

# How Does The Internet Work?

Introduction to technical resources

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#### **Rocket Science?**









the premature shutdown of two engines in the S-II stage. After this occurred, the trajectory deviated significantly from the nominal throughout the remainder of the mission. Separation Instrument Unit ¬ A shift from normal performance occurred at approximately 319 seconds. **3259** The performance change is evidenced by a thrust decrease of 33,806 Newtons (7600 lbf). This has been attributed to an ASI fuel line leak on engine 260" S-IVB No. 2. At approximately 413 seconds a large step cecrease in stage Dia performance was evidenced by a reduction of stage thrust to 3,002,535 2747 Newtons (675,000 lbf) and a change of propellants flowrate from 1213 to 2646 (Gimbal) 730.3 kg/s (2675 to 1610 lbm/s). This abrupt change in performance, 2519 approximately 40 percent, was caused by the shutdown of engines No. 2 396" Dia S-II A chronological list of events that are believed to have led to the failure of engine No. 2 are discussed briefly in Table 6-4. Postflight 1760 1664 (Gimbal) 1564 data analysis led to the conclusion that the ASI fuel line, shown in Figure 6-8, had cracked at approximately 225 seconds and continued to 1541 leak progressively until 319 seconds. Since the flight, testing at S-IC Engine No. 3 cutoff resulted from a wiring harness installation error; the control harnesses for engines No. 2 and 3 LOX prevalve solenoids were interchanged. (Plug 206W17P7 was misconnected to receptable 206A507J1 instead of 206A508J1 and plug 206W17P8 was misconnected to 206A508J1.) 100 (Gimbal) -116 Nine of the sixteen primary objectives of this mission were completely accomplished, six partially accomplished, and one (S-IVB restart) was not accomplished. One of the two secondary objectives was completely accomplished, and one partially accomplished.

The actual trajectory parameters of the AS-502 were close to nominal until

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#### **Lessons to Learn?**



- It relies on a complex interaction between different systems, all doing part of the job
- You need redundancy
- You need spare capacity
- Mistakes can and will happen

### **Be Pragmatic in Your Solutions**



- Wires were shortened to make the accidental crossover impossible
  - ...and they redesigned the fuel line



# The Internet Model Understanding the layers





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(PS: OSI ≠ Internet)













# Compatible





#### Interoperable





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(PS: OSI  $\neq$  Internet)

# Implement What You Need





#### **Interactions Between Layers**



- Be open
- Be flexible
- Don't interfere with the other ones
  - Consider their constraints and requirements

### The Internet Model







# **Technical Resources** Standards

### "Internet Standards"



- Are developed by the Internet Engineering Task Force (IETF)
  - Open community
  - Transparent process
  - Decisions by rough consensus
- Process driven by observations and needs
- Organised in working groups
  - Each group focusses on a particular issue or topic

### **Request For Comments (RFC)**



- Output of the IETF standardisation process
- Public documents
  - Access is free
  - Implementation is free
- Also can be informational or "historic"
- An RFC can update or obsolete another one
  - That does not invalidate the old one
  - A published RFC will never be changed

### **RFCs Are Voluntary Standards**



• Your choice to implement a particular one

#### • Two Rules:

- If you implement, fully adhere to the standard
- If you don't implement, don't break anything
- You can always create your own standard
  - Document your solution to benefit others
  - Peer review and discussion can improve it

# **Competing Standards**



- It is perfectly fine
  - It means you have a choice
- Important that they are not interoperable
  - Avoid any confusion or doubt
  - Don't interfere with other standards
- Important they are compatible
  - They need to co-exist side by side
  - They need to interface with other layers

### **Mutual Benefit**



There is a commercial incentive

- Interoperability creates a bigger market
- Networking effect will strengthen your choice
- Ability for "permissionless innovation"
  - Build on or further develop other people's work
  - They might also benefit from your development



# **Technical Resources** number spaces

#### **Protocols Rely on Numbers**



- To be interoperable:
  - Find each other, e.g. IP addresses
  - Understand each other, e.g. response codes
- To be compatible:
  - Distinguish between standards, e.g. TCP and ICMP
  - Connect the different layers, e.g. tcp port numbers

