
Internet Evolution

Vint Cerf

July 2008

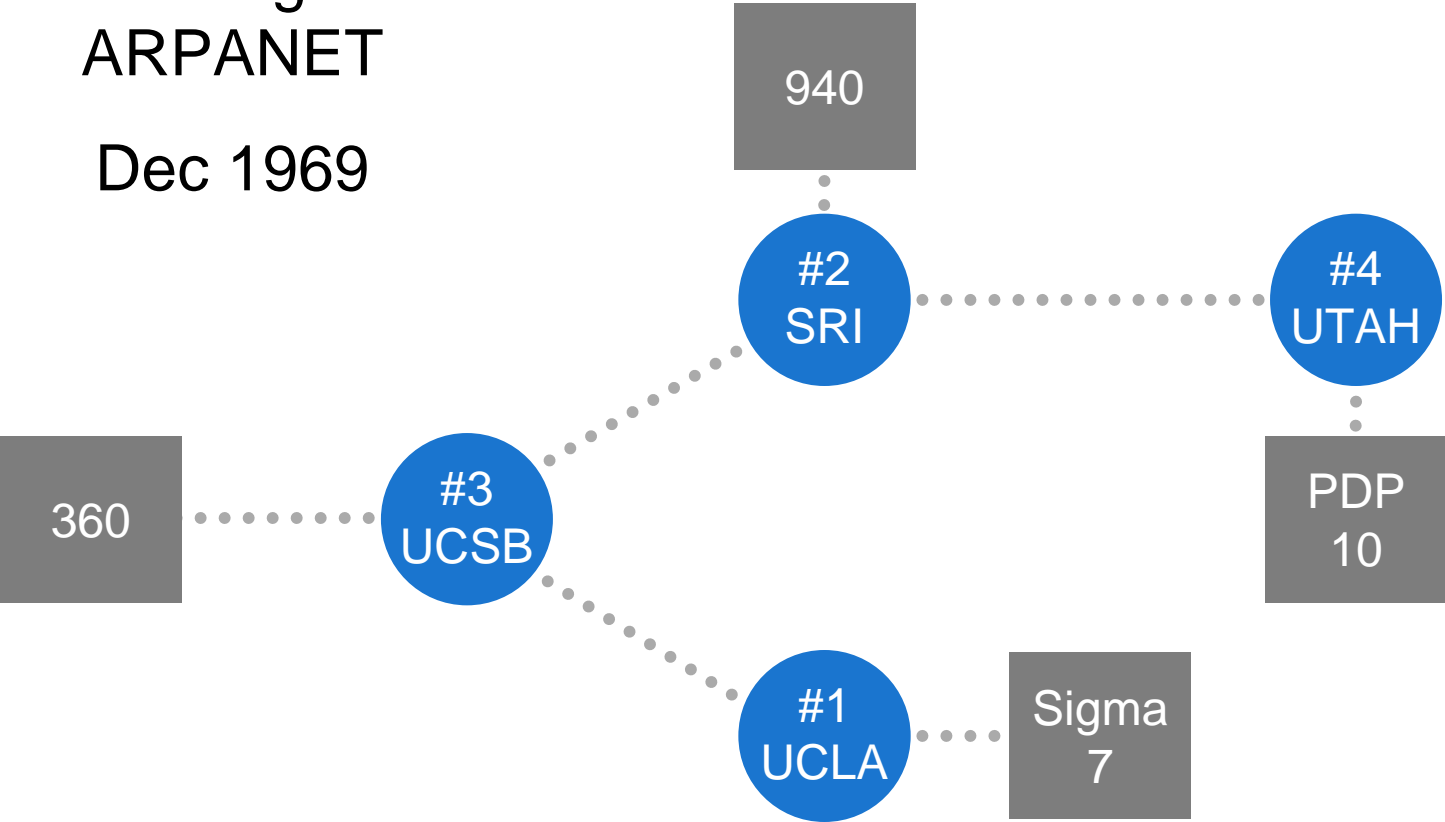




Internet Evangelist at Work

The Original ARPANET

Dec 1969



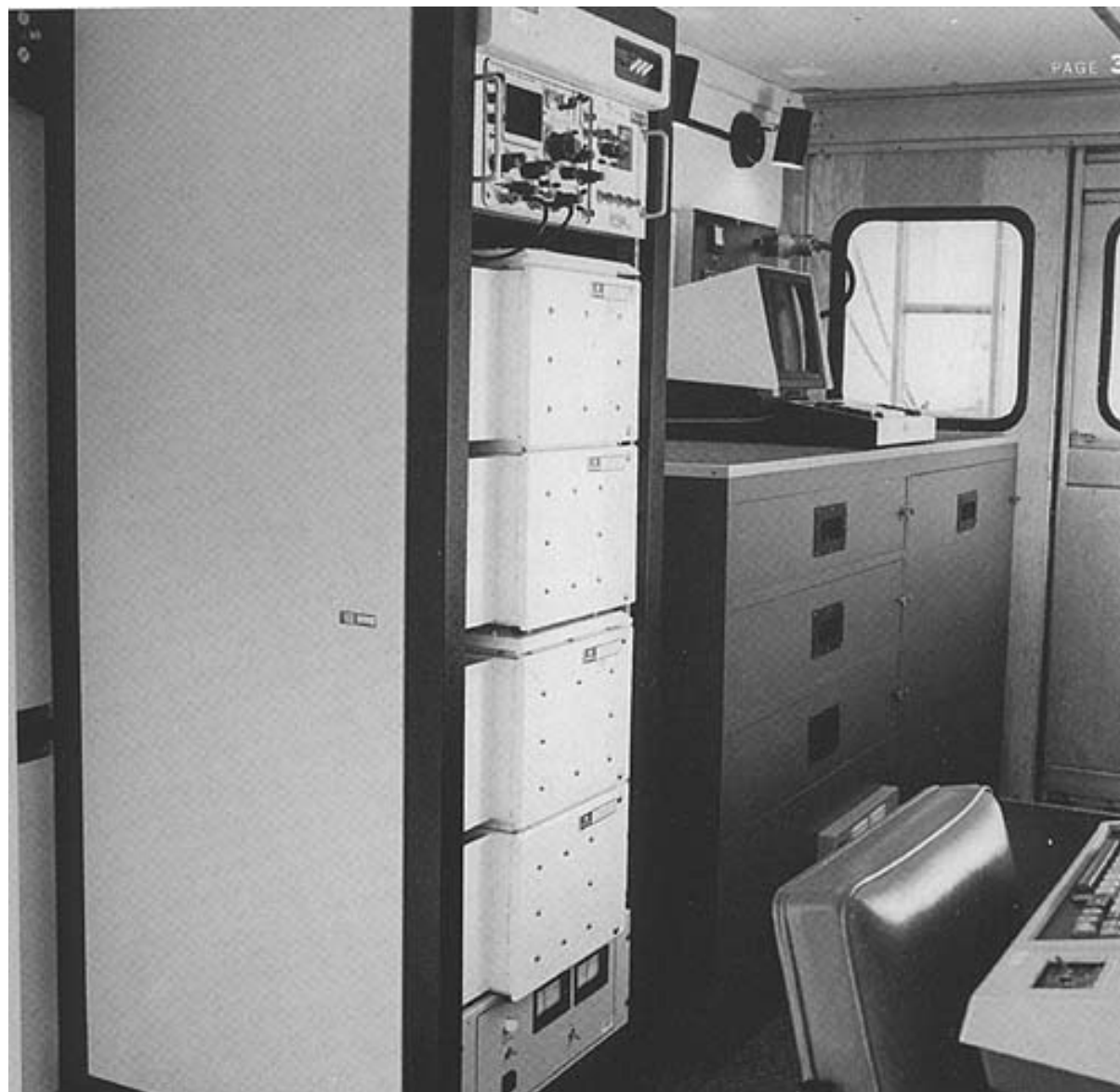
The ARPANET IMP



