The Internet as a Liquidity Mechanism: From Analogy to Isomorphism (?)

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Started as a simple analogy....

- **Routed public IP addresses = logical “ends”**
  - Grouped based on country code of origin-AS
  - Plus uncountable RFC 1918, private nets
  - Recognizing that pre-CIDR patterns were very different

- **Access facilities terminations = physical “ends”**
  - PSTN “main lines,” cable “subscriber households”
  - Plus harder to count coax, fiber, terminations

- **1:1 correlations not expected, but observation of similar countries: similar ratios might be interesting...**

- **Question: Are national jurisdictions relevant?**
Early results - interesting (?)

Internet Production (unique IPv4 originated by ASNs, m), 2003
Terrestrial Access lines (copper+coax, m), 2003
Analogy *inoperable* without knowing more about ASNs...

- **ASNs** as network service brokers / financially responsible parties for routing (access) services
  - Wholesale telecom inputs are a prerequisite for ASN eligibility, utility
  - Potential for growth bounded by service revenues/input costs
  - Leading input cost has *until recently* always been telecom inputs
  - Size variations (*normalized*) give rise to *market structure-like* patterns
  - Quantity of originated resources is cumulative fact, so *age matters*
  - Scope of service provision not always aligned with national territory
  - Many other data interpretation challenges (ARDs, region codes, etc.)
“Similar” countries & ratios (?)

1. LDCs, some newly online
   - Domestic-only operators
   - No foreign competitors

2. China
   - Domestic cross-border ops
   - No foreign competitors

3. OECD countries
   - Domestic cross-border ops
   - Plus foreign entrant ISPs

4. Some post-colonial states
   - Domestic-only operators
   - Plus foreign entrant ISPs

Y: Operational scope of country’s domestic network operators (ASNs)
X: Local presence of foreign network operators (ASNs)
Z: “Time online” (i.e., ASN-years since NNE became visible in the routing table)
Analogy inoperable without knowing more about ASNs...

- **ASNs as micro-level redistributors of scarce IP address resources, with responsibility for implementing “prudent stewardship” mandate**
  - ASNs presumably impose some approximation of RIR-level needs-based distribution rules on individual customers
  - Ideally, such “prudence” would enable end user value-creation to pace or exceed routing system upkeep costs, thereby maximizing sustainability & overall system lifetime
  - However, competition plus customer demand for greater addressing and routing flexibility may promote *perverse incentives* to *over-assign* and/or excessively *de-aggregate*...
  - Conversely, absent competition such customer demands may go unfulfilled even when they are “technically justified,” as a result of *perverse incentives* to *under-assign* and/or *over-aggregate*...

(part of some RIRs’ founding folklore)
Knowing more about ASNs requires historical understanding of addressing & routing

- RIRs emerged to fulfill economic & commercial need for an independent maintainer for critical industry-wide shared resources

  - CIDR shaped the technical requirement, and RFC 2050 codified overarching rationale & mechanics, but accelerating growth and competition-driven risks of resource exhaustion were the ultimate root cause for all of these developments

  - Limited availability of addresses and of routing system “carrying capacity” imposed firm (but somewhat dynamic) limits on max number of directly attachable resources, and also max population of independently varying entities that could be added by competing, autonomous routing services providers

  - RIR *initial allocation* and *subsequent allocation* rules were intended to mitigate and forestall the inevitable conflicts of interest over these shared resources
Dev history of IP addressing & routing suggests the top risks

- **Exhaustion of unique (public) IP addresses...**
  - Inability to attach additional resources to the Internet
  - Recovery requires address multiplexing or new address format(s), either of which require introduction of new conversion frontiers

- **Introduction of variably independent routing entities in excess of routing system carrying capacity...**
  - Increasing risk of catastrophic routing system collapse
  - Prevention or recovery requires partitioning DFZ into two or more routing domains -- end of one-stop shopping global default route, plus new conversion frontiers

- **Partitioning bad b/c functionally equivalent to trade barriers that limit the “extent of the market”**
Epiphany... (?)

Working Backwards:

Tightly integrated, high value exchange system built with critical shared resources...

...one vulnerable to risks of premature disintegration resulting from hoarding or squandering of those resources...

...and composed of many competing independent agents, all with conflicting private incentives to maximize their own use of the resource...

...because of its unique value as a means of accessing and integrating new participants and resources into the system....

...which is vastly more versatile and efficient than the nonshared precursor exchange system it builds upon....

...manages the conflict by outsourcing resource administration and synchronizing resource policies around a neutral, community-operated administrator....
In generic graph form...

Deprivation-driven collapse/partition

Increasing risks from hoarding, deprivation

Policies & mechanisms to mitigate these risks

Open, high value exchange system

Max. theoretical system size/value at time of obsolescence

Critical shared resource distribution chain

Neutral, community-operated administrator

Overload-driven collapse/partition

Increasing risks from squandering, excessive use

Policies & mechanisms to mitigate these risks

Many competing independent redistributors

Many competing independent end users

Relationships, interactions

Direct effect

Indirect effect

Agents

Policies

Outcomes

Critical Shared resource

Max. theoretical system size/value at time of obsolescence

Y: Productive lifetime of system from creation to obsolescence
...Or labeled to map the Internet...

- System atrophy or abandonment in favor of something more open
- Increasing risks of address rationing & over-aggregation
- Open, high value exchange system
- Many competing LIRs, ISPs
- Critical Shared resource

Y: Productive lifetime of system from creation to obsolescence

Max. theoretical system size/value at time of obsolescence

Agents

Policies

Outcomes

Direct effect

Indirect effect
...it maps neatly onto another graph...

Monetary system abandonment or partition (ala barter)

Unsustainable monetary contraction (deflation)

Open, high value exchange system

Max. theoretical system size/value at time of obsolescence

Monetary system catastrophic failure (ala hyperinflation), followed by more granular partitioning

Unsustainable monetary expansion (inflation)

Agents

Direct effect

Indirect effect

Policies

Outcomes

Critical Shared resource

Central Bank (or Bankers Club)

Mint (or private issuers)

Monetary instrument distribution chain

Bank establishment & capitalization rules

Borrower qualification & collateral requirements

Bank reserve & reporting requirements

Borrower credit history evaluation

many competing LIRs, ISPs

many competing independent end sites, users

System launch

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TCP/IP is a liquidity technology, and the Internet is a liquidity system, in exactly the same way that this is true of the monetary technologies and the banking and financial system.

• Association with a public IP address defines the instantaneous boundaries of the system, just as possession of money does in the conventional economy.

• Unlike money, IP addresses do not need to circulate to provide sustained liquidity because packet-borne real factors are non-rival.

• Statistical multiplexing provides one of the most important sources of efficiency in both systems (in the monetary world it's called fractional reserve banking).

• IPv4’s quantity constraints make it exactly like the monetary gold, e.g., during the most recent “gold standard” era. That said, even an infinite supply of currency is subject to many of the same risks...
...and leads to other intriguing insights...

- "End to End Arguments" is a normative liquidity rule, functionally equivalent to the kind of rules that central bankers rely on to try to maintain a functional monetary environment.

- The "IPv6 transition" is the functional equivalent of a voluntary currency migration under "normal" (non-collapse) economic conditions.

  There is no precedent for something like this in human history, although episodes of total failure are quite common.

- This insight might provide a useful update or counterpoint to RFC 5218...
Questions...thanks!

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