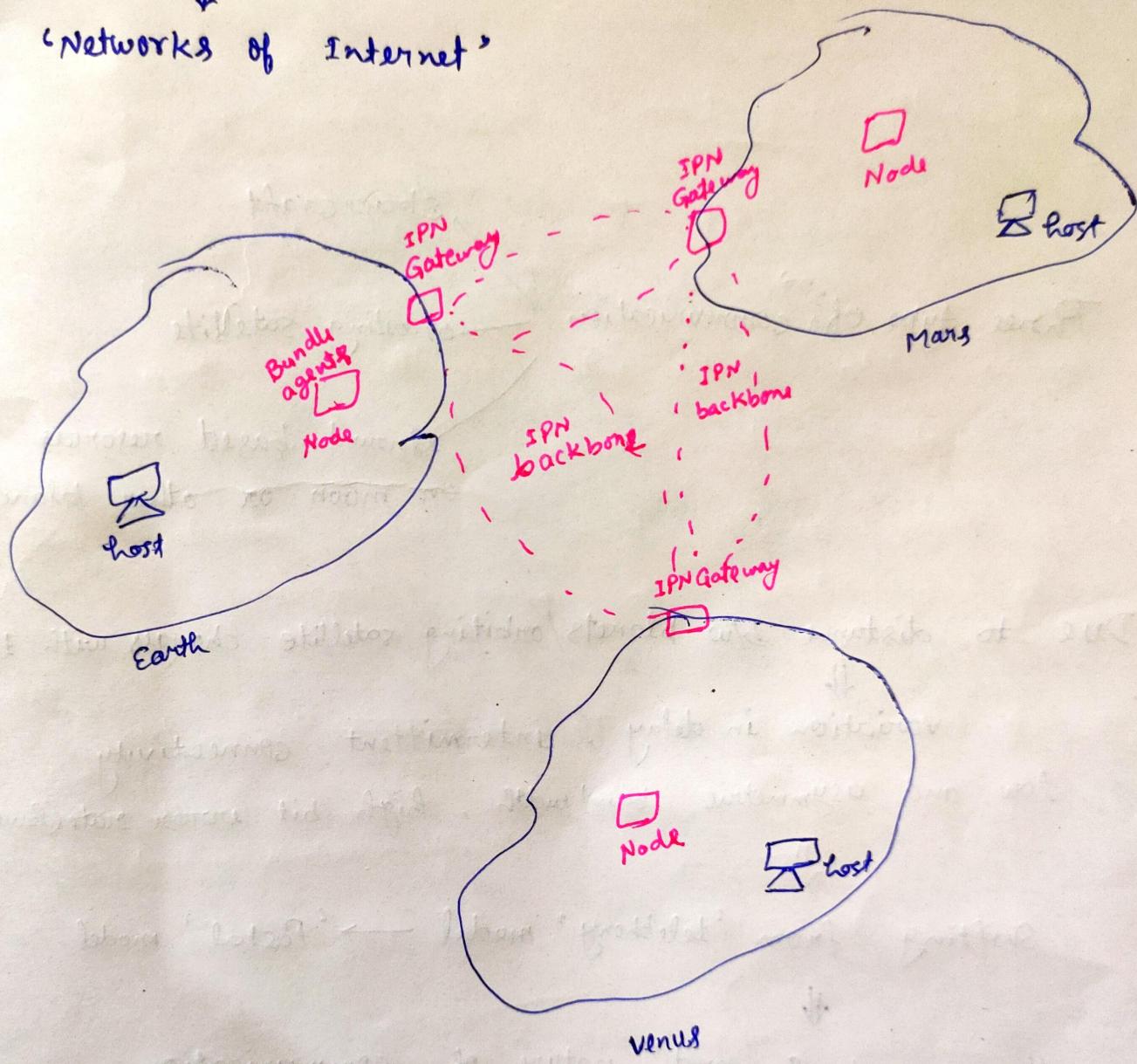


Interplanetary Internet (IPN)

↓
'Networks of Internet'



Three type of ^{IPN} communication

- Spacecraft
- Orbiting satellite
- Ground based resources
on moon or other planet.