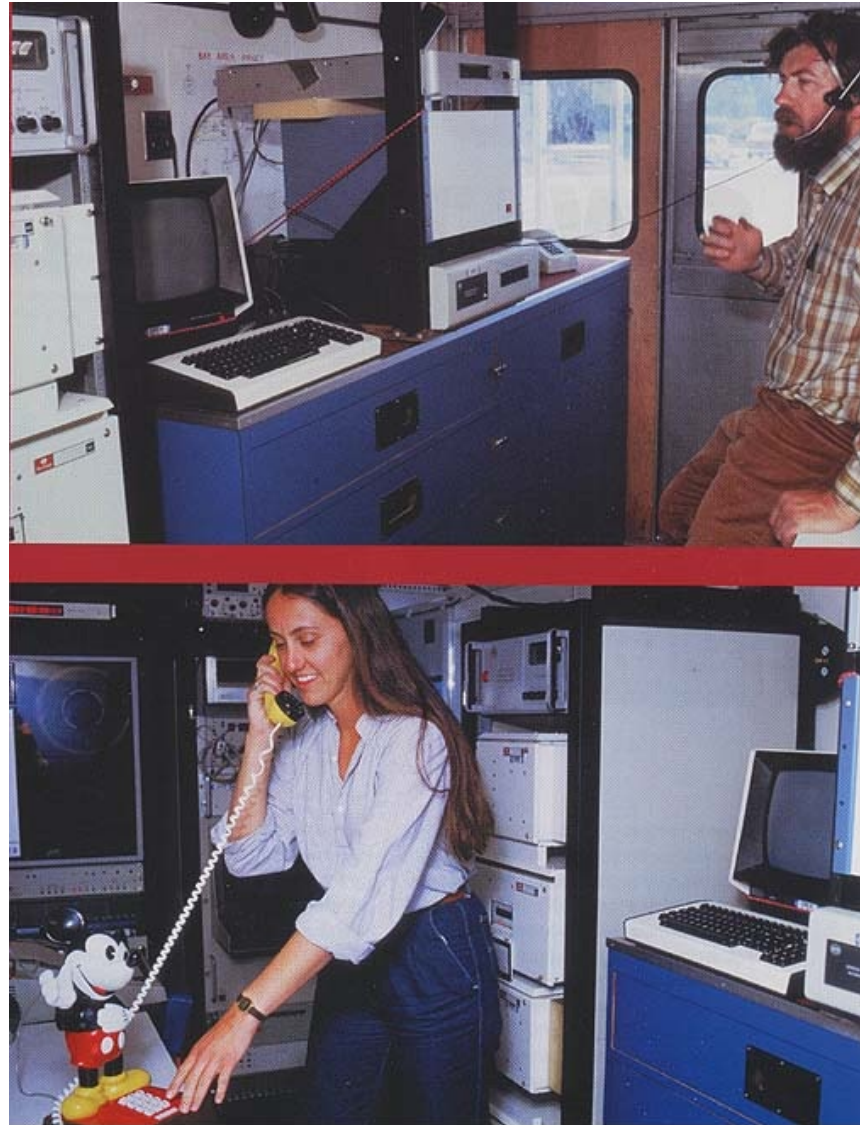
Packet Radio Van



Inside the PR Van



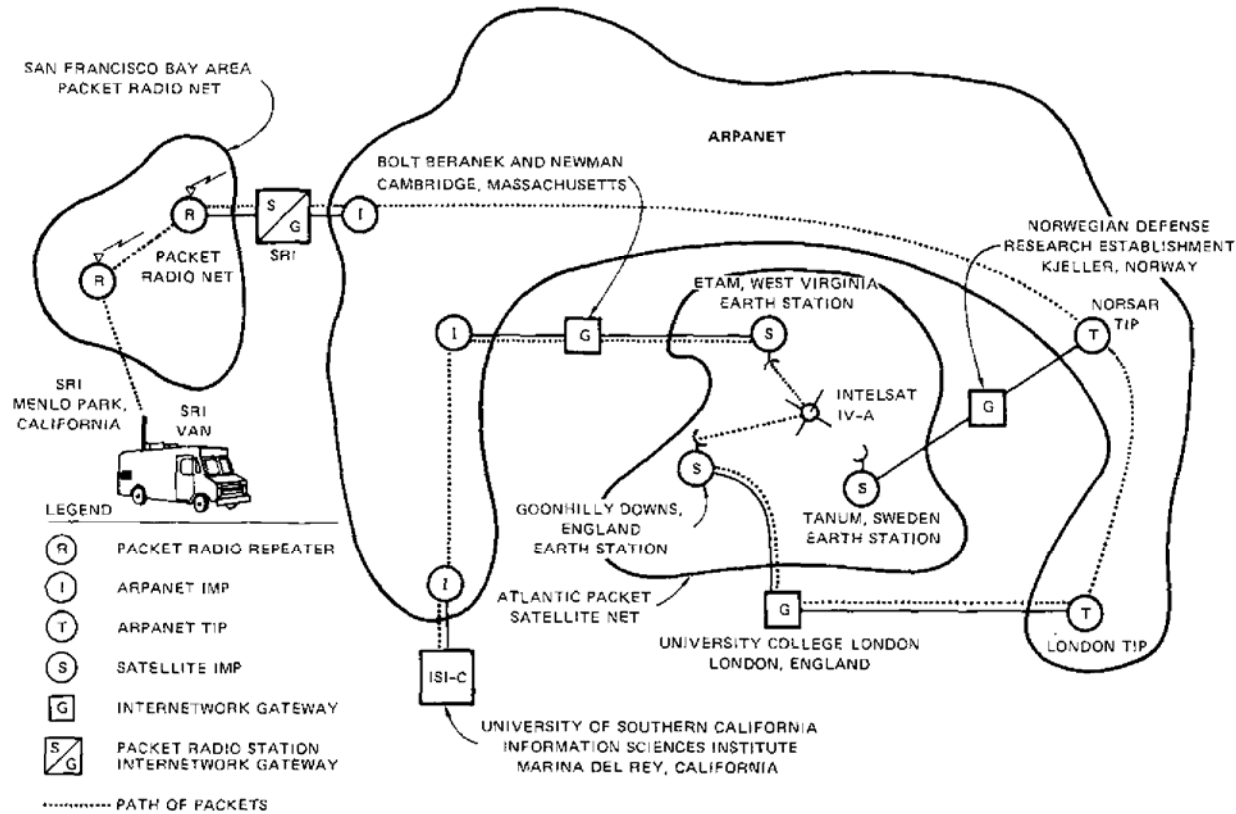
Inside the PR Van (2)



Intelsat IVA - Packet Satellite Network

