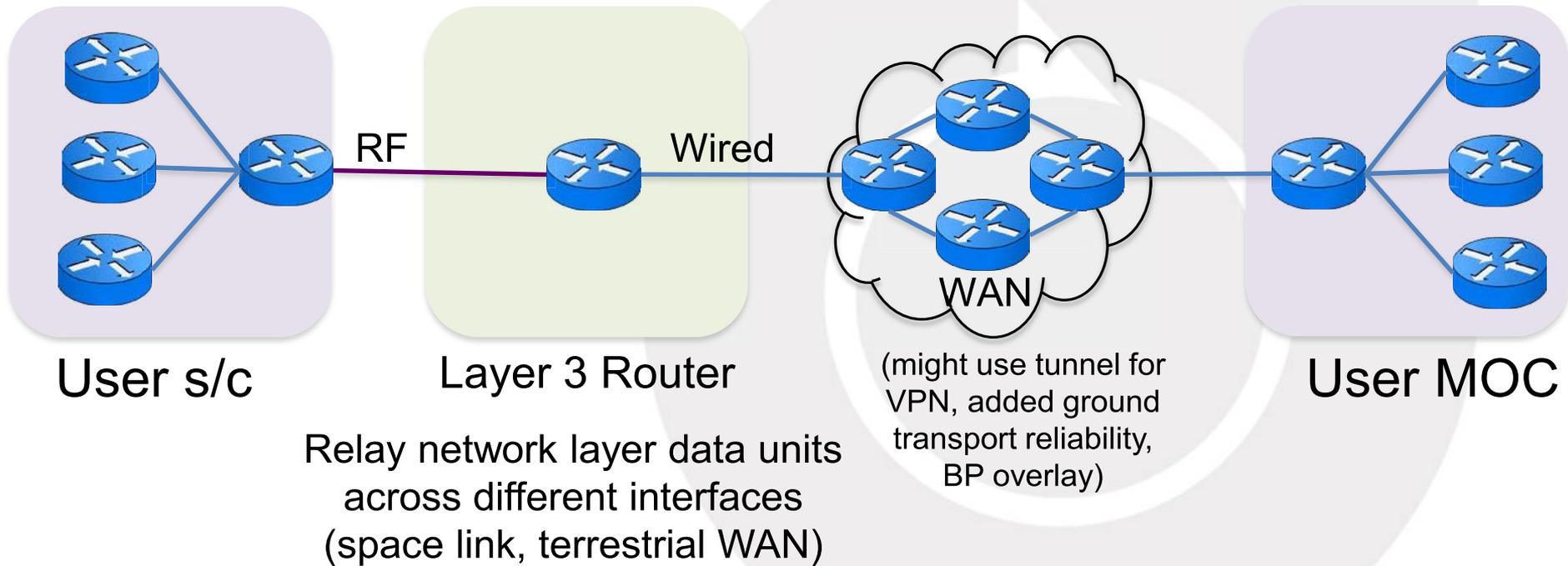
# Contrast: Frame Service



# Augmented Packet Service



## Contrast: Space Internetworking



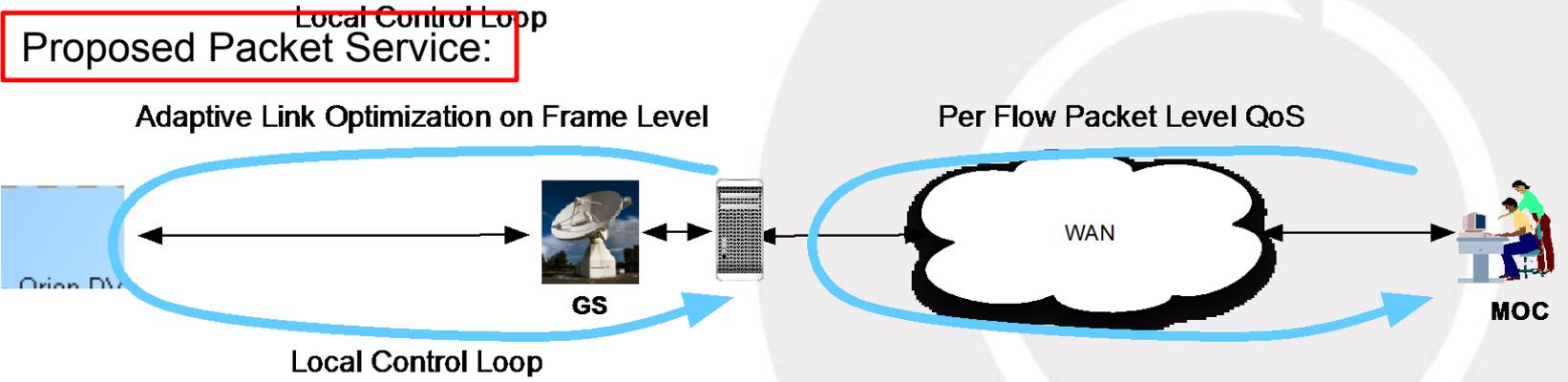
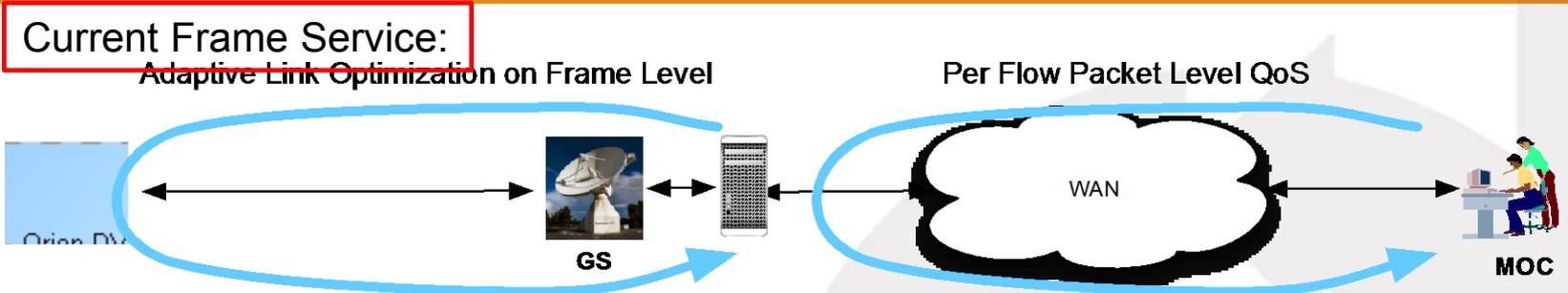
## Basic Packet Service Definition

- Packet Service SDUs may have variable length
- No assumption of internal structure within SDU
  - Could be CCSDS Space Packet, IP packet, DTN bundle or LTP segment, CFPD PDU, user-defined SDU
- Monitoring and performance reporting
  - Running counts of packets transmitted/received
  - Augmented accountability possible if constrain packet structure to standard
- Operation over existing CCSDS space data links that can multiplex Packet Service instances

## Packet Service Benefits

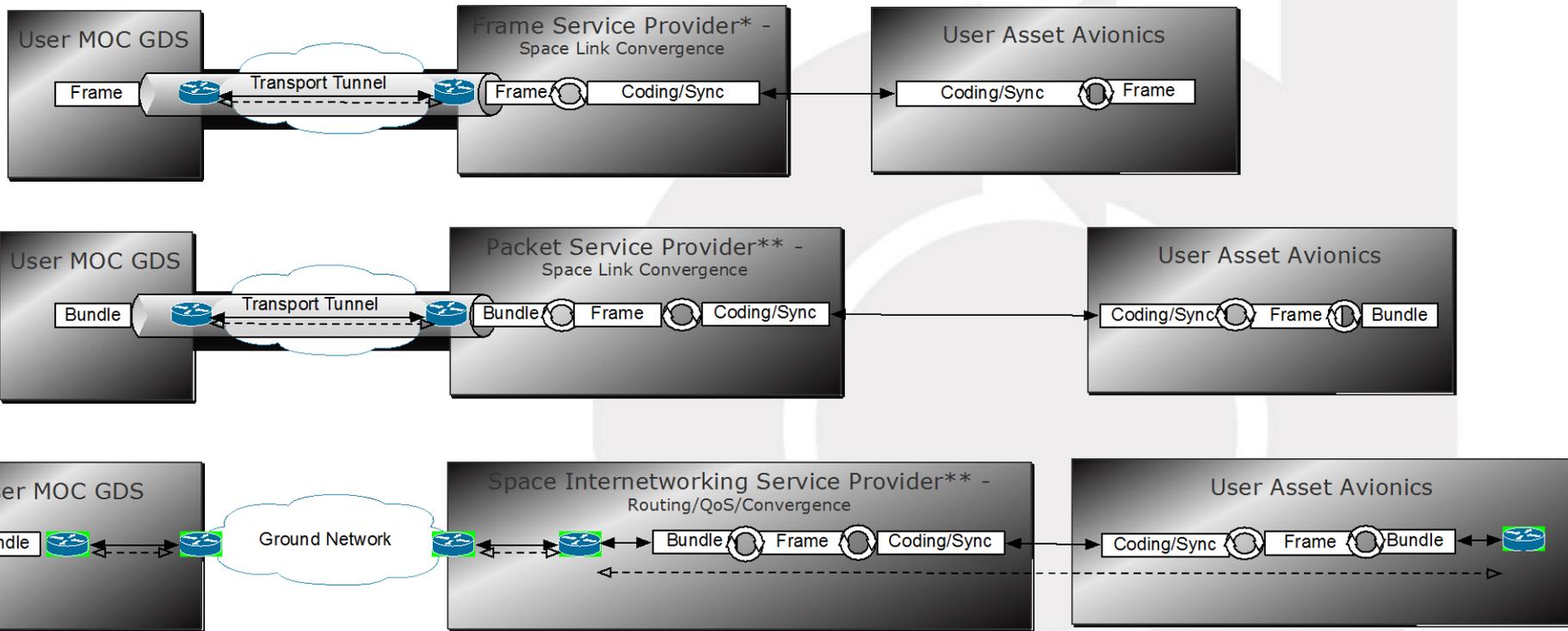
- Enables improved space link efficiency and reliability
  - Enables Provider application of adaptive coding & modulation (ACM), adaptive data rate (ADR), and automated retransmission (ARQ) directly with User spacecraft
  - Increases space data rates by safely operating with tighter margins
- Enhances ground communications efficiency and operations
  - Removes idle fill frames over ground path
  - Removes need for User MOC to maintain synchronous frame stream (fwd AOS)
- User applications not constrained by communications artifacts
  - Service data units sized to meet application needs
  - DVB-S2 spec: “Framing is application independent”
- Reduces ground User processing
  - User MOC not required to perform space link framing and packetization
- Provides crucial progress evolving to Space Internetworking (SI)
  - Develops User/Provider interfaces necessary for SI
  - Gain familiarity with operating with asynchronous packets and dynamic links

