



# Providing Unsignaled Critical Services for a Future Satellite-Based Packet Network

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# Future Satellite-based Packet Networks

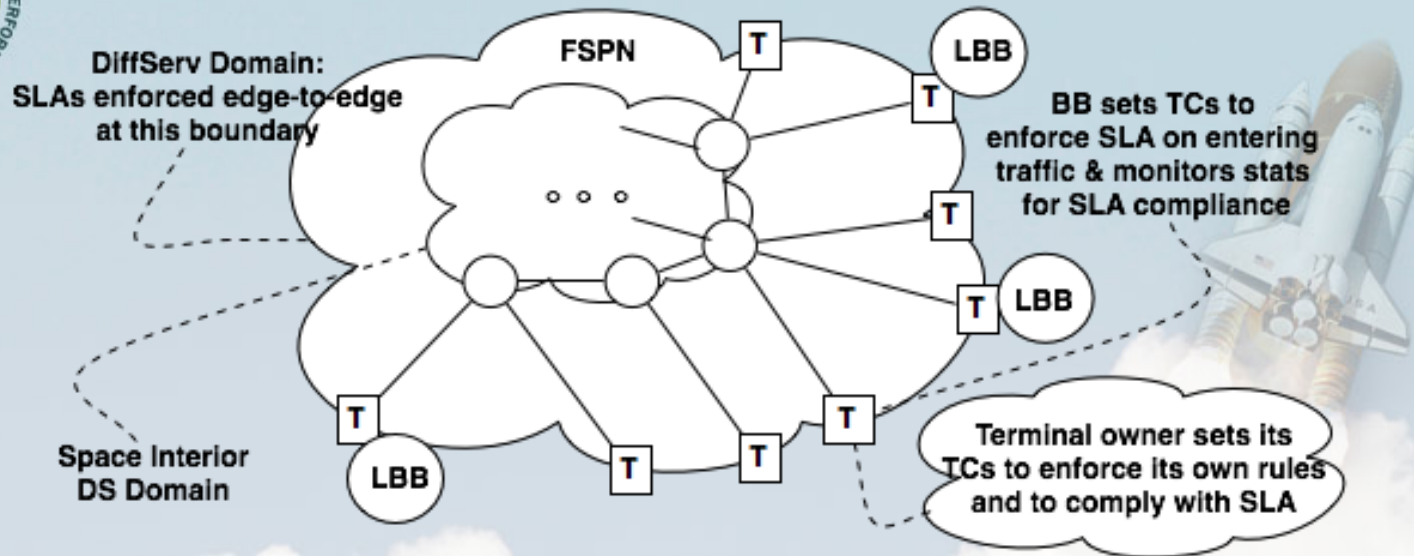
- Enable flexible assignment of resources according to military needs
- Deliver services to terminals that span range from highly mobile and cost-constrained to fixed-location with complex hardware
- Have terminals for which connectivity may be intermittent and location may change
- Function as a “black core” (i.e. encrypted packets with limited information exposed)
- Will provide a limited amount of low-latency, bounded-delay packet communications in addition to simple packet connectivity



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# Differentiated Services for FPSN