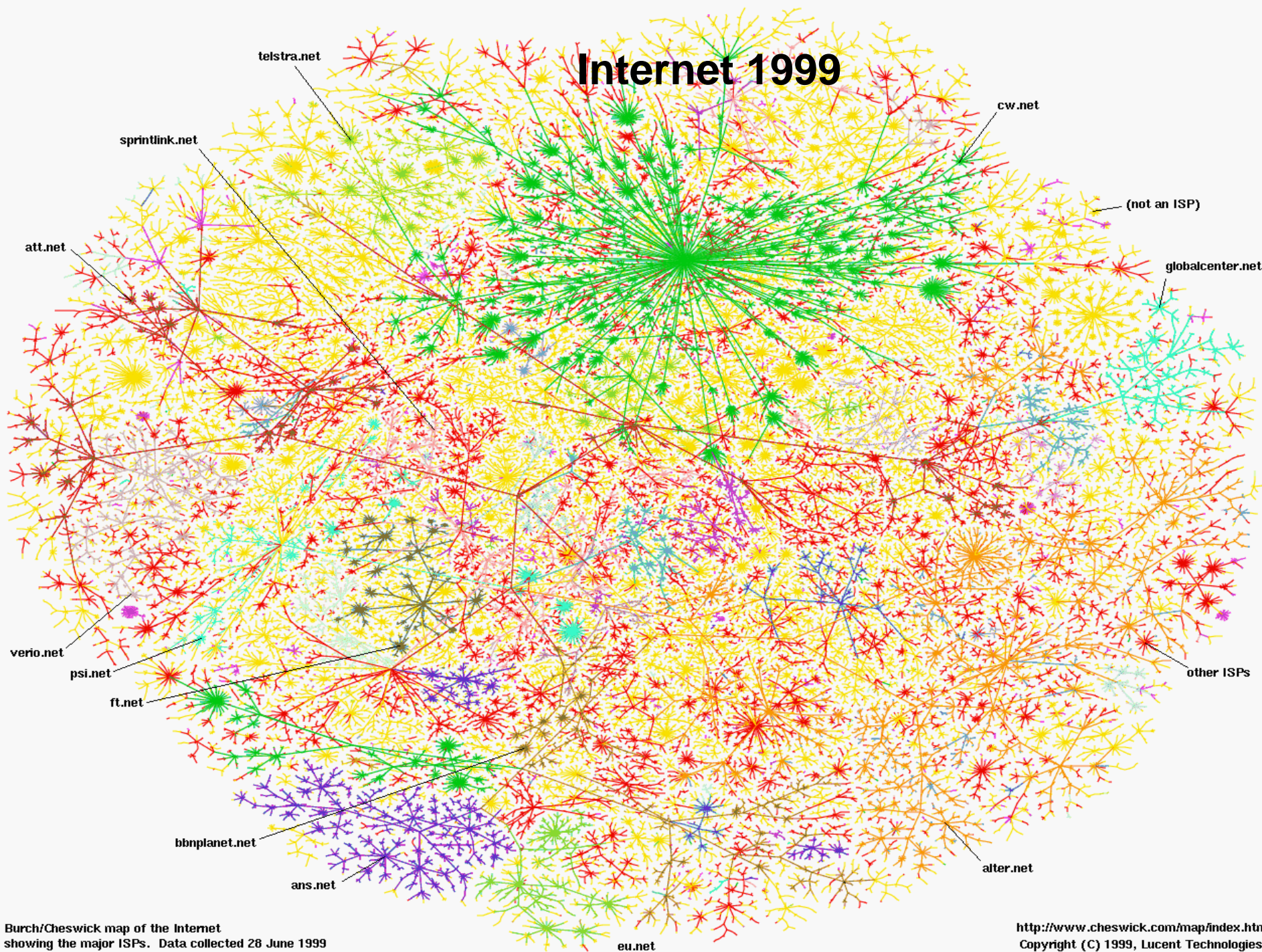


First Three-Network Test of Internet



November 22, 1977

Internet 1999



Burch/Cheswick map of the Internet
showing the major ISPs. Data collected 28 June 1999