• Due to distance b/w planets/orbiting satellite changes with time

↓
variation in delay , intermittent connectivity
low and asymmetric bandwidth , high bit error rate (Power problem)



Shifting from 'telephony' model → 'Postal' model.



"Store-and-forward" nature of communication

* Principles of design :

- In the (terrestrial) Internet, names (host name) are administrative in nature like i.e. www.en.wikipedia.org
 - In our initial design, we considered creating a new top-level domain, e.g. ".sol". So for earth use "earth.sol" for mars .. "mars.sol"
 - We denote the name in the IPN in the following manner : {administrative part, routing part}.
- So if "earth.sol" encompassing the hole earth
 the website will be {www.en.wikipedia.org, earth.sol}
- ↓ ↓
 administrative part routing part (IPN
 region)

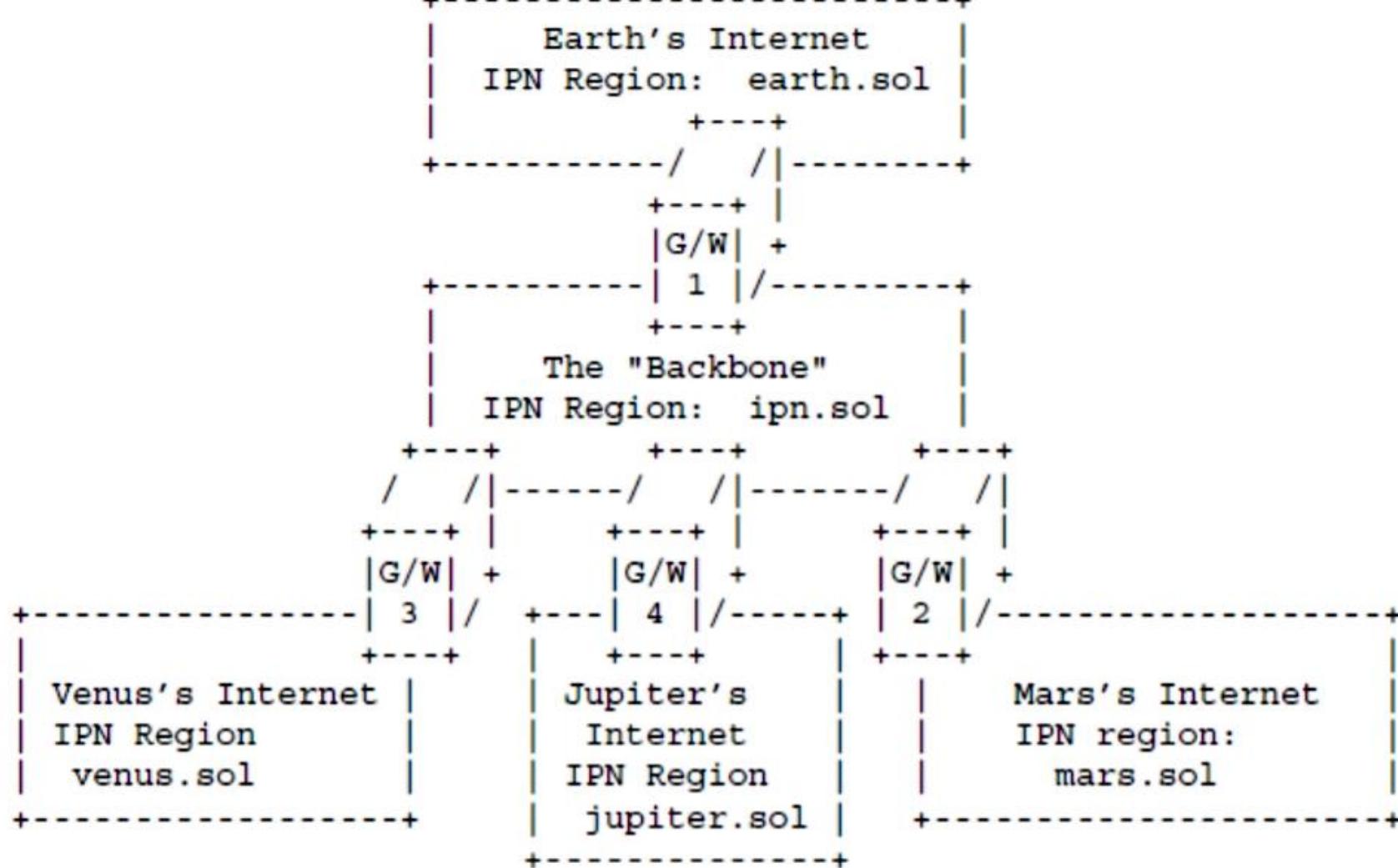


Figure 2. An Interplanetary Internet of Five IPN Regions

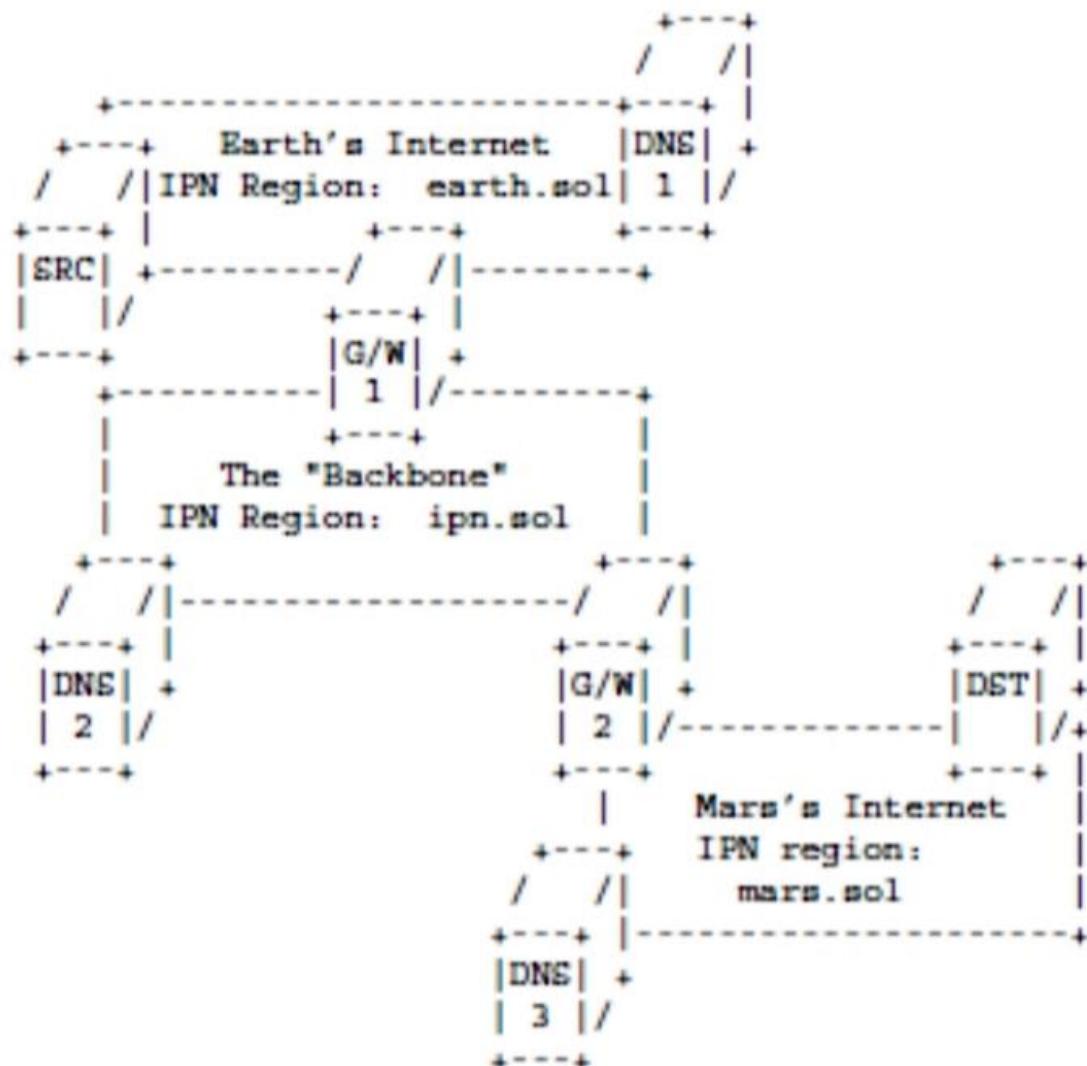


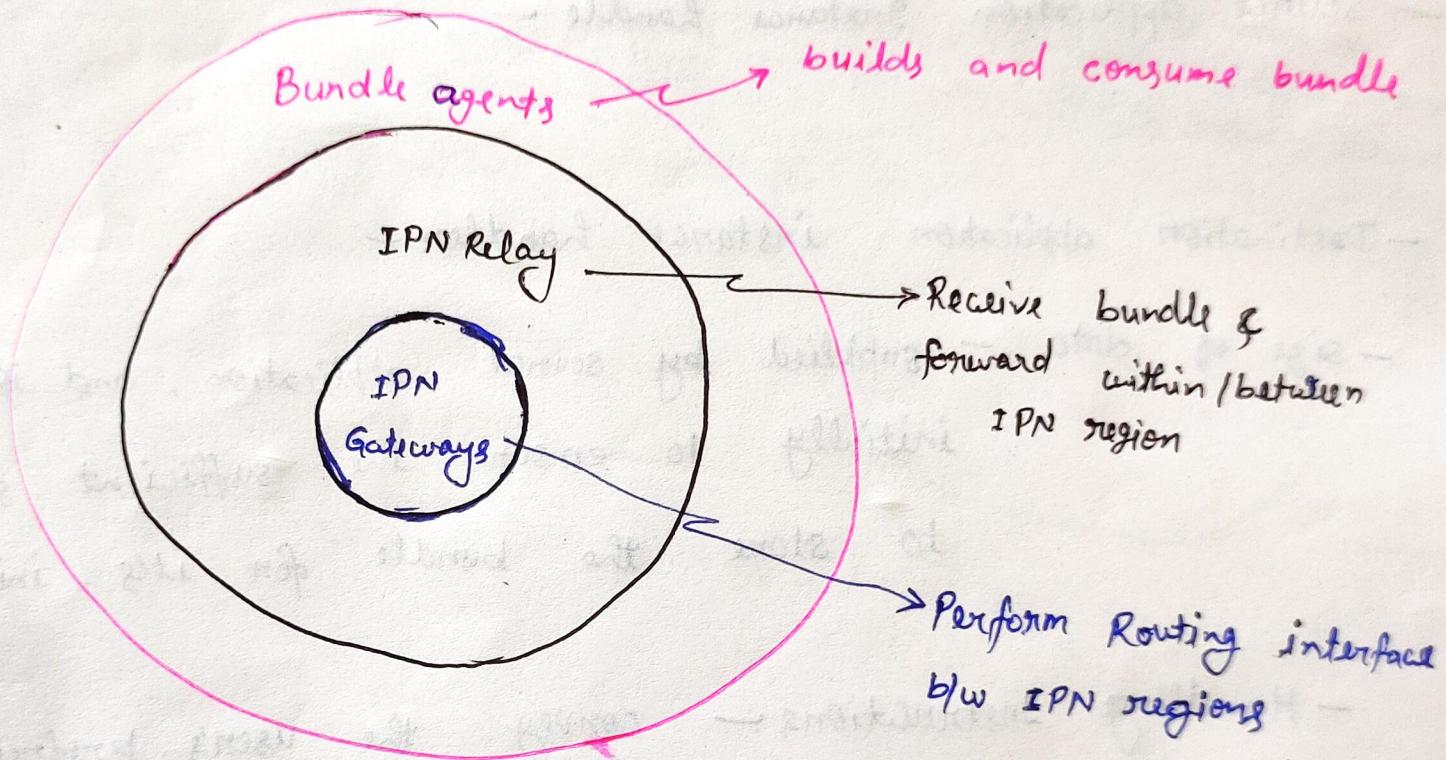
Figure 4. Interplanetary Internet showing principal systems.

Table 1. Host name tuples.