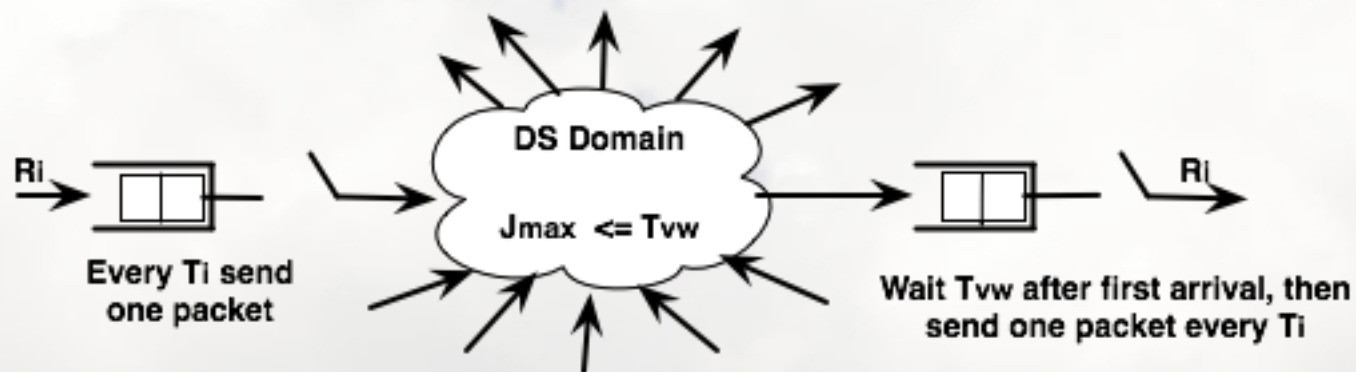


- FPSN uses a Differentiated Services architecture; Per-Domain Behaviors implement distinct service classes of SLAs
- FPSN has an enforceable, monitorable SLA with terminal owners; terminal owners may have SLAs with attached networks
- Use Bandwidth Manager style control with Satellite-Local Bandwidth Brokers for monitoring stats and providing quick response. LBBs ensure sum of traffic permitted by all TCs  $\leq$  provisioned amounts



# Unsignaled Critical Services (UCS)

- UCS is a low-latency, bounded-delay, zero congestive loss service of a peak bandwidth
  - built on Virtual Wire PDB, utilizes DiffServ edge mechanisms to control entry of properly marked packets into the network and DiffServ forwarding path mechanisms to ensure timely delivery of packets
  - concept is to ensure the traffic aggregate runs in flow balance; if a new packet enters the domain every  $T_{vw}$ , then at least one packet departs





# Suitability of UCS for FSPN

- In-band signaling protocols a poor match
  - security, cost, and network considerations of maintaining a signaling stream in presence of link intermittency, terminal mobility, and fine-grained resource tracking
  - terminals include UAVs and units maintaining radio silence
- UCS is a low-latency, bounded-delay, zero congestive loss service of a peak bandwidth
  - can be provided to a terminal, lists of terminals, or unspecified destination terminals; applied to multicast and unicast packets
  - set up may be by third-party and in advance of use
  - capacity planning yields limits on UCS but allocation and commitment of specific resources is flexible
- FSPN has simple topology
  - allocations can be end-point-specific and conservative or domain-general and based on statistical use patterns or combination