<http://www.cheswick.com/map/index.html>
Copyright (C) 1999, Lucent Technologies

542 Million Hosts

(ISC Jan 2008)

1,464 Million Users

(InternetWorldStats.com,
June 30, 2008)

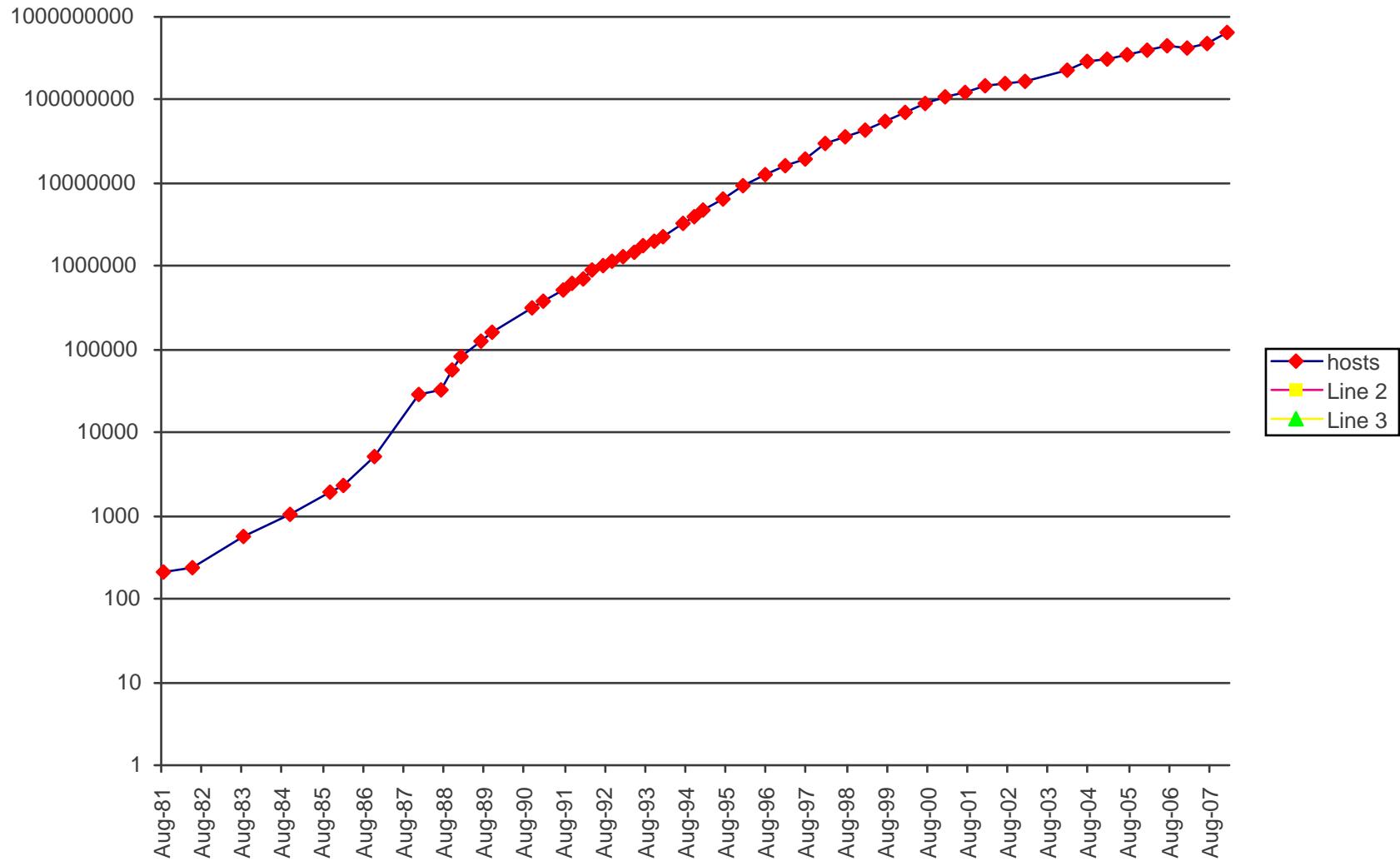
(approx. 3 B mobiles and 1 Billion PCs)

Regional Internet Statistics 6/30/08



Region	Internet Population	% penetration
Asia	578.5 Mil.	15.3 %
Europe	384.6 Mil.	48.1 %
North Am.	248.2 Mil.	73.6 %
LATAM/C	139.0 Mil.	24.1 %
Mid-East	41.9 Mil.	21.3 %
Oceania	20.2 Mil.	59.5 %
Africa	51.0 Mil.	5.3 %
TOTAL	1,463.6 Mil.	21.9 %