#### **Fixed and Variable Numbers**



- Some are fixed within the standard
  - IP version numbers, response codes, etc.
- Some are defined as variables
  - IP address, DHCP option codes
- Some are semi-flexible
  - HTTP defines response 400-499 as "Client error"
  - 451 recently defined as "Blocked for legal reasons"

# **Keeping Track**



- Numbers often need to be unique
  - Assurance for compatibility and interoperability
- Several option exist
  - Document them as part of the standard
  - Define them via a separate standard
  - Use a registry to administer them

# Coordination



- Somebody needs to coordinate all of this
  - Ensure uniqueness
  - Provide available numbers
  - Document what everybody is using
- Internet Assigned Numbers Authority"
  - Used to be an IETF volunteer: Jon Postel
  - Contracted by US Government
  - IANA is now a department within ICANN

### **Standards Are Voluntary**



- This reflects in the number spaces
  - Standard compliance involves following the registry
- Mutual benefit is the driver
  - Using registered numbers makes me compatible
  - Adherence to registry rules makes me interoperable

#### **RIRs: A Matter of Scalability**



- IP addresses became a fundamental resource
  - Everything was being build on top of the Internet Protocol
- Operational requirements asked for details
  - Who is responsible for a particular set of addresses?
  - How can I contact them?
- This registry grows with each network or device that connects to the Internet



# The RIR System

### **Regional Internet Registries**



- There are five RIRs globally:
  - RIPE NCC (est. '92), APNIC ('93), ARIN ('97), LACNIC ('01) and AFRINIC ('05)
- Origins can be traced back to IETF
  - They started looking for ways to scale up the registry

- Loosely modelled to the IETF
  - Open and transparent policy development
  - Decisions made by rough consensus

# **Benefits Of Being Regional**



- Policy development can take into account regional differences in market developments
- Closer to the resource users
  - We need to know who they are
  - Easier to maintain an accurate registry

# Keeping An Accurate Registry



- Ensures the resources are unique
- Provides transparency on distribution
- Enables contact with the network operator

# **Global Coordination**



- IANA is responsible for global resources
  - Protocol parameter registries
  - Global IPv4 and IPv6 address registries
- Policy for IP addresses is created through the five regional RIR community processes
- Protocol parameters are defined using the IETF standardisation process
  - Includes special use IP addresses, e.g. multicast



# Making It Work Connecting to the Internet

#### **Network of Networks**



- Any network can become part of the Internet
  - It is free and it is open
- Implement the open IETF standards
  - IP protocol, BGP and a few others
- Get a set of globally unique resources
  - Ask your RIR for IP addresses and an AS number
- Connect to a network that did the same

#### It Is a Matter of Trust



- This is a "social contract"
  - Only send/receive traffic according to the standards
  - Only use resources that are registered to you
- Don't harm other networks
  - Or other people's packets
- Cooperate operationally with other networks
  - Keep the Internet stable
  - Keep the Internet secure

#### **Mutual Benefit**



- Nobody "owns" the Internet
  - There is no backbone
  - Your network, your rules
- You choose who you connect with
  - Settlement free peering arrangements
  - Paid connection via a carriage provider (transit)
- Customers on both side have benefit
  - Which is reflected in your business



# **A Bit on Names**

# Because We Are Bad With Numbers



- Humans have hard time remembering them
  - Computers are better with numbers than names
- An IP address represents a network location
  - Change your location, your IP address changes
  - Addresses can be and are commonly shared

# **Domain Name System**



- A set of protocols developed by the IETF
  - Distributed database that maps names to numbers
  - Will tell you the IP address (network location) of a service or device you want to connect to
- It is an application on the Internet

#### Management of the DNS



- Coordinated via ICANN
  - Pay attention to the next talk :)



# **Future?** A quick look forward

# Internet of Things



- A lot of IoT does not use the IP protocol
  - That doesn't mean it isn't part of the Internet
  - It might use other "Internet" protocols
- The network of networks keeps expanding
  - IPv6 is the enabler of this future growth

#### Keep a High Level View



- Don't get too strict on definitions
- Competitive standards are a feature
  - They enable further innovation
  - Evolution is a natural property of the Internet
- Support and encourage the open model
  - Participate in the relevant forums
  - Cooperate with other stakeholders



# Please tell us how we can help you.





# Questions

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