

The Benefits and Pit-Falls of IP to Space

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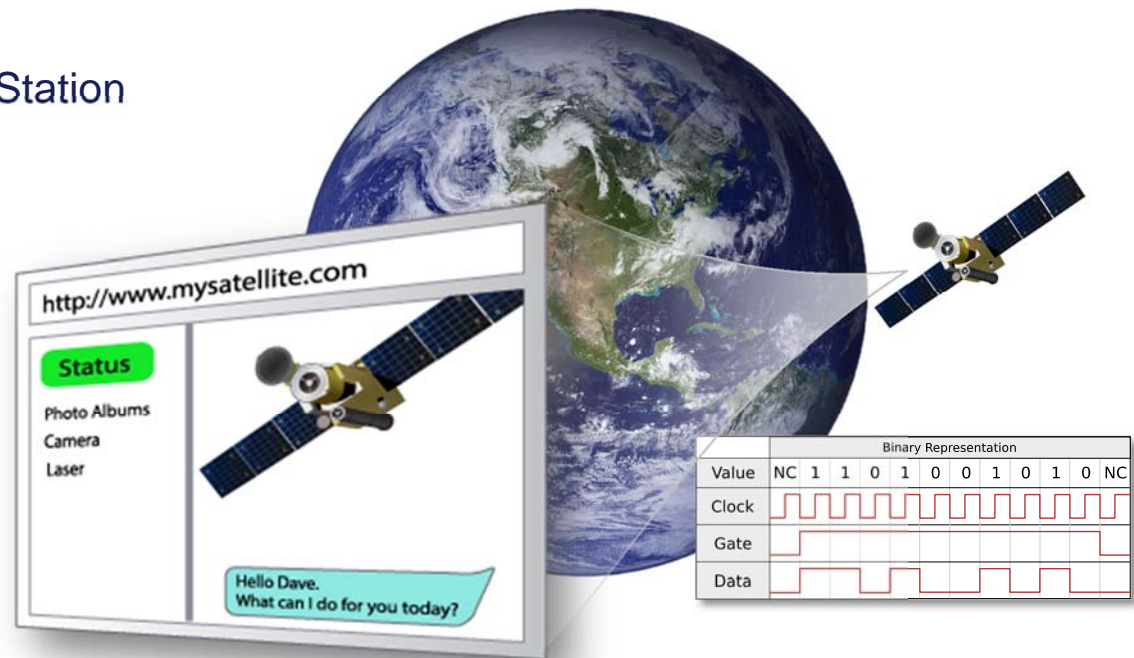
- **The Changing Landscape of Satellite Communications**
 - Moving from old-school TDM to complex networks in space
 - Ground technology is now driving space technology
 - Aging Workforce – new grads know Internet technologies



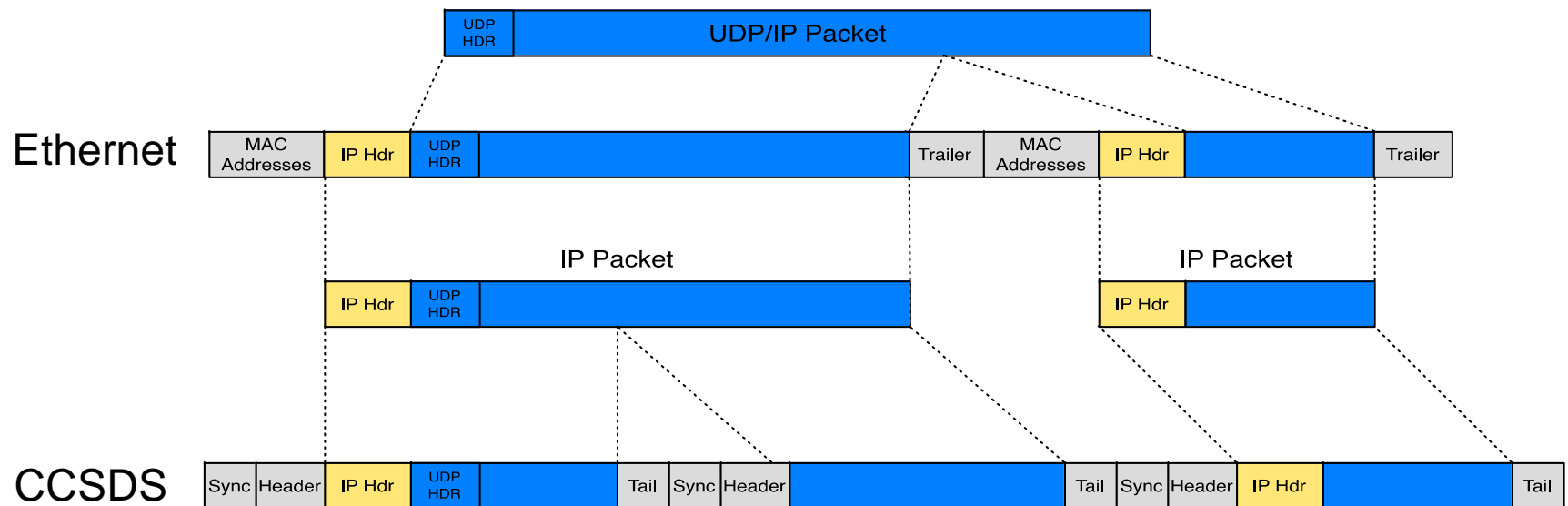
IP-to-Space is an attractive option, but is it a good choice?

