IPv4 as MIMO Spectrum

Reliable Use of Probable Prefixes

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Previous Work

Presentation builds upon the work presented at NANOG49

Prefixes as Probabilities: A Modest Proposal to Radically Extend the Life of IPv4

The basic proposal:

Allocate unique resources to those who need them at a premium and massively discount multiply allocated resources.

Several critiques of that work, variations on a theme:

- Prefixes collisions will be inobvious and blackhole traffic
- Transmission errors/redirection difficult to detect
- It cannot possibly work (of course it can!)

Additional Previous Work

ESSTCP: Enhanced Spread-Spectrum TCP

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Most previous work focused on security, privacy, use of adversarial networks.

Reuse these notions for basic functionality

Problem Statement

- IPv4 prefixes are increasingly rare and with contention
- IPv4 prefixes are no longer unique and may become even less unique *(grammar error intentionally inserted for Neil's Bækker)*
- IPv4 and IPv6 will be coexisting for some time
  - at client-side and server-side
  - unless IPv6 goes away
- There is no current mechanism to collapse the matrix of possible or probable adjacencies across these prefixes/protocols into usable TCP connection

Problem Statement Expanded

- Hosting content in a single IPv4 prefix has serious vulnerabilities (single prefix can be hijacked, spoofed) [pakistan youtube]
- Prefixes as Probabilities are only a "security problem" while prefixes are assumed to be unique
- Prefixes as Probability has no graceful degradation
- Very similar to radio: ***SOLVED PROBLEM***
- Use a fix borrowed from radio and spread spectrum systems to create a "prefix and path agile" TCP/IP stack

Proposal

Consider addressing to be a sparse matrix representing minimum entropy between endpoints that want to communicate.

Central Problem: convergence.

Conventional convergence model: push. Each destination advertises the appropriate matrix

LISP, SHAM6, 6RaD, etc.: pull model

Our proposal:
Use MIMO techniques to probe all available source/destination paths, producing optimal set of functional IP paths across IPv4 and IPv6 and multiple, multiply reused prefixes.

Discussion

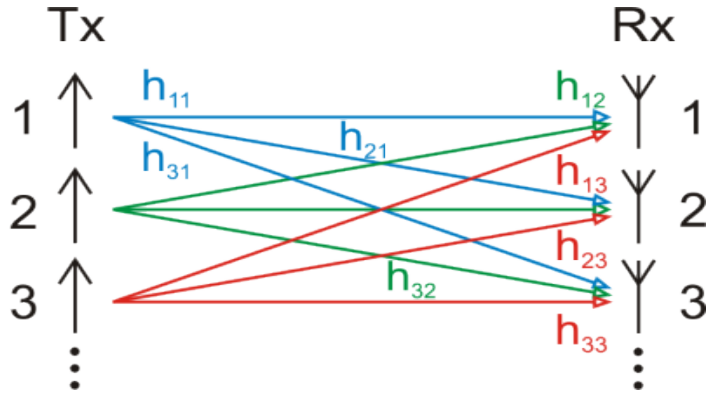
- Smart edge vs dumb core: widening that cap considerably between prefix-agile edge and the stochastic core
- Location-Oblivious Spectrum Technologies (LOST) enable probabilistic clients and servers to locate each other
- Simultaneous exploration of all A and AAAA records provides for any desired level of redundancy
    - It's not just *optional,* it's ***REQUIRED***
- Use "Math" to reduce the Collision Rate Associated with a Prefix

Net result:

- IPv6 transition becomes ***probabilistic*** (presumably with low probability) rather than ***undefined***
- ***Obviously a huge improvement***

Modeling Dynamic Channel Efficiency

- "Internet" as a unknown, lossy channel - must probe it efficiently
  - Lots of academic work on this
- Hosts are now represented as "sets" of transmitters and receivers
- Transmit and receive "antennas" are now probabilistic IPvX numbers
- Least-square error estimates suggest *improved* end-to-end performance!
- Error reduction is not only likely, but **guaranteed**



$$\mathbf{H}_{\text{LS-estimate}} = \mathbf{Y}\mathbf{P}^{H}(\mathbf{P}\mathbf{P}^{H})^{-1}$$

Modeling Dynamic Channel Efficiency (2)

[I'll provide some really impressive math on this slide that will totally justify the research budget. Will submit the slide no later than 11am. No worries. --tkap]

Path Detection Dynamics

Terms:

- Endpoints have Exits and Entries
- Path: A mapping between an Exit and an Entry
- Endpoint Address Receiver (EAR): subsystem to detect a functioning Path
- Selection Weighting Availability Graph (SWAG): the data structure that stores the weights (including 0) of possible Paths between an Exit and Entry
- Orthogonal Vector Exit/Entry Receipt: algorithm for adding a Path to SWAG
- Backup Exit/Entry Network Dynamic: algorithm for weighting and constantly re-weighting a Path in SWAG based on conditions

Availability Receive Side Entry (ARSE) is dependent upon the Backup Entry Network Dynamic (BEND) and the Orthogonal Vector Entry Receipt (OVER).

Likewise for Exit.

Future Work and Unanswered Questions

Need: proof of concept of the original Prefixes as Probabilities work (look for results from Mahtin Levy)

- Refinement of the SWAG inclusion/maintenance system
- Better modeling of loss metrics across lossy Internet networks (and IPv6, too!)
- Prototyping and Real-world implementations

Questions, Kvetches, Irrational Exuberance?

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