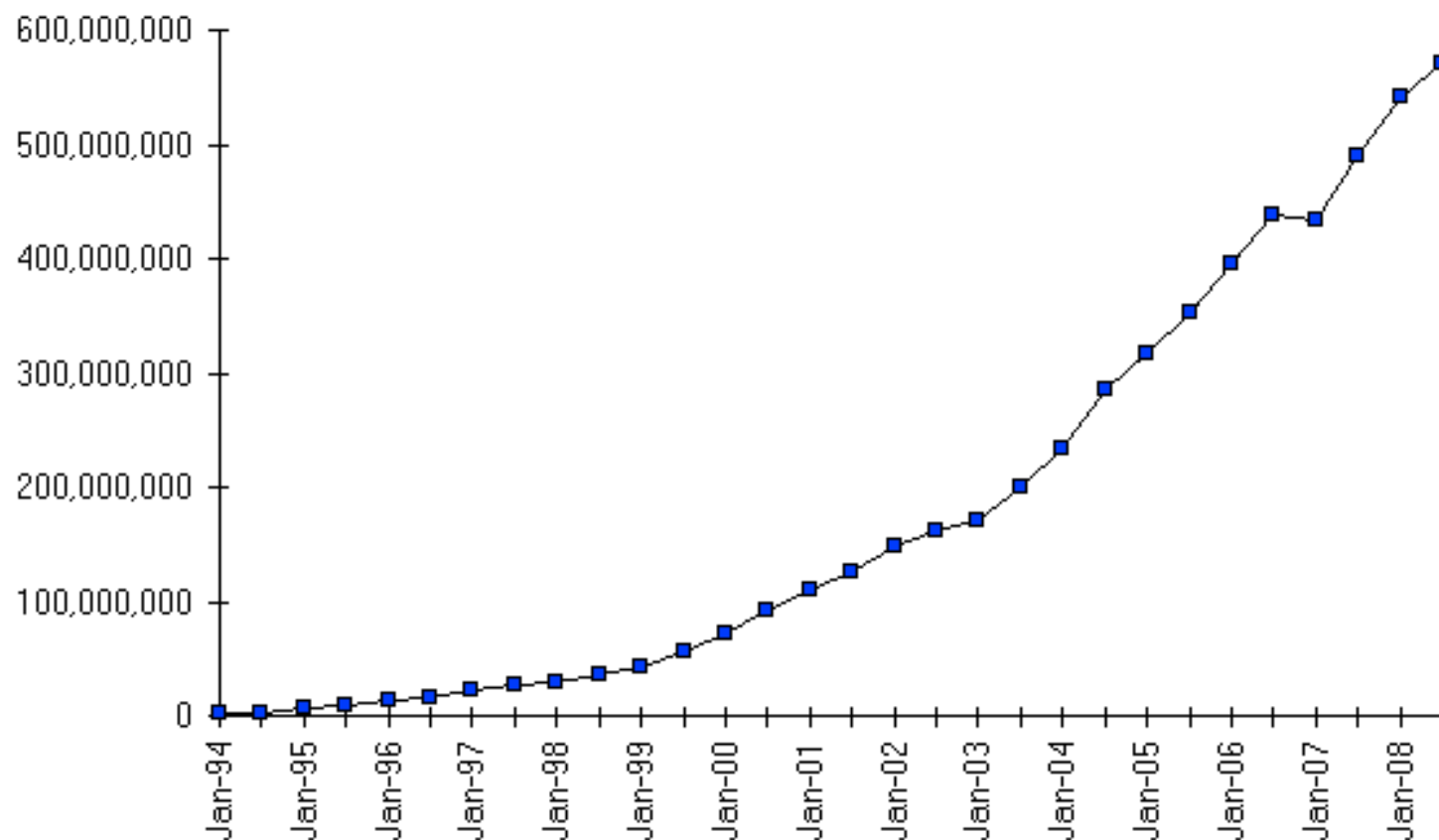
Internet Host Growth 1981-2008



Past Results

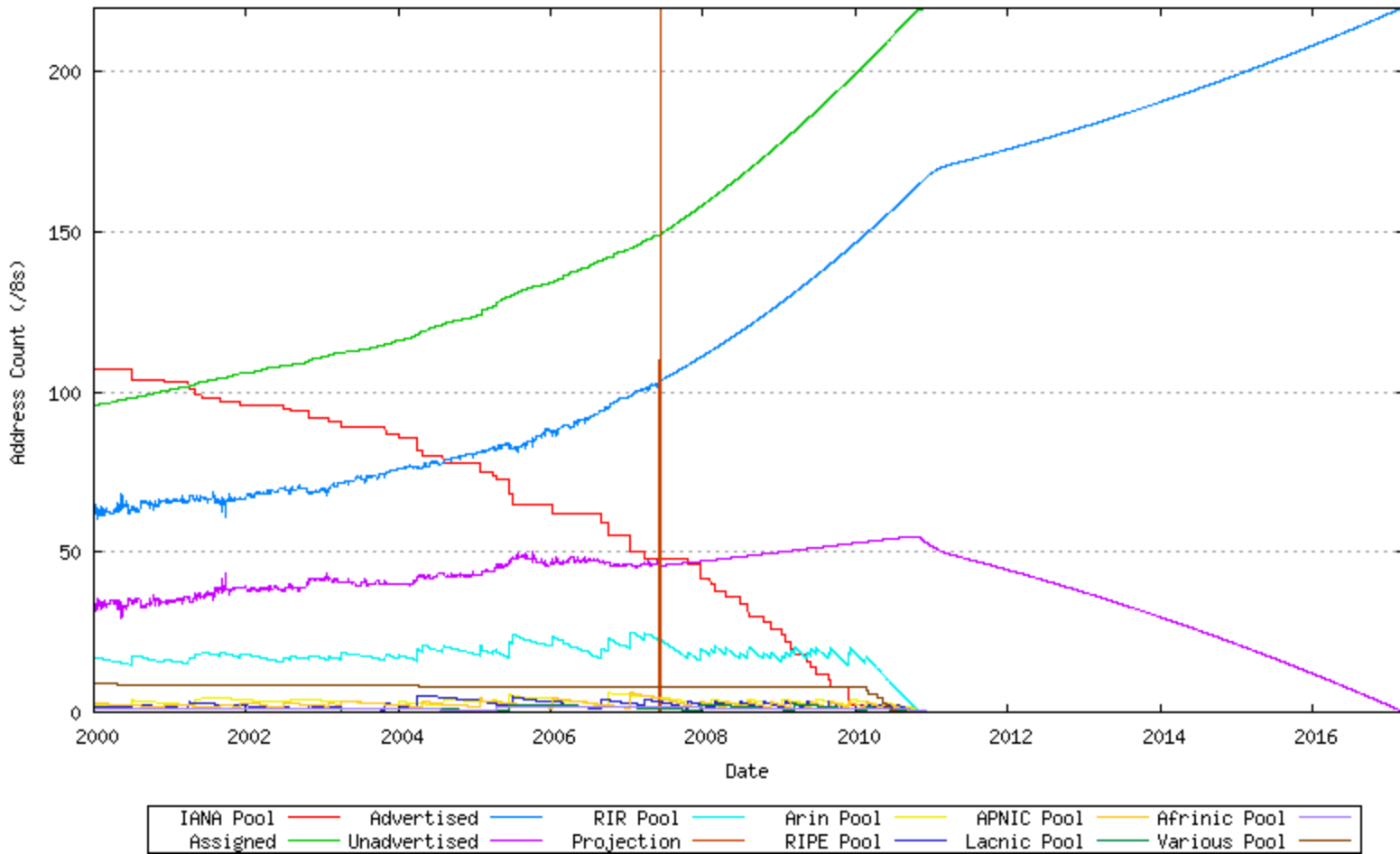
Jan 08
 Jul 07
 Jan 07
 July 06
 Jan 06
 Jul 05
 Jan 05
 Jul 04
 Jan 04
 Jan 03
 Jul 02
 Jan 02
 Jul 01
 Jan 01
 Jul 00
 Jan 00
 Jul 99
 Jan 99
 Jul 98
 Jan 98