- **Traditional Satellite Communication**
 - Based on 1960s concepts – serial data and clock
 - A lot of effort is spent converting these bits to network packets
- **Can We Extend The Network To Space?**
 - Computers on the ground are talking to computers in space
 - Enables direct use of network technologies
 - It is already being done on some space vehicles
 - Small Satellites
 - International Space Station

I want to browse to
my vehicle!



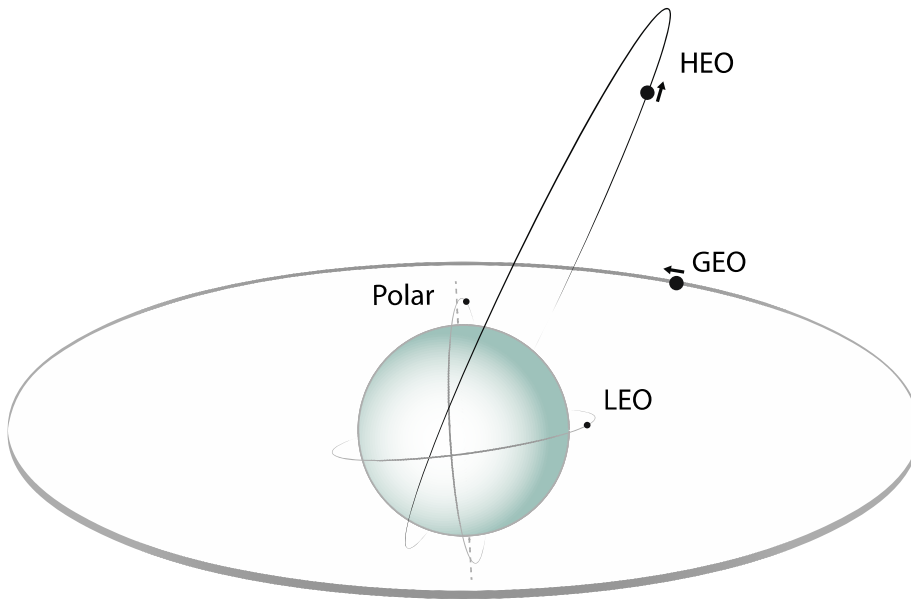
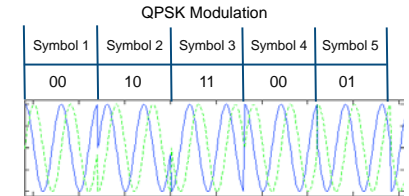
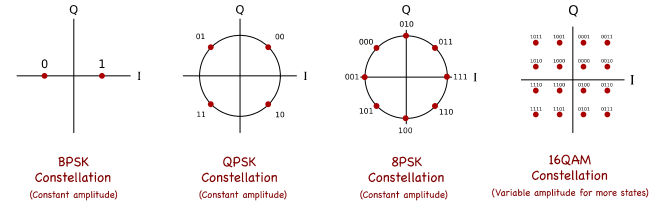
- **The IP Packets Must Be Placed In A Bit Stream For Modulation**
 - Replace the physical and data link layers in the OSI stack
 - Standards Exist For IP Encapsulation
 - Ethernet, CCSDS, HDLC, WiFi
 - These all map an IP Packet to a transport
 - CCSDS was designed for space