# Decouples Space and Ground Domains



- Provider takes over performance optimization based on service-level agreement, using knowledge of station and link performance, reconfiguring link as needed through a control loop with the spacecraft
- Ground User exchanges data as “packets” appropriate to the User’s application, independent of space link. User spacecraft also operates using “packets” with “convergence” to CCSDS link protocol
- Space Internetworking (SI) shares these same features

# Evolution to Space Internetworking



-  Ground Network Router
-  SI Network Router - BP routing & QoS
-  Router Update
-  Bearer Traffic

\* Showing F-Frame Service  
 \*\* Example showing DTN's Bundle Protocol

## Packet Service Implementation

- **Packet Service is fully compatible with CCSDS standards**
  - All CCSDS Space Data Link Protocols offer Packet service interface and segmentation/reassembly methods; no changes needed
- **Packet Service builds on CCSDS technologies**
  - CSS Service Management remains essential and operates similarly (with potential extensions, e.g. configuring buffer for packet bursts)
  - Builds on CSTS Forward-Frame service and Virtual Channels
- **Seamlessly allows simultaneous use of other Provider services**
  - E.g., CLTU service may be contemporaneous, fulfilling concern for reptilian brain communications with a spacecraft in safe mode
- **Packet Service capabilities will be required for SI**
  - SI achieved by adding Network Layer functions & protocols
  - Packet Service requires substantially less development/integration/testing (e.g., Network Management) than SI
- **SCaN largely already capable of offering Packet Service**
  - SCaN requires authority to provide additional service functions

## Packet Service Augmentations

- **Convergence layer services**
  - E.g., IPE/ENCAP for IP, CLA for DTN
- **Improved accountability**
  - Agree to internal packet structure that Provider uses
  - E.g., CCSDS Forward Space Packet
- **Quality of Service support**
  - Agree to internal packet structure that Provider uses
  - E.g., IP DiffServ, DTN BP COS
- **Timed Radiation**
  - E.g., CCSDS Forward Space Packet

## Summary

- Packet Service applies to all missions
  - Most missions served today are for single space data link
- Packet Service enables Provider to support adaptive links
  - 7.7dB gain estimated for deep space (Mars) Ka-band
  - Adaptive coding, modulation, rate; automatic retransmission (ARQ)
- Packet Service advances evolution toward SI
  - Moves packet encapsulation/extraction and framing functions from the user MOC to the provider side
  - Advances interface and operational processes for handling variable-size data units through flow control and prioritized multiplexing at the packet level
  - Packet Service will advance the culture of operating at higher layer, familiarizing missions and Providers with new operational paradigm
- Packet Service is compatible with and leverages CCSDS standards



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