Internet Domain Survey Host Count



Source: Internet Systems Consortium (www.isc.org)

IPv4 runout diagram (Geoff Huston)



<http://www.potaroo.net/tools/ipv4/index.html>

- 128 bits of address space

340 X 10³⁶ unique addresses

- IPSEC not optional
- Flow ID
- ipv6.google.com (animated Google logo)

- Concurrent operation with IPv4
- Routing table sizes, update rates, scaling
- Non-interoperability of IPv4 and IPv6
- Network Management and Provisioning
- Fragmented connectivity (peering implications)
- Allocation and Assignment units
- Business models

- 3 Billion Mobiles and counting (15% Internet enabled)
- Text/Web Access
- Payment systems
- Innovative interfaces - Note I/O discovery
- Navigation systems
 - GPS, Galileo?, Mobile Tower triangulation, Bldg Announcements?
- Geo-location based services

Internet-enabled Devices



An Internet of Things



Programmable – Java, Python, etc.

Examples:

- WebTV, Personal Digital Assistants, Mobiles, Video games, Picture Frames, Washing Machines, Surf Board!
- Refrigerator (and the bathroom scales)
- Automobiles
- Internet-enabled wine corks (also note new quantum theory of wine: Schrödinger's wine bottle)
- Internet-enabled socks (clothing)
- Universal Remote Controls
- Sensor Networks

- IPv6 - 128 bit addresses (3.4×10^{38})
- DNSSEC (.se, .pr, .bg, .br, others?)
 - Root zone a big issue
 - Challenge for *.google.com
- Internationalized Domain Names
 - Non-Latin Unicode characters
 - ASCII Punycode encoding “xn--...”
 - Potential hazards (e.g. paypal, .py (paraguay or russia?))
- New ccTLDs and gTLDs
 - ISO 3166-1 (ASCII 2 char) -> iCCTLDs?

Security at all levels

Internet “Erlang” formulas

QOS debates (smart routers?)

Internationalized Domain Names (ccTLDs & GTLDs)

Distributed Algorithms

Presence (multi-level)

Mobility, persistence (processes, connections, references)

Multihoming

Multipath routing

Broadcast utilization

Mesh and Sensor networks

Virtualization (net, storage, processing)

Authentication, Identity,
Authorization

Multi-core Processor Algorithms

Delay and Disruption Tolerance

Integration of Applications (e.g.
drag/drop gadgets in calendar)

Intellectual Property Protection
(tracking rights, enforcement)

Role of Layering

Governance:

- Law Enforcement
- Policy Development
- Homologation
- Facilitation of ecommerce
- Privacy and confidentiality

Mobile operation

Dynamic joining (new IP address?, Authentication?)

Dynamic Routing (Dynamic Topology)

Persistent connection (ID at TCP/UDP/RTP layer?)

Interplanetary Long-Haul Architecture (RFC 4838)

Licklider Transport Protocol (LTP)

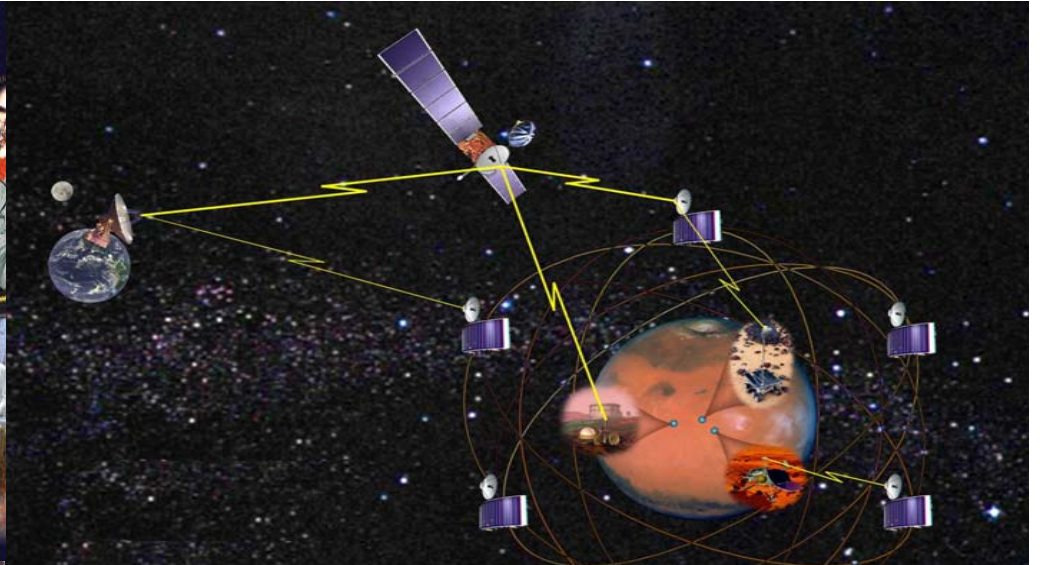
Bundle Protocol (RFC 5050)

Delayed Binding of Identifiers

Email-like behavior

- Streaming and Downloading
 - iPOD and vPOD behaviors?
- Mixing of all media as IP packets
- Ancillary information access
 - Downloaded texts, programs, videos, audio, captions
 - Advertising material
- Screen Control (icons, widgets)
- Multiple streams to multiple displays (beauty of packet switching)
- Online interaction while viewing
 - Group commentary
 - Advertising and product information

- Intellectual property treatment
 - Digital material is easy to copy and distribute
- Semantic Web
- Complex objects that can only be rendered via computer
 - 3D interactive objects
 - Complex spreadsheets
 - Interactive environments
- BIT ROT!
 - Preserving interpretive programs (Windows 3000 and PPT 1997)
 - And the operating systems that run them
 - And the hardware that run the operating systems
 - For thousands of years!!