Relative header/payload sizes are not to scale

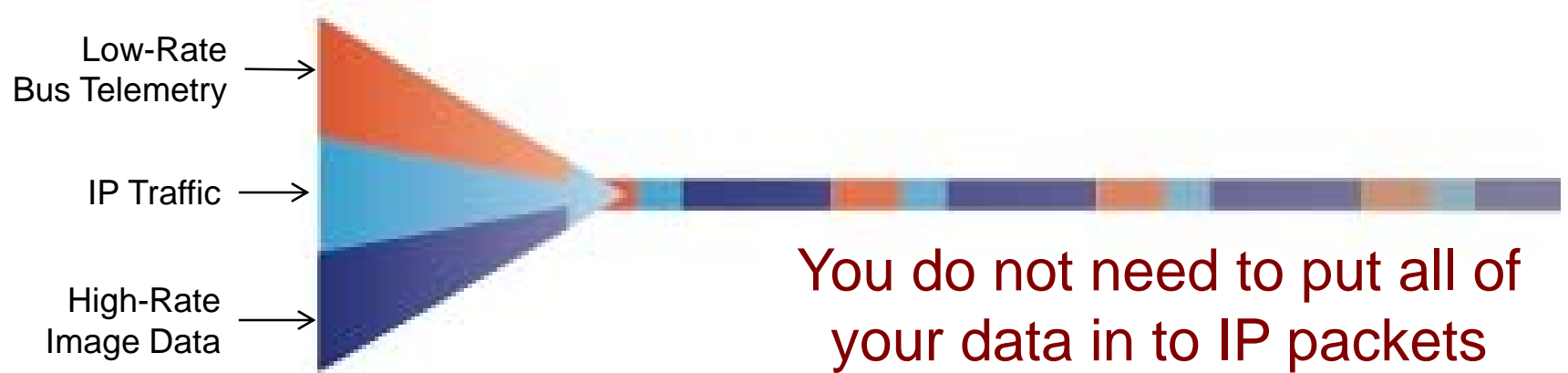
- **We Cannot Ignore The Realities of Space Communication**

- Space link considerations
- Limited contact times
- Asymmetric up/downlinks
- Requires specialized equipment
- Limited Bandwidth
- Extreme Latency
- Vehicle anomalies

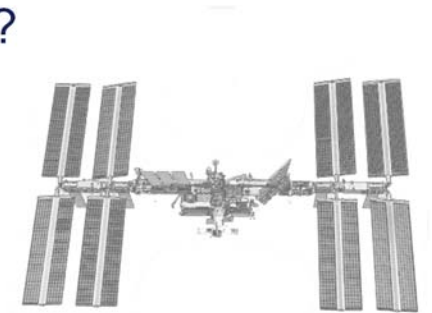


Most network protocols are not designed for this

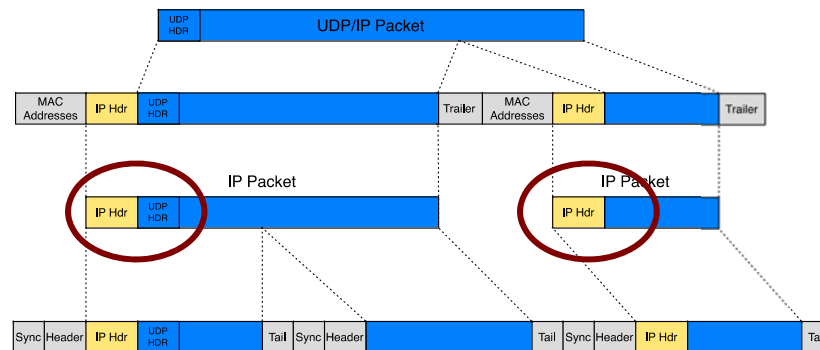
- **IP Packets Were Designed For Ground Networks**
 - IP Overhead: 20 bytes per packet – mostly IP address information
 - Larger packets decrease percentage of overhead
- **Higher Level Protocols Add Even More**
 - UDP (+8 bytes), TCP (+24 bytes)
 - Layered on top are even more: HTML, DDS, SOAP, CORBA etc.
 - And you still haven't transmitted any useful information!
- **Bandwidth Is Valuable**
 - Is it worth sacrificing extra images or other sensor data?
 - Consider CCSDS Virtual Channels



- **This Is Not A Normal IT Problem**
 - Ground network architectures change
 - Should a space vehicle know the ground IP Addresses?
 - How do you dynamically route your data?
- **International Space Station**
 - Video & Voice need to be routed dynamically
 - These are downlinked in IP packets (e.g. VOIP)
 - Used IP-Readdressing to solve the routing problem
 - This wasn't as easy as it seemed



UDP Header
separated from
IP fragment



- **You Are Connecting Your Space Vehicle To A Network**
 - Connecting your ground and space networks requires routing/bridging
 - Often involves placing NICs in promiscuous mode
 - What happens to other network traffic, especially broadcast traffic?
- **What About Other Security Considerations?**
 - Command Encryption: *What crypto do you use for IP?*
 - Multi-level Security Domains: *How do you cross these?*
 - Authentication: *Do you need to worry about network attacks in space?*



- **There Are Benefits In Using IP-To-Space**
 - Get to use standard “Internet” technologies
 - Cheaper to implement, more flexible down the road
 - CCSDS IP Encapsulation Works!
 - Eliminates some of the custom ground hardware and software
 - Creates “one big happy network”
- **But There Are Costs**
 - Added bandwidth
 - More security concerns
- **Also Consider Intangibles**
 - What about existing standards, software, hardware?
 - How does IP to Space change your concept of operations?

**Don't use it just because
it sounds “fun”**

Questions?

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