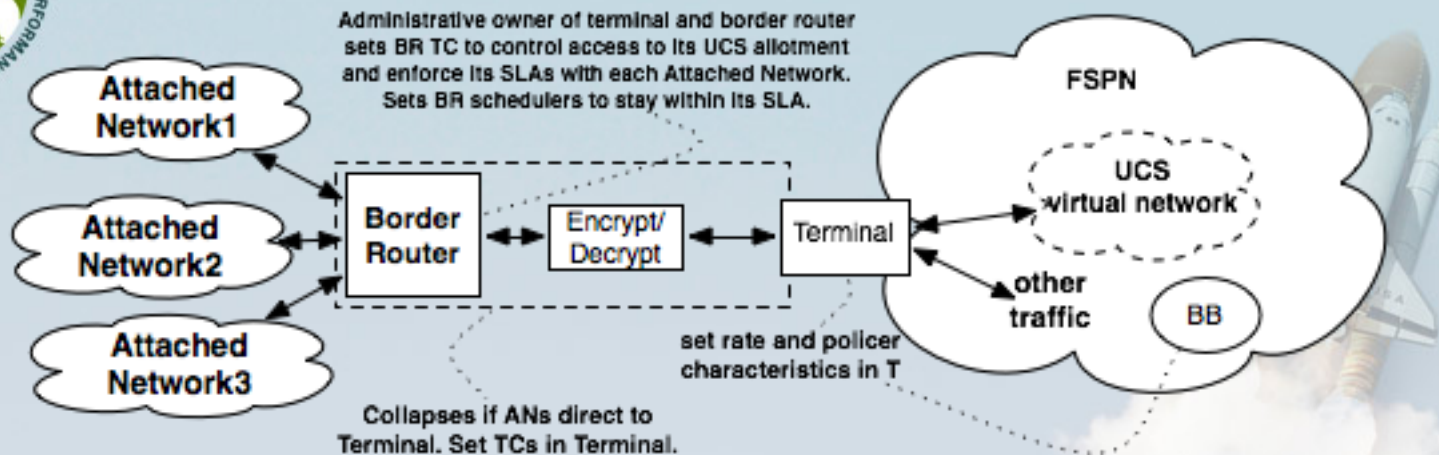


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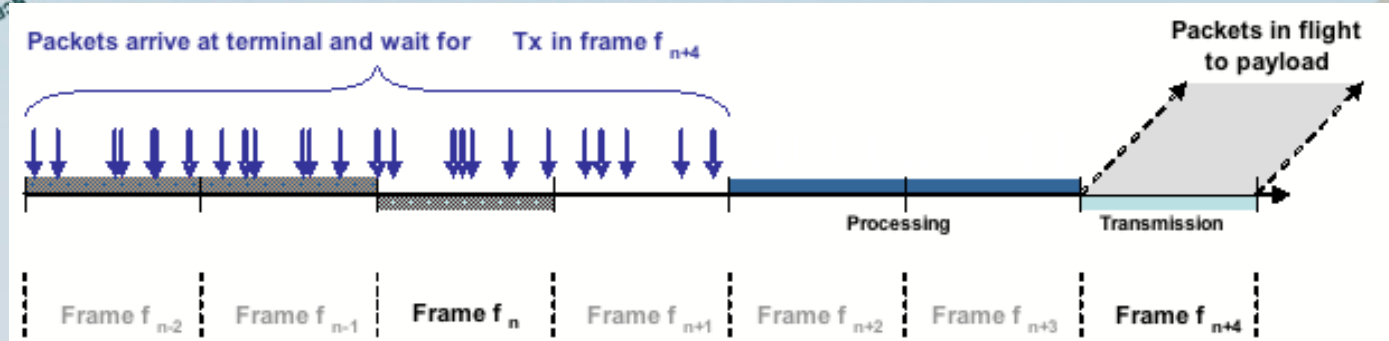
# How Attached Networks use UCS



- FSPN provides a UCS allotment at each terminal; terminal controls use of this allotment
- FSPN cannot match packets to specific flows; only in-clear header available
- BR's TCs are set to enforce its SLA with ANs - must all fit into the Terminal-FSPN SLA
- If ANs directly to Terminal, may use port ids to discriminate or other unique information



## Lower Layer Delay Characteristics in FSPN



- Lower layers of FSPN can introduce large magnitude and variability of delay in packets across link
  - TDMA Framing, processing, transmission, propagation
  - Can dominate all others sources of delay including layer 3
  - Makes low bounded delay VW PDB for UCS unsupportable
- MAC layer treatment in FSPN should be selectively tuned to minimize delay and delay variation bounds across hop for UCS



## MAC Layer Requirements for UCS in FSPN

- Constant Rate Allocation for UCS to mitigate the effects of long Bandwidth-on-Demand response times found in FSPN
  - Dynamic request/grant rate allocation based on traffic loading measurements not appropriate for VW PDB
  - Rate allocated based on total VW PDB rate configured on terminal
- Constraints on number and distribution of timeslots assigned to terminal within superframe
  - Rate assigned must be enforced over timescales equivalent to desired bound on delay variation
  - Timeslots assigned to ensure  $S_{\text{mac}}$  VW bytes can be transmitted every  $T_{\text{vw}}$  time period such that:

$$S_{\text{mac}} = T_{\text{vw}} \times R_{\text{vw}}, \quad \text{where } R_{\text{vw}} \text{ is the configured rate for ingress VW for a terminal}$$



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# Summary

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- UCS is an integral part of an IP Differentiated Services solution
- A relatively low delay service is made available
- Resources can be allocated and committed across a continuum from static with planning cycles to immediate via network management interactions
- Resources can be requested by any authorized agent and allocations can respond rapidly to high-level changes in needs and policies
- UCS allocation can evolve even after deployment
- UCS allocation is flexible, allowing rules to be customized for each mission
- Satellite comm necessitates tuning lower layers



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