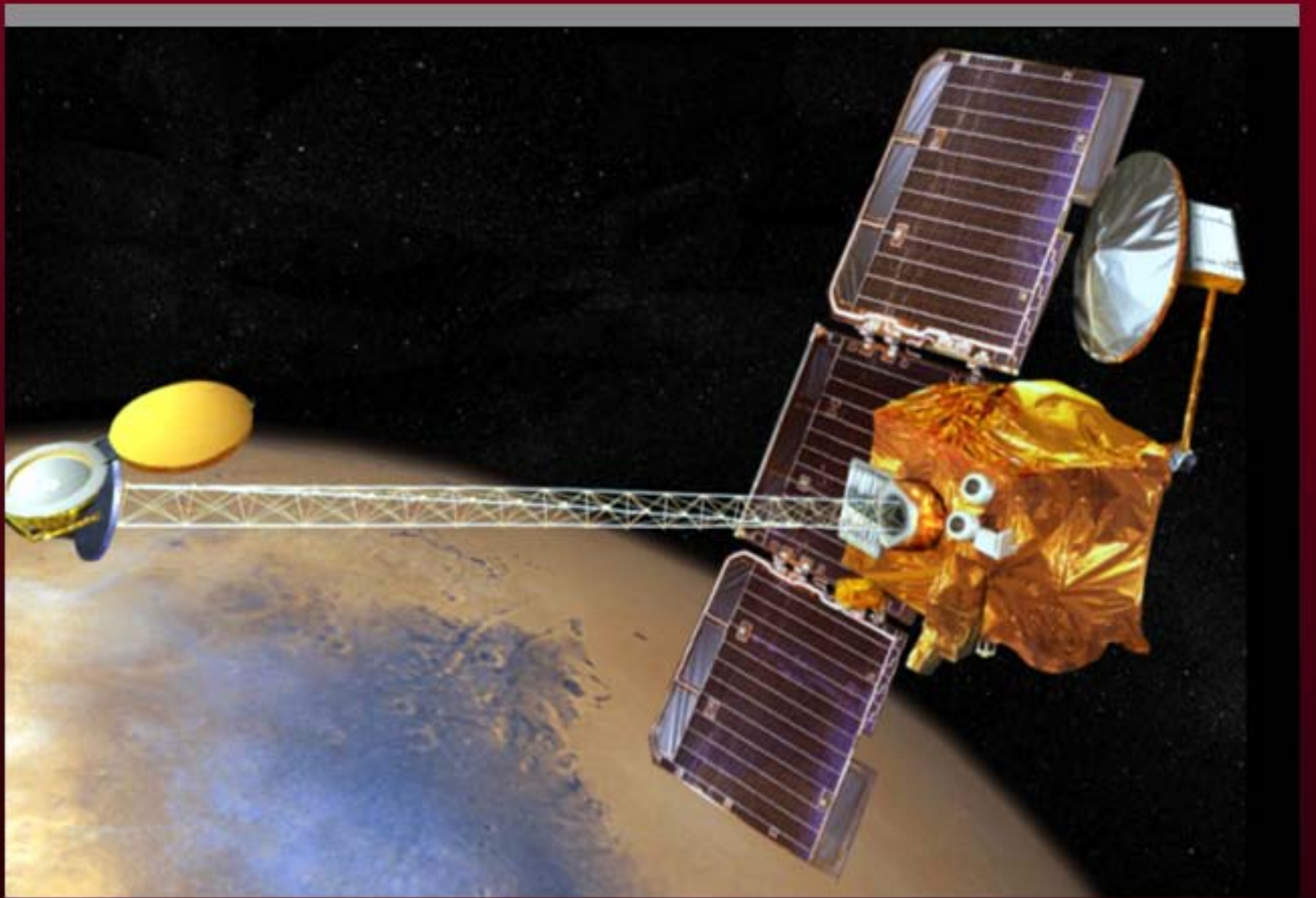


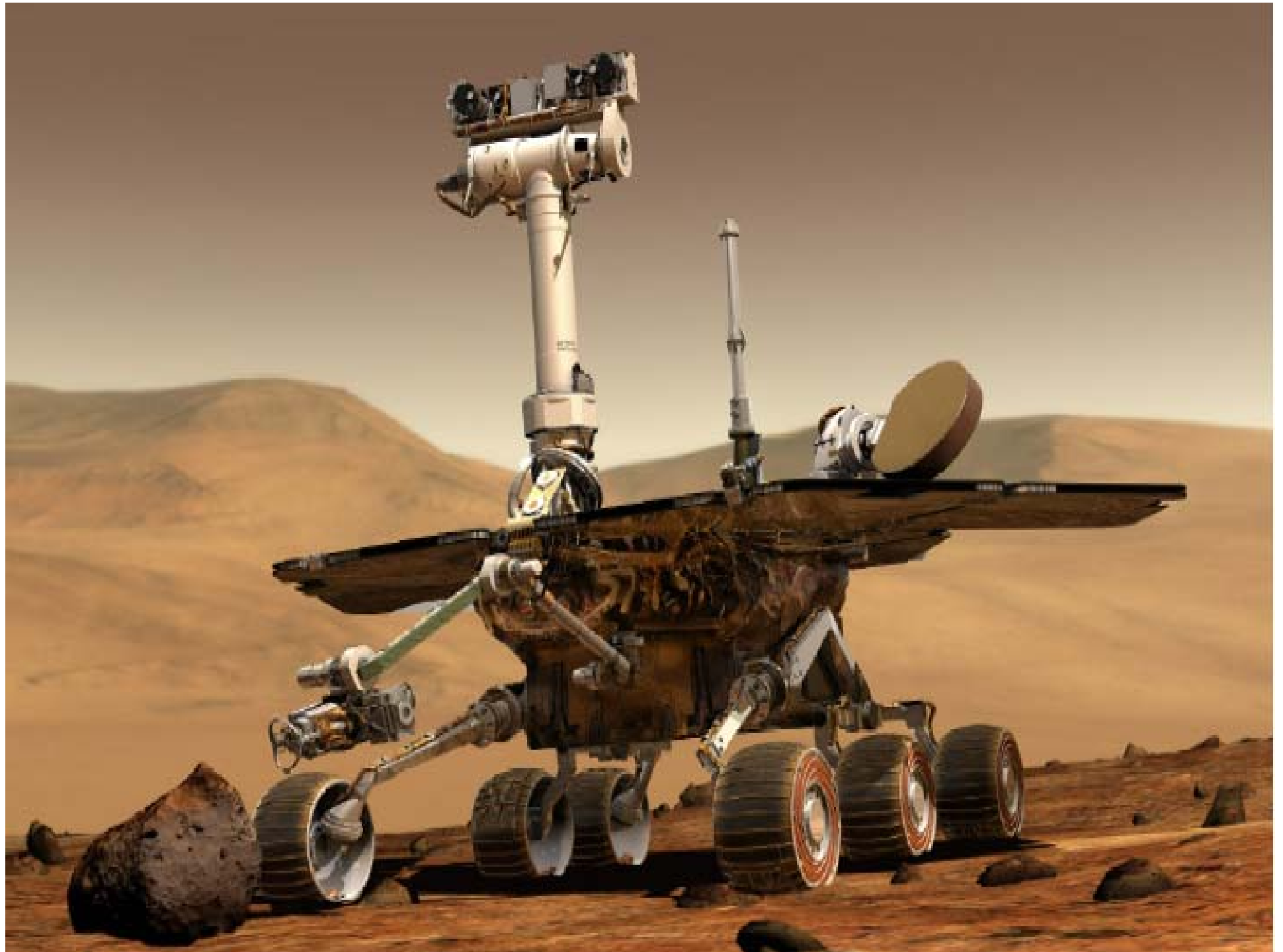
InterPlaNetary Internet

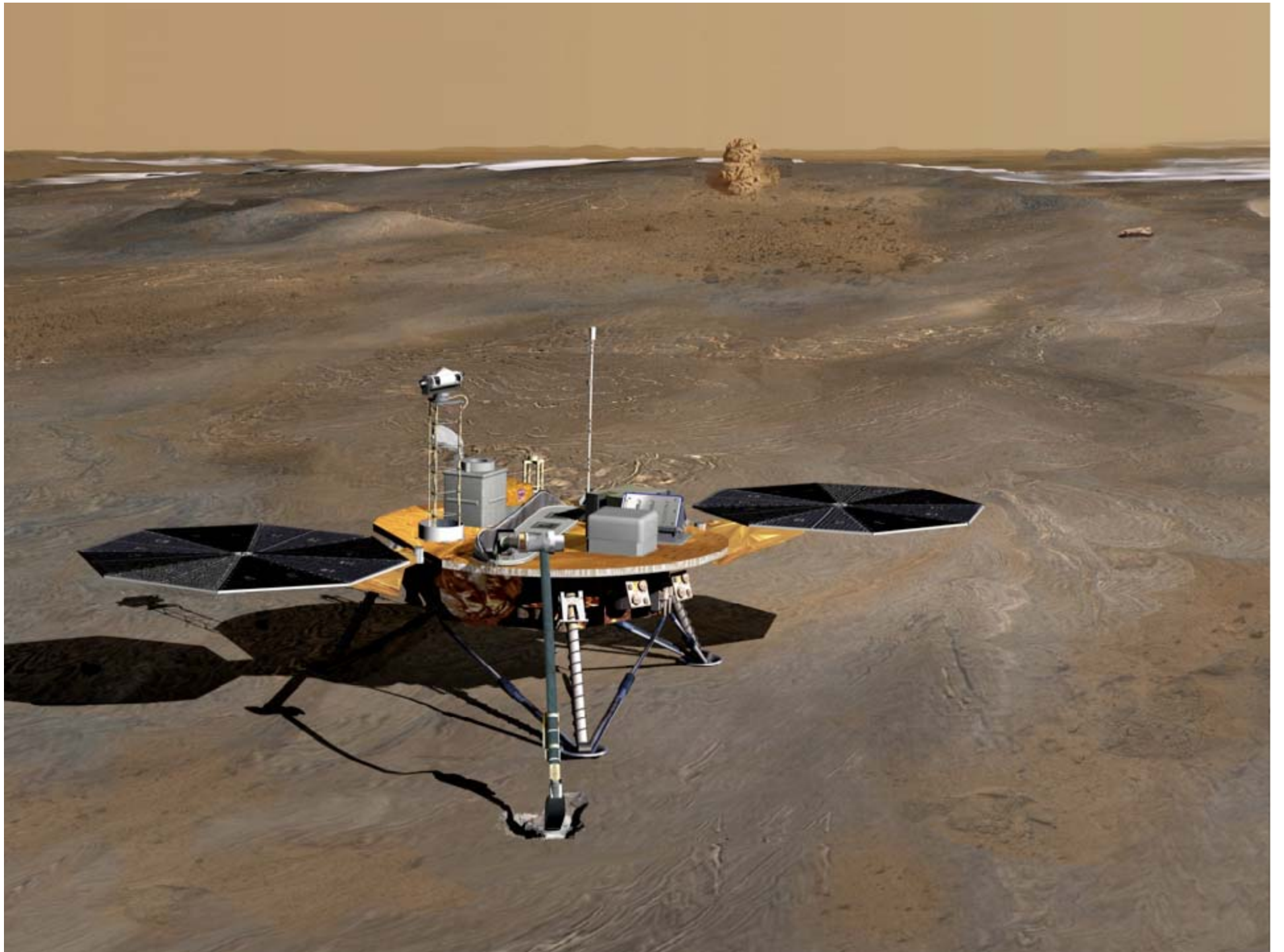














Interplanetary Internet: “InterPlaNet” (IPN)



- Planetary internets
- Interplanetary Gateways
- Interplanetary Long-Haul Architecture (RFC 4838)
 - Licklider Transport Protocol (LTP)
 - Bundle Protocol (RFC 5050)
 - Delayed Binding of Identifiers
 - Email-like behavior
- TDRSS and NASA in-space routing
- Delay and Disruption Tolerant Protocols
 - Tactical Mobile applications (DARPA)
 - Civilian Mobile applications (SameNet!)
 - Deep Impact Testing October 2008
 - Space Station Testing 2009



Interplanetary Internet

- *End-to-end information flow across the solar system*
- *Layered architecture for evolvability and interoperability*
- *IP-like protocol suite tailored to operate over long round-trip light times*
- *Integrated communications and navigation services*