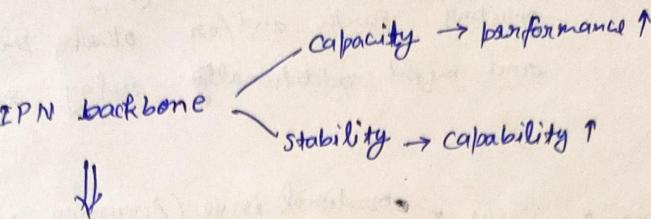
Host	IPN Regions	Host name tuples
SRC	earth.sol	{src.jpl.nasa.gov, earth.sol}
IPN G/W1	earth.sol ipn.sol	(ipngw1.jpl.nasa.gov, earth.sol) (ipngw1.jpl.nasa.gov, ipn.sol)
IPN G/W2	ipn.sol mars.sol	(ipngw2.nasa.mars.org, ipn.sol) (ipngw2.nasa.mars.org, mars.sol)

Types of Node

⑤



Building a stable backbone for the IPN:



high capacity, high availability links b/w points
to access to high activity subnets i.e. Earth, venus & mars.

- Media
 - In IPN → radiation
 - Terrestrial → optical fibre

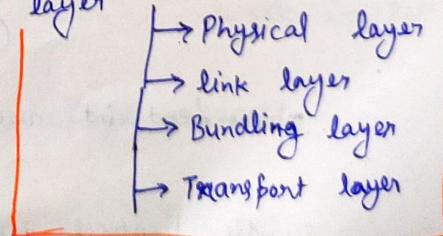
- Nature of connectivity
 - IPN → operational, directed & highly dynamics
 - Terrestrial → structural & relatively static.

cost IPN > terrestrial

- Band width is important

Retransmission & error correction → increases reliable delivery
But consume B.W.

⇒ Design constraints divides four layer



- Physical layer → IPN backbone consist antennae, mounted in aboard orbiting or landed spacecraft.

near/medium future term → Infrastructure Earth based tracking system like DSN

In long future \rightarrow might augmented by optical comm. satellites orbiting Earth and/or other planet and might additionally relay satellite LaGrange point

challenging issue \rightarrow operational issue (Accuracy in pointing and tx. scheduling)
 \downarrow
for most efficient use
 \rightarrow one another orbital dynamics
 \rightarrow current time (connectivity b/w a given pair of backbone antennae)
 \downarrow
due to the interposition of large radiant planetary bodies.

Link layer \rightarrow require link protocol that minimizes overhead
• low noise / low point-to-point tx. latency.
ccsds protocol \rightarrow reduces bit error rates, B.W.↑

Bundling layer \rightarrow backbone have no need of network layer
because
no need for routing
 \downarrow
we expect the endpoints of transport layer
(direct line of sight)

selection of endpoint need Routing that addressed bundling layer.

Bundle protocol just above the Transport protocol
 \downarrow

Relatively optimistic about tx. success
 \downarrow

It must recover from failure
 \downarrow

Capacity for time out detection & custodian-to-custodian retransmission

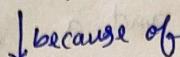
Transport protocol : Very different operation from TCP

- connection time is very low



so operation is asynchronous mode with acknowledgement

- Data arrives at final destination out of order



Retransmission data arrive later

- Accurate time out detection \rightarrow success of retransmission regime

- Premature time out \rightarrow unnecessary retransmission

↓
B.W.↑ & degrading link utilization.

- Late time out \rightarrow delay bundle delivery

Deployed Internet :

- Differentiate two type of network in IPN

Long haul
backbone

deployed internet

G/W + (planetary)
/ Mars N/W

A

Bundle layer / Bundle protocol — Resides above the transport layer

An experimental disruption-tolerant network (DTN) Protocol
(designed for unstable communication)

- It groups data blocks into 'bundle' & then transmit using a store and forward technique.
- Where each bundle have enough semantic information to permit applications to make progress.

bundle layers have no. of services: Information

- Bundle identifiers : how much bundle passes (Provide robustness against system crashes)
- Remote Entity name : destination address
- Source Entity name
- Source application instance handler : bundle handle from source node.
- handling instruction : given by user in the bundle on basis of
 - Priority
 - quality of service
 - Elapsed time
 - Reliability Requirement
- Time to leave
- Current bundle custodian